Model 346 User's Manual



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Manual version 2.3

Firmware version 2.3

CONTENTS

1 Introduction **4**
- 1.1 Product Description . . . 4
- 1.2 Model 346 Key Specifications . . . 6
- 1.3 Safety Summary and Symbols . . . 7
- 1.4 Legal Disclaimers . . . 10

2 Installation **15**
- 2.1 Inspection and Unpacking . . . 15
- 2.2 Front Panel . . . 16
- 2.3 Rear Panel Overview and Line Input . . . 17
- 2.4 Diode/Resistor Sensor Inputs . . . 20
- 2.5 Thermocouple Sensor Inputs (Model 3402) . . . 27
- 2.6 Heater Output setup . . . 29

3 Operation **35**
- 3.1 General . . . 35
- 3.2 Display Overview . . . 36
- 3.3 Input Setup . . . 41
- 3.4 Output and Control Setup . . . 56
- 3.5 Locking and unlocking the front panel . . . 71

4 Advanced Operation **72**
- 4.1 Curve Setup and Usage . . . 72
- 4.2 Zone Settings . . . 76
- 4.3 Heater Groups . . . 79
- 4.4 Monitor Out . . . 81
- 4.5 Control Stability . . . 84
- 4.6 Warm-up . . . 86
- 4.7 Alarms . . . 89
- 4.8 Relays . . . 92
- 4.9 System Settings . . . 96

5 Remote Interface Operation **106**

5.1 Message Flow Control 108
5.2 USB Interface 109
5.3 Ethernet Interface 112
5.4 GPIB Interface 116
5.5 Model 346 Command Summary 117

6 Options and Accessories 199
6.1 General 199
6.2 Models 199
6.3 Options 199
6.4 Accessories 200
6.5 Rack Mounting 200
6.6 Input Option Card Installation 200

7 Service 202
7.1 General 202
7.2 USB Troubleshooting 202
7.3 Calibration Information 203
7.4 Rear Panel Connectors 204
7.5 Error Messages 214
7.6 Firmware Updates 215
7.7 Electrostatic Discharge 218
7.8 Summary of Internal Memory Devices 219
7.9 Technical Inquiries 221

CHAPTER

ONE

INTRODUCTION

1.1 Product Description

Features:

- Operates down to 300 mK with appropriate NTC RTD sensors
- Supports 10 sensor inputs as standard with easy expandability up to 26
- Includes four high-power outputs for heaters up to 100 W
- Four additional low-power outputs for up to 1 W of heater power or as analog outputs for temperature references
- Ethernet IPv4 and IPv6, USB, and optional IEEE-488 GPIB interfaces
- Two relays and two digital inputs for external device triggering
- NRTL and CE certified

The touchscreen interface ensures simple setup and monitoring, while the included ColdSync™ software facilitates advanced setup, initial configuration, and comprehensive data monitoring.

1.1.1 Sensor Inputs

The Lake Shore Model 346 temperature controller includes 10 standard sensor inputs compatible with diode and RTD temperature sensors. With additional option cards, the controller can accommodate up to 26 total sensors, providing flexibility for complex or multi-zone measurement setups.

Supported sensors include:

- Negative temperature coefficient (NTC) resistive temperature devices (RTDs) up to 100 kΩ such as Lake Shore Cernox® and Rox™ sensors
- Positive temperature coefficient (PTC) RTDs up to 1 kΩ such as Lake Shore PT-100 Series sensors

- Diodes with a maximum forward voltage of 2.5 V such as Lake Shore DT-670 sensors
- Thermocouples with operating levels between ±50 mV (requires option card)

For resistance sensors, current reversal minimizes thermal electromotive force (EMF) errors. Seven selectable excitation currents support temperature measurement and control down to 300 mK using appropriate sensors. Autorange mode automatically scales excitation current to reduce self-heating at low temperatures, where sensor resistance can vary by several orders of magnitude.

The Lake Shore Model 346 temperature controller includes standard temperature sensor response curves for silicon diodes, platinum RTDs, and ruthenium oxide RTDs. Non-volatile memory can also store up to 40 200-point CalCurves for Lake Shore calibrated temperature sensors or user curves.

1.1.2 Temperature Control

Up to 8 independent control loops can be configured on the Lake Shore Model 346 temperature controller, with the first 4 being high-power 100 W outputs for 25 Ω heaters. The high-resolution PID-based control loops allow precise control of temperature with many control features and modes to suit most cryogenic systems. The physical heaters can also be grouped for situations where more than 100 W is desired in a single location. A special warm-up mode has also been included to simplify the process of warming a system up for sample exchange, reducing overall turn-around time.

Temperature limit settings for inputs are provided as a safeguard against system damage. Each input is assigned a temperature limit, and if any input exceeds that limit, all control channels are automatically disabled.

1.1.3 Interface

The Model 346 comes standard with Ethernet and USB interfaces, with an optional IEEE-488 (GPIB) parallel interface. Nearly all instrument functions can be controlled remotely, in addition to data acquisition. The USB interface emulates an RS-232 serial port at a fixed baud rate of 921,600, while still using standard USB connectors.

The 0 V to 10 V analog voltage outputs on outputs 5 to 8 can be configured to send a voltage proportional to temperature to a data acquisition system. You may select the scale and data sent to the output.



Figure 1.1: Model 346 rear panel

1.1.4 Option Card Slots

Up to four option cards can be installed in the Model 346. These option cards further expand the application versatility of the Model 346 by allowing specialized sensors to be switched in and out to achieve specific measurement objectives. Option cards and be mixed and matched in any combination.

For example, addition of the 2-channel thermocouple input option card (Model 3402) enables continuous measurement to 1000 K and above. The 4-channel scanner option card (Model 3401) enables use of additional sensors for supplemental monitoring.

Additional option cards may be released in the future. To support the potential need for additional power to run future option cards, a 24 VDC auxilliary input has been included on the back of the instrument. This input is not needed for any of the currently available option cards, so this input is currently unused.

1.2 Model 346 Key Specifications

Full specifications about the Model 346 are provided on lakeshore.com.

Power requirement	100 to 240 VAC, ±10%, 50 or 60 Hz, 520 VA max
Size	435 mm wide × 89 mm high × 369 mm deep (17 in × 3.5 in × 14.5 in), full rack
Weight	6.2 kg (13.6 lb)
Approval	See https://www.lakeshore.com/compliance/
Temperature	15 °C to 35 °C at rated accuracy; 5 °C to 40 °C at reduced accuracy

1.3 Safety Summary and Symbols

Observe these general safety precautions during all phases of instrument operation, service, and repair. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended instrument use. Lake Shore Cryotronics, Inc. assumes no liability for Customer failure to comply with these requirements.

The Lake Shore Model 346 temperature controller protects the operator and surrounding area from electric shock or burn, mechanical hazards, excessive temperature, and spread of fire from the instrument. Environmental conditions outside of the conditions below may pose a hazard to the operator and surrounding area.

- Indoor use
- Altitude to 2000 m
- Temperature for safe operation: 5 °C to 40 °C
- Maximum relative humidity: 60% for temperature up to 31 °C decreasing linearly to 50% at 40 °C
- Power supply voltage fluctuations not to exceed ±10% of the nominal voltage
- Overvoltage category II
- Pollution degree 2

Follow the guidelines below to ensure safety

Ground the Instrument

To minimize shock hazard, the instrument is equipped with a 3-conductor AC power cable. Plug the power cable into an approved 3-contact electrical outlet or use a 3-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet Underwriters Laboratories (UL) and International Electrotechnical Commission (IEC) safety standards.

Ventilation

The instrument has ventilation holes in its side covers. Do not block these holes when the instrument is operating.

Do Not Operate in an Explosive Atmosphere

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

Keep Away from Live Circuits

Operating personnel must not remove instrument covers. Refer component replacement and internal adjustments to qualified maintenance personnel. Do not replace components with power cable connected. To avoid injuries, always disconnect power and discharge circuits before touching them. Do not position the instrument so that it is difficult to disconnect the power cord.

Child Safety

This equipment is not suitable for use in locations where children are likely to be present.

Do Not Substitute Parts or Modify Instrument

Do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an authorized Lake Shore Cryotronics, Inc. representative for service and repair to ensure that safety features are maintained. If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Cleaning

Do not submerge instrument. Clean only with a damp cloth and mild detergent. Exterior only.

Desktop Installation

When installing the instrument in a desktop environment, ensure it is mounted on a flat, level surface.

Improper Use

If the instrument is used in a manner that is not specified by Lake Shore, the safety protections provided by the instrument are no longer guaranteed, and may be impaired.

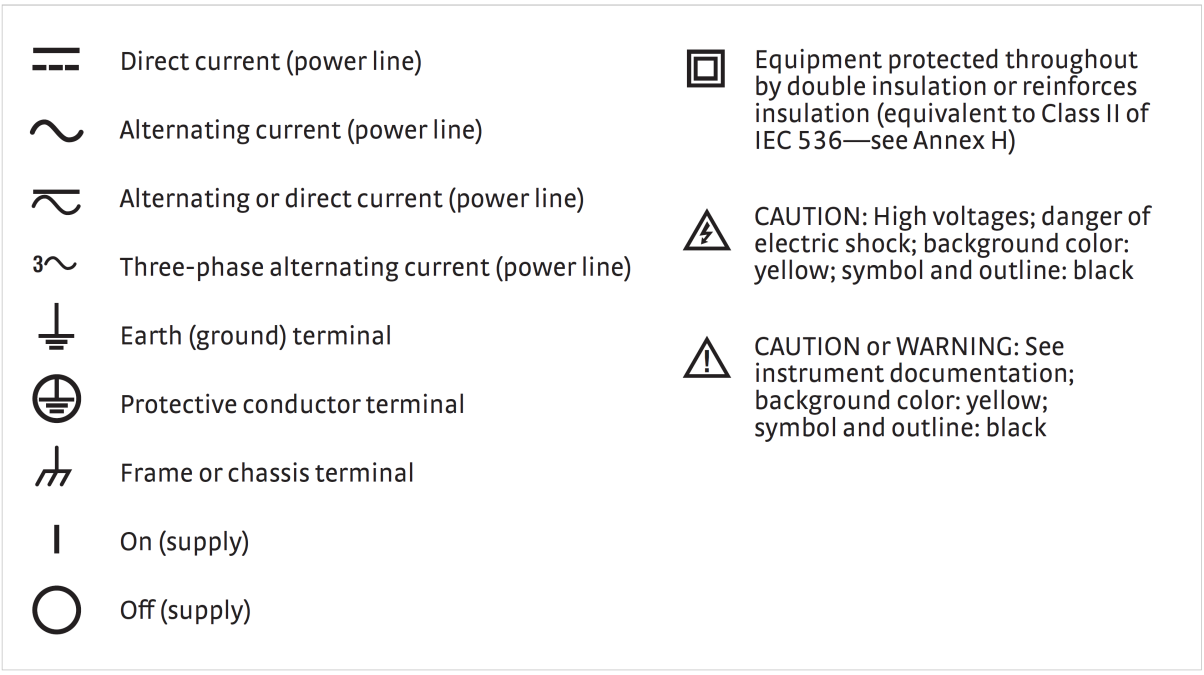


Figure 1.2: Safety symbols

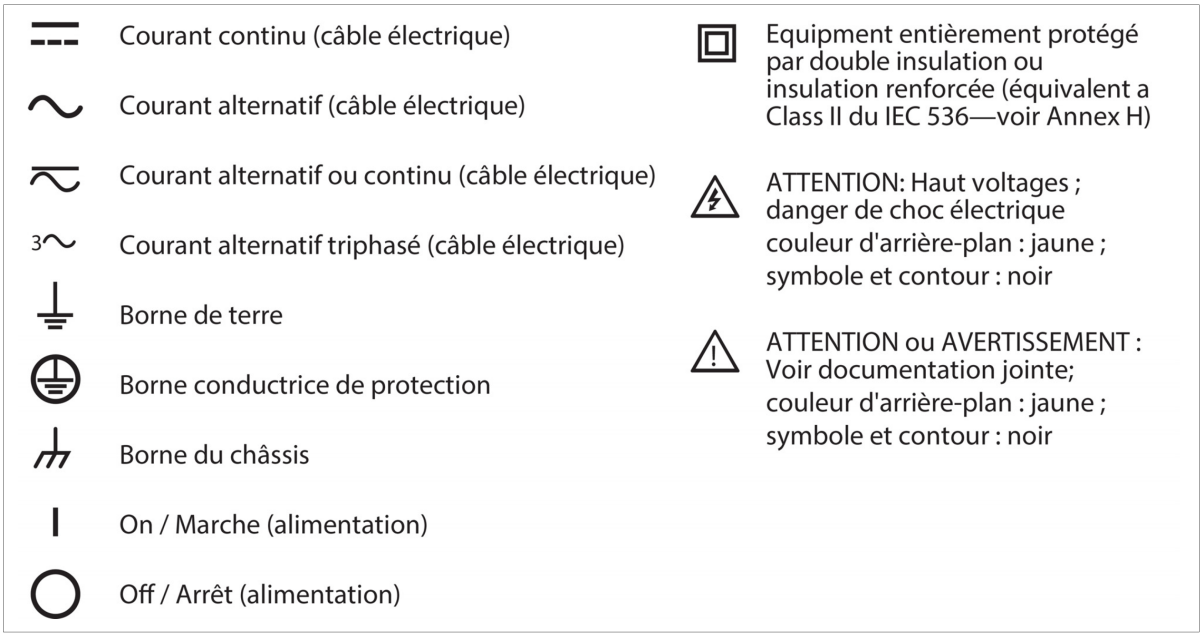


Figure 1.3: Symboles de sécurité

1.4 Legal Disclaimers

1.4.1 PROPRIETARY RIGHTS

Methods and apparatus disclosed and described herein have been developed solely on company funds of Lake Shore Cryotronics, Inc. No government or other contractual support or relationship whatsoever has existed which in any way affects or mitigates proprietary rights of Lake Shore Cryotronics, Inc. in these developments. Methods and apparatus disclosed herein may be subject to U.S. Patents existing or applied for.

Lake Shore Cryotronics, Inc. reserves the right to add, improve, modify, or withdraw functions, design modifications, or products at any time without notice. Lake Shore shall not be liable for errors contained herein or for incidental or consequential damages in connection with furnishing, performance, or use of this material.

1.4.2 LIMITED WARRANTY STATEMENT

WARRANTY PERIOD: THREE (3) YEARS

1. Lake Shore warrants that products manufactured by Lake Shore (the "Product") will be free from defects in materials and workmanship for three years from the date the Product leaves Lake Shore (the "Warranty Period"). If Lake Shore receives notice of any such defects during the Warranty Period and the defective Product is shipped freight prepaid back to Lake Shore, Lake Shore will, at its option, either repair or replace the Product (if it is so defective) without charge for parts, service labor or associated customary return shipping cost to the Purchaser. Replacement for the Product may be by either new or equivalent in performance to new. Replacement or repaired parts, or a replaced Product, will be warranted for only the unexpired portion of the original warranty or 90 days (whichever is greater).
2. Lake Shore warrants the Product only if the Product has been sold by an authorized Lake Shore employee, sales representative, dealer or an authorized Lake Shore original equipment manufacturer (OEM).
3. The Product may contain remanufactured parts equivalent to new in performance or may have been subject to incidental use when it is originally sold to the Purchaser.
4. The Warranty Period begins on the date the Product ships from Lake Shore's plant.
5. This limited warranty does not apply to defects in the Product resulting from (a) improper or inadequate installation (unless OT&V services are performed by Lake Shore), maintenance, repair or calibration, (b) fuses, software, power surges, lightning and non-rechargeable batteries, (c) software, interfacing, parts or other supplies not furnished by Lake Shore, (d) unauthorized modification or misuse, (e)

operation outside of the published specifications, (f) improper site preparation or site maintenance (g) natural disasters such as flood, fire, wind, or earthquake, or (h) damage during shipment other than original shipment to you if shipped through a Lake Shore carrier.

6. This limited warranty does not cover: (a) regularly scheduled or ordinary and expected recalibrations of the Product; (b) accessories to the Product (such as probe tips and cables, holders, wire, grease, varnish, feed throughs, etc.); (c) consumables used in conjunction with the Product (such as probe tips and cables, probe holders, sample tails, rods and holders, ceramic putty for mounting samples, Hall sample cards, Hall sample enclosures, etc.); or, (d) non-Lake Shore branded Products that are integrated with the Product.
7. To the extent allowed by applicable law,, this limited warranty is the only warranty applicable to the Product and replaces all other warranties or conditions, express or implied, including, but not limited to, the implied warranties or conditions of merchantability and fitness for a particular purpose. Specifically, except as provided herein, Lake Shore undertakes no responsibility that the products will be fit for any particular purpose for which you may be buying the Products. Any implied warranty is limited in duration to the warranty period. No oral or written information, or advice given by the Company, its Agents or Employees, shall create a warranty or in any way increase the scope of this limited warranty. Some countries, states or provinces do not allow limitations on an implied warranty, so the above limitation or exclusion might not apply to you. This warranty gives you specific legal rights and you might also have other rights that vary from country to country, state to state or province to province.
8. Further, with regard to the United Nations Convention for International Sale of Goods (CISC), if CISG is found to apply in relation to this agreement, which is specifically disclaimed by Lake Shore, then this limited warranty excludes warranties that: (a) the Product is fit for the purpose for which goods of the same description would ordinarily be used, (b) the Product is fit for any particular purpose expressly or impliedly made known to Lake Shore at the time of the conclusion of the contract. (c) the Product is contained or packaged in a manner usual for such goods or in a manner adequate to preserve and protect such goods where it is shipped by someone other than a carrier hired by Lake Shore.
9. Lake Shore disclaims any warranties of technological value or of non-infringement with respect to the Product and Lake Shore shall have no duty to defend, indemnify, or hold harmless you from and against any or all damages or costs incurred by you arising from the infringement of patents or trademarks or violation or copyrights by the Product.
10. THIS WARRANTY IS NOT TRANSFERRABLE. This warranty is not transferrable.
11. Except to the extent prohibited by applicable law, neither Lake Shore nor any of its

subsidiaries, affiliates or suppliers will be held liable for direct, special, incidental, consequential or other damages (including lost profit, lost data, or downtime costs) arising out of the use, inability to use or result of use of the product, whether based in warranty, contract, tort or other legal theory, regardless whether or not Lake Shore has been advised of the possibility of such damages. Purchaser's use of the Product is entirely at Purchaser's risk. Some countries, states and provinces do not allow the exclusion of liability for incidental or consequential damages, so the above limitation may not apply to you.

12. This limited warranty gives you specific legal rights, and you may also have other rights that vary within or between jurisdictions where the product is purchased and/or used. Some jurisdictions do not allow limitation in certain warranties, and so the above limitations or exclusions of some warranties stated above may not apply to you.
13. Except to the extent allowed by applicable law, the terms of this limited warranty statement do not exclude, restrict or modify the mandatory statutory rights applicable to the sale of the product to you.

1.4.3 CERTIFICATION

Lake Shore certifies that this product has been inspected and tested in accordance with its published specifications and that this product met its published specifications at the time of shipment. The accuracy and calibration of this product at the time of shipment are traceable to the United States National Institute of Standards and Technology (NIST); formerly known as the National Bureau of Standards (NBS).

1.4.4 FIRMWARE LIMITATIONS

Lake Shore has worked to ensure that the firmware is as free of errors as possible, and that the results you obtain from the instrument are accurate and reliable. However, as with any computer-based software, the possibility of errors exists.

In any important research, as when using any laboratory equipment, results should be carefully examined and rechecked before final conclusions are drawn. Neither Lake Shore nor anyone else involved in the creation or production of this firmware can pay for loss of time, inconvenience, loss of use of the product, or property damage caused by this product or its failure to work, or any other incidental or consequential damages. Use of our product implies that you understand the Lake Shore license agreement and statement of limited warranty.

1.4.5 FIRMWARE LICENSE AGREEMENT

The firmware in this instrument is protected by United States copyright law and international treaty provisions. To maintain the warranty, the code contained in the firmware must not be modified. Any changes made to the code is at the user's risk. Lake Shore will assume no responsibility for damage or errors incurred as result of any changes made to the firmware.

Under the terms of this agreement you may only use the firmware as physically installed in the instrument. Archival copies are strictly forbidden. You may not decompile, disassemble, or reverse engineer the firmware. If you suspect there are problems with the firmware, return the instrument to Lake Shore for repair under the terms of the Limited Warranty specified above. Any unauthorized duplication or use of the firmware in whole or in part, in print, or in any other storage and retrieval system is forbidden.

1.4.6 TRADEMARK ACKNOWLEDGMENT

Many manufacturers and sellers claim designations used to distinguish their products as trademarks. Where those designations appear in this manual and Lake Shore was aware of a trademark claim, they appear with initial capital letters and the ™ or ® symbol.

- Alumel™ and Chromel™ are trademarks of Conceptech, Inc., Corporation
- Apiezon™ is a registered trademark of M&I Materials, Ltd.
- ColdSync™, MeasureReady™, MeasureLINK™, CalCurve™, Cernox®, SoftCal™, Rox™, 2Dex™, TiltView™, and TruZero™ are trademarks of Lake Shore Cryotronics, Inc.
- Java® is a registered trademark of Oracle.
- LabVIEW® is a registered trademark of National Instruments.
- Mac® is a registered trademark of Apple, Inc., registered in the U.S and other countries.
- Microsoft Windows® and Excel® are registered trademarks of Microsoft Corporation in the United States and other countries.
- Stycast® is a trademark of Henkel Corporation.
- USB Type-C™ and USB-C are trademarks of USB Implementers Forum.
- WinZip™ is a registered trademark of Nico Mak of Connecticut.

1.4.7 COMPLIANCE AND CERTIFICATIONS

See https://www.lakeshore.com/compliance/.

1.4.8 ELECTROMAGNETIC COMPATIBILITY (EMC)

Electromagnetic compatibility (EMC) of electronic equipment is a growing concern worldwide. Emissions of and immunity to electromagnetic interference is now part of the design and manufacture of most electronics. To qualify for the CE Mark, the Model 346 meets or exceeds the requirements of the European EMC Directive 2014/30/EU.

WARNING: This is a Class A product. In a domestic environment, this product may cause radio interference in which case the user may be required to take adequate measures.

The instrument was tested under normal operating conditions with interface cables attached. If the installation and operating instructions in this user's manual are followed, there should be no degradation in EMC performance.

Exposure to RF interference greater than that found in a typical laboratory environment may disturb the sensitive measurement circuitry of the instrument.

Pay special attention to instrument cabling. Improperly installed cabling may defeat even the best EMC protection. For the best performance from any precision instrument, follow the grounding and shielding instructions in the user's manual. In addition, the installer of the instrument should consider the following:

- Shield measurement and computer interface cables.
- Leave no unused or unterminated cables attached to the instrument.
- Make cable runs as short and direct as possible. Higher radiated emissions are possible with long cables.
- Do not tightly bundle cables that carry different types of signals.

1.4.9 COPYRIGHT

Copyright September 2, 2026, Lake Shore Cryotronics, Inc. All rights reserved. No portion of this manual may be reproduced stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the express written permission of Lake Shore.

CHAPTER

TWO

INSTALLATION

This chapter provides general installation instructions for the Model 346 temperature controller. Please read this entire chapter before installing the instrument and powering it on to ensure the best possible performance and to maintain safety.

2.1 Inspection and Unpacking

Inspect shipping containers for external damage before opening them. Photograph any container that has significant damage before opening it. Inspect all items for both visible and hidden damage that occurred during shipment. If there is visible damage to the contents of the container, contact the shipping company and Lake Shore immediately, preferably within five days of receipt of goods, for instructions on how to file a proper insurance claim. Lake Shore products are insured against damage during shipment, but a timely claim must be filed before Lake Shore will take further action. Procedures vary slightly with shipping companies. Keep all damaged shipping materials and contents until instructed to either return or discard them.

Open the shipping container and keep the container and shipping materials until all contents have been accounted for. Check off each item on the packing list as it is unpacked. Instruments themselves may be shipped as several parts. The items included with the Model 346 temperature controller are listed below. Contact Lake Shore immediately if there is a shortage of parts or accessories. Lake Shore is not responsible for any missing items if not notified within 60 days of shipment.

If you need to return the instrument for recalibration, replacement or repair, a return authorization (RMA) number must be obtained from a Lake Shore representative.

Items Included with Model 346:

- 1 Model 346 temperature controller
- 1 Model 346 temperature controller Quick Start Guide
- 5 DE-9 D-sub connectors for sensors
- 1 DB-15 D-sub connector for heaters

- 2 10-pin terminal blocks for analog outputs, digital inputs, and relays
- 1 Line power cord

2.2 Front Panel

The Model 346 has a 5 in capacitive touch, color TFT display with LED backlight, which is used to control the instrument and display information.



Figure 2.1: Model 346 front panel

1. **Power button** Turns line power to the instrument on and off.
2. **TiltView™ touchscreen** The screen adjusts from a 0° to a 47° viewing angle, whether mounted in a rack or on a benchtop.
3. **USB-C™ port** Connect a USB flash drive for firmware updates.

2.2.1 TiltView™ Touchscreen

The TiltView™ feature makes seeing the screen and operating the touch interface comfortable from any angle, even when mounted in a rack. The screen adjusts from a 0° to a 47° viewing angle, whether mounted in a rack or on a benchtop.

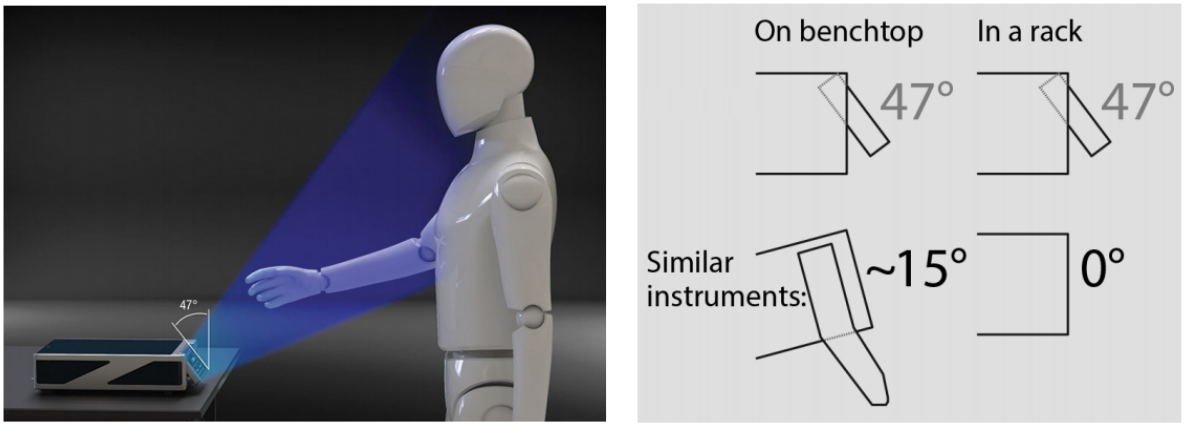


Figure 2.2: TiltView™ angle comparison

2.3 Rear Panel Overview and Line Input

This section provides a description of the Model 346 rear panel connections.

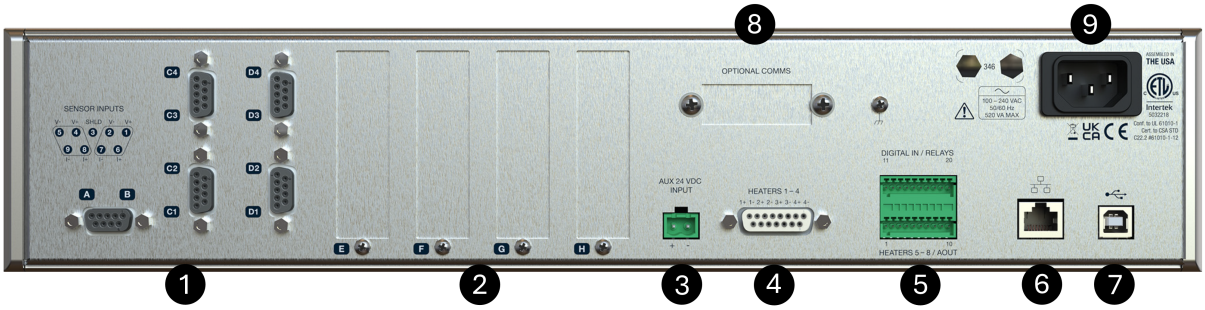


Figure 2.3: Model 346 rear panel

1. **Sensor input connectors** Connect up to 10 diode, NTC RTD, or PTC RTD sensors to inputs A, B, C and D.
2. **User option card slots** Install up to 4 option cards, including the Model 3401 4-channel scanner and Model 3402 2-channel thermocouple.
3. **Auxiliary 24 VDC input** Auxiliary power for future user option cards, presently not used.
4. **Heater outputs** Heater outputs 1 to 4, up to 100 W each, for 400 W total.
5. **Terminal block** Includes low power voltage source/analog outputs 5 to 8, relays 1 and 2, digital inputs 1 and 2, auxiliary 5 V output low power supply.
6. **RJ-45 Ethernet connector** For remote communication over a network.
7. **USB-B connector** For remote communication using a virtual COM port.
8. **Optional communication slot** For remote communication over GPIB.
9. **Line input assembly** Electrical power is provided through the line input assembly.

CAUTION **Always turn off the instrument before making any rear panel connections. This is especially critical when making sensor to instrument connections.**

ATTENTION **Éteignez toujours l'instrument avant d'effectuer toute connexion sur le panneau arrière. Ceci est particulièrement critique lors de la réalisation de connexions entre le capteur et l'instrument.**

2.3.1 Line Input Assembly

This section describes how to properly connect the Model 346 to line power. Please follow these instructions carefully to ensure proper operation of the instrument and the safety of operators.



Figure 2.4: Model 346 line input assembly

Line Voltage

The Model 346 operates between the range of 100 VAC to 240 VAC, with 50 Hz or 60 Hz configurations so that it can be operated from line power anywhere in the world. No user configuration is required for different voltage operations

2.3.2 Power Cord

The Model 346 includes a 3-conductor power cord that mates with the IEC 320-C14 line cord receptacle. Line voltage is present on the two outside conductors and the center conductor is a safety ground. The safety ground attaches to the instrument chassis and protects the user in case of a component failure. A CE-approved power cord is included with instruments shipped to Europe; a domestic power cord is included with all other instruments (unless otherwise specified when ordered).

WARNING Always plug the power cord into a properly grounded receptacle to ensure safe instrument operation. In addition, the receptacle must be protected by a 15/20 A circuit breaker. The breaker must meet Underwriters Laboratories (UL) and International Electrotechnical Commission (IEC) safety standards.

AVERTISSEMENT Branchez toujours le cordon d'alimentation dans une prise correctement mise à la terre pour assurer un fonctionnement sécuritaire de l'instrument. De plus, la prise doit être protégée par un disjoncteur de 15/20 A. Le disjoncteur doit être conforme aux Underwriters Laboratories (UL) et International Normes de sécurité de la Commission électrotechnique (IEC).

WARNING Position the Model 346 in such a way to enable easy access to the disconnecting device. Failure to comply could result in death or injury to personnel.

AVERTISSEMENT Positionnez le modèle 346 de manière à permettre un accès facile au dispositif de déconnexion. Le non-respect de ces consignes peut entraîner la mort ou des blessures au personnel.

Note: If the power supply cord is damaged or lost, it must be replaced. Contact Lake Shore for a replacement to ensure proper voltage, current and type of cord. The power supply cord must not exceed 3 m (10 ft) in length.

The delicate nature of the measurements being taken with this instrument may necessitate additional grounding including ground strapping of the instrument chassis. In these cases the operator's safety should remain the highest priority and low impedance from the instrument chassis to safety ground should always be maintained.

2.3.3 Power Switch

The power switch is located on the front panel of the Model 346 and turns line power to the instrument on and off. When the button is depressed, power is on. When the line is released, power is off.

2.4 Diode/Resistor Sensor Inputs

This section details how to connect diode and resistor sensors to the Model 346 standard inputs and the 4-channel scanner option card input channels.

2.4.1 Sensor Input Connector and Pinout

The input A to D connectors are standard DE-9 sockets. The sensor connector pins are defined in the figure and table below. Five mating connectors (DE-9 plugs) are included in the connector kit shipped with the instrument. These are common connectors; additional mating connectors can be purchased from local electronics suppliers.

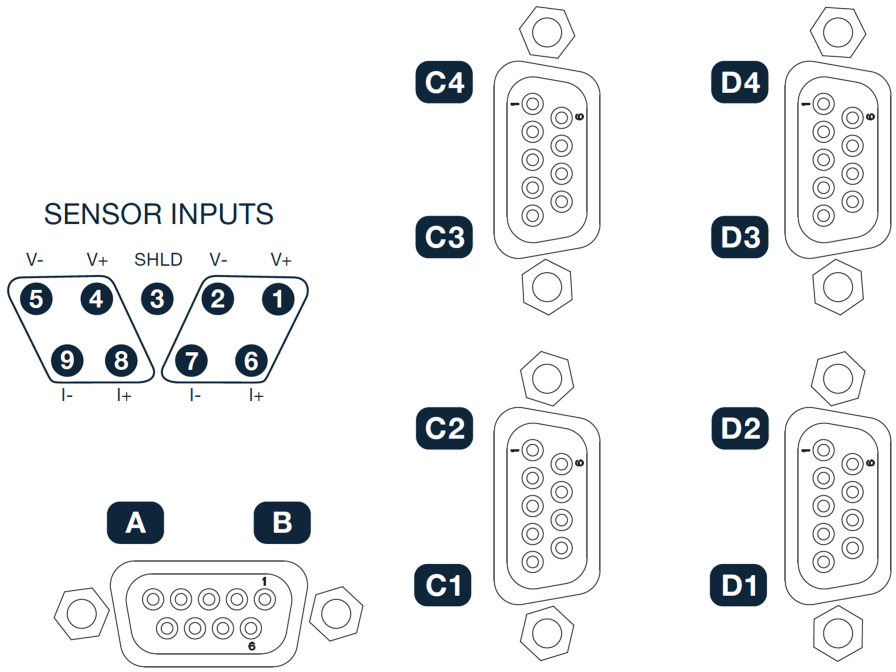


Figure 2.5: Sensor input connectors

Table 2.1: Diode/resistor input connector pinout

Pin	Symbol	Description
8	I+	+current source
9	I-	-current source
4	V+	+voltage measure
5	V-	-voltage measure
6	I+	+current source
7	I-	-current source
1	V+	+voltage measure
2	V-	-voltage measure
3	shield	sensor measurement common (isolated from chassis)

Note: In the above table, pins 8, 9, 4, and 5 represent inputs A, C1, C3, D1, and D3, while pins 6, 7, 1, and 2 represent inputs B, C2, C4, D2, and D4.

2.4.2 Sensor Lead Cable

The sensor lead cable used outside the cooling system can be much different from what is used inside. Between the instrument and vacuum shroud, heat leak is not a concern. In this case, choose cabling to minimize error and noise pick up. Larger conductor, 22 AWG to 28 AWG stranded copper wire is recommended because it has low resistance yet remains flexible when several wires are bundled in a cable. The arrangement of wires in a cable is also important. For best results, twist voltage leads V+ and V- together, and twist current leads I+ and I- together. Cover the twisted pairs of voltage and current leads with a braided or foil shield that is connected to the shield pin of the instrument.The twisted pairs of voltage and current leads should then be covered with a braided or foil shield that is connected to the shield pin of the instrument. This type of cable is available through local electronics suppliers. Instrument specifications are given assuming 3 m (10 ft) of sensor cable. Longer cables, 30 m (100 ft) or more, can be used, but environmental conditions may degrade accuracy and noise specifications.

2.4.3 Grounding and Shielding Sensor Leads

The sensor inputs are isolated from earth ground to reduce the amount of earth ground referenced noise that is present on the measurement leads. Connecting any of the sensor leads to earth ground via the chassis of the instrument, or in the cooling system, will defeat that isolation.

Shielding the sensor lead cable is important to keep external interference/noise from entering the measurement. A shield is a conductive layer that surrounds one or more wires, forming a continuous enclosure to reduce electromagnetic coupling and interference. Foil-only shielding loses effectiveness above 1 MHz, so braid-over foil is better for RF performance.

Note: Sensor leads should never connect to the enclosure or cable shield at any point. Use the shield only for shielding, not as a signal return path.

Types of interference

Interference can range from lower frequencies, such as 50/60 Hz power line cycles, to high frequencies, such as radio frequency (RF) signals from a nearby transmitter.

Low-frequency refers to ranges where wavelengths are very long, and reactive components (inductance and capacitance) have minimal influence. In EMC contexts, this generally means frequencies below a few hundred kilohertz (kHz). High frequency describes ranges where reactive effects dominate, and even short wires exhibit significant inductance. In EMC applications, this typically applies to signals above about one megahertz (MHz).

To mitigate low-frequency AC interference, such as 50/60 Hz from building power, a simple wire connecting the cable shield to earth ground (also known as a pigtail connection), usually mitigates this type of interference, by keeping the shield at zero potential, relative to earth ground. At these low frequencies, the impedance of a pigtail connection is much lower than the capacitive coupling path, making it an effective shielding method.

Above a few MHz, the discussion turns to high-frequency AC interference. At these frequencies, a single-wire "pigtail" connection behaves like an inductor, introducing impedance and degrading shielding performance. **Proper RF shielding requires a solid RF connection—a continuous, low-impedance bond, such as a full 360° connection of the cable shield to the sensor input connector metal backshell.** This maintains shielding integrity and extends the Faraday cage.

Best Practices

A break in the shield compromises its effectiveness. The best practice is to connect the shield at both ends of the cable to chassis/earth ground (full 360° termination). However, connecting both ends can create ground loops if the instrument chassis, and cryostat chassis, are at different potentials. The common advice to connect the shield at only one end reduces ground loop risk but breaks the Faraday cage, which hurts RF performance (although it still helps with low-frequency interference).

Ensure the instrument chassis shares the same earth ground circuit as the cryostat. If that is not possible, use one or more low-impedance (solid RF) shield connections to minimize potential differences between the two. In extreme circumstances, a Parallel Earth Conductor (PEC) may be required to maintain equipotential bonding and safely carry any ground currents that may occur. A PEC is typically a heavy-gauge conductor or bonded metalwork routed alongside the signal cable and connected at both ends to the chassis earth points of the instrument and cryostat. This approach reduces common-mode impedance and provides a controlled return path for fault currents.

As stated earlier, the sensor input circuit is isolated from chassis/earth ground. Therefore, a connection is still required in the system to connect measurement common to chassis/earth ground. On the measurement input connector, a shield pin (at measurement common) is provided to allow for this connection to occur. Connecting the shield pin (at measurement common) to chassis ground helps stabilize the reference potential and reduce common-mode noise. If measurement common is left floating, it can develop a voltage difference relative to the shield and chassis, causing unwanted currents through cable shields and increasing susceptibility to hum and low-frequency interference. A direct bond between measurement common and chassis provides a predictable return path for these low-frequency currents, improving signal integrity and reducing noise coupling.

Note: Be sure to only make the measurement common and chassis/earth connection in one location. It is recommended to do this using the shield pin located inside the sensor input connector of the Model 346. Making an additional measurement common to chassis/earth connection at the cryostat will likely cause ground loops to form.

Note: The backshells of the input connectors of Model 346 are at chassis/earth ground. Older Lake Shore controllers are not configured this way, and have backshells at isolated measurement common.

The following figure illustrates the recommended techniques mentioned above.

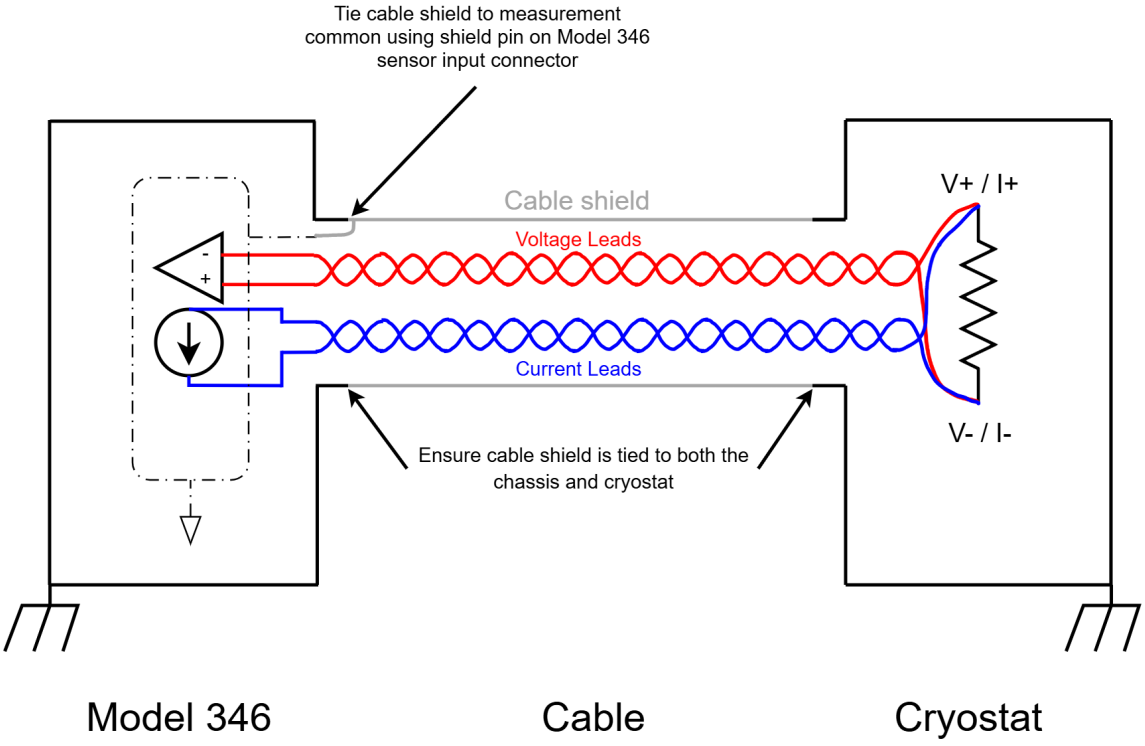


Figure 2.6: Example of sensor wiring and shielding

2.4.4 Sensor Polarity

This section describes the diode/resistor sensor inputs.

Lake Shore sensors are shipped with instructions that indicate which sensor leads are which. It is important to follow these instructions for plus and minus leads (polarity) as well as voltage and current when applicable. Diode sensors do not operate in the wrong polarity; they appear as an open circuit to the instrument. Two-lead resistors can operate with any lead arrangement and the sensor instructions may not specify. Four-lead resistors can be more dependent on lead arrangement.

Note: Follow any specified lead assignment for four-lead resistors. Mixing leads can give a reading that appears correct, but is not accurate.

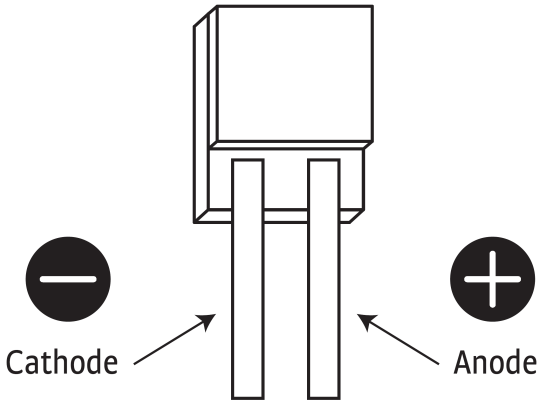


Figure 2.7: DT-670-SD diode sensor leads

2.4.5 Four-Lead Sensor Measurement

All sensors, including both two-lead and four-lead, can be measured with a four-lead technique. The purpose of a four-lead measurement is to eliminate the effect of lead resistance on the measurement. If it is not removed, lead resistance is a direct error when measuring a sensor.

In a four-lead measurement, current leads and voltage leads are run separately up to the sensor. With separate leads there is little current in the voltage leads, so their resistance does not enter into the measurement. Resistance in the current leads will not change the measurement as long as the voltage compliance of the current source is not reached. When two-lead sensors are used in four-lead measurements, the short leads on the sensor have an insignificant resistance.

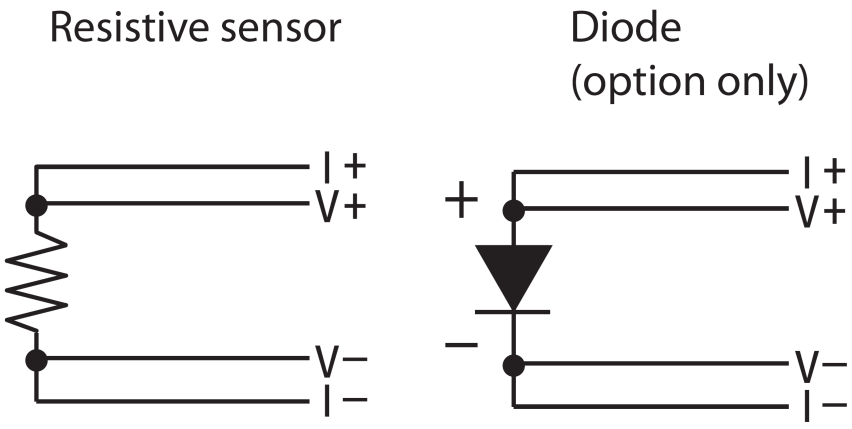


Figure 2.8: 4-lead measurement

2.4.6 Two-Lead Sensor Measurement

There are times when crowding in a cryogenic system forces users to read sensors in a two-lead configuration because there are not enough feedthroughs or room for lead wires. If this is the case, attach leads from plus voltage to plus current and minus voltage to minus current at the back of the instrument, or at the vacuum feedthrough

The error in a resistive measurement is the resistance of the lead wire run with current and voltage together. If the leads contribute 2 Ω or 3 Ω to a 10 kΩ reading, the error can probably be tolerated. When measuring voltage for diode sensors, you can calculate the error in voltage as the lead resistance times the current, typically 10 µA.

For example: a 10 Ω lead resistance times 10 µA results in a 0.1 mV error in voltage. Given the sensitivity of a silicon diode at 4.2 K, the error in temperature would be only 3 mK. At 77 K the sensitivity of a silicon diode is lower so the error would be close to 50 mK. This may not be a problem for every user. Connectors are also a big source of error when making two-lead measurements. Connector contact resistance is unpredictable and changes with time and temperature, which may cause a source of error when making two-lead measurements. Refer to FIGURE 3-6 for an image of a two-lead sensor measurement.



Figure 2.9: 2-lead sensor measurement

2.4.7 Lowering Measurement Noise

Proper instrument hardware setup technique is one of the least expensive ways to reduce measurement noise. The suggestions fall into two categories: (1) do not let noise from the outside enter into the measurement, and (2) let the instrument isolation and other hardware features work to their best advantage. Here are some further suggestions:

- Use four-lead measurement whenever possible

- Do not connect sensor leads to chassis or earth ground
- Use twisted shielded cable outside the cooling system
- Attach the shield pin, located on the sensor connector, to the cable shield
- All cable shields should be connected to earth ground on the instrument chassis
- Do not attach more than one cable shield at the other end of the cable
- Run different inputs and outputs in their own shielded cable
- Use twisted wire inside the cooling system
- Use similar technique for heater leads
- Use a grounded receptacle for the instrument power cord
- Consider ground strapping the instrument chassis to other instruments or computers

2.5 Thermocouple Sensor Inputs (Model 3402)

The information in this section is for a Model 346 configured with one or more thermocouple sensor inputs. Thermocouple inputs are not installed on the standard Model 346, but can be added by purchasing the Model 3402 dual thermocouple input option card.

Note: Do not leave thermocouple inputs unconnected. Short inputs when not in use.

2.5.1 Sensor Input Terminals

Attach sensor leads to the screws on the off-white ceramic terminal blocks. Sensor connection is important when using thermocouples because the measured signal is small. The block has two thermocouple inputs and each input has two screw terminals; one positive, one negative. See Figure 2.10.

Remove all insulation, then tighten the screws on the thermocouple wires. Keep the ceramic terminal blocks away from heat sources including sunlight and shield them from fans or room drafts.

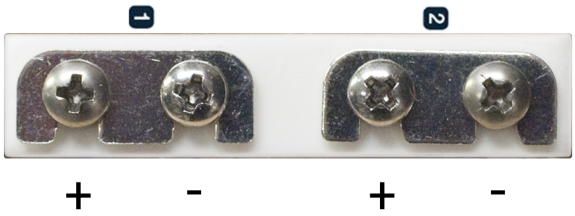


Figure 2.10: Thermocouple input definition and common connector polarities (inputs shown shorted)

2.5.2 Thermocouple Installation

Thermocouples are commonly used in high-temperature applications. Cryogenic use of thermocouples offers some unique challenges.Consider the following when using thermocouples at low temperatures:

- Thermocouple wire is generally more thermally conductive than other sensor lead wire. Smaller gauge wire and more thermal anchoring may be needed to prevent leads from heating the sample.
- Attaching lead wires and passing them through vacuum tight connectors is often necessary in cryogenic systems. Remember, the thermocouple wire is the sensor; any time it joins or contacts other metal, there is potential for error.
- Temperature verification and calibration of room temperature compensation is difficult after the sensor is installed. When possible, keep a piece of scrap wire from each installation for future use.
- Thermocouples can be spot-welded to the cryostat for good thermal anchoring as long as the cryostat has a potential close to earth ground.

2.5.3 Grounding and Shielding

Care must be taken to minimize the amount of noise contributed by ground loops when grounding thermocouple inputs. For lowest measurement noise, do not ground thermocouple sensors. The instrument operates with slightly more noise if one of the thermocouples is grounded. Be sure to minimize loop area when grounding both thermocouples. The instrument does not offer a shield connection on the terminal block. Twisting the thermocouple wires helps reject noise. If shielding is necessary, extend the shield from the oven or cryostat to cover the thermocouple wire, but do not attach the shield to the instrument.

2.6 Heater Output setup

The following section covers the heater wiring from the vacuum shroud to the instrument for both heater outputs. Specifications are detailed on the Technical Specifications page at https://www.lakeshore.com/346.

2.6.1 Heater Output Description

Heater outputs 1 to 4 are variable DC current sources used for cryogenic temperature control. Each output supports software-defined ranges and limits, and can be optimized for 25 Ω or a 50 Ω heater resistance. At 50 Ω, output current is limited to 1 A; at 25 Ω, the heater output current is 2 A. The compliance voltage of each output is 50 V minimum, but may reach 53 V if the heater resistance is higher than the nominal setting. Heater power is applied in either high or low range, with each range differing by a factor of 100.

2.6.2 Heater Output Connectors

15-pin DA-15 style connector is used for the heater outputs. A mating connector (DA-15 plug) is included in the connector kit shipped with the instrument. These connectors may be ordered from lakeshore.com.

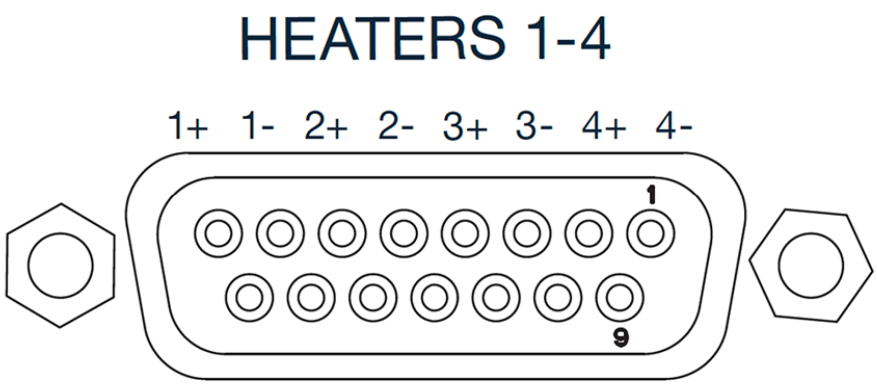


Figure 2.11: Rear panel heater output connector

Table 2.2: Heater output connector pinout

Pin	Description
8	Heater 1 HI
7	Heater 1 LO
6	Heater 2 HI
5	Heater 2 LO
4	Heater 3 HI
3	Heater 3 LO
2	Heater 4 HI
1	Heater 4 LO
10,12,14	Additional chassis/earth ground connections
9,11,13,15	No connect

2.6.3 Heater Output Wiring

Heater output current is what determines the size (gauge) of wire needed to connect the heater. The maximum current that can be sourced from the heaters is 2 A. When less current is needed to power a cooling system, it can be limited with range settings.

When setting up a temperature control system, the lead wire for the heater must be capable of carrying a continuous current that is greater than the maximum current. Wire manufacturers recommend 26 AWG or larger wire to carry 2 A of current, but there is little advantage in using wire smaller than 20 AWG to 22 AWG outside the cryostat. Inside the cryostat, smaller gauge wire is often desirable.

It is recommended to use twisted heater leads. Large changes in heater current can induce noise in measurement leads and twisting reduces the effect. It is also recommended to run heater leads in a separate cable from the measurement leads to further reduce interaction.

There is a chassis ground screw at the rear panel of the instrument for shielding the heater cable if necessary. The cable shield can be tied to this point using a 3.18 mm (#4) spade terminal, or ring connector.

Note: The shield should never be tied to the heater output leads.

Note: For best noise performance, do not connect the resistive heater or its leads to ground. Also avoid connecting heater leads to sensor leads or any other instrument inputs or outputs.

2.6.4 Heater Output Noise

The heater output circuitry in the Model 346 is capable of sourcing 100 W of power. This type of circuitry can generate some electrical noise. The Model 346 was designed to generate as little noise as possible, but even noise that is a small percentage of the output voltage or current can be too much when sensitive measurements are being made near by.

2.6.5 Powering Outputs 5 to 8 Using an External Power Supply

Outputs 5 to 8 are unipolar, DC voltage sources, and can power heaters directly. However, they are limited to 1 W output (10 V at 100 mA). In addition, these outputs can also be used to program an external power supply, which powers a heater. This section describes choosing and installing an external supply.

Choosing an External Power Supply

- **Voltage Programmable**: the external power supply must be voltage programmable so that Outputs 5 to 8 can control it. Ideally the supply's programming input should have a range of 0 to 10 V that corresponds to 0 to 10 V range of the control output. This guarantees that 0 to 100% of the control output scales to 0 to 100% power out of the supply. Supplies with different programming input ranges can be used as described below.
- **DC Output Capable**: the external power supply must be capable of continuous DC output. Most commercial audio amplifiers are not suitable because they are AC coupled and cannot provide a DC output.
- **Output Type**: most available voltage programmable power supplies are configured for voltage output. This is different than Outputs 1 to 4 on the 346 which are configured for current output.
- **Output Voltage**: Lake Shore recommends supplies with a working output voltage between 10 V and 50 V. Voltage higher than 50 V poses a shock hazard and should only be used if operator safety can be assured by the installer. Voltage lower than 10 V becomes impractical because the current necessary provide any meaningful power is too high for most cryogenic wiring.
- **Output Power**: there is no limit to the maximum power of the external power supply. Typical warm up applications normally range between 25 W and 200 W.

External Power Supply Setup

Follow all operation and safety instruction in the external power supply manual during setup. Consider the following suggestions for protecting the external power supply and heater load.

- Short circuits are common in cryogenic lead wiring. If the external power supply does not specify that it is short circuit protected the power output should be wired with a fuse in series to prevent damage.
- Unipolar power supplies are designed to use a positive programming voltage and some can be damaged if the programming voltage is negative. Be careful when wiring the system to maintain the correct polarity.
- Some external power supplies can be damaged if there is a programming voltage present at their input when they are turned off. This can happen if the Model 346 and the external power supply use a different source of line power or are turned on and off individually. It can be avoided if the two instruments share a switched power strip.
- The heater and wiring in the system must be rated for both the maximum current and maximum voltage provided by the external power supply. The Model 346 can be set to warm up using less than full power if the load will not tolerate the full power of the external power supply.

Connecting to the Model 346

Connect the voltage programming cable (not provided) to the removable terminal block on the rear panel of the Model 346 (see figure below). Output number and polarity of the output leads are indicated on the rear panel. The negative (–) terminals are connected internally to the instrument chassis to provide a ground reference.

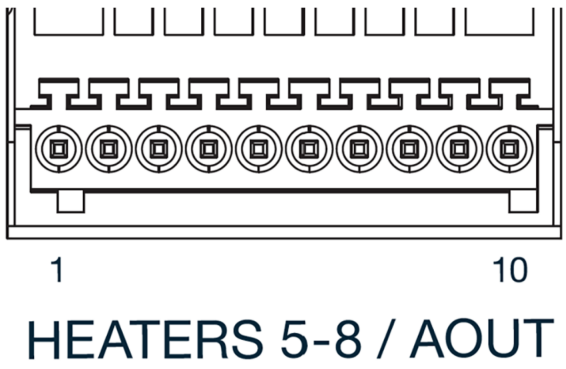


Figure 2.12: Rear panel showing outputs 5 to 8 connector

In the most basic configuration, connect a two-conductor cable directly from the output

terminals to the external power supply programming input. Copper wire size 20 AWG to 26 AWG is recommended.

Table 2.3: Outputs 5-8 connector pinout

Pin	Description
1	Output 5 +
2	Output 5 -
3	Output 6 +
4	Output 6 -
5	Output 7 +
6	Output 7 -
7	Output 8 +
8	Output 8 -
9	+5 V isolated supply
10	+5 V isolated supply return

Programming Voltages Under 10 V

To ensure full output resolution, and protection against overloading the external supply programming inputs, a voltage divider, shown in the following figure, can be used to reduce the control output voltage if the programming input of the external power supply has a range of less than 0 V to 10 V.

The output voltage is proportional to the ratio of resistors R1 to R2: V_{out} = 10 V × R1/(R1+R2). It is also important to keep the sum of R1 + R2 > 1000 Ω or the Model 346 output may not reach the output voltage setting due to internal overload protection.

- For a programming input range of 0 V to 5 V, recommended values are: R1 = R2 = 2000 Ω.
- For a programming input range of 0 V to 1 V, recommended values are: R1 = 500 Ω, R2 = 4500 Ω.
- Exact resistor value, type and tolerance are generally not important for this application.

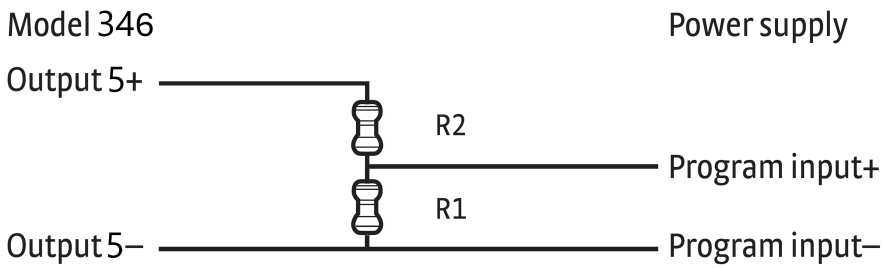


Figure 2.13: Voltage divider circuit for output 5

CHAPTER

THREE

OPERATION

3.1 General



Figure 3.1: Model 346 front panel

3.1.1 Instrument Power

The power switch is a round metal button, located on the left side of the front panel of the Model 346, and turns line power to the instrument on and off. When the button is depressed, power is on. When the button is released, power is off.

3.1.2 USB-C

This port is used only for firmware updates, not for remote operation. The USB-B port on the rear panel, along with Ethernet, are used for remote communications. For more information, see the Firmware Updates section of the Service chapter.

3.1.3 Cold Sync™

Lake Shore is proud to offer ColdSync™, a software tool facilitates advanced setup, initial configuration, and comprehensive data monitoring. ColdSync™ is available for download on our website, and can be used to set up the Model 346 before installation, or for remote monitoring and control after installation.

ColdSync™ can be downloaded, free of charge, at
https://www.lakeshore.com/resources/software

3.2 Display Overview

The following section provides an overview of the front panel of the Model 346.

The navigation panel on the left side of the screen allows access to the various views that make up the front panel interface:

1. **Home**: used to configure and monitor a control loop, along with monitoring other temperature inputs in the system.
2. **I/O**: used to configure individual temperature inputs and heater/analog outputs in the Model 346
3. **Settings**: used to access general instrument settings.
4. **ALL OFF**: tap this button to quickly de-energize all the outputs and set their ranges to OFF.

3.2.1 Home screen

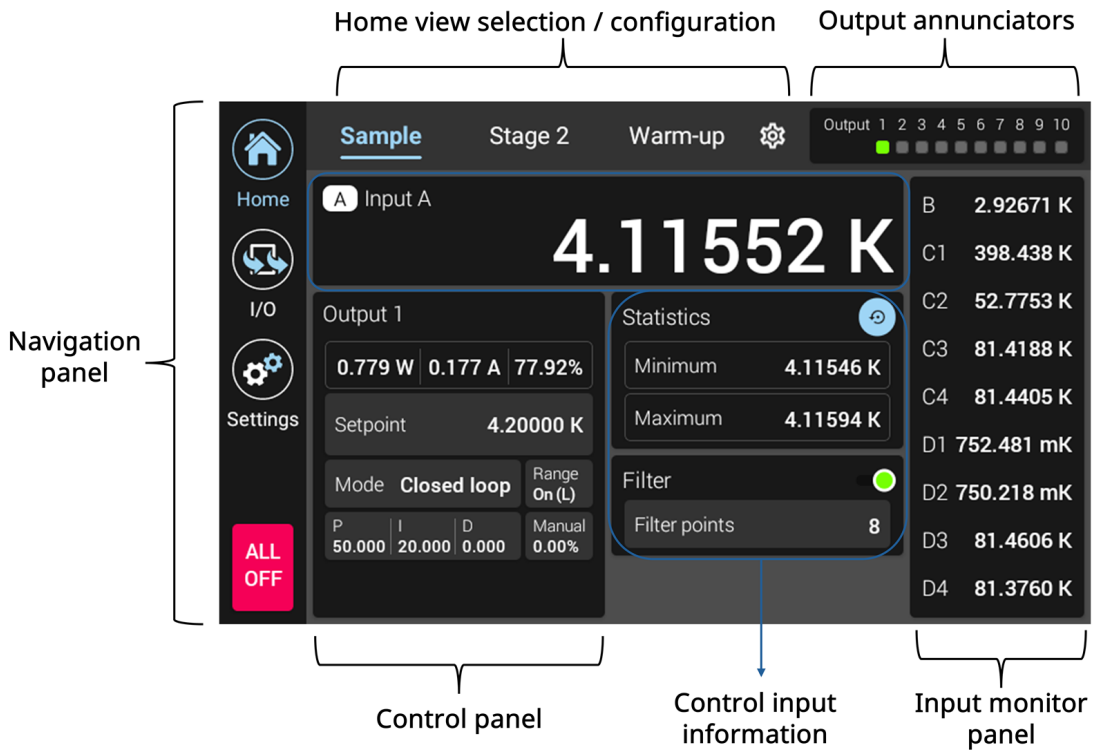


Figure 3.2: Model 346 home screen

The home screen is intended to display user defined control loops. Control loop is a term used to describe the pairing of a temperature input to a heater output. Control loops are output referenced. This means that in order to create a control loop, an input must be assigned to a given output. This can be done via the output settings menu, or by using the OUTMODE remote interface command. The following sections break down the various parts of the home screen.

Home screen selection / configuration

The home screen allows for two customizable control loop views. The view that is currently active is highlighted in blue. In addition, there is a fixed "Warm-up" view that will be described later in this manual.

Tap the name to go to the given view.

Home screen configuration

The home screen allows for two customizable control loop views. To assign an output to a given view, tap the gear icon at the top of the front panel to view the customization page:

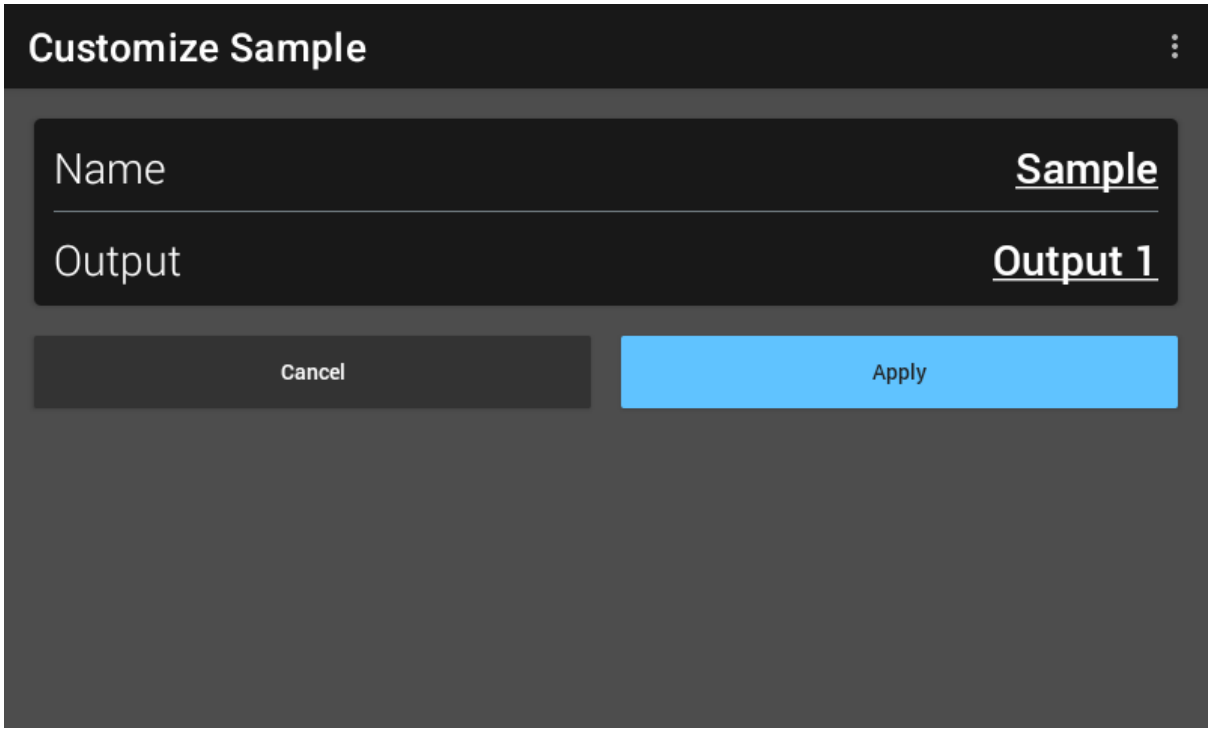


Figure 3.3: Home screen customization screen

A user-specified name can be assigned to the view. In the example above, the name is 'sample'. In addition, the output can be selected. Valid output selections are 1 to 10.

Output annunciators

These indicators are illuminated green when the corresponding output is in an energized/on state. They are off when the corresponding output is in the off state.

Input monitor panel

The input monitor panel displays the temperature readings of other Model 346 inputs. Only temperatures are displayed here. If an input is disabled, the word "DISABLED" will be displayed. If an input is enabled, but no curve applied, then "NO CURVE" will be displayed.

Tap an input to go to its respective input settings page.

Only 9 inputs at a time can be displayed. However, the panel is scrollable if more inputs are present.

Control input information

At the top of this section, the temperature reading of the control loop's input is prominently displayed. Tap on the input reading to navigate to its input details page. Like the monitor panel, if the input is disabled, the word "DISABLED" will be displayed. In addition, if no curve is applied, "NO CURVE" will be displayed.

The Statistics panel shows the minimum and maximum readings since the last reset. Minimum and maximum readings are captured continuously. The readings are reset when the instrument is turned off, sensor type is changed, the blue reset icon is tapped, or the MNMXRST remote interface command is issued.

The Filter panel allows enabling and disabling of the exponential smoothing filter that can be applied to the control input. In addition, the number of filter points can be set here. More details of the filter will be explained later in this manual.

Control panel

This is the heart of the home screen, and allows for setting control loop parameters such as setpoint, PID values, and manual output. In addition, calculated (not measured) output power, current, and percentage out are displayed here.

Tap the **Range** button to set an output's range to On, which is how the output is energized/turned on. If heater autorange is off, tapping the range button will allow selection of the LOW or HIGH heater range.

Touch the panel to navigate to the output details page for the given output.

3.2.2 I/O Screen

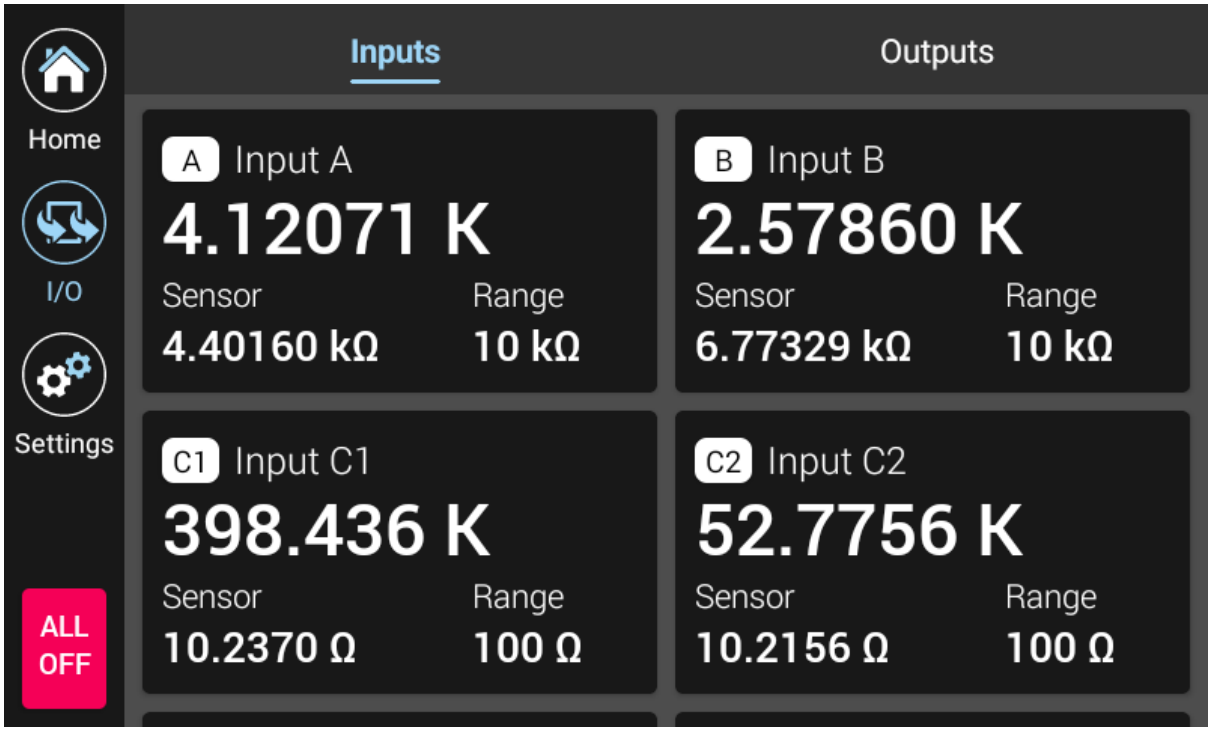


Figure 3.4: Model 346 I/O screen

The I/O screen is used to setup and configure all inputs and outputs in the Model 346.

Tap either **Inputs** or **Outputs** at the top of the screen to navigate to the respective input or output listing page.

3.2.3 Settings

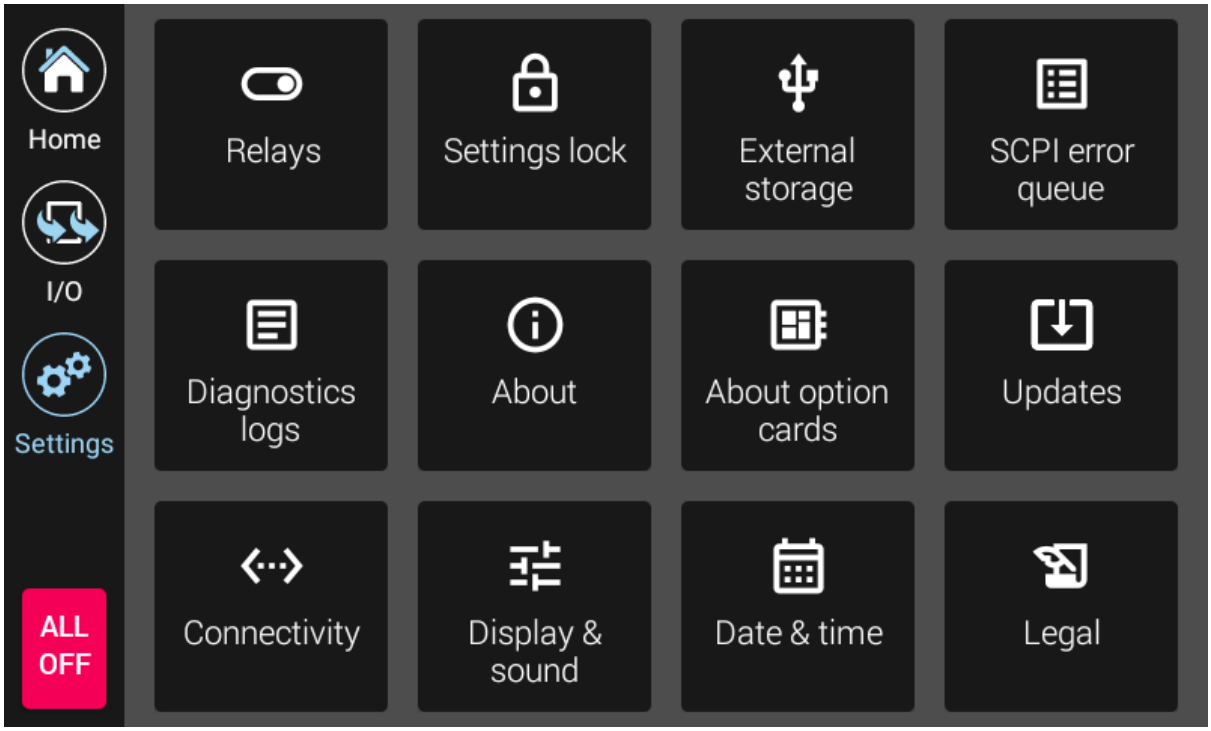


Figure 3.5: Model 346 Settings screen

The settings screen contains various settings and information that aren't specific to temperature inputs or outputs. Settings located here include, but are not limited to, Relays, Connectivity, Updates, and Reset.

3.3 Input Setup

The Model 346 supports a variety of temperature sensors manufactured by Lake Shore and other manufacturers. An appropriate sensor type must be selected for each input. If the exact sensor model is not shown, use the following sensor input performance chart to choose an input type with similar range and excitation. For additional details on sensors, refer to the Lake Shore Temperature Measurement and Control Catalog or visit our website at www.lakeshore.com.

Note: Any unused input should be set to disabled.

Table 3.1: Sensor input types

Sensor type	Display message	Input range	Excitation	Coeffi-cient	Curve format	Lake Shore sensors*
Silicon diode	Diode	0 V to 2.5 V	10 µA	Negative	V/K	DT-670 series
Platinum RTD	PTC RTD (Platinum)	0 Ω to 1 kΩ (3 ranges)	1 mA	Positive	Ω/K	PT-100 series platinum
Negative temperature coefficient (NTC) RTD	NTC RTD (Cernox™)	100 Ω to 100 kΩ (7 Ranges)	100 nA to 100 µA (decade steps in power, autorange maintains <10 mV)	Negative	log Ω/K	Cernox™, Rox™
Thermocouple (option 3402 only)	Thermo-couple	±50 mV	NA	Positive	mV/K	Type E (Chromel-Constantan), Type K (Chromel-Alumel)

ColdSync™ provides a convenient way to setup and configure the inputs of the Model 346. The following image shows the input setup screen in ColdSync™:

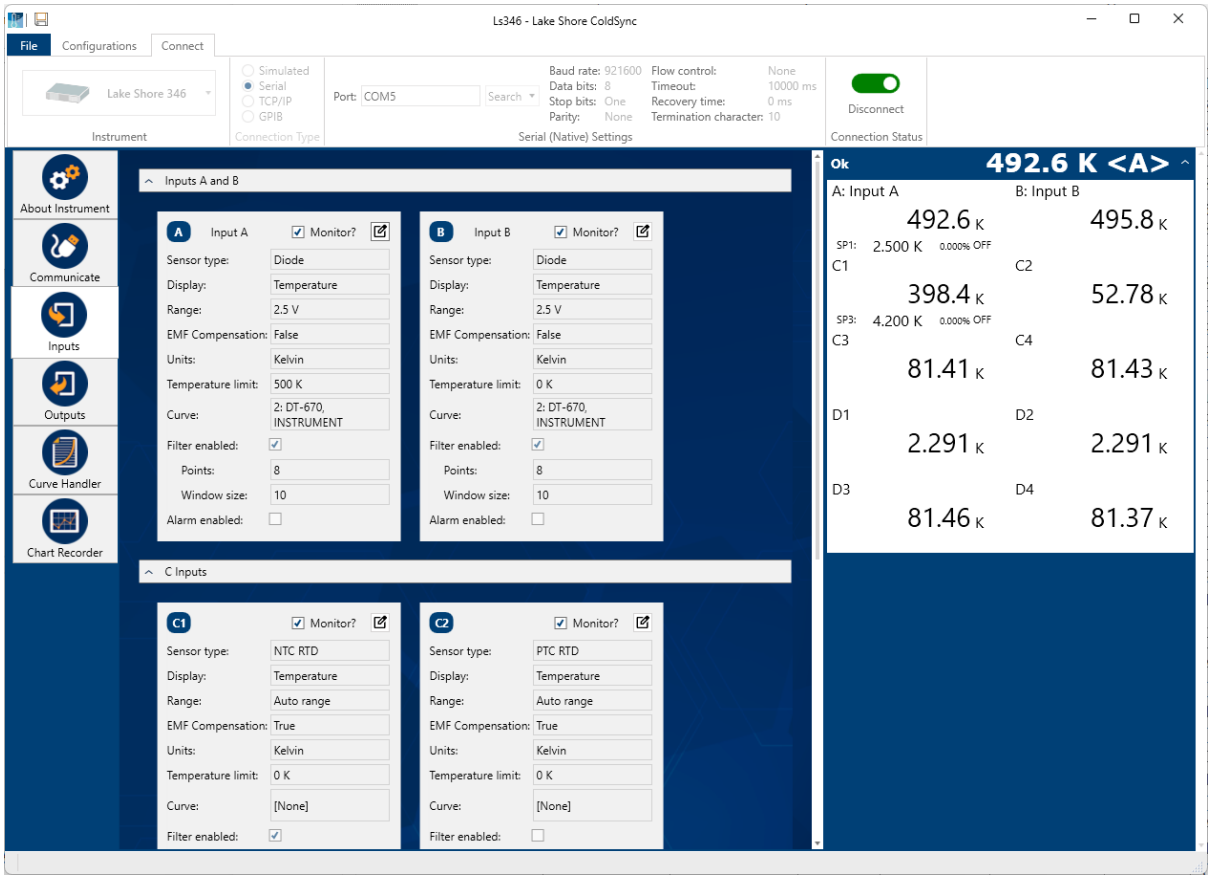


Figure 3.6: ColdSync™ input setup screen

3.3.1 Input sensor type selection

Along with ColdSync™, the Model 346 allows for input setup from the front panel. This is done from the input details page, which can be accessed by tapping the input card visible on either the Home screen or the I/O page. The following image shows the input details page.

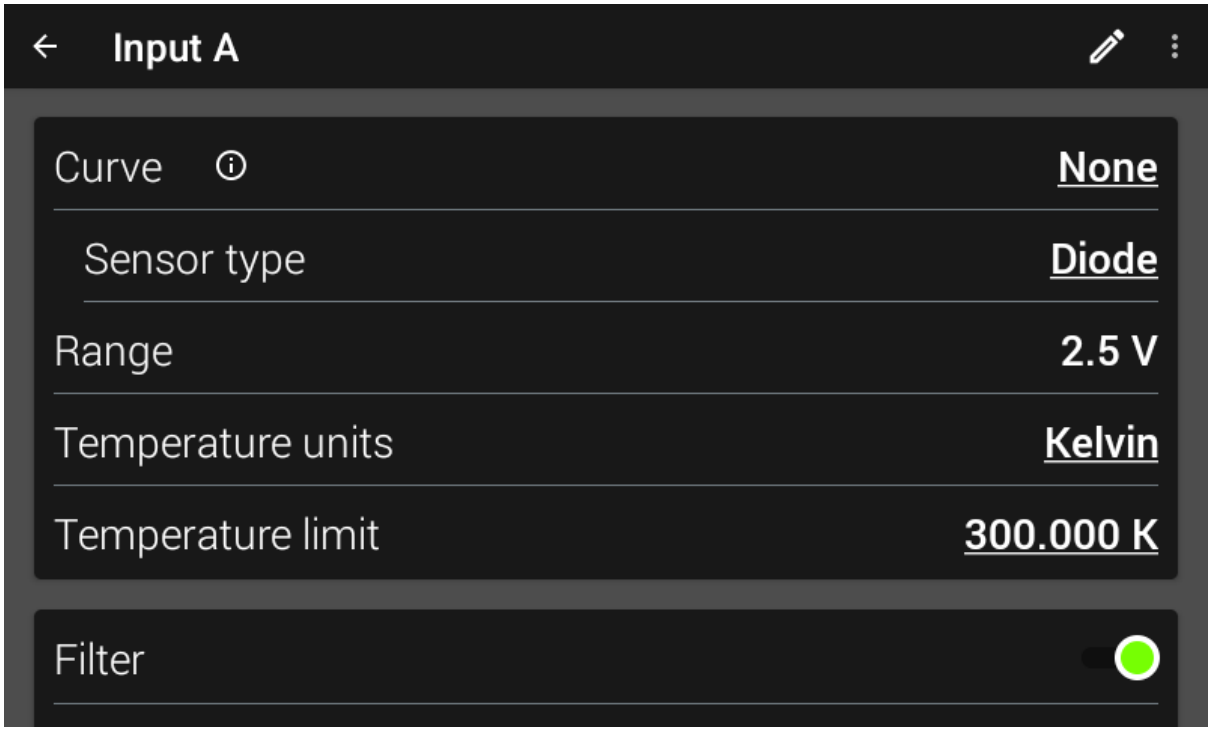


Figure 3.7: Model 346 input details page

The input details page is designed to automatically select the sensor type upon selection of a curve. However, if a curve is not selected, then the Model 346 allows for direct selection of the sensor type.

Available sensor types are *Disabled, Diode, PTC RTD (Platinum), and NTC RTD (Cernox™)*.

Default: Disabled

Interface Command: **INTYPE**

3.3.2 Diode sensor input setup

Diode sensors include the silicon sensors detailed in Table 3.1. The input range is fixed at 0 to 2.5 V, and standard excitation current is 10 µA.

3.3.3 Positive temperature coefficient (PTC) resistor sensor input setup

PTC resistor sensors include the platinum sensor detailed in Table 3.1. The Model 346 supplies a 1 mA excitation current for the PTC resistor sensor type. A resistance range selection is available in order to achieve better reading resolution. By default, autorange is enabled in order to provide the best possible reading resolution, but does not affect the sensor current excitation. Compensation (current reversal) is also enabled by default in order to compensate for thermal EMF voltages.

3.3.4 Negative temperature coefficient (NTC) resistor sensor input setup

NTC resistor sensors include Cernox™, Rox, and others detailed in Table 3.1. The excitation current for the NTC RTD sensor type can vary between 100 nA and 1 mA, depending on resistance range. When autoranging is enabled, the range will be automatically selected so that the excitation voltage is below 10 mV. This keeps the power dissipated in the sensor at a minimum, yet still enough to provide accurate measurements. Compensation (current reversal) is also enabled by default in order to compensate for thermal EMF voltages.

3.3.5 Range selection

The Model 346 is equipped with an autoranging feature that automatically selects the appropriate resistance range for the connected resistive temperature device. In some cases it may be desirable to manually select the resistance range. To manually select a resistance range, select the desired range from the list of available ranges, which de-selects Autorange. By default, Autorange will be On whenever the Sensor type parameter is set to PTC RTD or NTC RTD. Autorange is not available for the Diode sensor type.

Default: On

Interface Command: **INTYPE**

Table 3.2: Range and sensor power

Sensor type	Available range settings	Maximum sensor power	Sensor excitation
Diode	2.5 V (Silicon)	25 µW (at 10 µA excitation)	10 µA
PTC RTD (Platinum)	10 Ω	10 µW	1 mA
	100 Ω	100 µW	
	1 kΩ	1 mW	
NTC RTD (Cernox)	100 Ω	1 µW	100 µA
	300 Ω	270 nW	30 µA
	1 kΩ	100 nW	10 µA
	3 kΩ	27 nW	3 µA
	10 kΩ	10 nW	1 µA
	30 kΩ	2.7 nW	300 nA
	100 kΩ	1 nW	100 nA

3.3.6 Thermal electromotive force (EMF) compensation

Sensor excitation is kept low to keep power low, which helps avoid sensor self-heating. There are two major problems that occur when measuring the resulting small DC voltages. The first is external noise entering the measurement through the sensor leads, which is discussed later in this manual with sensor setup. The second is the presence of thermal EMF voltages, or thermocouple voltages, in the lead wiring. Thermal EMF voltages appear when a temperature difference exists between the junction of two dissimilar metals. Thermal EMF voltages must exist because the sensor is almost never the same temperature as the instrument. To minimize them, use careful wiring, make sure the voltage leads are symmetrical in the type of metal used and how they are joined, and keep unnecessary heat sources away from the leads. Even in a well-designed system, thermal EMF voltages can be an appreciable part of a low voltage sensor measurement.

"The Model 346 can help with a thermal compensation algorithm by automatically reversing the polarity of the current source every other reading. The average of the positive and negative sensor readings will cancel the thermal EMF voltage that is present in the same polarity, regardless of current direction. This correction algorithm is enabled by default for RTD sensor types, but can be turned off using the Current Reversal parameter.

The Current Reversal parameter defaults to On any time the Sensor Type parameter is changed to PTC RTD or NTC RTD.

Default: On

Interface Command: **INTYPE**

3.3.7 Thermocouple sensor input setup (Model 3402 Only)

When a Model 3402 thermocouple option is installed in the Model 346, its two inputs will appear under the Inputs tab in the I/O view, as either Input E, F, G, or H.

Thermocouples include a variety of commercial (such as E, K, T) and specialty types (such as cryogenic Chromel–AuFe). Standard curves are included in the Model 346 for the types listed in Table 3.1. Other types can be used as long as an appropriate temperature response curve is loaded as a user curve. The Model 346 provides one thermocouple range and no excitation because thermocouples do not require it. Room temperature compensation is included for convenience, and should be calibrated before use. Room temperature compensation is enabled by default, but can be turned off if external compensation is being used.

Interface Command: **INTYPE**

Room temperature compensation

Room-temperature compensation is required to give accurate temperature measurements with thermocouple sensors. It corrects for the temperature difference between the instrument thermal block and the curve normalization temperature of 0 °C. An external ice bath is the most accurate form of compensation, but is often inconvenient. Every thermocouple option card has a temperature sensor integrated into its ceramic thermal block, which allows the instrument to perform internal room-temperature compensation that is adequate for most applications. You can turn room-temperature compensation on or off. The thermocouple option card operates with any thermocouple type that has an appropriate temperature response curve loaded. Room-temperature compensation is not meaningful for sensor units measurements.

Note: Room temperature compensation should be calibrated as part of every installation.

Room temperature compensation calibration procedure

Factory calibration of the instrument is accurate to within approximately ±1 K. Differences in thermocouple wire and installation technique create errors greater than the instrument errors. To achieve the best accuracy, calibrate with the thermocouple actually being used, because it eliminates most sources of error. If that is not possible, use a thermocouple made from the same wire.

Note: It is best practice to use the same material for thermocouple wires; if it is at all

possible, it is also best to avoid splices. When splices are necessary, continue the splice with the same type of material.

For less demanding applications, a short across the input terminals will suffice. Both thermocouple inputs should be calibrated, even if they use the same type of thermocouple. An appropriate curve must be selected and room temperature compensation must be turned on before calibration can be started.

The following image shows the room temperature screen, within the thermocouple input details page

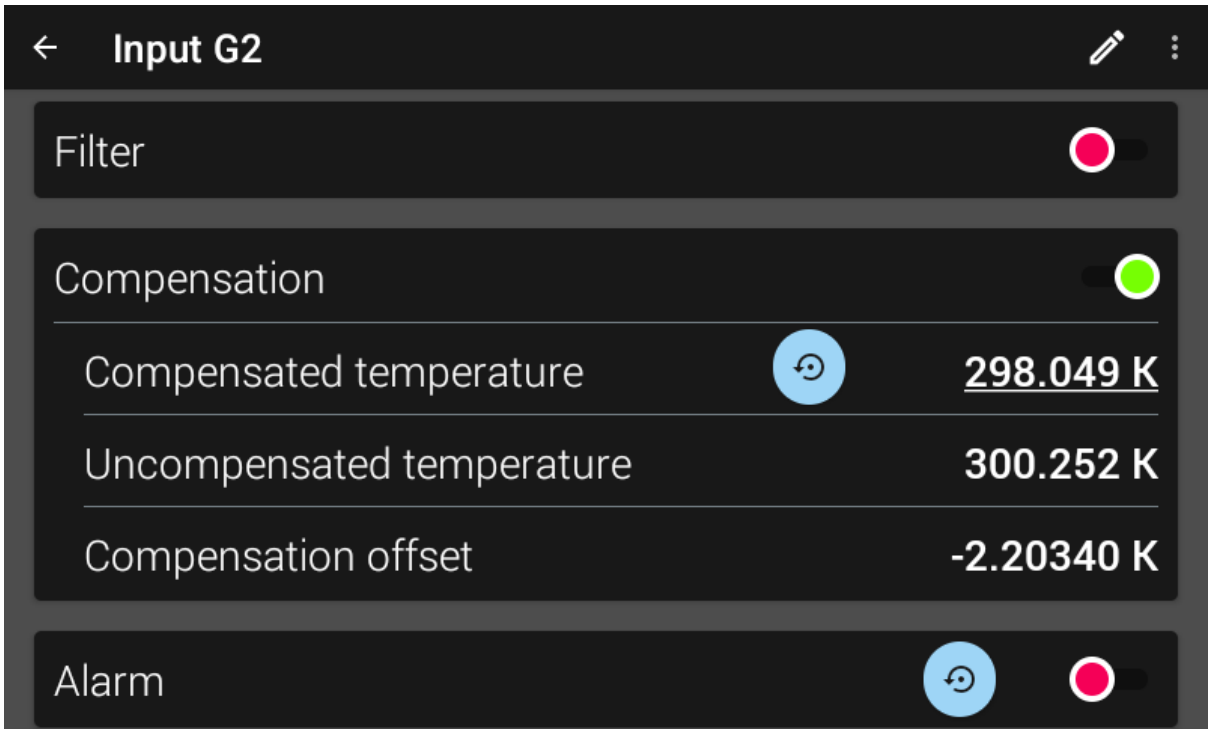


Figure 3.8: Thermocouple compensation screen

- **Compensated temperature:** the "true" user entered temperature when performing the calibration.
- **Uncompensated temperature:** the temperature that the Model 346 reports using just the integrated temperature sensor in the thermal block.
- **Compensation offset:** the difference between the user entered compensated temperature, and the compensated temperature. Strictly for informational purposes.

Follow this procedure to calibrate room temperature compensation:

Note: For best results, the calibration temperature should be close to the measurement

temperature that requires best accuracy.

1. Attach a thermocouple sensor or direct short across the input terminals of the thermocouple input.
2. Place the instrument away from drafts. If calibrating using a short, place an accurate room-temperature thermometer near the terminal block.
3. Allow the instrument to warm up for at least 0.5 hr without moving or handling the sensor.
4. If calibrating with a short, skip to step 6, otherwise insert the thermocouple into the ice-bath, liquid nitrogen, helium dewar, or other known, fixed temperature.
5. On the thermocouple input details page, read the uncompensated temperature. If the temperature display is not as expected, check to be sure that the thermocouple is making good thermal contact. If possible, add a thermal mass to the end of the thermocouple.
6. On the thermocouple input details screen, enter the true Compensated temperature that the thermocouple should read. If input is shorted, then enter the actual room temperature measured by the thermometer.
7. Scroll up to the top of the input details screen to make sure the newly entered Compensated temperature is being displayed.

3.3.8 4-Channel RTD/Diode option card (Model 3401 Only)

When a Model 3401 4-channel RTD/diode option card is installed in the Model 346, 4 additional input channels become available for use. These 4 additional input channels are labeled as Input E, F, G, or H, depending on which input option card slot the Model 3401 is using. For example, if the Model 3401 is installed in input option card slot G, then the input channels would be referred to as G1, G2, G3, and G4. These input channels can be configured for diode, NTC RTD, or PTC RTD sensors, just like the core input channels of A, B, C1 to C4, and D1 to D4.

Default: Disabled

Interface Command: **INTYPE**

Type and range selection

The Model 3401 is equipped with an autoranging feature that will automatically select the appropriate resistance range for the connected resistive temperature device. In some cases it may be desirable to manually select the resistance range. To manually select a resistance range, select the desired range from the list of available ranges, which de-selects Autorange. By default, Autorange will be On whenever the Sensor type parameter is set to PTC RTD or NTC RTD. Autorange is not available for the Diode sensor type.

Available ranges can be seen in Table 3.2.

Reading update rate

The reading update rate for the Model 3401 is dependent on the number of channels enabled. The Model 3401 channels are scanned at a rate of 10 rdg/s (100 ms/rdg).

Table 3.3: Model 3401 reading update rate

Number of channels enabled	Update rate
1	10 rdg/s (100 ms/rdg)
2	5 rdg/s (200 ms/rdg)
3	3.33 rdg/s (300 ms/rdg)
4	2.5 rdg/s (400 ms/rdg)

Note: Note, the reading rates in Table 3.3 are applicable for inputs C and D as well.

Note: System control performance may be affected by a decreased update rate. Filtering is affected by a decreased update rate.

3.3.9 Temperature curve selection

The Model 346 supports a variety of temperature sensors manufactured by Lake Shore and other manufacturers. Use a curve to convert voltages or resistances to a temperature. The Model 346 can use curves from several sources. Standard curves are preloaded with every instrument and numbered 1 to 20. User curves, numbered 21 to 60, can be used when a sensor does not match a standard curve. The complete list of sensor curves preloaded in the Model 346 is provided in Table 3.4.

Table 3.4: Sensor curves

Curve number	Curve name	Sensor type	Model number	Temperature range
01	Reserved	—	—	—
02	DT-670	Diode	DT-670	1.4 - 500 K
03	Reserved	—	—	—
04	Reserved	—	—	—
05	Reserved	—	—	—
06	PT-100	PTC RTD	PT-100	30 - 800 K
07	Reserved	—	—	—
08	RX-102A-AA	NTC RTD	Rox RX-102A	0.05 - 40 K
09	RX-202A-AA	NTC RTD	Rox RX-202A	0.05 - 40 K
10	RX-103A-AA	NTC RTD	Rox RX-103A	1.4 - 40 K
11	Reserved	—	—	—
12	Type K	Thermocouple	Type K	3 - 1645 K
13	Type E	Thermocouple	Type E	3 - 1274 K
14-20	Reserved	—	—	—
21-60	User Curves	—	—	—

It is highly recommended to use ColdSync™ software for loading and editing curves from the remote interface. Loading curves with ColdSync™ is discussed in the Advanced Operation section of this manual.

To select a curve from the front panel, navigate to the input details page of the respective input, and tap the Curve setting. The curve selection screen will appear:

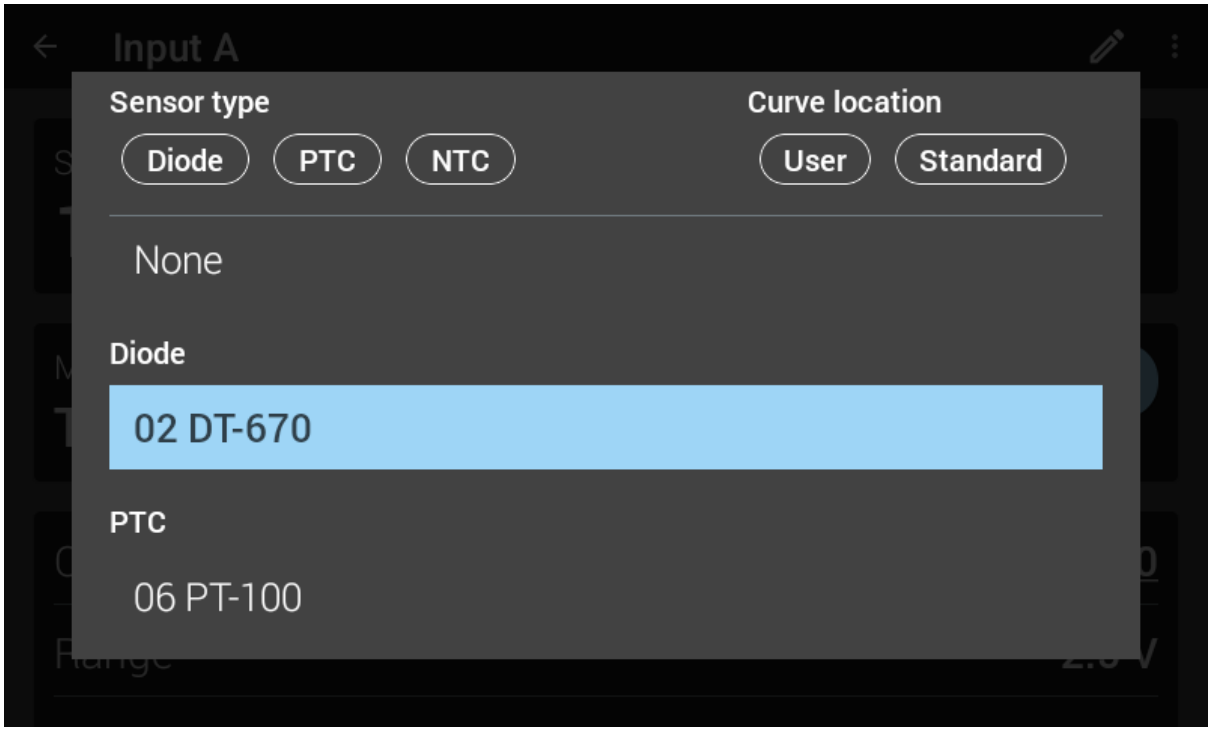


Figure 3.9: Curve selection screen

The curve selection screen is grouped by Sensor type and Curve location (User or Standard).

- Tap the buttons at the top of the screen to filter to certain types of sensors or curves.
- Tap the curve you wish to select.
- If you decide not to make a selection, scroll to the bottom of the menu and tap **OK**.
- When the curve is set to None, front panel temperature reading fields will display the NO CURVE message, and the interface will report 0 K and –273.15 °C for KRDG and CRDG queries, respectively.

Note: If a curve is not assigned to an input, control and display readings will be in sensor units. When a curve is assigned to an input, control and display readings be in temperature units.

Upon selection of a curve, the Model 346 will automatically select the appropriate sensor type for that curve.

Interface Command: **INCRV**

Note: On the remote interface, you must first configure the input using the INTYPE command. At that point, a curve that matches the configured sensor type can be assigned to the input using the INCRV command. If the sensor type in the curve header does not match the configured input type, the command is rejected and the curve number returns to 0 (none).

3.3.10 Filter

The reading filter applies exponential smoothing to the sensor input readings. If the filter is turned on for a sensor input, all reading values for that input are filtered. The filter is a running average so it does not change the update rate of an input. **Filtered readings are not used for control functions** but they are used for all input features including Max/Min.

The number of filter points determines filter bandwidth. One filter point corresponds to one new reading on that input. A larger number of points does more smoothing, but also slows the responsiveness of the temperature reading, relative to real changes in temperature. The default number of filter points is 8, which settles to within six time constants of a step change value in 45 readings, or 4.5 s

The time constant (time it takes to settle to within 36.8% of the step value after a step change) for a given number of filter points can be derived using the following formula: TC

= 0.1 / (ln (N / (N - 1)), where TC is one time constant, and N is the number of filter points. A reading is usually considered settled after six time constants. The following table shows a sampling of filter settings and the resulting time constant, settle time, and equivalent noise bandwidth.

Table 3.5: Filter settle time and bandwidth

Filter points	Time constant	Settle time (6 time constants)	Equivalent noise bandwidth (¼ TC)
2	0.14 s	0.9 s	1.733 Hz
4	0.35 s	2.1 s	0.719 Hz
8	0.75 s	4.5 s	0.334 Hz
16	1.55 s	9.3 s	0.161 Hz
32	3.15 s	18.9 s	0.079 Hz
64	6.35 s	38.1 s	0.039 Hz

The filter window is a limit for restarting the filter. If a single reading is different from the filter value by more than the limit, the instrument will assume the change was intentional and restart the filter. The Filter Window is set in percent of full scale range.

When the Model 3401 4-channel RTD/diode option card is installed, the time it takes to get a new reading is increased if more than one scanner channel is enabled. This reduction in update rate modifies the time constant of the filter. The time constant of the filter can be derived using the formula TC = T/(In(N/(N-1)), where TC is one time constant, T is the update rate of the channel in seconds per reading, and N is the number of filter points. Refer to Table 3.3 for information on update rates of the Model 3401. The following table shows a sampling of enabled scanner channels with the number of filter points set to 8 and resulting time constant, settle time, and equivalent noise bandwidth.

Default: Filter–>Disabled, Filter Points–>8, Filter Window–>10% of full scale range

Interface Command: **FILTER**

Table 3.6: Model 3401 settle time and bandwidth

Scanner channels enabled	Time constant with 8 filter points	Settle time (6 time constants)	Equivalent noise bandwidth (¼ TC)
1	0.75 s	4.5 s	0.334 Hz
2	1.50 s	9 s	0.167 Hz
3	2.25 s	13.5 s	0.111 Hz
4	3.00 s	18.0 s	0.083 Hz

Note: Note, the settle times and ENB in Table 3.6 are applicable for inputs C and D as well.

3.3.11 Input name

To increase usability and reduce confusion, the Model 346 provides a means of assigning a name to each of the sensor inputs. The designated input name is used on the front panel display to indicate which sensor reading is being displayed.

Default: Blank/no-name

Interface Command: **INNAME**

Note: In a default state, the INNAME query will return a blank string. However, the front panel will display a default name of "Input X".

To change the input name, navigate to the input details page and tap the pencil icon in the upper right corner of the screen. The following screen will appear:

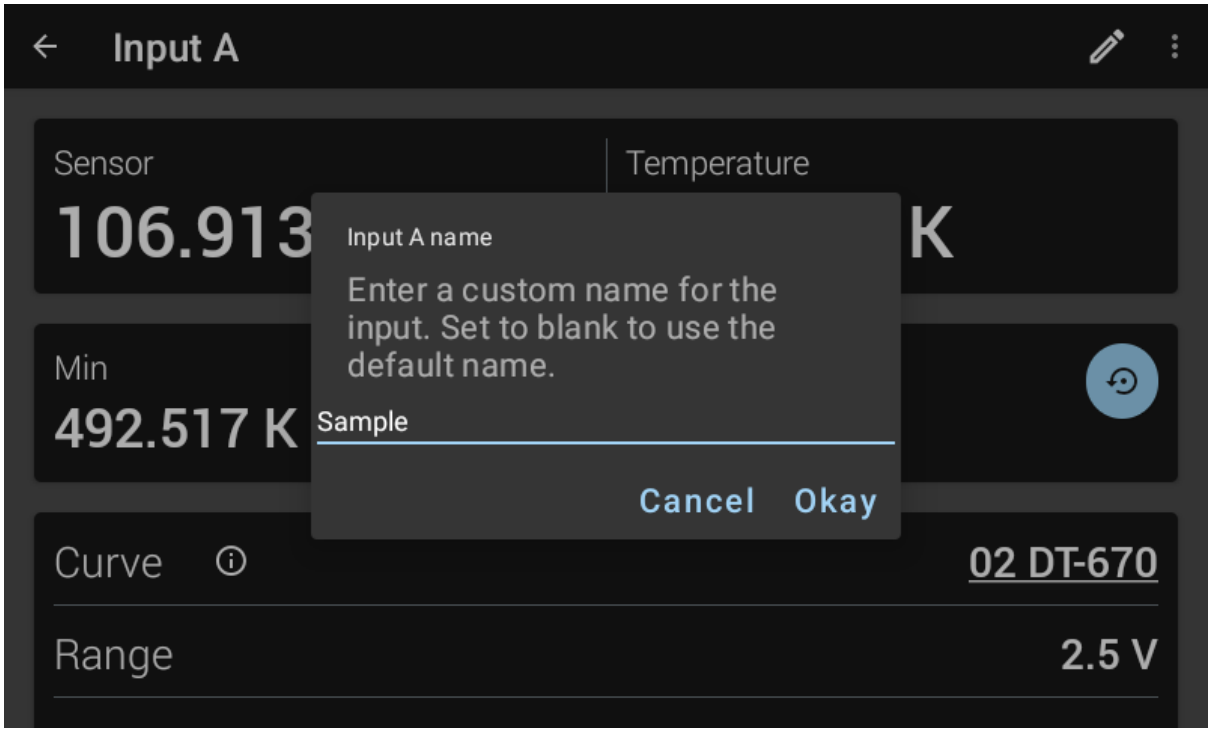


Figure 3.10: Input name screen

1. Tap the name field and use the keyboard to enter a name for the input.
2. Tap the checkmark on the bottom right of the keyboard.
3. Tap **Okay**.

Note: Names are limited to 32 characters. It is recommended to use only ASCII characters. The keyboard will allow entry of non-ASCII characters, which will display properly on the front panel, but may not be reported properly over the remote interface.

Note: To set the input name to the default state from the front panel, bring up the name entry window, erase the string, and tap **Okay**.

3.3.12 Temperature limit

The Temperature Limit parameter protects your equipment from damage by shutting down all control outputs when the assigned temperature limit is exceeded on **any** sensor input. The parameter is available for each of the sensor inputs. A temperature limit of 0 K (default value) turns this feature off.

Default: 0.0000 K

Interface Command: **TLIMIT**

3.3.13 Temperature units

The Temperature units parameter setting determines which units are used to display and/or configure the following:

- Temperature reading
- Max/Min
- Setpoint
- Output stability acceptable error
- Alarm high and low setpoints, and deadband
- Temperature threshold values
- High and low values for outputs 5 to 8 when in monitor output mode

Default: Kelvin

Interface Command: **INTYPE**

3.3.14 Max/Min

The Max/Min feature captures and stores the highest (Max) and lowest (Min) reading taken since the last reset. If no curve is assigned to the input, the Max/Min readings are in sensor units. If a curve is assigned, then the Max/Min readings are dependent on the temperature units setting.

Minimum and maximum readings are captured continuously. The readings are reset when the instrument is turned off, sensor type is changed, a new curve is assigned to an input, or the Max/Min **Reset** button is pressed.

Interface Commands: **MNMXRST, MDAT?**

Over the remote interface, the Max/Min values are reported for every input. On the front panel, they are only visible in the input details screen. Max/Min values are visible for inputs assigned to an output, which can be assigned to one of the views on the home screen.

To reset Max/Min, tap the blue **Reset** icon, located near the Max/Min readings.

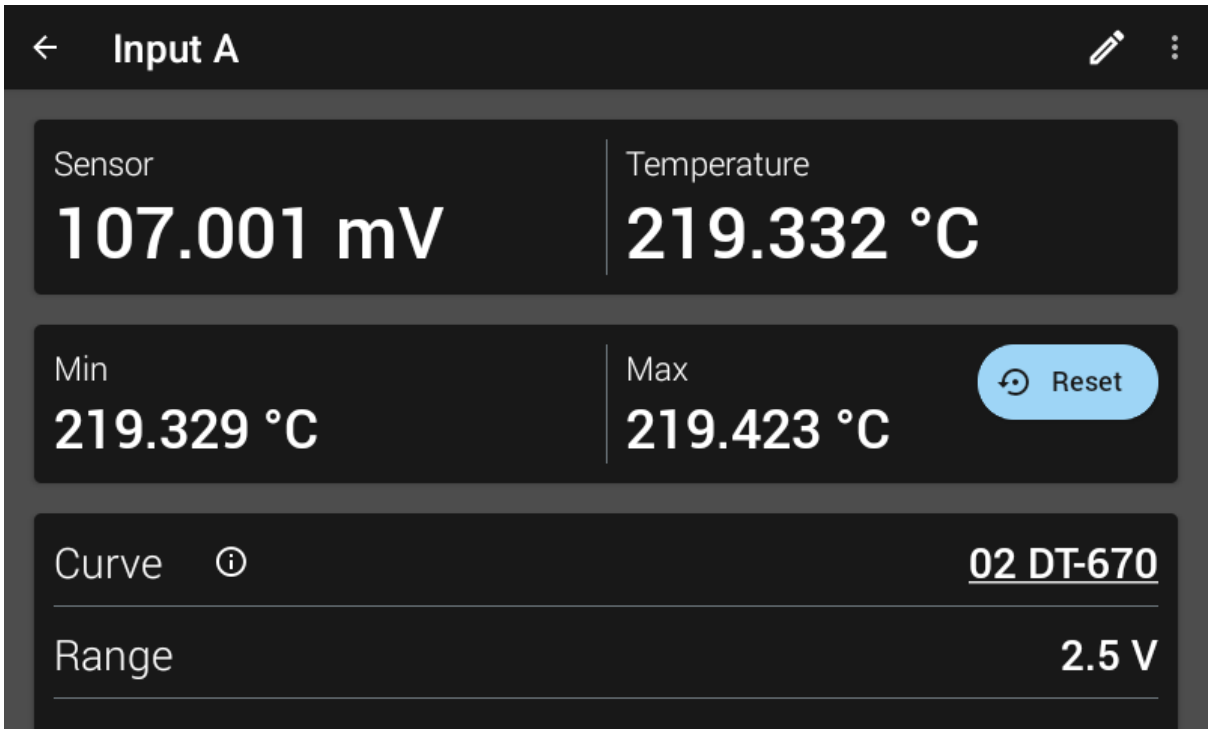


Figure 3.11: Max/Min reset screen

3.4 Output and Control Setup

Once the sensor inputs have been configured (see *Input Setup* (page 41)), the outputs can be configured. This can be done from the output details page, which is accessible from tapping any of the outputs listed under the I/O > **Outputs** tab. The settings on the output details page are used to create control loops for controlling temperature, whether using feedback (closed loop) or manually setting the output (open loop).

This section describes how to configure and operate the output and control features, and how to set control parameters. Each control parameter should be considered before turning on a control loop output, or the instrument may not be able to perform the most simple control functions. A good starting point is deciding which control loop to use, whether to operate in open or closed control mode, and which tuning mode is best for the application.

To see the control loop on the front panel, assign it to one of the two home screen customizable views. See the Home Screen section under *Display Overview* (page 36) for more information.

ColdSync™ software provides a convenient way to setup and configure the outputs of the Model 346. The following image shows the output setup screen in ColdSync™:

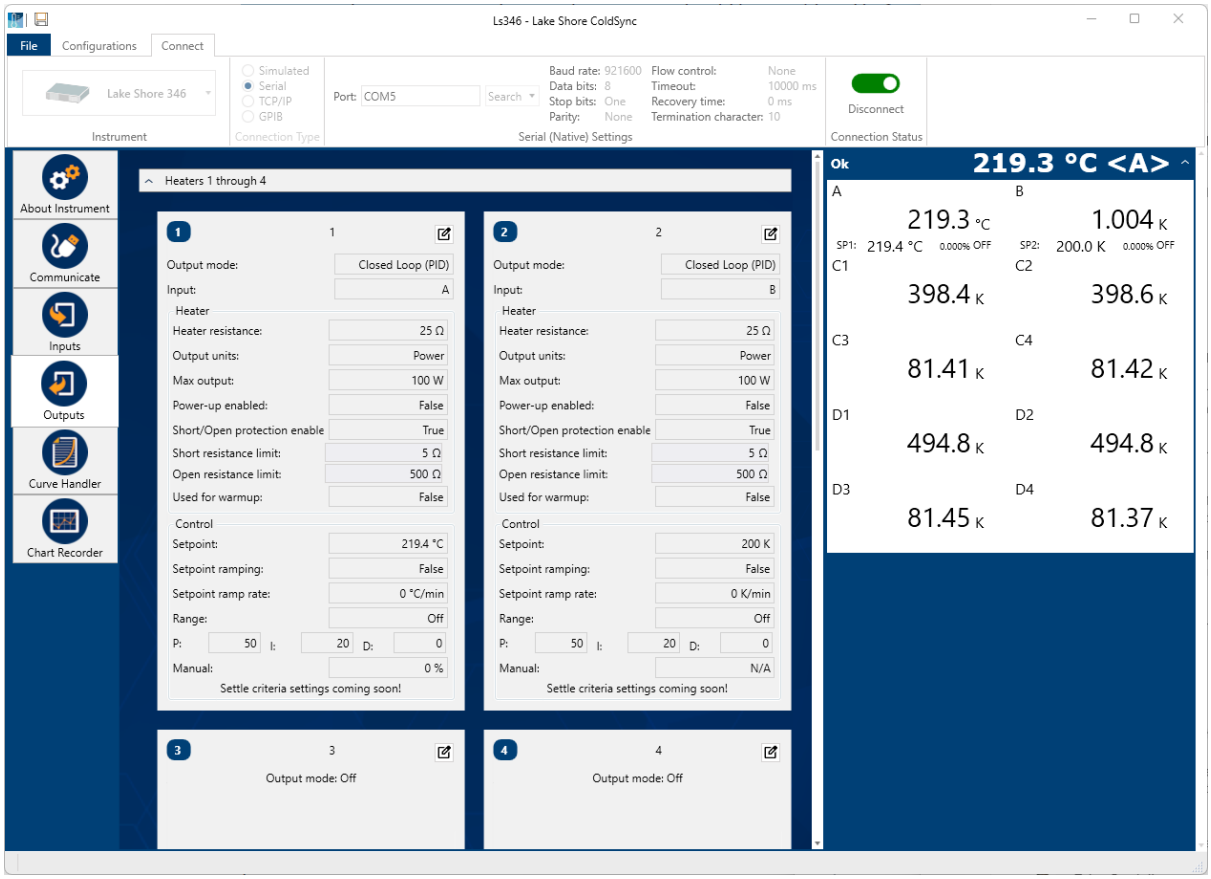


Figure 3.12: ColdSync™ output setup screen

3.4.1 Heater output overview

Heater Outputs 1, 2, 3, and 4 are traditional control loop heater outputs for a cryogenic temperature controller. Each output includes a large set of hardware and software features, making them flexible and easy to use.

The 4 outputs are identical, well-regulated DC current sources, with a maximum current output of 2 A and a compliance voltage limit of 50 VDC. This provides quiet, stable control for a broad range of temperature control systems in a fully integrated package.

For a maximum power output of 100 W, the heaters are optimally designed to drive 25 Ω loads. The heaters have been designed and tested to drive resistive loads ranging from 10 Ω to 100 Ω. Resistive loads outside of that range can be driven within the operating limits of the 2 A/50 V current source, but performance is not guaranteed.

In addition, there are two full-scale power ranges available. The High range is capable of providing up to 100 W (2 A), while the Low range is better suited for low temperature applications, and has a maximum output power of 1 W (200 mA).

3.4.2 Max output and heater resistance

During setup and configuration, the heaters can be configured in terms of output power, or output current. The Heater resistance and Max output parameters work together to limit the maximum available power into the resistive heater. This is useful for preventing heater damage or limiting the maximum heater power into the system. The Max output setting allows for a current or power limit that keeps the output operating within the voltage compliance limit to ensure the best possible resolution.

Default: Heater resistance>25 Ω, Output units>Power (W), Max output>100 W

Interface Command: **HTRSET**



Figure 3.13: Heater setup screen

Note: Max output and Heater resistance work with the heater range setting to provide safety and flexibility.

Output units

The current/power output units settings determines how the output percentage is applied to the heater. When in units of current, the heater output percentage is a percentage of the full-scale current, as specified in the Max output parameter. When in units of power, the output percentage is a percentage of full-scale power, also specified by the Max output parameter.

For example, if the full-scale output is 100 W, units are set to Power, and 50% output is requested, the heater current source will provide 1.41 A to your 25 Ω load for a total of 50 W.

Note: The heater output display is a calculated value intended to aid in system setup and tuning. It is not a measured value, and may not accurately represent actual power in the heater.

Max output

As mentioned before, the Max output setting allows for a current or power limit that keeps the output operating within the voltage compliance limit to ensure the best possible resolution.

It should also be noted that this Max output value is applicable only for the HIGH heater range. If the LOW range is selected, the Model 346 automatically scales down the Max output setting accordingly. For example, in power mode, if the Max output is set to 50 W, then 50 W will be the maximum output (100%) when the HIGH range is selected. When the LOW range is selected, maximum output (100%) will be 500 mW, since the LOW range hardware is designed to output 1/100th of the HIGH range power. The same idea applies to current. If the Max output is set to 1 A, then 1 A will be used for the HIGH range Max output (100%), while 100 mA will be used for the LOW range Max output (100%), since the LOW range hardware is designed to output 1/10th of the HIGH range current.

For use with heater groups (9 and 10), the Max output and Heater resistance parameters are unused, as the physical channels (1 to 4) are used to determine the Max output and Heater resistance of their respective heater loads. Heater groups are discussed in the Advanced Operation section of this manual.

Note: From the front panel, if you attempt to set a Max output that exceeds the current/power hardware limits of the output, based on the Heater resistance, the Model 346 will limit the Max power output accordingly. For example, if the Heater resistance is set to 50 Ω, and you attempt to enter a Max output of 70 W, the Model 346 will limit the Max output to 50 W, as that is the maximum power the 2 A/50 V current source can deliver to a 50 Ω load.

3.4.3 Power-up enable

All heater configuration parameters of the Model 346 can be retained through a power cycle. Some systems require that the Heater Range is turned off when power is restored. The power-up enable feature allows you to choose whether or not the Heater Range is turned off each time the instrument power is cycled. Set the Power-up enable parameter to Off to ensure that the Heater Range is turned off on power up. Set it to On to return the Heater Range to its previous setting when power is restored.

Default: Off

Interface Command: **OUTMODE**

3.4.4 Output modes

The heater outputs can be configured in one of four output modes: Off, Closed loop PID, Zone, or Open loop. The Off mode prevents current from being sourced to the given output. Closed loop PID is the mode most often used for controlling temperature. Zone mode builds on the Closed loop mode by providing automatic changing of control parameters at up to ten different temperature zones. Open loop mode provides a means of applying a constant output.

Default: Off

Interface Command: **OUTMODE**

Closed loop PID mode

The Closed loop PID mode is the most commonly used control mode for tightly controlling temperature using the heater outputs of the Model 346. In this mode the controller attempts to keep the environment at exactly the user-entered setpoint temperature, using feedback from the control input sensor to calculate and actively adjust the control output setting. The Model 346 uses a control algorithm called PID that refers to the three terms used to tune the control. In Closed loop PID mode, the controller will accept user-entered Proportional, Integral, and Derivative parameters to provide 3-term PID control. Manual output can be used during closed loop control to add to the calculated PID control output.

Zone mode

Optimal control parameter values are often different at different temperatures within a system. Once control parameter values have been chosen for each temperature range (or zone), the instrument will update the control settings each time the setpoint crosses into a new zone.

Note: The control parameters can be changed manually. As in Closed loop PID mode, they will be automatically updated once the setpoint crosses a zone boundary

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The control algorithm used for each zone is identical to that used in Closed loop PID mode. The Zone feature is useful by itself, but it is even more powerful when used with other features. It is recommended to use zone mode with setpoint ramping. Refer to the Advanced Operation section of this manual for details on setting up zones.

Open loop mode

Open loop output mode allows you to directly set the output using only the Manual output and Range parameters. This guarantees constant output to the load, but it does not actively control temperature.

You can configure any output to Open loop mode. The manual output percentage and the heater range are selectable from the output details page, and more conveniently, when that output is assigned to one of the views on the Home screen.

CAUTION Since there is no sensor feedback in Open loop mode, there is nothing to prevent the system from being overheated. We recommend using the Temperature Limit feature to help protect the system from overheating.

ATTENTION Puisqu'il n'y a pas de retour de capteur en mode boucle ouverte, rien n'empêche le système d'être surchauffé. Nous vous recommandons d'utiliser la fonction Limite de température pour vous aider protéger le système de la surchauffe.

3.4.5 Control parameters

Once the output mode is chosen, the control parameters can be used to begin controlling temperature. Control Input is used to create a control loop. The P, I, and D parameters provide fine tuning of the control algorithm. Manual Output provides a baseline output power about which to control. Setpoint is used to set the desired target temperature.

Note: Heater Range is used to turn on the control output and set the power range of the output.

These parameters are described in detail in the following sections.

The most convenient way to set the control parameters is to assign the output to one of the two control loop views on the Home screen. See the view configuration section of *Display Overview* (page 36).

The following image shows the parameters available for use on the control parameters section, located on the bottom left side of the Home screen.

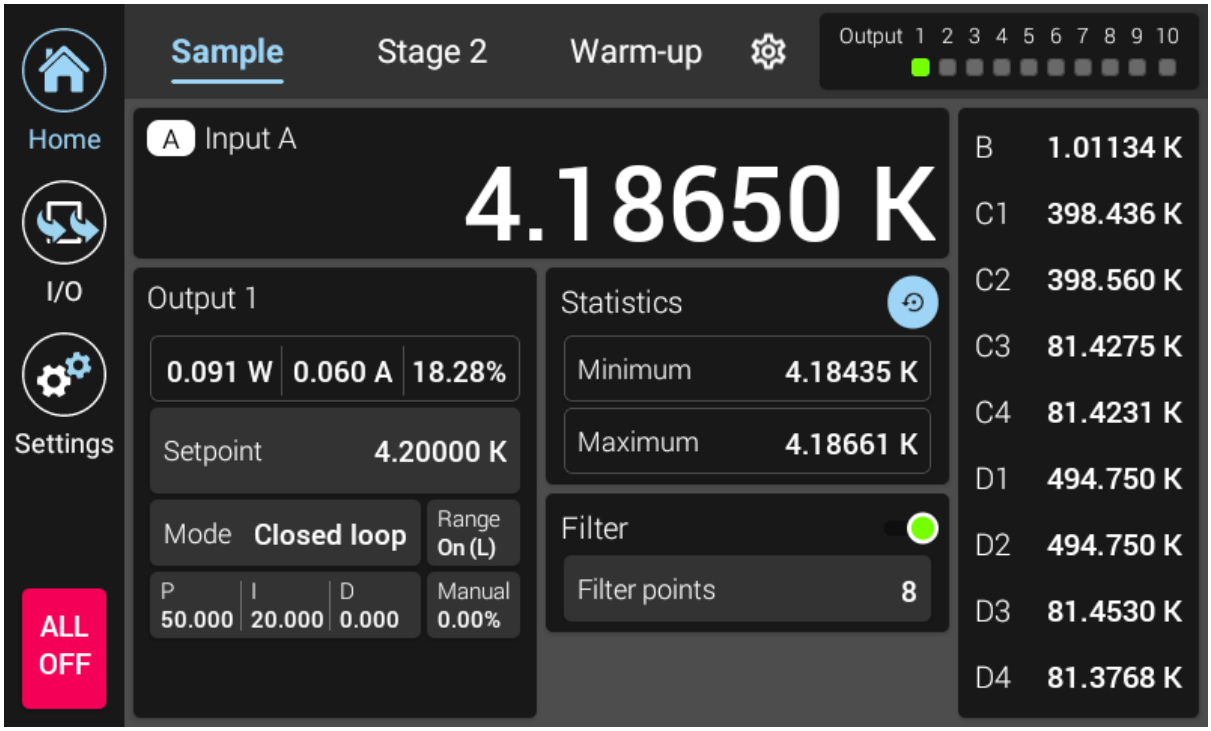


Figure 3.14: Example of control settings available on the home screen

In addition, the control parameters for every output are available within the Output details screen. The Output details screen for a given output can be found by tapping the I/O icon from the navigation panel, then tapping the output summary card for the given output.

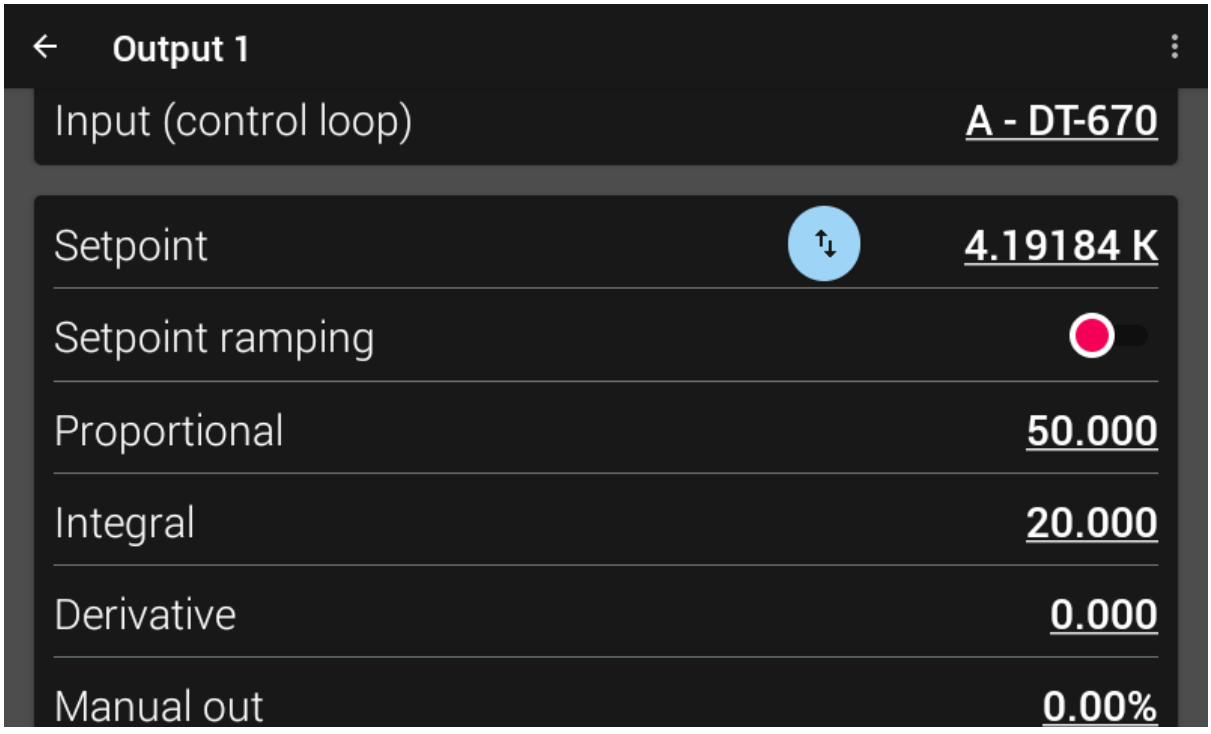


Figure 3.15: Example of control settings available on the output details page

Control loop input

For closed loop control (Closed Loop PID, Zone) a control loop must be created. A control loop consists of a control output for controlling the temperature, and an input for feedback into the control algorithm. On the Output details page, use the **Input (control loop)** setting to assign the control input sensor to the desired output. In Open loop mode, the Control Input parameter can be set simply for convenience in order to view the input on the Home screen.

Default: Output 1>Input A, Output 2>Input B, Output 3>Input C1, Output 4>Input D1

Interface Command: **OUTMODE**

Proportional (P)

The proportional parameter (also called gain) is the P part of the PID control equation. It has a range of 0 to 100,000. The default value is 50. Enter a value greater than 0 for P when using closed loop control. If proportional is acting alone, with no integral, there will always be some level of error present between the setpoint and the temperature reading.

Default: 50

Interface Command: **PID**

Integral (I)

The integral parameter (also called reset) is the I part of the PID control equation. It has a range of 0 to 100,000. The default value is 20. Setting I to 0 turns the reset function off. The I setting is related to seconds by:

$I_{setting} = 1000 / I_{seconds}$

For example, a reset number setting of 20 corresponds to a time constant of 50 s. A system will normally take several time constants to settle into the setpoint. The 50 s time constant, if correct for the system being controlled, would result in a system that stabilizes at a new setpoint in between 5 min and 10 min.

By adding the integral to proportional contributions, the error that is necessary in a proportional only system can be eliminated. When the error is at 0, controlling at the setpoint, the output is held constant by the integral contribution. The integral setting (I) is more predictable than the gain setting. It is related to the dominant time constant of the load.

Default: 20

Interface Command: **PID**

The P value must be non-zero for the I term to work.

Derivative (D)

By reacting to a fast changing error signal, the derivative can work to boost the output when the setpoint changes quickly, reducing the time it takes for temperature to reach the setpoint. It can also see the error decreasing rapidly when the temperature nears the setpoint and reduce the output for less overshoot. The derivative term can be useful in fast changing systems, but it is often turned off during steady state control because it reacts too strongly to small disturbances. The derivative setting (D) is related to the dominant time constant of the load similar, to the I-setting, and is therefore set relative to I-setting when used.

The derivative time constant should normally be somewhere between p and 1/i the integral time in seconds, if used at all. As a convenience to the operator, the Model 346 derivative time constant is expressed in percent of ¼ the integral time. The range is between 0% and 20,000%. Start with settings of 0%, 50%, or 100%, and determine which setting gives you the type of control you desire. Do not be surprised if the setting you prefer is 0%. Note that by using a percent of integral time, derivative scales automatically with changes in the integral value and does not have to be revisited frequently.

Default: 0%

Interface Command: **PID**

A non-zero value for both P and I must be entered for the D term to work.

Manual output

Manual output is a manual setting of the control output. It can function in two different ways depending on control mode. In open loop control mode, the Manual Output is the only output to the load. You can directly set the control output from the front panel or over the remote interface. In closed loop control mode, Manual output is added directly to the output of the PID control equation. In effect, the control equation operates about the Manual output setting.

The Manual output setting is in percent of full scale. Percent of full scale is defined as percent of full-scale current or power on the selected Heater Range. Available full scale current and power are determined by the Heater resistance, Max output, and Heater Range.

Manual output setting range is 0% to 100%.

Default: 0%

Interface Command: **MOUT**

Setpoint

Use the Setpoint parameter to set the desired load temperature for a control loop. Before entering a setpoint, a control loop must be created by configuring an input sensor and assigning it to a control output using the Control Input parameter. The Setpoint can be entered in either temperature units or sensor units, based on whether a curve is assigned to the input. The Setpoint ramping feature is available when controlling in temperature units to provide smooth, continuous control from one temperature to the next.

Most applications require control in units of temperature. To control in units of temperature, assign a temperature curve to the input, then set the Temperature units parameter of the control input to either kelvin or Celsius. When controlling in temperature, the available setting range of the setpoint is limited by the Setpoint limit parameter, that is specified within the assigned temperature curve.

Note: The Setpoint limit feature only limits the Setpoint entry. For even greater protection, the Temperature limit feature can be used to turn off all heater outputs if a sensor reading above the specified temperature is observed.

There are some instances when temperature control in sensor units may be desired, for example when a temperature curve is not available. For these applications the Model 346 can control temperature in sensor units. To control in sensor units, ensure a curve is not assigned to the input.

Default: 0.0000 K

Interface Command: **SETP**

Note: Temperature control in sensor units can be unpredictable since most sensors do not have a linear response to temperature, and therefore have can have different sensitivity in different temperature ranges.

Note: When controlling in temperature, setpoint is limited by the control input temperature curve's Setpoint limit. When controlling in sensor units, setpoint is limited by the limits of the configured control sensor.

Setpoint ramping

The Model 346 can generate a smooth setpoint ramp when the setpoint units are expressed in temperature. You can set a ramp rate in degrees per minute with a range of 0 to 100. Once the ramping feature is turned on, its action is initiated by a setpoint change. When you enter a new setpoint, the instrument changes the setpoint temperature from the old value to the new value at the ramp rate. A positive ramp rate is always entered; it is used by the instrument to ramp either up or down in temperature.

Use the ramping feature to minimize temperature overshoot and undershoot. When ramping is not used, a setpoint change can cause the error used by the PID equation to become very large, which causes the I contribution of the control output equation to become larger the longer the error exists. This will result in a large overshoot or undershoot once the setpoint temperature is reached, since the I contribution will only decrease when the error polarity is reversed. Use a ramp rate that keeps the control output from reaching the extremes of 100% or 0% while ramping for optimal results.

The ramping feature is useful by itself, but it is even more powerful when used with other features. Setpoint ramps are often used with zone control mode. As temperature is ramped through different temperature zones, control parameters are automatically selected for best control. Ramps can be initiated and status read back using a remote interface. During computer-controlled experiments, the instrument generates the setpoint ramp while the computer is busy taking necessary data.

Note: When an incomplete ramp is shut off, the setpoint will remain on the most current setting (the reading will not jump to the end of the ramp).

Note: If the input type or input curve is changed while a ramp is in progress, both ramping and the heater are turned off.

Note: If Ramp is on and the setpoint is set to sensor units, the ramping function will remain on but when another setpoint is entered, the setpoint goes directly to the new setpoint value.

To stop a ramp, either from the output details page, or from the home screen, tap **Setpoint**, then press **Enter** on the keypad. This stops the ramp at the current setpoint, but leaves the ramping function activated. To continue the ramp, enter a new setpoint.

Default: Off

Interface Command: **RAMP**

Heater range

The Heater Range setting is used for turning a control output on, as well as setting the output power range for the heater outputs. All eight outputs provide an Off setting for turning the output off. The heater outputs, 1 to 4, provide LOW and HIGH settings and can be explicitly set when autorange is disabled. The high range provides maximum power, and the low range provides 1/100th of the maximum power.

The unpowered analog output voltage sources, 5 to 8, do not have multiple output ranges, only a fixed 0 V to 10 V output. Therefore, they only provide an On range setting for enabling the output.

Default: Off

Interface Command: **RANGE**

The following example is meant to illustrate the behavior of the output when a manual range change occurs. For example, lets say a heater is setup for a max power of 100 W and a 25 Ω load, and is in units of Watts. If you set the manual output to 1% and turn the range to HIGH, the heater will be outputting 1% of 100 W, or 1 W. If you then change the range to LOW, the output will continue to output 1%. However, because the range is LOW range, and LOW is defined as 1/100th of the HIGH range output power, the 1% output is now 1% of 1 W, or 10 mW.

Note: While controlling temperature, the following will cause the heater range to automatically turn off:

- Exceeding the Temperature limit setting
- Setup changes to the control input
- Power loss with Power-up enable feature turned off
- Input errors such as T. Over, T. Under, S. Over, and S. Under

---

Note: Available full scale current and power are determined by the Heater resistance, Max current setting, and Heater Range.

Because it may be more desirable to change range and have the output power or current remain constant, the heater autorange feature is introduced.

Heater autorange

While manually changing the heater range maintains the output percentage, autorange is designed to automatically pick the heater range and maintain output power or current between range changes.

When deciding to range up, if the output percentage goes above 10% of current or 1% of power, the Model 346 will set the range to HIGH. When deciding to range down, if the output percentage drops below 8% of current or .8% of power, the Model 346 will set the range to LOW.

Default: On

Interface Command: **HTRAUTO**

Note: Over the remote interface, even with auto range set to ON, the RANGE command is still needed to turn the output OFF. If the range is set to LOW or HIGH using the RANGE, and autorange is ON, the Model 346 will pick the appropriate range, based on the output percentage.

Output limit

This feature is designed to limit the output percentage of an output, as an extra layer of protection for the system. As a method to limit power output while using zone commands, or when large setpoint changes occur, the output limit can be set to restrict the maximum percentage of allowed output. This prevents spikes of power that are not desired in low cooling power environments that can occur with large step changes. When the output is limited, a chip is displayed on the front panel, and a bit is set in the OUTST? register.

When a limit is set, any command or control loop that attempts to drive the output will be limited to this percentage.

Default: 100%

Interface Command: **OUTLIMIT**

Note: This setting is only settable over the remote interface.

Manual heater range selection

If manually selecting the Heater Range, this percentage limit is applied to the output, and the output percentage will not go above that limit. This is the case if the control loop is asking for an output percentage higher than the limit in Closed loop mode, or the user manually attempts to output a percentage greater than the specified limit in Open loop mode.

For example, if the limit is set to 30%, and the Model 346 is operating in Closed loop mode, if the control loop algorithm attempts to set the output percentage to anything greater than 30%, the output percentage will remain capped as 30%, and a 'limited' indicator will appear on the outputs summary panel.

Autorange selection

If autorange is enabled, the output limit is used to limit output power or current, rather than purely output percentage as a function of range. For example, if Heater autorange is enabled, and the Max output setting is set to 100 W, and the Output limit is set to 50%, then the output will be capped at 50 W out (50% of 100 W). Continuing on with this example, if the Max output is then set to 60 W, and the Output limit is kept at 50%, then the Heater output will be capped at 30 W (50% of 60 W).

Heater limits

The Model 346 includes a feature to detect if the heater outputs are attempting to drive an open or a short load. This is done to notify users that something has likely gone wrong with wiring or the heating element, and that the system may not be operating as expected.

The heater outputs are constantly being monitored. If an open or short is detected continuously for 5 s, the heater will be disabled and a notification will appear on the front screen.

Default: Short Resistance–> 5 Ω, Open Resistance–>500 Ω

Interface Command: **HTRLIM**

Note: This setting is only settable over the remote interface.

Note: The heater must also be outputting at least 10% of full scale to get an accurate reading of the heater load's resistance. If the output percentage is less than 10%, then

the heater limits are not checked nor enforced.

ALL OFF

The **ALL OFF** button is provided as a means of shutting down all control outputs with one button. It is located on the bottom left side of the front panel.

It is equivalent to setting the Heater Range parameter of all outputs to Off.

3.4.6 Analog outputs

Analog outputs 5 to 8 are variable DC voltage sources that can have a range from 0 V to +10 V. The voltage is generated by a 16-bit D/A converter with resolution of 0.3 mV or 0.003% of full scale. These voltage sources are designed to provide a regulated voltage output across a resistive load, as low as 100 Ω. Because of this, the analog outputs are intended to function as auxiliary low-power heaters, capable of providing at most, 1 W of power, when driving a 100 Ω load.

Similar to Heater outputs 1 to 4, the analog outputs include open-loop and Closed loop modes. However, they cannot be used in Zone mode. The analog outputs features include the power-up enable, and control settings like Setpoint/Setpoint ramping, PID, and manual out.

Default: Off

Interface Command: **OUTMODE**

The analog outputs have a single 0 to 10 V range. Therefore, the outputs can be turned on by setting the range parameter to ON

Default: Off

Interface Command: **RANGE**

In addition, the analog outputs can be configured in Monitor out mode, which provides a voltage proportional to an input temperature reading. This can be used by an external device such as a data logger. More information on Monitor out mode can be found in the advanced operation section of this manual.

Overload protection

Outputs 5 to 8 are DC voltage sources. DC voltage sources can be damaged due to overload conditions. Overloading can occur as a result of having too low of a load resistance applied. Because of this, the Model 346 implements an overload protection feature for outputs 5 to 8. Similar to the open/short detection for outputs 1 to 4, the Model 346 continuously monitors the overload state of the analog outputs. If an overload is detected continuously for 5 s, the output will be disabled, and a notification will appear on the front screen.

Overload conditions are determined in the following ways:

- The current that the voltage source is providing, is measured to be equal to, or greater than, approximately 110 mA.
- The calculated load resistance, based on the measured current and the voltage setting, is less than approximately 95 Ω.

3.5 Locking and unlocking the front panel

The Settings lock feature prevents accidental changes to setting values. When the front panel is locked, some setting values may be viewed, but most cannot be changed from the front panel. ALL OFF is the only front panel function that remains active when the front panel is locked.

Locking out the ability to change settings from the front panel can be done in two ways:

- Tap the **Settings** button located on the navigation panel. Then tap the **Settings lock** button. Finally, tap the **UNLOCKED** button. The status will change to LOCKED.
- From any details page, tap the overflow icon (three vertical dots) located in the top right corner of the screen, then tap **Lock**.

Unlocking the front panel can be accomplished in several ways:

- Tap the **Settings** button located on the navigation panel. Then tap the **Settings lock** button. Finally, tap the **LOCKED** button. The status will change to UNLOCKED.
- From any details page, tap the lock icon located in the top right corner of the screen, then tap **Unlock**.
- Outside of any details page, tap the blue lock icon located in the bottom right corner of the screen, then tap **Unlock**.

If the settings lock feature is enabled, and a user attempts to change a setting from the front panel, a notification will appear on the screen that says *Settings locked, keypad lock enabled*. Tap **Unlock** on this notification bar will unlock the front panel settings as well.

CHAPTER

FOUR

ADVANCED OPERATION

4.1 Curve Setup and Usage

4.1.1 Introduction

At a given temperature, electronic temperature sensors produce either a voltage or a resistance that is a function of temperature. A group of sensor value to temperature pairs are called breakpoints. Breakpoints and header parameters together form a curve file, or more succinctly, a curve. Lake Shore provides curves to users in a file using the .340 file format. A .340 file format is an ASCII text file that can be read using ColdSync™. This process is described later in this section.

The Model 346 has 20 standard curve locations, numbered 1 through 20. Currently, not all locations are occupied by curves; the others are reserved for future updates. Standard curves cannot be changed by the user, and reserved locations are not available for user curves.

The Model 346 has 40 user curve locations, numbered 21 through 60. Each location can hold up to 200 breakpoints, including a value in sensor units and a corresponding value in kelvin. Using fewer than 200 breakpoints will not increase the number of available curve locations.

Note: A curve requires at least 2 points to be valid

4.1.2 Curve Header Parameters

Each curve has parameters that are used for identification and to allow the instrument to use the curve effectively. The parameters must be set correctly before a curve can be used for temperature conversion or temperature control. When using calibrated curves provide by Lake Shore, these values are set correctly in the .340 file.

- Name: defaults to the *Sensor Model* field in the .340 file. However, ColdSync™ allows for entry of a custom curve name up to 31 characters long.
- Serial Number: a sensor serial number of up to 15 characters (letters or numbers) is assigned to the curve within the .340 file.
- Format: the format parameter tells the instrument what breakpoint data format to expect. Different sensor types require different formats. Formats for Lake Shore sensors are described in the table Table 4.1.
- Setpoint Limit: limits the control setpoint to values less than or equal to this setting. A setpoint limit is included with every curve, and is usually set to the highest temperature in the curve.
- Temperature Coefficient: the temperature coefficient is derived by the Model 346 from the first two breakpoints. A positive coefficient indicates that the sensor value increases with increasing temperature. A negative coefficient indicates that the sensor signal decreases with increasing temperature.

Table 4.1: TABLE 5-3 Curve header parameter

Number	Format	Description	Sensor units full-scale range	Sensor units maximum resolution
1	mV/K	Millivolts vs. kelvin for thermocouple sensors	±100 mV	0.0001 mV
2	V/K	Volts vs. kelvin for diodes	10 V	0.00001 V
3	Ω/K	Resistance vs. kelvin for PTC RTD sensors	10 kΩ	0.001 Ω
4	LogΩ/K	Log resistance vs. kelvin for NTC RTD sensors	5 log Ω	0.00001 log Ω

4.1.3 Curve Breakpoints

As mentioned above,temperature response data of a calibrated sensor must be reduced to a table of breakpoints before entering it into the instrument. A curve consists of 2 to 200 breakpoints and each breakpoint consists of one value in sensor units and one temperature value in kelvin. The Model 346 uses linear interpolation to calculate the temperature between breakpoints.

Note: If the sensor reading is outside of the range of the curve, the instrument extrapolates using last two points, up to a maximum of 50% lower than the lowest temperature point, or 5% higher than the highest temperature point.

The instrument will show T.OVER or T.UNDER on the display if the sensor reading is outside the extrapolated range of the breakpoints. Sensor units are defined by the format setting in table Table 4.1.

Breakpoint setting resolution is six digits in temperature. Most temperature values are entered with 0.001 resolution. Temperature values of 1000 K and greater can be entered to 0.01 resolution. Temperature values below 10 K can be entered with 0.0001 resolution. Temperature range for curve entry is 0 K to 9999.99 K.

4.1.4 Loading Curve Files with ColdSync™

A key feature of ColdSync™ is the ability to upload temperature curve files to the Model 346. It is also capable of reading curves from the Model 346 and writing them to a file for storage.

The ColdSync™ Curve Handler™ supports standard Lake Shore temperature curve files in the ".340" file format. Curve files are provided with calibrated sensors purchased from Lake Shore in the ".340" file format.

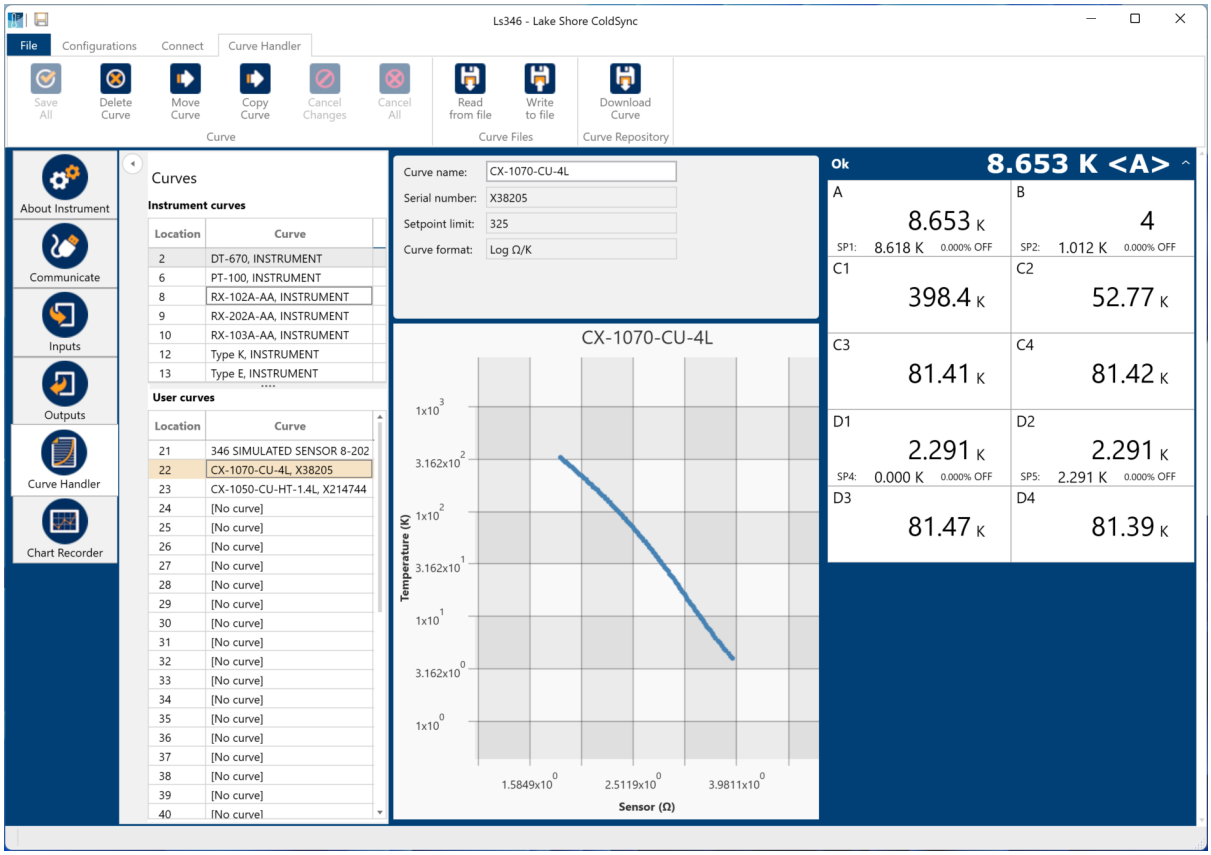


Figure 4.1: ColdSync™ curve handler screen

To load a temperature curve, follow this procedure.

1. Open ColdSync™ and press the toggle switch under *Connection Status* to connect to the Model 346.
2. On the left side of the window, press the *Curve Handler* button. A similar view to the one above should be present.
3. Under *User curves*, press the desired user curve location (21 to 60) to which the curve will be uploaded.
4. At the top of the window, press *Read from file.* A window will open allowing you to select the .340 curve file.
5. The curve should now appear in the window, similar to the one above. If desired, change the *Curve name.*
6. Navigate to the upper left of the window and press the *Save All* button.
7. After pressing OK when prompted, the curve will load into the Model 346 and a window will appear indicating that the curve was written successfully.

Alternatively, if you do not have the file, but do have the serial number, ColdSync™ can download and install the curve for you.

1. Follow steps 1 to 3 above.
2. At the top of the window, press *Download Curve.* A window will open allowing you to enter the serial number of the sensor.
3. Enter the serial number. If successful, the window will display the sensor model number. Press import curve to continue.
4. Navigate to the upper left of the window and press the *Save All* button.

4.2 Zone Settings

The Model 346 allows you to establish up to ten custom contiguous temperature zones where the controller will update PID, heater range, manual output, output limit, ramp rate, and control input settings to pre-programmed values, upon transitioning into the zone. Zone control can be active for multiple control loops at the same time. Configure the zones using 1 as the lowest to 10 as the highest zone. Zone boundaries are always specified in kelvin (K). The bottom of the first zone is always 0 K; therefore, only the upper limit is required for all subsequent zones.

To use the programmed zones, set the output mode to Zone. In Zone mode, the instrument updates the control settings each time the setpoint crosses into a new zone. If you change the settings manually, the controller uses the new setting while it is in the same zone, and updates to the programmed zone table settings when the setpoint crosses into a new zone.

The zone settings include a Control Input parameter for each temperature zone. This allows a different feedback sensor to be used for each temperature zone. For example, a diode sensor can be used while cooling down from room temperature to 10 K, at which point the Control Input could be switched to a Cernox™ sensor for temperatures under 10 K.

Note: Zone parameters can only be configured over the remote interface. Therefore, it is highly recommended to use ColdSync™ to configure zones for a given output.

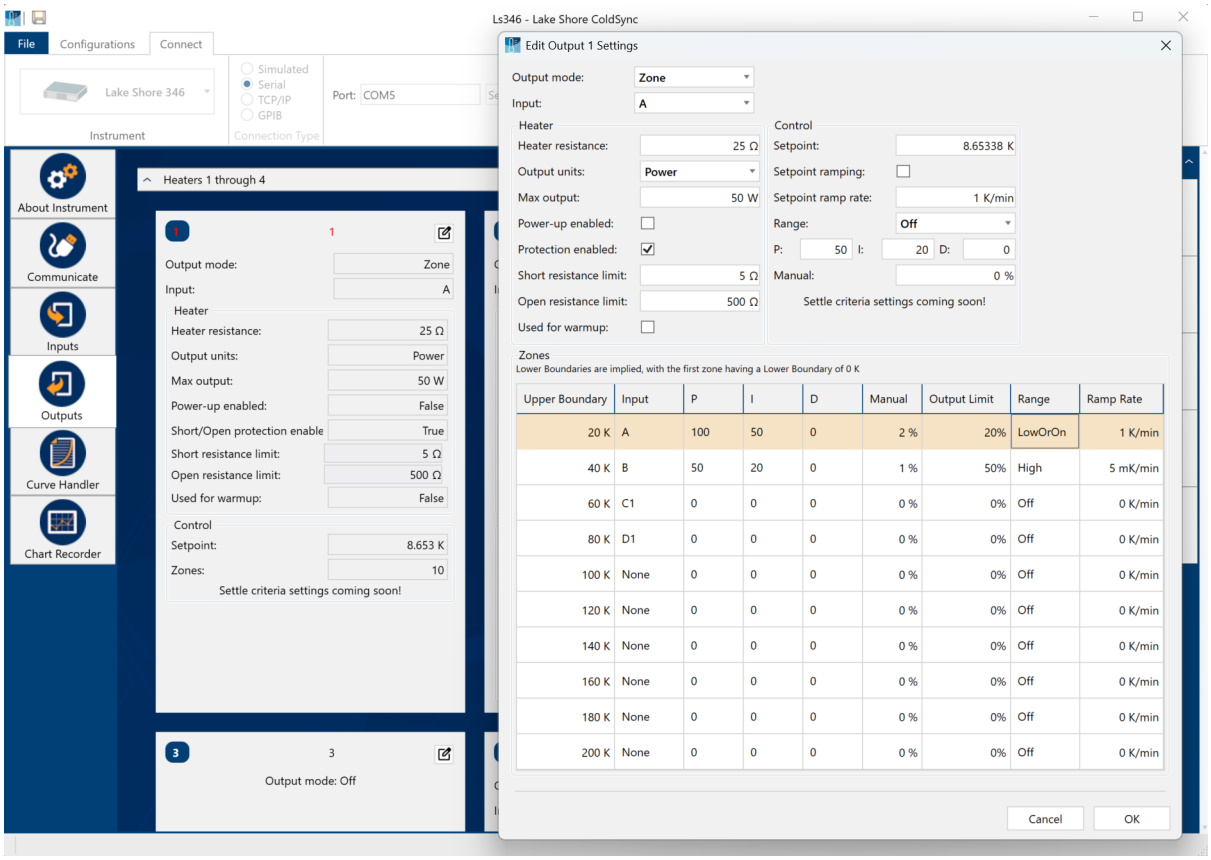


Figure 4.2: ColdSync™ zone setup screen

To illustrate how the control parameters are updated in Zone mode, consider the zone settings from the table below. Starting from room temperature (about 300 K) and setting a setpoint of 2 K (with Setpoint Ramping turned on), the setpoint will begin ramping at the current setpoint Ramp Rate. Once the setpoint crosses 100 K, the control parameters from Zone 8 will be used. The setpoint ramp will then continue toward 2 K at a rate of 20 K/min until crossing 50 K, at which point the control parameters from Zone 7 are loaded. This pattern will continue until the final setpoint value of 2 K is reached, or another setpoint is entered. Note that Input B will be used in all zones greater than 10 K (Zones 4 to 8), and Input A will be used in all zones below 10 K (Zones 1 to 3).

Table 4.2: TABLE 5-2 Zone settings example

Zone	Lower boundary (implicit)	Upper boundary	P	I	D	Manual output	Output limit	Range	Ramp rate	Control input
10	n/a	0 K	50	20	0	0.0%	100%	Off	0.1 K/Min	Default
9	n/a	0 K	50	20	0	0.0%	100%	Off	0.1 K/Min	Default
8	100.001 K	500 K	200	20	0	0.0%	100%	High	30 K/Min	Input B
7	50.001 K	100 K	185	25	0	0.0%	100%	Med	20 K/Min	Input B
6	25.001 K	50 K	150	30	0	0.0%	100%	Med	10 K/Min	Input B
5	15.001 K	25 K	100	30	0	0.0%	100%	Med	5 K/Min	Input B
4	10.001 K	15 K	85	35	0	0.0%	100%	Med	2 K/Min	Input B
3	7.001K	10 K	85	35	0	0.0%	100%	Med	0.9 K/Min	Input A
2	4.001 K	7 K	70.0	40.0	0	0.0%	80%	Low	0.7 K/Min	Input A
1	0 K	4 K	50.0	50.0	0	0.0%	50%	Low	0.5 K/Min	Input A

Note: Sensor accuracy and placement affects how smoothly the transition from one feedback sensor to another is performed. A large difference between the temperature readings of each sensor at the time of transition could cause a temporary instability in the temperature control due to the sudden large error introduced into the control equation

Note: It is highly recommended to use the Setpoint Ramping feature when using the Control Input zone parameter to change sensor inputs. Otherwise, a setpoint change may cause a control input sensor to operate outside of its usable range, which can result in an overload condition that shuts down the control loop.

4.2.1 Zones with heater autoranging

The Model 346 enables the heater autorange feature to be used in conjunction with zones. Even with heater autorange enabled, the ZONE remote interface command still requires a range parameter of LOW or HIGH to be specified when the user wants the heater to be on in a given zone. If the range is not OFF and autorange is enabled, the specified range will be disregarded, and the Model 346 will use the range selection algorithm as described in the Output and Control Setup - Control Parameters section of the Operation chapter.

Default: On

Interface Command: **HTRAUTO**

Note: A range of OFF can still be set to turn the heater off in situations where control is

not desired, such as at room temperature, or base temperature.

Note: If autorange is enabled, the output limit can be considered a tool to limit output power or current, rather than simply output percentage as a function of range. If autorange is disabled, the specified range will be used in a given zone, and the output percentage will not exceed the limit for that zone.

4.3 Heater Groups

In some situations, it is helpful to treat two or more physical heaters as if they were a single virtual heater.

Example scenarios include:

- Requiring more than 100 W of heating power into a single location
- Distributing heating power around a large area using multiple discrete heaters

Heater groups 9 and 10 were created for this purpose. These Heater groups allow the user to create a single control loop, pairing one input temperature sensor, with up to 4 physical heaters. The setup of the Heater group is done in the same way outputs 1 to 4 are setup. There is an additional step required in order to tell the Model 346 which physical heaters to associate with a given Heater group.

Note: Heater groups are not intended to allow multiple heater outputs to be wired together to drive a single heater load. The feature is intended to allow for unified control of multiple discrete heater loads.

Note: A physical heater can only be associated with one Heater group at a time.

4.3.1 Creating a Heater group

Before pairing Heater outputs with a group, it is recommended to ensure the Heater resistance and Max output settings are configured properly for the respective physical heaters. This is because the power output of each heater in the group will be adjusted proportionally based on their individual Max output and Heater resistance settings.

To configure a Heater group, begin by navigating to the output details page of either Heater group 9 or 10.

The following shows the Heater group configuration page:

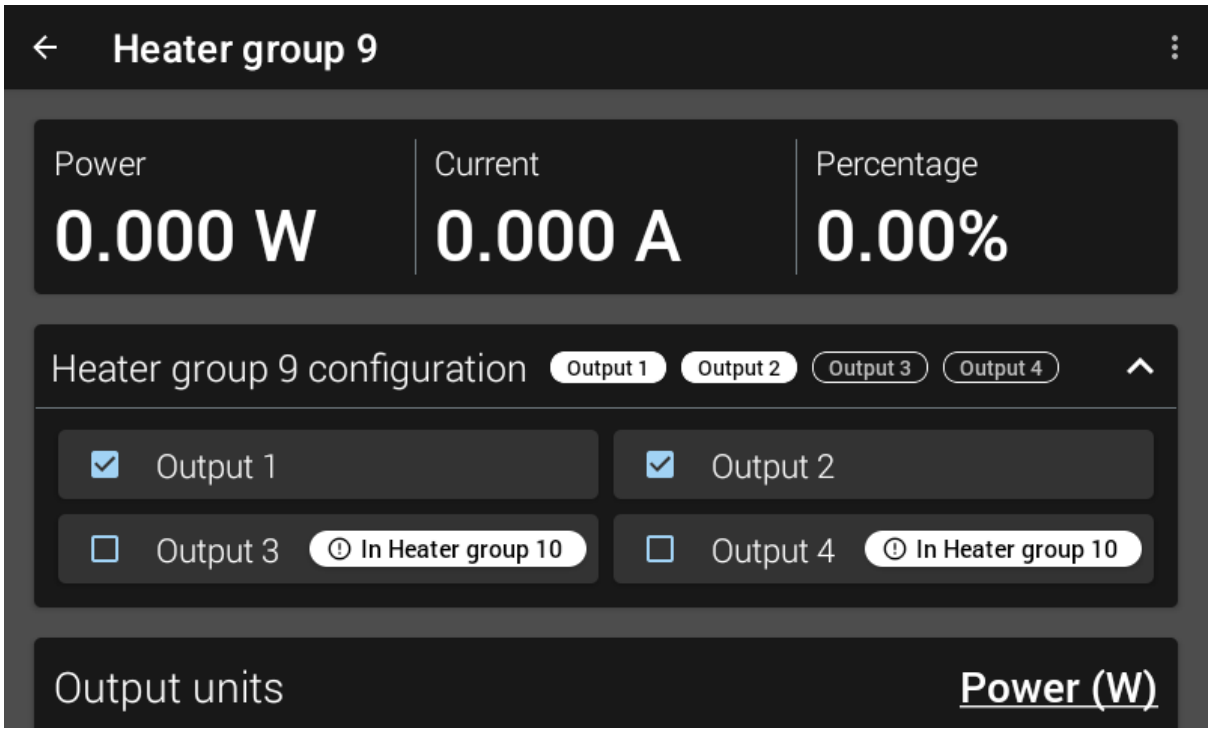


Figure 4.3: Heater group configuration screen

To add a physical output to the group, tap the name of the output listed under the Heater group configuration section. In the example above, Output 1 and Output 2 are paired with Heater group 9. A visual indication shows that Output 3 and Output 4 are paired with Heater group 10. If you decide to pair Output 3 with Heater group 9, this can be done, but only after acknowledging the prompt that appears to confirm you want to move Output 3 from Heater group 10 to Heater group 9.

Default: None

Interface Command: **OUTGROUP**

Note: If any individual heater in a group has a fault condition (short/open), the entire group will be disabled to ensure safety. The group will remain disabled until the fault condition is cleared and the heaters are manually re-enabled.

4.3.2 Using a Heater group

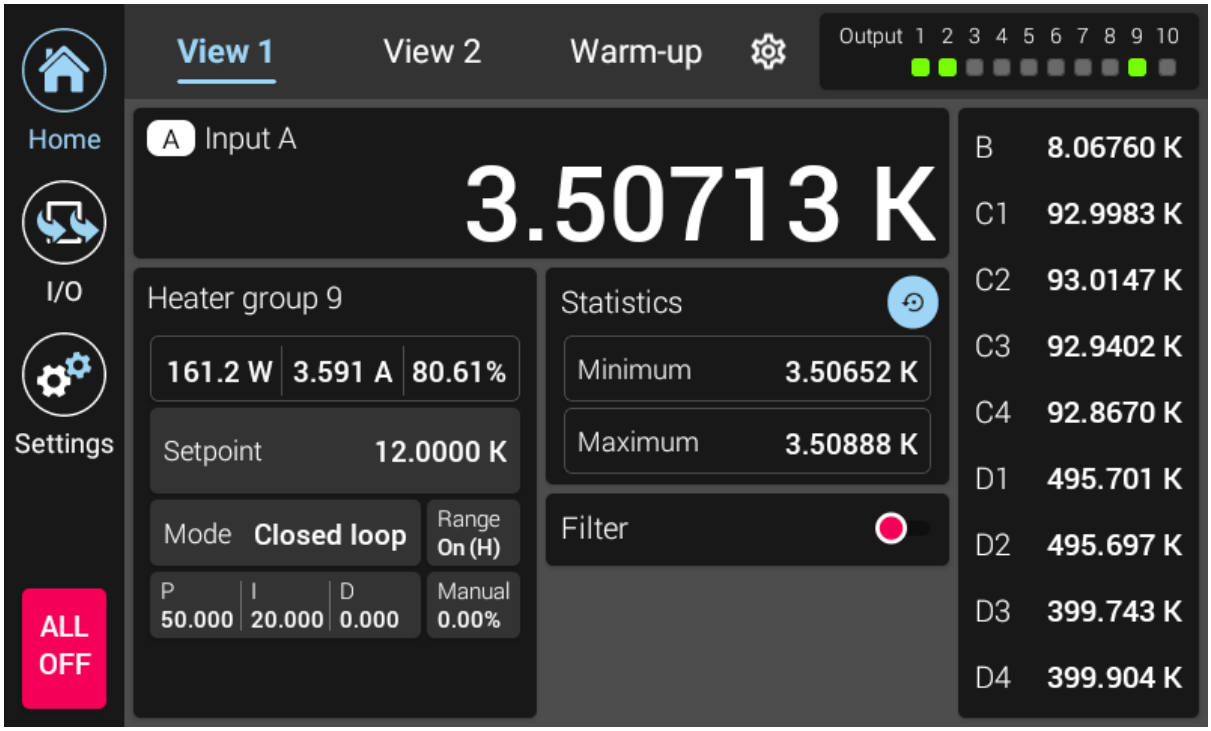


Figure 4.4: Heater group home screen

Once the Heater group is configured, it can be used in the same way as any other heater output by assigning PID, Manual out, Range and Setpoint settings. The figure above shows an example of a Heater group being assigned to a view in the Home screen and controlling in Closed loop. The Heater group shows the total output power being applied to all Heater outputs.

4.4 Monitor Out

Accessing temperature readings is most accurate when performed digitally via USB, Ethernet or GPIB (option card). However, there are some applications where a voltage-based temperature reference is more convenient.

In Monitor out mode, analog outputs 5 to 8 will track the assigned control input according to the scaling parameters entered. A common use for this function would be to send a voltage proportional to temperature to a data acquisition system.

The Input (control loop) setting determines which sensor input is tracked by the output. The remaining parameters detailed in this section dictate how the output value is determined.

The following figure shows an example of Output 6 configured for Monitor out mode. In

this example, Input B is assigned to Output 6, and the 0 V to +10 V analog output is scaled to a 0 K to 100 K temperature range.

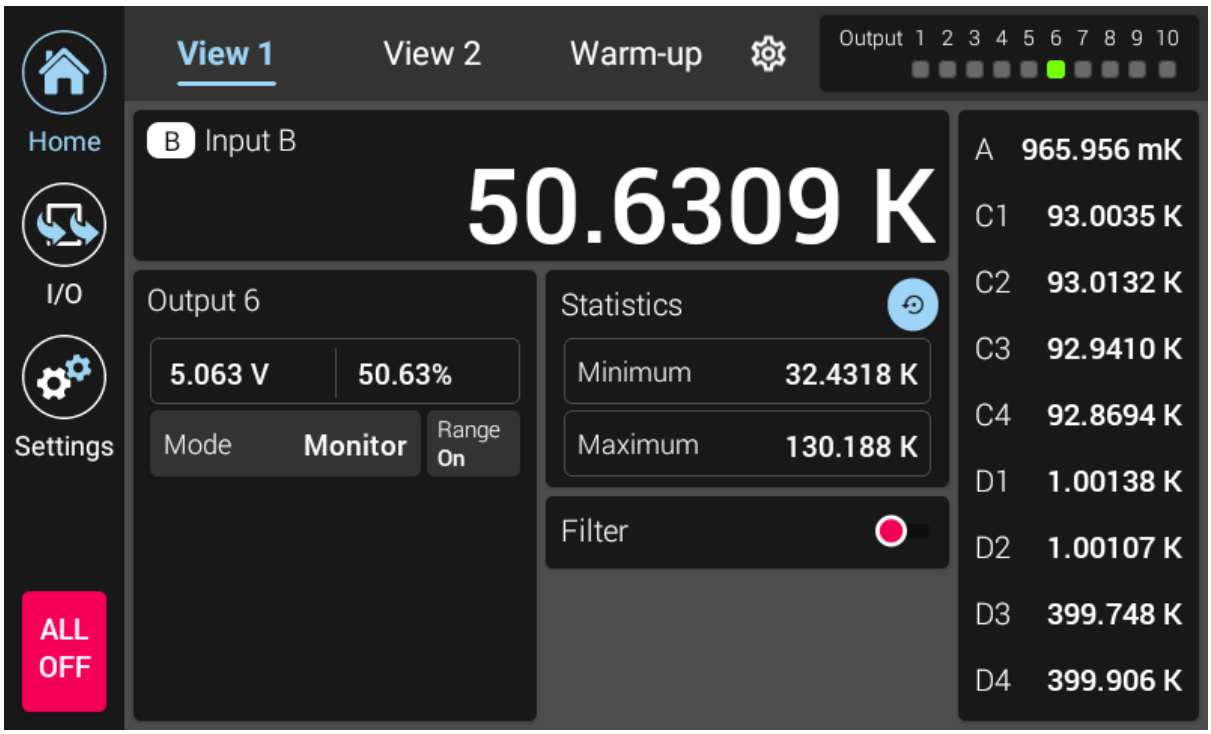


Figure 4.5: Monitor out home screen example

The output scaling is discussed in the following section.

Interface Command: **OUTMODE**

4.4.1 Monitor units and scaling

The units of the input reading are dependent on whether a curve is assigned to the specified input. If a curve is not assigned to the specified input, the reading will be in sensor units. This causes the Monitor out high and low limits to be interpreted in sensor units. When a curve is assigned to an input, this causes the Model 346 to interpret the high and low limits in temperature units. Temperature units are configured in the input setup menu.

Note: The high and low limits can only be set using the remote interface. ColdSync™ software provides a convenient way to set the limits.

The following figure shows the ColdSync™ Output configuration screen.

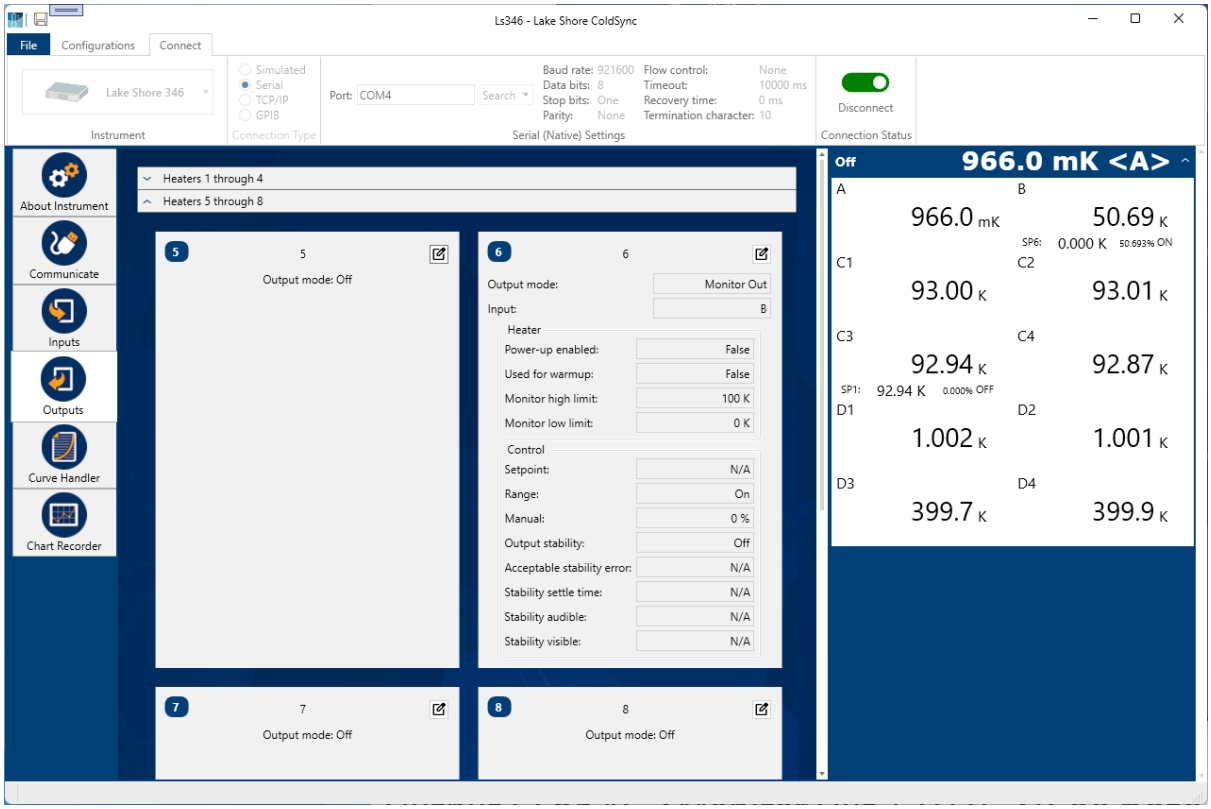


Figure 4.6: Monitor out home screen example

The Monitor high limit setting determines the temperature or sensor value at which the output will be +10 V. The Monitor out low limit setting determines the temperature or sensor value at which the output will be 0 V.

Interface Command: **ANALOG**

The following figure illustrates the input temperature to output voltage relationship for the 0 K to 100 K example shown above. In this case, if the actual reading was 50 K, the analog output would be +5 V (middle of the scale).

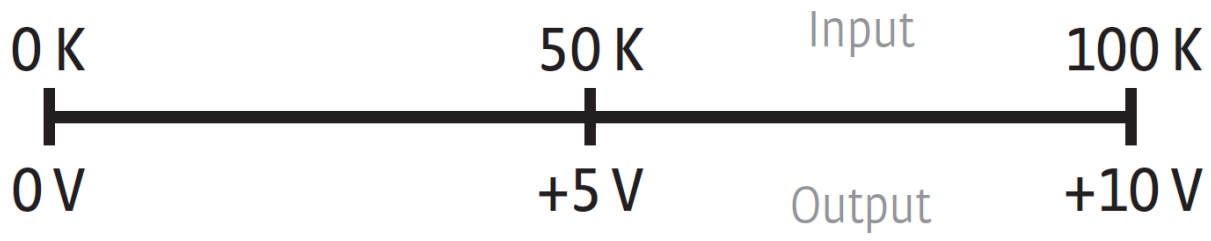


Figure 4.7: Monitor out scaling illustration

4.5 Control Stability

When automating an experiment with multiple temperature steps, it is useful to know when the temperature of the sample has stabilized and is ready for measurement. It is important to not only wait for the temperature of the stage to stabilize, but also to wait a sufficient amount of time to allow the sample to reach this temperature as well. The Model 346 Control stability feature will report when the temperature of the stage has stabilized. In order to do so, the following parameters must be configured:

- Setpoint
- Acceptable error
- Settle time

4.5.1 Theory

Before explaining how to set up the Control stability feature, a brief explanation of how it works is warranted.

When the Control stability feature is enabled for an output, the Model 346 monitors the oscillation of a Input control temperature reading above and below the Setpoint. It then determines if the variation of the temperature reading is within acceptable bounds. The user provides an Acceptable error in which the reading must oscillate within, along with a Settle time component, to ensure that the reading does not drift out of the Control stability range.

Note: The output must be paired with an input to form a control loop in order to use the Control stability feature. The output must also be configured in Closed loop or Zone mode.

The Model 346 requires at least one minimum reading below the setpoint and one maximum reading above the setpoint, both within the Acceptable error limit, to enter into the Stabilizing state. Once in the Stabilizing state, the input temperature readings must remain within the Acceptable error limit for the Settle time to be considered Stable.

The following figure illustrates how the feature works.

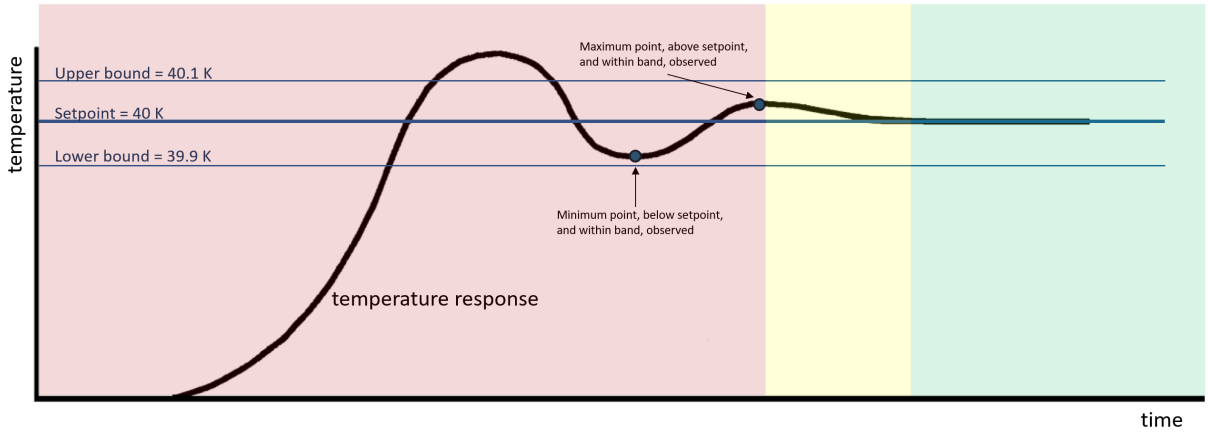


Figure 4.8: Control stability diagram

In the example above, the Acceptable error is set to 100 mK. With a setpoint of 40 K, this results in an error band 39.9 K to 40.1 K.

The red-shaded area represents a non-stable state. Once the minimum and maximum readings have been observed within the error band, the Control stability state changes to Stabilizing, and the Settle time timer starts counting down. The Stabilizing state is represented by the yellow-shaded area. If the temperature reading continues to remain within the error band for the duration of Settle time, the Control stability state changes to Stable, which is represented by the green-shaded area. The state will remain Stable as long as the temperature reading remains within the error band. If the reading drifts outside of the error band, the state will change back to non-stable and the process will repeat.

4.5.2 Setup

Navigate to the output setup page to configure Control stability settings. Tap **Control stability** to enable and disable the feature

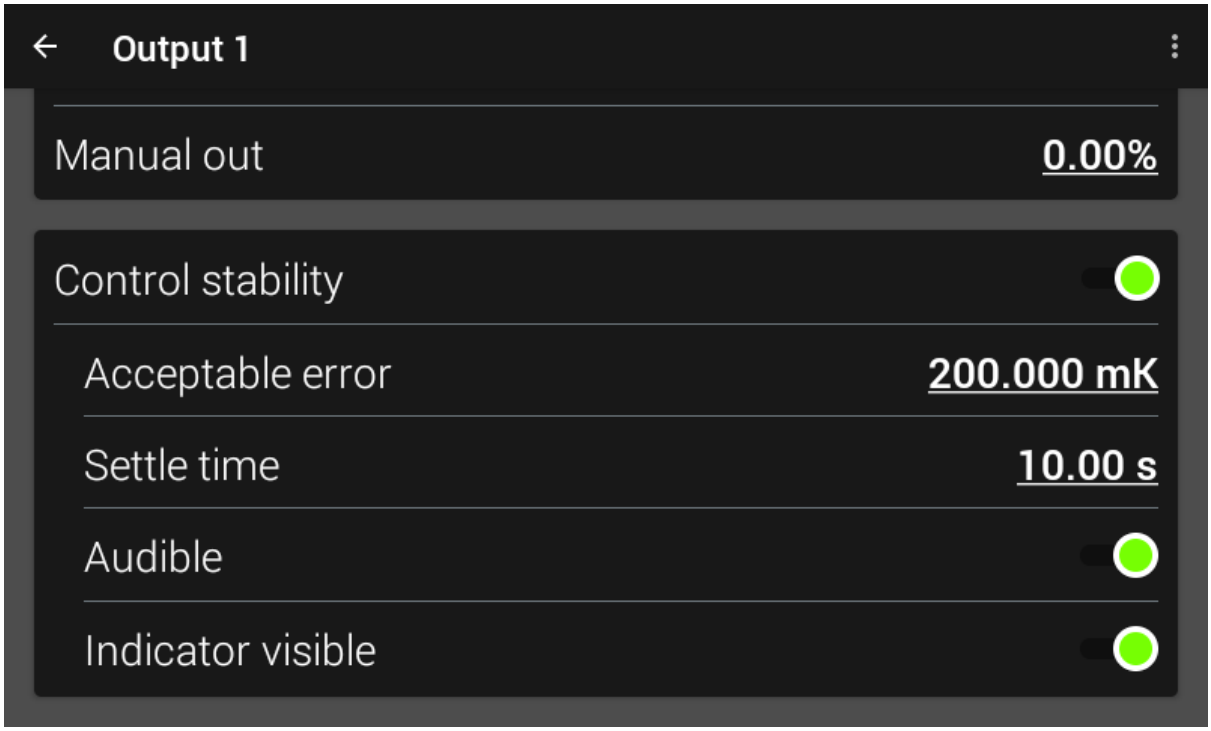


Figure 4.9: Control stability setup screen

Acceptable error and Settle time are discussed above. Enable **Audible** to have the Model 346 emit a tone when the Stable state is reached. If Audible is enabled and the Model 346 starts annunciating, a pop-up will appear allowing you to silence the tone. If the input reading drifts out of band but comes back to the stable state, the Model 346 will annunciate again.

Enable **Indicator Visible** to allow the front panel to display indicators of when the Stabilizing and Stable states are reached.

Interface Command: **OUTSTABLE, OUTOPR?**

4.6 Warm-up

Exchanging a sample at the conclusion of an experiment can be risky if done too quickly. Exposing a cryogenic chamber to the outside environment while components are still cold can result in those components attracting frost and requiring extra steps to prepare the system to cool down again. Warm-up mode simplifies this process by turning on all heaters in a single step and notifying the user when the system is likely in a safe state to expose internal components to outside atmosphere.

The Model 346 allows heaters 1 to 4 and groups 9 and 10 to be used together to deliver up to 400 W into the system for Warm-up mode. Outputs used for Warm-up mode must be configured in either Closed loop or Zone mode, and must be paired with a

temperature input to form a control loop. If a heater mode is set to Off or Open-loop, and Warm-up mode is initiated, those heaters will be forced to Closed-loop mode in order to execute the Warm-up.

4.6.1 Setup

To use Warm-up mode, tap the **Warm-up** tab under the Home view on the front panel. The following screen will appear.

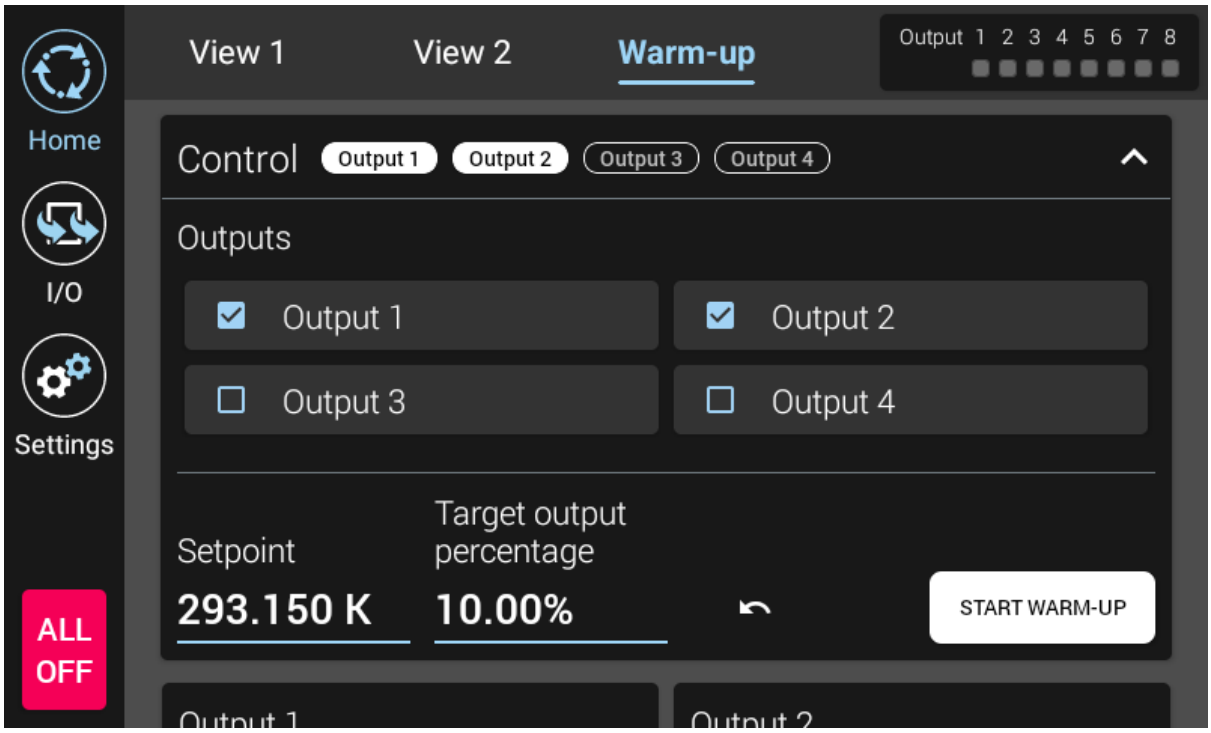


Figure 4.10: Warm-up screen

Expand the Control view to see the heater outputs that are available for Warm-up mode. Tap each output that you wish to use for Warm-up mode. Once the outputs are selected, enter a desired Setpoint and Target output percentage. Setpoints ranging from 275 K to 325 K can be entered.

Due to varying thermal masses and thermal lag within systems, there may be cases where the input reading prematurely reports that a stage has reached the setpoint temperature. To address this phenomenon, the output power delivered to the heater by the Model 346 can be used as an indicator of whether the stage has fully warmed up. The reason is that as sections of the system continue to warm, a large output is required to keep the sensor at a stable temperature. When this additional cooling is finally overcome, the output will drop, indicating that the system can be considered warm.

The Target output percentage setting is used in conjunction with the Setpoint temperature to determine if the system has truly warmed up. The default for this value is

10%. For the Model 346 to report the system is warm, the Setpoint temperature must be achieved for all inputs, and all outputs must go below the target output percentage.

Note: It is recommended to set the setpoint slightly colder than room temperature so that minimal output is required to keep the system at temperature.

Note: Any change to the output control mode or Setpoint for a given output will cause that output to drop out of "Warming" state.

4.6.2 Use

Once the outputs are selected, and the Setpoint and Target output percentage values are entered, tap the **START WARM-UP** button to begin the warm-up process. Each output is set to the HIGH range, and Closed loop control takes over, likely setting each output percentage to 100%. During this time, a "Warming" indicator will appear next to each output. The following image shows outputs in a warming state.

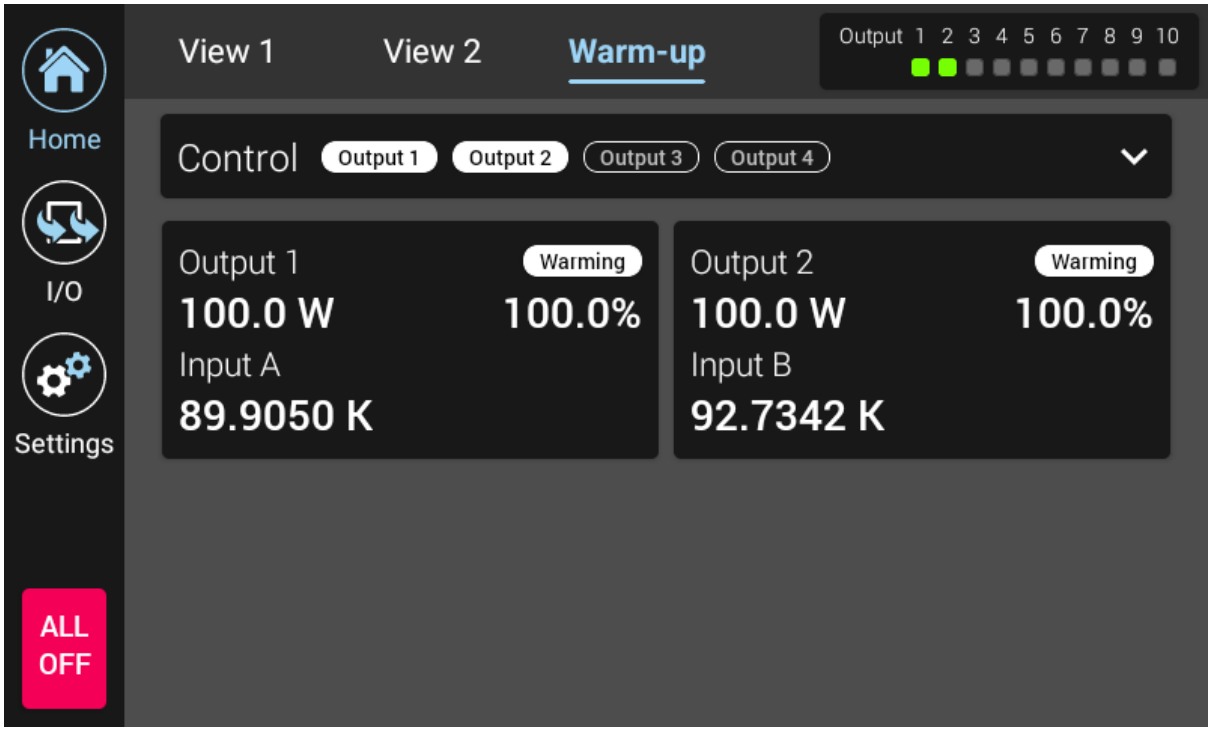


Figure 4.11: Warm-up warming state example

As each control loop reaches the Warm state, a green checkbox appears in that output's card to indicate it has reached the Warm state. Once every output selected for Warm-up

mode has reached the Warm state, a message will appear indicating the system is warmed up.



Figure 4.12: Warm-up warm state example

Tapping **Continue control** will cause the Model 346 to continue to actively control the system. Tapping **ALL OFF** will cause the Model 346 to stop actively controlling the system, and the outputs will be turned off.

Interface Commands: **WARM, OUTMODE, OUTOPR?**

4.7 Alarms

Each input of the Model 346 has high and low alarm capability. Sensor input reading data can be compared to the alarm setpoint values. A reading higher than the High setpoint triggers the high alarm for that input. A reading lower than the Low setpoint triggers the low alarm for that input.

Along with ColdSync™, the Model 346 allows for alarm setup from the front panel. This is done from the input details page, which can be accessed by tapping the input card visible on either the Home screen or the I/O page. The following image shows the alarm settings within the input details page.

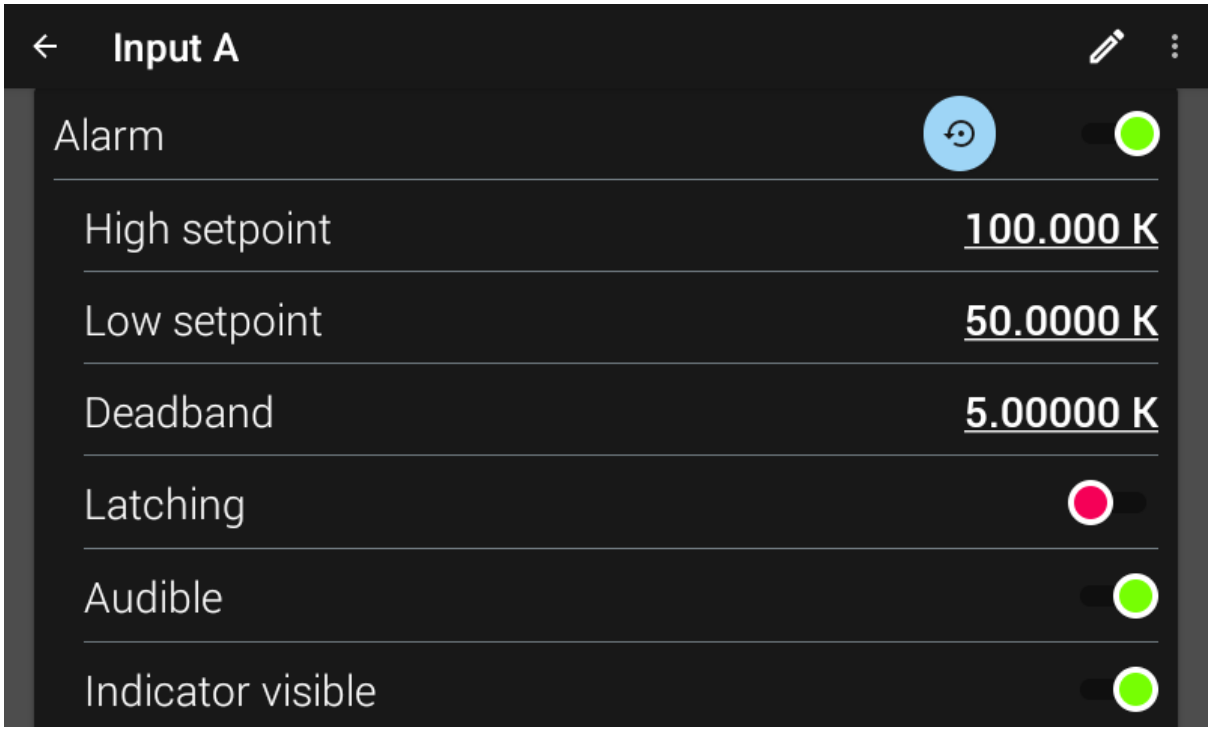


Figure 4.13: Alarm settings screen

The units of High setpoint, Low setpoint, and Deadband are dependent on whether a curve is assigned to the specified input. If a curve is not assigned to the specified input, the settings will be interpreted in sensor units. When a curve is assigned to an input, this causes the Model 346 to interpret the High setpoint, Low setpoint, and Deadband in Temperature units. Temperature units are also configured in the input setup menu.

Interface Command: **ALARM**

Note: Changing between sensor types, or assigning / removing a curve, will cause these values to return to default to prevent an alarm from going off accidentally.

4.7.1 Alarm Annunciators

If the Audible setting is enabled for an enabled alarm, the beeper inside the instrument will sound when the alarm activates. The Audible setting can also be set to disabled to keep the audible alarm from sounding when an alarm is triggered. The setting for alarm volume is found by tapping **Settings** on the navigation panel, then **Display & Sound**, then adjusting alarm volume. When an alarm is triggered and becomes audible, a pop-up will appear on the front screen to quickly allow the user to silence the alarm.

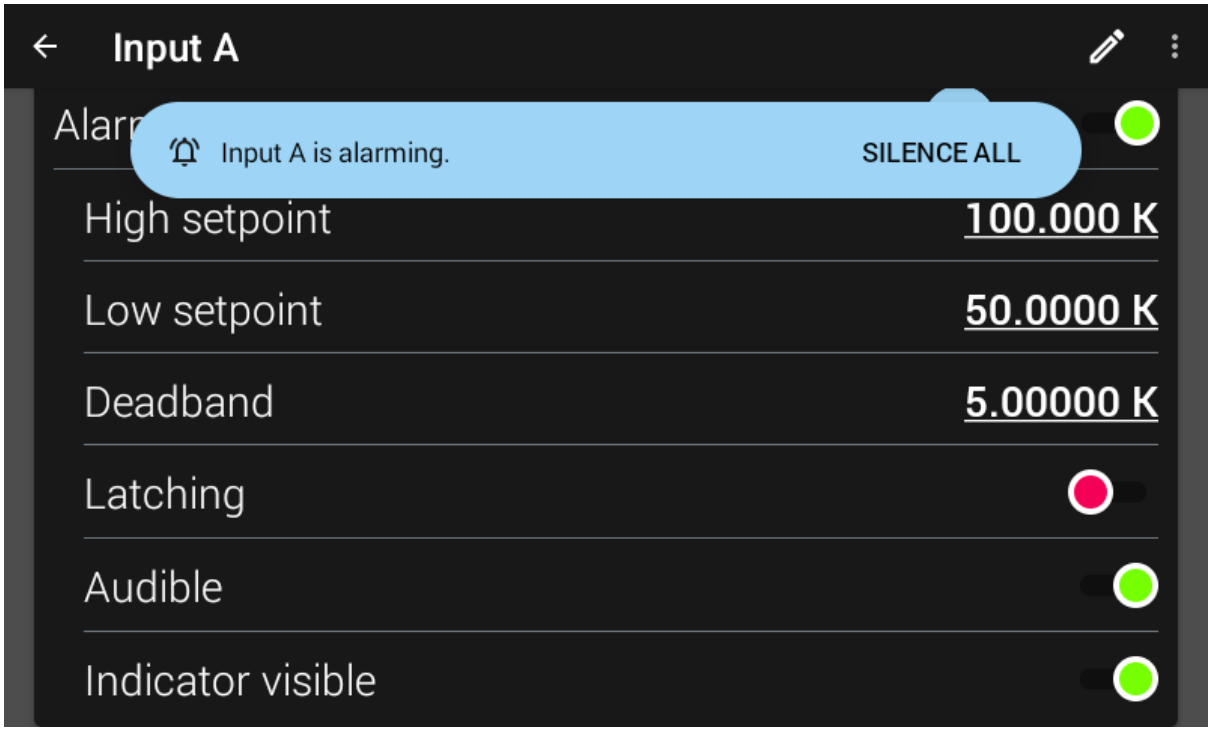


Figure 4.14: Alarm silence pop-up

The alarm indicator is displayed when an alarm is enabled, actively alarming, and has the Indicator Visible setting enabled. If viewing an input card, the indicator will state ALARM. If viewing an input details page, a more specific LOW ALARM or HIGH ALARM indicator will be displayed. You may want to set the Indicator visible setting to disabled if there is no need to show the alarm state on the front panel, for instance, if you are using the alarm function to trigger a relay.

Note: The two relays on the Model 346 can also be tied to alarm functions as described in the Relays section of this manual.

4.7.2 Alarm latching

Latching alarms are often used to detect faults in a system or experiment that requires operator intervention. The alarm state remains visible to the operator for diagnostics even if the alarm condition is removed. When paired with a relay, the relay can signal remote monitors, or for added safety, disable critical equipment.

You can clear a latching alarm by navigating to the Input details page. A pop-up will appear at the bottom of the screen asking if you want to reset all alarm latches. In addition, you can tap the blue **Reset all alarm latches** button located next to the Alarm enable setting.

Non-latching alarms are often tied to relay operation to control part of a system or experiment. The alarm state follows the reading value. The deadband parameter can prevent relays from turning on and off repeatedly when the sensor input reading is near an alarm setpoint.

The following figure illustrates the interaction between Alarm Setpoint and Deadband in non-latching operation. With the High setpoint at 100 K and the deadband at 5 K, the high alarm triggers when sensor input temperature increases to 100 K, and it will not deactivate until the temperature drops to 95 K. In addition, the same 5 K deadband is applied to the low alarm setpoint as well.

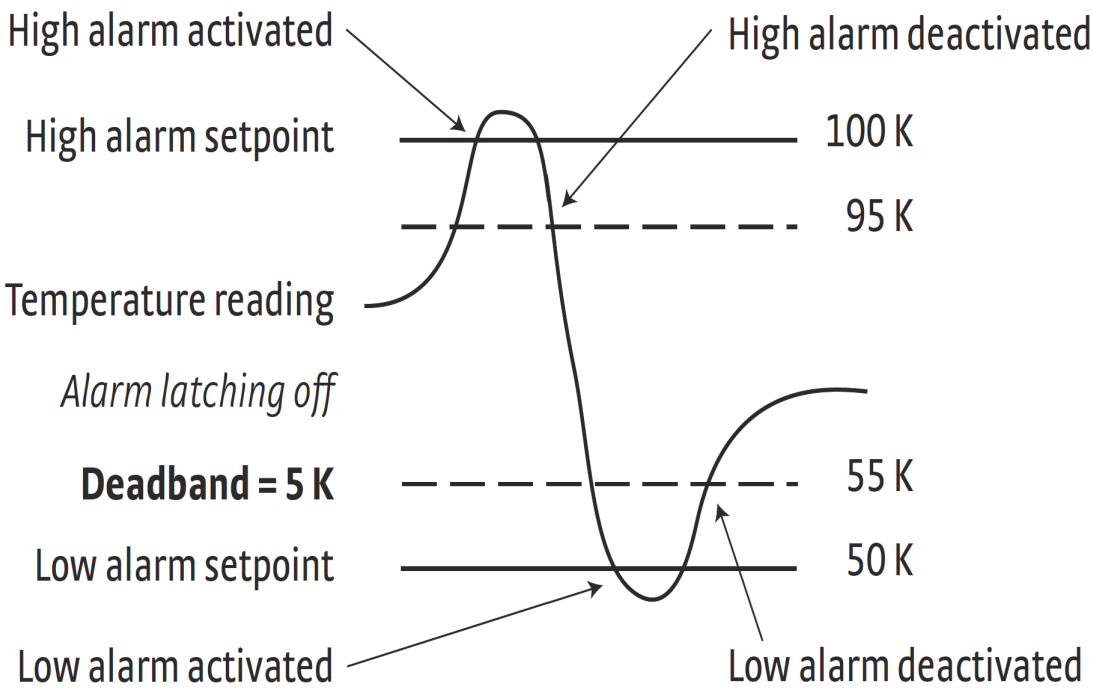


Figure 4.15: Alarm deadband example

4.8 Relays

There are two relays on the Model 346 numbered 1 and 2. They are commonly paired with input alarms, but can be paired with many other features that allow for system process control.

Interface Command: **RELAY**

Note: The relays are rated for 30 VDC and 2 A.

While it is recommended to use ColdSync™, Relays can be set up from the front panel by tapping **Settings** on the Navigation panel, then tapping the **Relays** button.

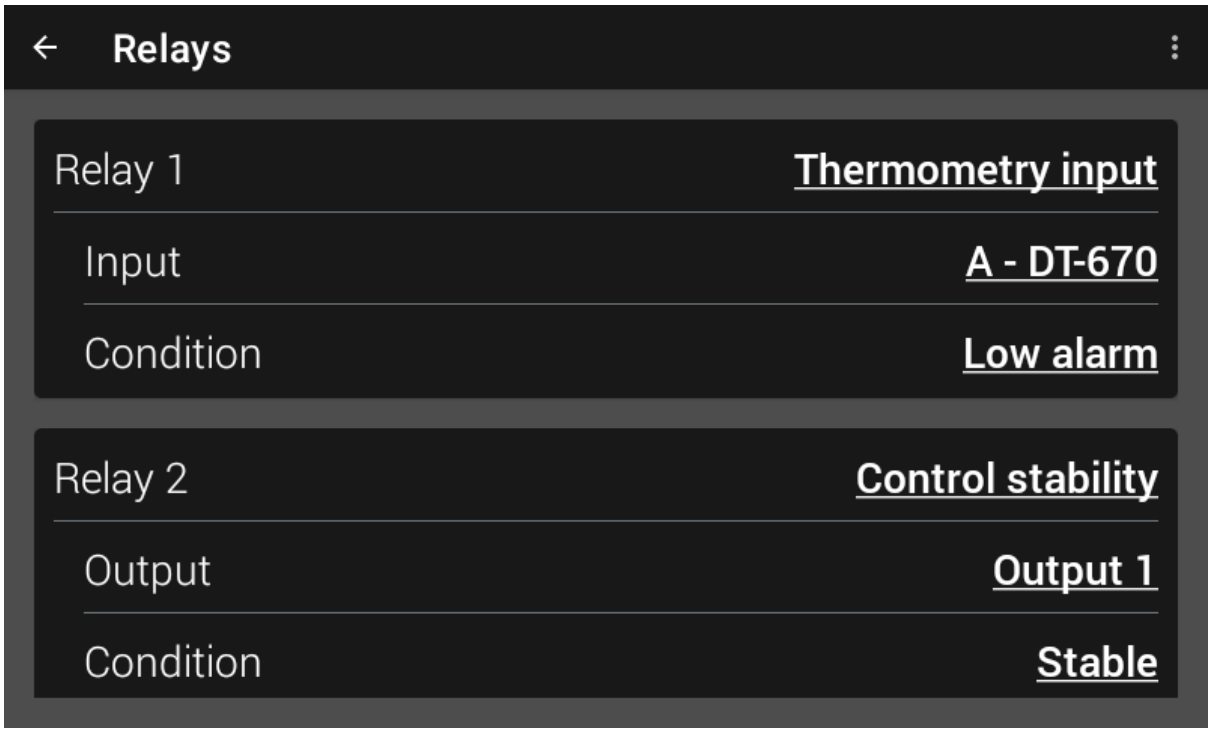


Figure 4.16: Relay settings screen

For each Relay, a Feature can be selected. The available Features are:

- **Off**
- **On**
- **Thermometry input**
- **Control stability**
- **Digital input**
- **System**

The following sections describe each of the available Relay features.

4.8.1 Off / on

When the **Off** feature is selected, the relay is un-energized, causing the normally open (NO) contacts to open and the normally closed (NC) contacts to close. When the **On** feature is selected, the relay is energized, so the NO contacts will close and the NC contacts will open.

4.8.2 Thermometry input

When set to the Thermometry input feature, the relay will activate based on the state of the configured Input sensor. The following sections describe the selectable Conditions available once the **Thermometry input** feature has been selected.

Alarm

The first four available Conditions available are alarm related. When using relays with alarm operation, before selecting the desired Input, set up alarms first.

Select from the following available alarm Conditions:

- **Low alarm:** The relay energizes if the Input alarm goes into a low alarm state
- **High alarm:** The relay energizes if the Input alarm goes into a high alarm state
- **Either alarm:** The relay energizes if the Input alarm goes into either a low alarm or a high alarm state.
- **Both alarms:** The relay energizes if the Input alarm goes into both a low and high alarm state. This can be achieved by setting the High setpoint with a lower temperature value than the Low setpoint. This allows the relay to energize when a temperature is inside a defined span.

Thresholds

The Threshold feature allows monitoring of up to four independent temperature thresholds per input. When the input reading crosses a threshold based on the configured comparison operator, either greater than or less than, the relay energizes. The Model 346 has 4 settable thresholds per input. Only one is selectable at a time for relay operation.

If a curve is assigned to the input, the threshold value is interpreted in Temperature units. If no curve is assigned, the value is in sensor units.

Thresholds are useful for monitoring temperature points without requiring alarm functionality, and can be used for process control or data logging triggers.

Select from the following available Threshold-related Conditions:

- **Threshold 1**
- **Threshold 2**
- **Threshold 3**
- **Threshold 4**

Note: Thresholds are only configurable over the remote interface using the **THRESHOLD** command.

Questionable readings

The following Conditions are available to energize the relay should the input reading become questionable.

- **Sensor fault:** The relay will energize if the Input sensor reading goes over / under full scale sensor units (S. OVER / S. UNDER)
- **Temperature fault:** The relay will energize if the Input reading goes over / under the ends of the curve (T. OVER / T. UNDER)
- **Extrapolated:** The relay will energize if the Input readings is in an extrapolated region of the curve.

4.8.3 Control stability

When set to the Control stability feature, the relay will activate based on the state of the configured output / control loop.

Once the **Control stability** feature is selected, and the associated **Output** is selected, the following Conditions are available to choose from:

- **Load fault:** The output has shut off due to detecting either an open or short load.
- **Ramp done:** Setpoint ramping is enabled, and the setpoint ramp has reached its destination and the ramp is complete.
- **Stabilizing:** The Control stability feature is enabled and the stability status is currently Stabilizing.
- **Stable:** The Control stability feature is enabled and the stability status is currently Stable.
- **Warm:** The warm-up mode has completed and the individual output is in a warm state.

4.8.4 Digital Inputs

The Model 346 has two digital inputs. Relays can be configured to energize based on the state of a digital input.

Once the **Digital input** feature is selected, select the associated **Digital input** and then the desired Condition:

- **Low:** The relay will energize when the digital input is logic low.
- **High:** The relay will energize when the digital input is logic high.

4.8.5 System

The System feature allows the relay to energize based on the state of the system. The following Conditions are available for selection:

- **All warm:** The relay will energize when the warm-up mode has completed and all outputs associated with warm-up have reached the warm state.

4.9 System Settings

The settings screen contains various settings and information that aren't specific to temperature inputs or outputs. Settings located here include, but are not limited to, Relays, Connectivity, Updates, and Reset. To navigate here, tap the **Settings** button located on the Navigation panel. The following screen will appear.

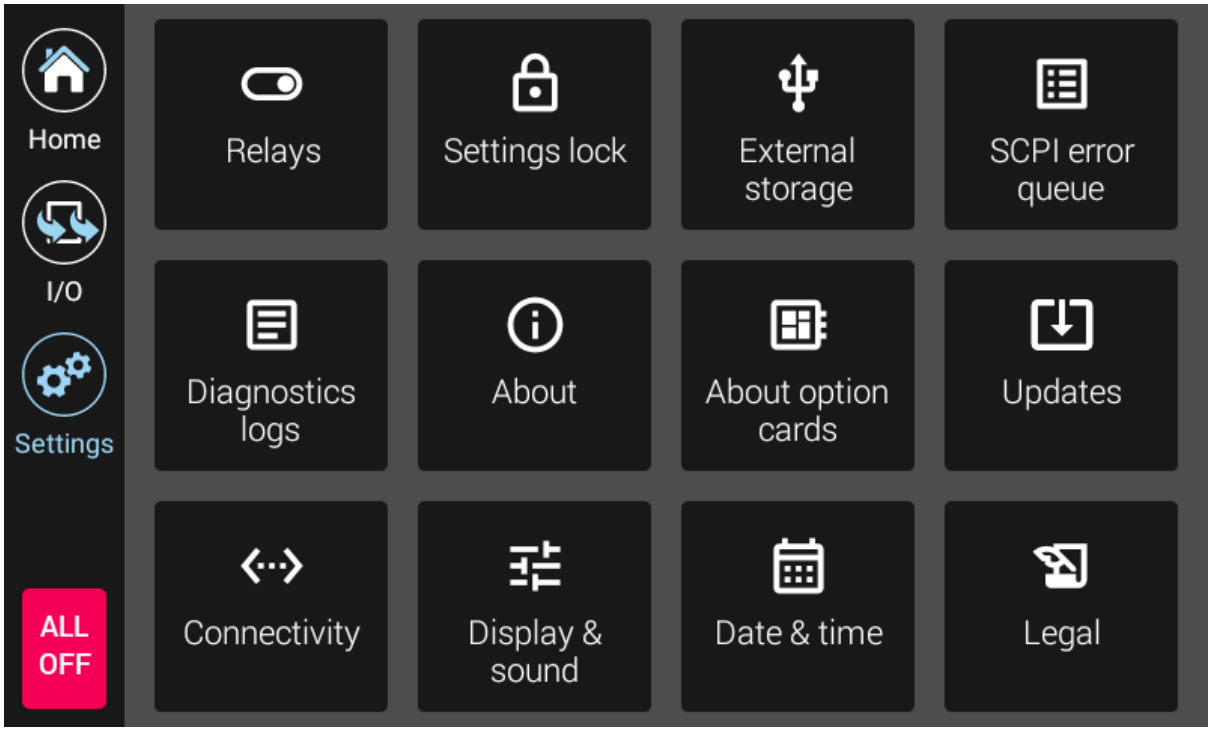


Figure 4.17: Model 346 Settings screen

Note:

- Firmware updates are discussed in the Service section.
- Settings lock is discussed in the Operation section.
- Relays are discussed in this Advanced operation section.

4.9.1 About

The About screen provides manufacturing information about the Model 346.

Field	Description
Model number	This field will always display 346.
Product name	This field will always display 346 Cryogenic Temperature Controller.
Serial number	The unique identifier for this specific 346, assigned during manufacturing.
Firmware version	The semantic version number assigned to the Lake Shore Firmware (LSFW) package presently running.
Calibration date	The date and time the 346 was last calibrated successfully at Lake Shore.
Calibration temperature	The ambient temperature the 346 was calibrated in at Lake Shore. This temperature is relevant when consuming the 1 year accuracy specifications for the 346.

4.9.2 About option cards

This screen displays information about the input option cards installed in slots E to H. If no card is installed, None will be displayed. If a card is installed, the cards Serial number, Calibration state, and Calibration date will be displayed.

4.9.3 Connectivity

The following fields are displayed on the Connectivity tab. More information about setting up Ethernet can be found in the remote operation section.

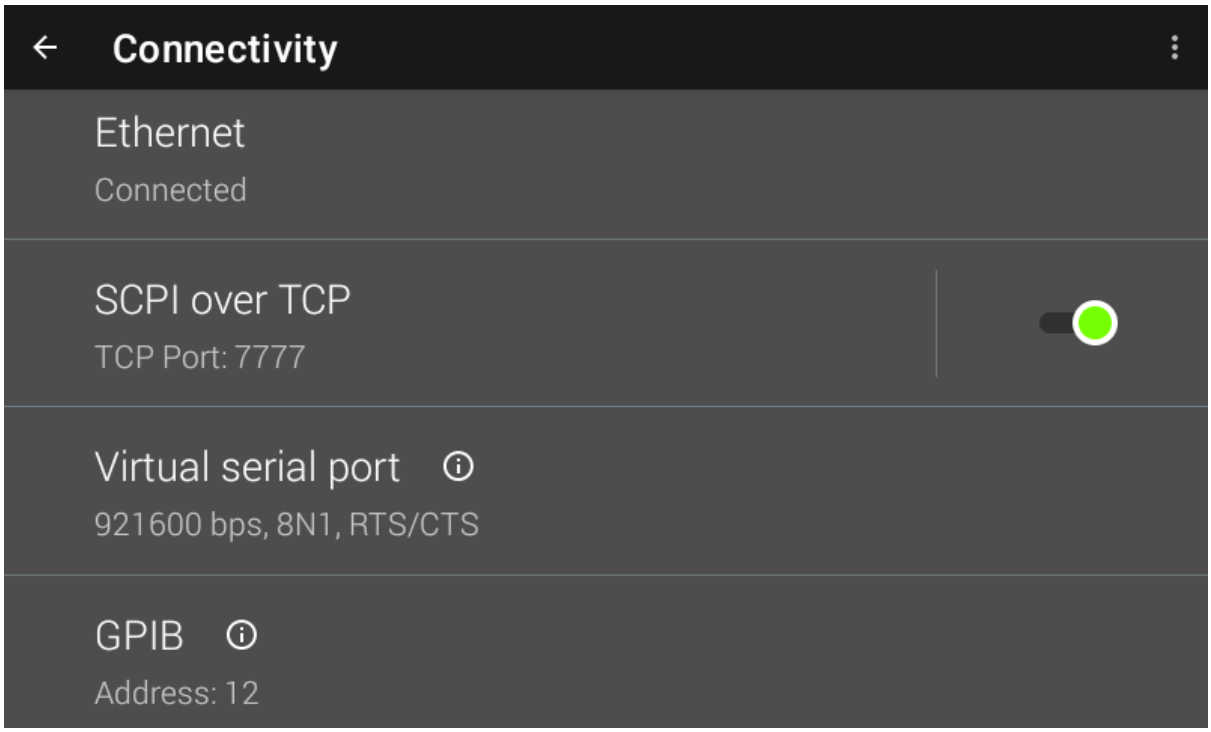


Figure 4.18: Connectivity screen

Field	Description
Ethernet	Touch the Ethernet box to see IP settings.
SCPI over TCP	Determines whether the 346 will respond to SCPI commands from the Ethernet connection. Must be enabled to communicate over Ethernet. When disabled, the 346 will not accept connection requests from clients.
Virtual serial port	Reports the non-settable configuration of the serial port. See the Remote Operation section for more information.
GPIB	Allows setting the GPIB address if the GPIB option card is installed.

4.9.4 Display & sound

The front panel display brightness can be adjusted for optimal viewing. The default value should work well in most standard room temperature environments, but deviations in room temperature and extreme viewing angles can cause the display brightness to require adjustment for optimal viewing.

As with many touchscreen LED backlit displays, keeping the brightness to a minimum will help to maximize the life of the display. The half-life of the display is rated with a typical value of 30,000 hours. In addition, to help further maximize the life of the display, the Model 346 source implements an auto dimming function when the display has not been touched for a prolonged period of time.

The Model 346 will produce sounds on various presses of the screen as a means to provide feedback to the user that a key press has occurred. The volume setting can be set to 100%, 75%, 50%, 25%, or off.

Alarms have their own volume control. The Alarm volume setting can be set to 100%, 75%, 50%, 25% or Quietest.

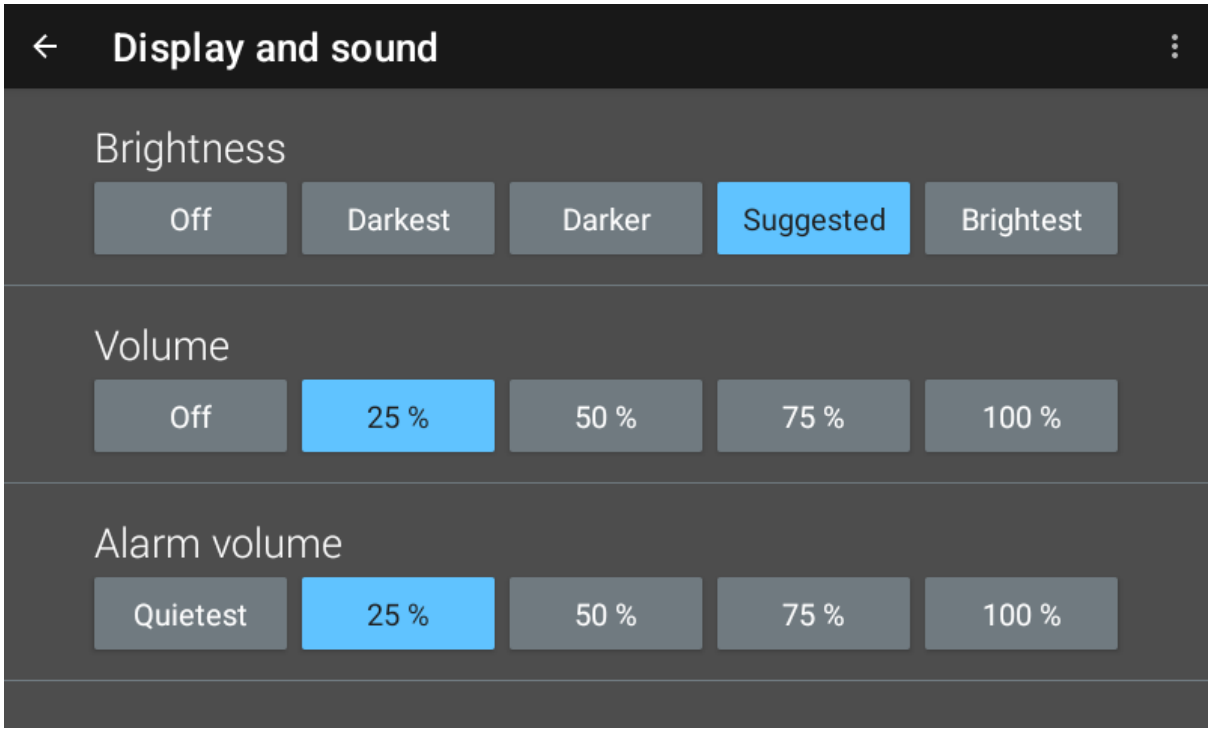


Figure 4.19: Display & sound screen

4.9.5 Legal

This screen is available for the user to see the various open source software used.

4.9.6 Date & time

The Model 346 contains a real-time clock, allowing the current date, time, and time zone to be stored. The time, date and time zone can be set and viewed via the front panel or over the remote interface.

In addition, the Model 346 has a feature to automatically set its date and time with a network connection.

Interface Commands:

SYSTem:DATE

SYSTem:AUTODATETIME

SYSTem:TIME

SYSTem:TZONE

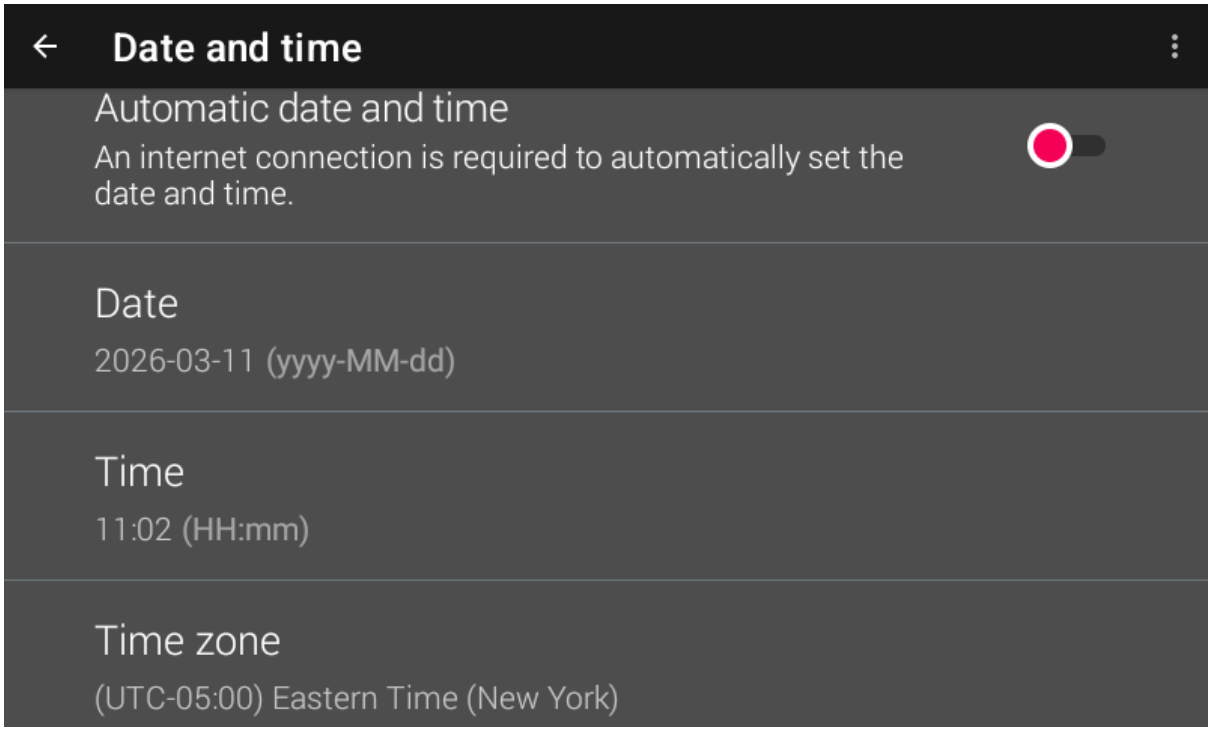


Figure 4.20: Date & time screen

4.9.7 Reset

The Model 346 has two types of settings: instrumentation and system. Instrumentation settings includes settings that are unique to the instrument, such as sensor type, output mode, PID, and ramp rate. System settings are settings common to most instruments, such as volume, brightness and TCP/IP settings. Both types of settings are stored in nonvolatile memory and can be reset to defaults.

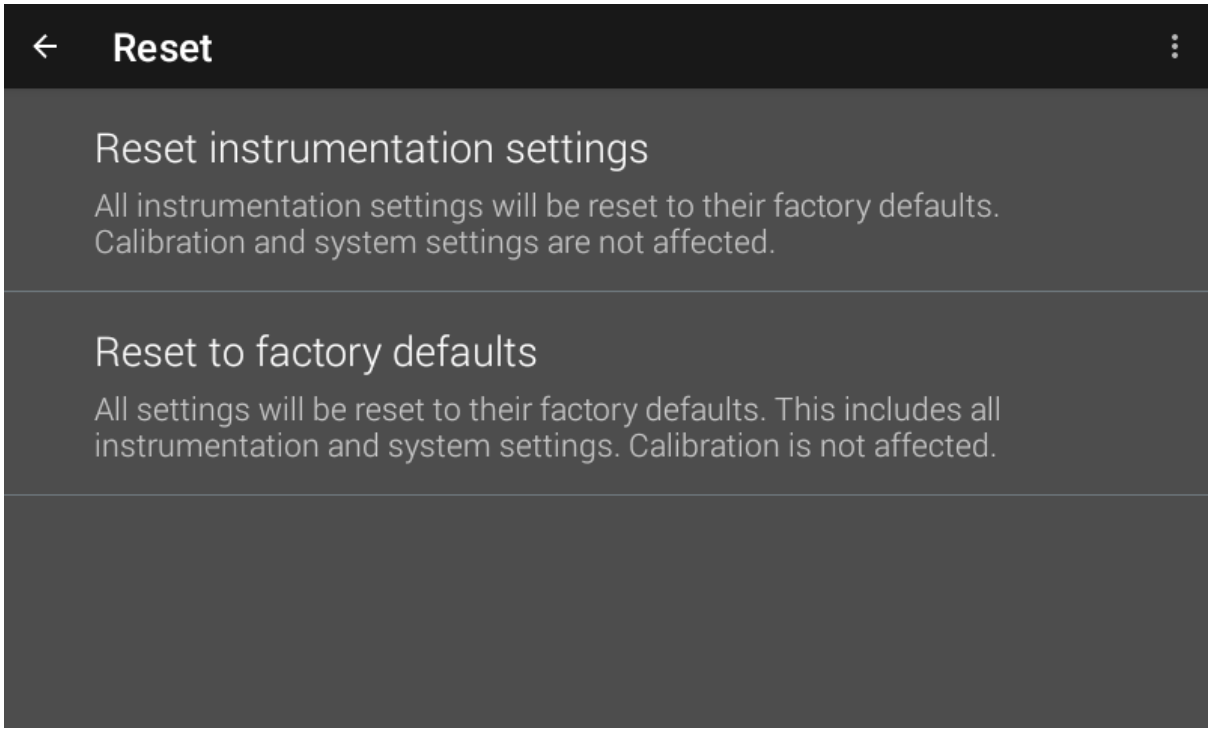


Figure 4.21: Reset screen

Reset instrumentation settings

Instrumentation settings are stored in non-volatile memory. Tap **Reset instrumentation settings** to reset the Model 346 to the following default settings:

Table 4.3: Input Setup—General Default Values

Input Setup—General	Default
Sensor type	Diode
Filter	Off
Input name	Input A (B, C, D)
Temperature limit	0 K (Off)
Input units	Kelvin
Curve	None

Table 4.4: Input Setup—Diode Default Values

Input Setup—Diode	Default
Range	2.5 V (Silicon)
Diode current	10 µA

Table 4.5: Input Setup—Platinum/NTC RTD Default Values

Input Setup—Platinum/NTC RTD	Default
Autorange	On
Current reversal	On

Table 4.6: Output Setup Default Values

Output Setup	Default
Output mode	Off
Control input	Input A for Output 1; Input B for Output 2; C1 for Output 3; D1 for Output 4; None for Outputs 5 to 8
Heater resistance	25 Ω
Power up enable	Off
Output units	Power (W)
Max output	100 W

Table 4.7: Alarm Default Values

Alarm	Default
Alarm	Off

Table 4.8: Relay Default Values

Relay	Default
Relay	Off

Table 4.9: PID/Manual Heater Power (MHP) Output Default Values

PID/Manual Heater Power (MHP) Output	Default
Proportional (P)	50.0
Integral (I)	20.0
Derivative (D)	0.0
Manual Output	0.000%

Table 4.10: Heater Default Values

Heater	Default
Heater range	Off
Autorange	On

Table 4.11: Setpoint Default Values

Setpoint	Default
Setpoint value	0.000 K

Table 4.12: Zone Settings—All Zones Default Values

Zone Settings—All Zones	Default
Upper boundary	0.000 K
Proportional (P)	50.0
Integral (I)	20.0
Derivative (D)	0.00
Manual output	0.000%
Range	Off
Ramp rate	0.000 K/min
Control input	Default
Output limit	100.000%

Reset to factory defaults

If necessary, the Model 346 instrument settings can be restored to factory defaults. System settings are stored in non-volatile memory. A factory default reset will reset both instrumentation settings and system settings. As with the reset instrumentation settings function, a factory default will not affect calibration. In addition, user curves will not be cleared.

When a factory reset in initiated, diagnostic logs and user added firmware repositories are cleared (the default firmware.lakeshore.com/production remains). In addition, the following system settings are reset back to their default state:

Table 4.13: Connectivity—General Default Values

Connectivity—general	Default
SCPI over TCP	Disabled
TCP socket port number	7777

Table 4.14: Connectivity—Ethernet Default Values

Connectivity—Ethernet	Default
IP Configuration	DHCP
Static IP	192.168.0.12
Static Gateway	192.168.0.255
Static Subnet mask	255.255.255.0
DNS 1	8.8.8.8
DNS 2	8.8.4.4

Table 4.15: Connectivity—GPIB Default Values

Connectivity—GPIB	Default
Address	12

Table 4.16: Display and Sound Default Values

Display and sound	Default
Brightness	Suggested
Volume	50
Alarm volume	50

Table 4.17: Date and Time Default Values

Date and time	Default
Automatic date and time	Disabled
Time zone	GMT

CHAPTER

FIVE

REMOTE INTERFACE OPERATION

This chapter provides operational instructions for the remote interface for the Model 346 temperature controller. The Model 346 supports the following remote interfaces for direct user control:

- USB
- Ethernet
- GPIB (optional)

Once connected via any of these interfaces, the Model 346 can be remotely operated in any of the following ways:

- **ColdSync**: A highly functional Windows-based software tool provided by Lake Shore for directly controlling the instrument.
- **Python**: Using the Lake Shore Python driver
- **LabVIEW**: LabVIEW driver
- **Other**: Directly sending *commands* (page 117) from your application

The Model 346 is the successor to the Lake Shore Model 336 temperature controller. As such, a similar IEEE 488.2 message string-based command set (non-SCPI subystem) implementation is employed in the Model 346. However, there are a few SCPI compliant commands added, specifically in the SYSTem subsystem, as it relates to error queues and OPERation and QUEStionable stats.

A message string is a group of characters assembled to perform an interface function. There are three types of message strings: commands, queries, and responses. The computer issues command and query strings through user programs, and the instrument issues responses. Two or more command strings or queries can be chained together in one communication, but they must be separated by a semicolon (;). The total communication string, including termination characters, must not exceed 1024 characters in length.

All data in each command message is encoded in the American Standard Code for Information Interchange (ASCII) format. A special ASCII character, the line feed (hex 0A,

decimal 10), is required by the instrument to know where the message ends. The instrument also allows an optional carriage return (hex 0D, decimal 13) to precede the line feed, if the client software desires to send it. For return strings back to the client software, the instrument always appends both a carriage return followed by a line feed for termination.

5.1 Message Flow Control

It is important to remember that the user program is in charge of instrument communication at all times, independent of the communications bus used to control the instrument. The instrument cannot initiate communication, determine which device should be transmitting at a given time, or guarantee timing between messages. All of this is the responsibility of the user program.

Most commands sent to the Model 346 execute within 100 ms of the last character being transmitted. However, the Model 346 command protocol does **not** return an acknowledge message when a given command is finished executing. Because of this, a user program could potentially flood and overload the command buffer.

It is highly recommended to append the operation complete query (*OPC?) to the end of any given command string. The operation complete query is a mandated IEEE 488.2 query that will cause the instrument to send a "1" back to the user program when all commands have been processed. This scheme closes the timing loop and provides the proper balance for a user program to maximize command throughput yet not risk overrunning the instrument command buffer. *OPC? can be appended onto a single command or a chained message.

5.2 USB Interface

The USB interface provides a convenient way to connect to most modern computers. The USB interface is implemented as a virtual serial com port connection. This implementation provides a simple migration path for modifying existing RS-232 based remote interface software. It also provides a simpler means of communicating than a standard USB implementation.

5.2.1 Physical Connection

The Model 346 has a B-type USB connector on the rear panel. This is the standard connector used on USB peripheral devices, and it allows the common USB A-type to B-type cable to be used to connect the Model 346 to a host PC. The maximum length of a USB cable, as defined by the USB 2.0 standard, is 5 m (16.4 ft). This length can be extended using USB hubs every 5 m (16.4 ft) up to five times, for a maximum total length of 30 m (98.4 ft).

Note: The Model 346 also has a USB-C connector located on the front panel for firmware updates. Only the USB-B connection can be used for remote commands.

5.2.2 Hardware Support

The USB interface emulates an RS-232 serial port at a fixed 921,600 baud rate, but with the physical connections of a USB. This programming interface requires a certain configuration to communicate properly with the Model 346. The proper configuration parameters are listed in the table below.

Baud rate	921600
Data bits	8
Parity	None
Stop bits	1
Flow control	None
Command terminator	LF (CR ignored)
Query response terminator	CR LF

The USB hardware connection uses the full speed (12,000,000 bit/s) profile of the USB 2.0 standard; however, since the interface uses a virtual serial com port at a fixed data rate, the data throughput is still limited to a baud rate of 921,600 bit/s.

5.2.3 Driver Installation

Installing the driver from Windows® Update

The USB driver is available through Windows® Update. This is the recommended method for installing the driver, as it will ensure that you always have the latest version of the driver installed.

1. Connect the USB cable from the Model 346 to the computer.
2. Turn on the Model 346.
3. When the Found New Hardware wizard appears, select **Locate and install driver software (recommended)**.
4. The Found New Hardware wizard should automatically connect to Windows® Update and install the drivers.
5. When the Found New Hardware wizard finishes installing the driver, a confirmation message stating "the software for this device has been successfully installed" will appear. Click **Close to complete the installation**.

Installing the Driver from the Web

If you are unable to install the driver from Windows® Update, refer to the instructions below to install the driver from the web. These procedures assume that you are logged into a user account that has administrator privileges.

The USB driver is available on the Lake Shore website. To install the driver, it must be downloaded from the website and extracted. Use the procedures below to download, extract, and install the driver using Windows®.

Download the driver

1. Locate the USB driver from https://www.lakeshore.com/resources/software/drivers.
2. Right-click on the USB driver download link, and select **Save as**.
3. Save the driver to a convenient place, and take note where the driver was downloaded.

Extract the driver

The downloaded driver is in a ZIP compressed archive. The driver must be extracted from this file. Windows® provides built-in support for ZIP archives. If this support is disabled, a third-party application, such as WinZip™ or 7-Zip, must be used.

1. Right-click on the file and click **extract all**.

2. An Extract Compressed (Zipped) Folders dialog box will appear. It is recommended the default folder is not changed. Take note of this folder location.
3. Click to clear the **Show extracted files when complete** checkbox, and click Extract.

Manually install the driver

The following section describes how to manually install the driver using Windows®. To install the driver, you must be logged in to a user account that has administrator privileges.

1. Connect the USB cable from the Model 346 to the computer.
2. Turn on the Model 346.
3. If the Found New Hardware wizard appears, click **Ask me again later**.
4. Open Device Manager. Use this procedure to open Device Manager.
    a. Click the Windows® **Start** button and type Device Manager in the **Start Search** box.
    b. Click on the Device Manager link in the Search Results Under Programs dialog box.
    c. If User Account Control is enabled click **Continue** on the User Account Control prompt.
5. Click **View** and ensure the **Devices by Type** check box is selected.
6. In the main window of Device Manager, locate **Other Devices** in the list of device types. In many instances this will be between Network adapters and Ports (COM & LPT). If the Other Devices item is not already expanded, click the + icon. Model 346 should appear indented underneath Other Devices. If it is not displayed as Model 346, it might be displayed as USB Device. If neither are displayed, click Action and then Scan for hardware changes, which may open the Found New Hardware wizard automatically. If the Found New Hardware wizard opens, click Cancel.
7. Right-click Model 346 and click **Update Driver Software**.
8. Click **Browse my computer for driver software**.
9. Click **Browse** and select the location of the extracted driver.
10. Ensure the **Include subfolders** checkbox is selected and click **Next**.
11. When the driver finishes installing, a confirmation message stating "Windows has successfully updated your driver software" should appear. Click **Close** to complete the installation.

5.3 Ethernet Interface

The Ethernet interface provides a means of connecting the Model 346 to an Ethernet-based computer network. These networks provide the ability to communicate across large distances, often using existing equipment (the internet, pre-existing local networks). The Ethernet interface of the Model 346 provides the following capabilities:

- Send remote interface commands via TCP socket
- Firmware updates

5.3.1 Network Configuration

Configuration and status for these network configurations can be found from the front panel by tapping the **Settings** button located on the Navigation panel, tapping the **Connectivity** card.

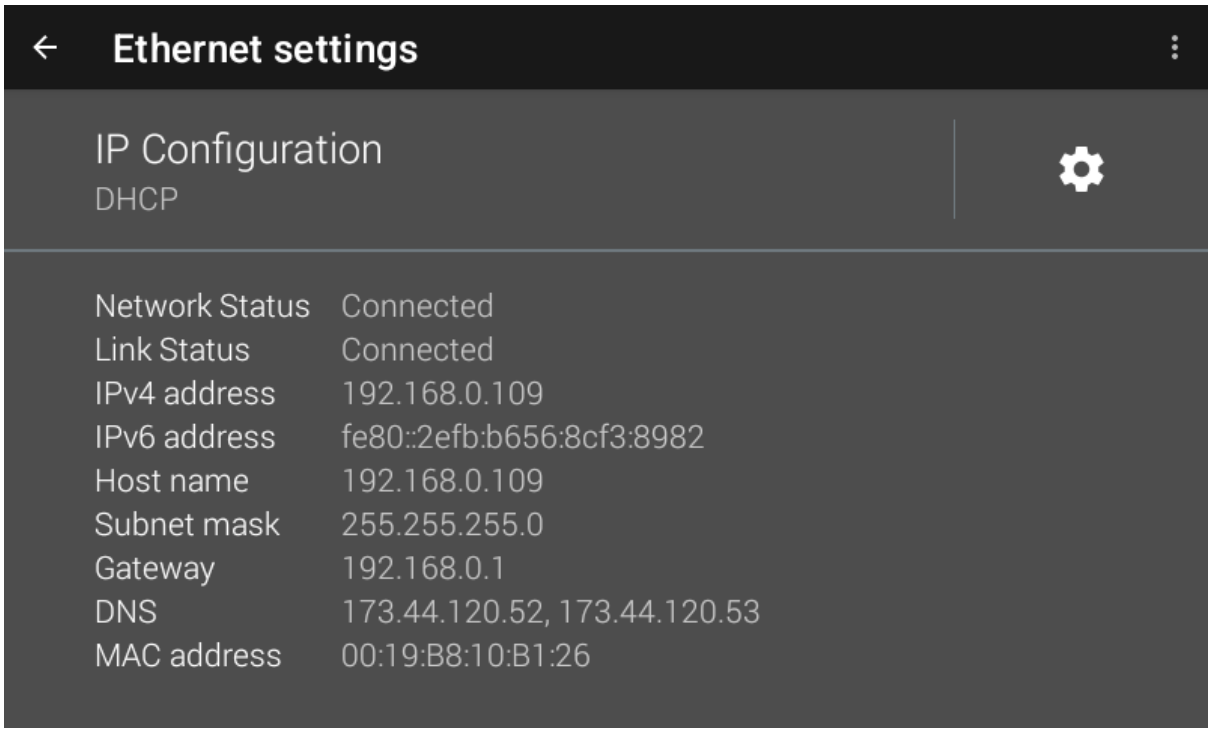


Figure 5.1: Ethernet settings

Network address parameters include the IP address, the subnet mask, gateway address, and DNS address.

- *IP address:* an IP address is required for a device to communicate using TCP/IP, which is the protocol generally used for Ethernet devices and the Model 346. The Model 346 supports both IPv4 and IPv6.

An IP address is a 32-bit (IPv4) or 128-bit (IPv6) logical address used to differentiate devices on a network. It is most often given in dotted decimal notation, such as nnn.nnn.nnn.nnn (IPv4) or nnnn:nnnn:nnnn:nnnn:nnnn:nnnn:nnnn:nnnn (IPv6). The Model 346 supports a dual stack TCP/IP architecture, meaning it can be assigned both IPv6 and IPv4 addresses at the same time. IPv6 addresses are automatically configured.

- *IPv6 Link Local and DHCP:* IPv6 will always have a link local address assigned, and additionally can have an assigned DHCP address. IPv6 link local is derived from its globally unique MAC address and is automatically assigned on power up. This differs from IPv4, where a link local address is only assigned after a node fails to get an address via DHCP. The IPv6 DHCP address is automatically configured when the Model 336 is connected to an IPv6 compatible router or network, similar to IPv4 DHCP.
- *Subnet mask (IPv4):* a sub network, or subnet, is a group of devices within a network that have a common, designated IP address routing prefix. A subnet mask is a 32-bit "bit mask" that signifies which part of the IP address represents the subnet routing prefix, and which part represents the device's address on the subnet. A subnet mask is most often given in dotted decimal notation, such as nnn.nnn.nnn.nnn where nnn is a decimal number from 0 to 255. When converted to a binary notation, the 32-bit subnet mask should consist of a contiguous group of ones, followed by a contiguous group of zeros. The ones represent which bits in the IP address refer to the subnet, and the zeros represent which bits refer to the device address. For example, the default static IP address of the Model 346 is 192.168.0.128, and the default static subnet mask is 255.255.255.0. Converting this subnet mask to binary shows that the first 24 bits are ones, and the last 8 bits are zeros. This means that the first 24 bits of the static IP address (192.168.0) represent the subnet, and the last 8 bits (12) represent the device.
- *Gateway address (IPv4):* a gateway is a network traffic routing device that is used to route communication between networks. If a gateway is not used, then devices on a network can only communicate with other devices on that same network. A gateway address is the IP address of the gateway on a network. Contact the network administrator for the gateway address for your network.
- *DNS address:* a domain name system (DNS) is a service that translates names into IP addresses. This service allows for using human readable names for devices on a network. As an example, when a web browser attempts to retrieve the web page at www.lakeshore.com, the browser first performs a forward-lookup on the assigned DNS server to attempt to retrieve the IP address that is represented by the name www.lakeshore.com. If successful, the web browser then uses the retrieved IP address to communicate with the web server that hosts the website at www.lakeshore.com.

5.3.2 Network Address Configuration Methods

The network address parameters of the Model 346 can be configured using one of two methods: DHCP or static IP. DHCP is an automatic configuration method while static IP requires manual configuration. If supported by the server, DHCP can also be used to automatically configure DNS server addresses, as well as IP address parameters.

Dynamic host configuration protocol (DHCP): DHCP is a method of automatically configuring the IP address, subnet mask, and gateway of Ethernet devices on a network. This method provides simple automatic configuration for users connecting to a network that provides a DHCP server. The network DHCP server will provide an IP address, subnet mask, and gateway address. Depending on the DHCP server configuration, it may also provide primary DNS and secondary DNS addresses as well. DHCP is the simplest method of IP configuration. DHCP does have the disadvantage of not necessarily preserving the IP address through a device reconfiguration, as well as the possibility of being automatically reconfigured when the DHCP "lease" expires. Contact your network administrator to find out the DHCP lease policy on your network.

Static IP: static IP is a method of manually configuring the IP address, subnet mask, and gateway of network enabled devices. When using the static IP method, the IP address, subnet mask, and gateway must be configured appropriately for the connected network, or for the connected PC, in order to establish connection to the network. A major advantage to the static IP method is that the IP address will not change during device reconfiguration (power cycle). Disadvantages of using the static IP method include the requirement of knowing how your network is configured in order to choose the correct configuration parameters.

5.3.3 TCP Socket Communication

A TCP socket connection interface is provided as the communication medium for the network interface of the Model 346. A TCP socket connection, or simply "socket connection," is a common connection protocol used by Ethernet devices. The transmission control protocol (TCP) is commonly used for creating a communication channel between one program on one computer and one program on another computer; for example, a web browser on a PC and a web server on the Internet. In the case of the Model 346, the protocol is used to create a communication channel between one program on one computer and the command line interface of the Model 346. TCP uses error correction and collision avoidance schemes that make it a very reliable form of network communication, but has drawbacks of having nondeterministic timing and can encounter relatively large delays, depending on network conditions. These delays can be on the order of seconds. Sockets use port numbers to identify sending and receiving endpoints on network devices. This allows for multiple separate communication links to exist on each device.

Note: The port number used for TCP socket connections on the Model 346 is 7777 by default. The port number can be configured from the Connectivity screen in System settings (top left corner of the screen).

Note: A maximum of five simultaneous socket connections can be made to the Model 346. Any attempts to open a new socket while five socket connections are already open on a Model 346 will fail.

5.3.4 SCPI over TCP

There may be scenarios where the user desires to have the Model 346 connected to the internet but does not want anyone to be able to connect to the Model 346 and start controlling it. The SCPI over TCP setting allows for this. If the setting is disabled then network connections are still allowed, allowing firmware or autodate time to still function. For example, remote control of the Model 346 will not be allowed even if another user knows the IP address and socket of the Model 346.

In order to issue SCPI commands over TCP and remotely control the instrument, this setting needs to be enabled. This can be done by touching the switch, as shown below.

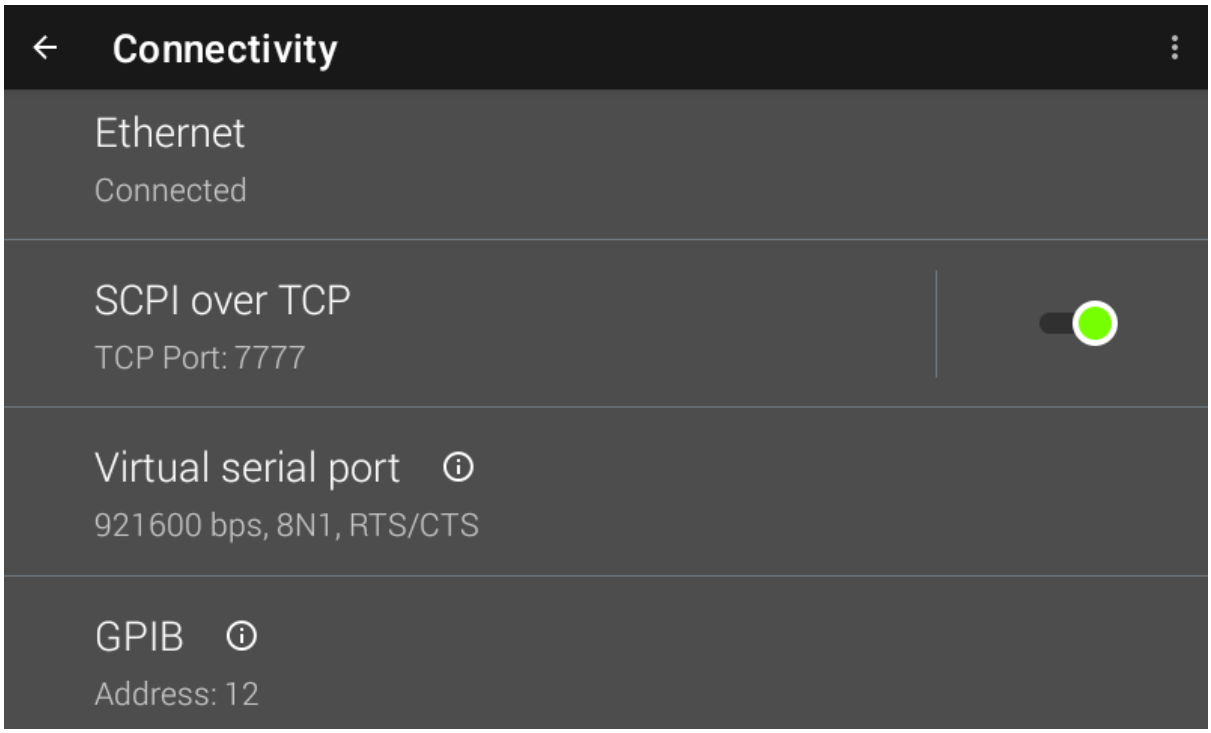


Figure 5.2: SCPI over TCP

5.4 GPIB Interface

The Model 346 provides an optional GPIB interface for controlling the instrument from a computer via a GPIB controller.

5.4.1 Setting the Address

All GPIB devices must be assigned a fixed address that is unique within the bus. The default address of the Model 346 is 12.

To view or edit the GPIB address of the Model 346, tap the **Settings** button, then tap **Connectivity**. Touch **GPIB** to configure the address.

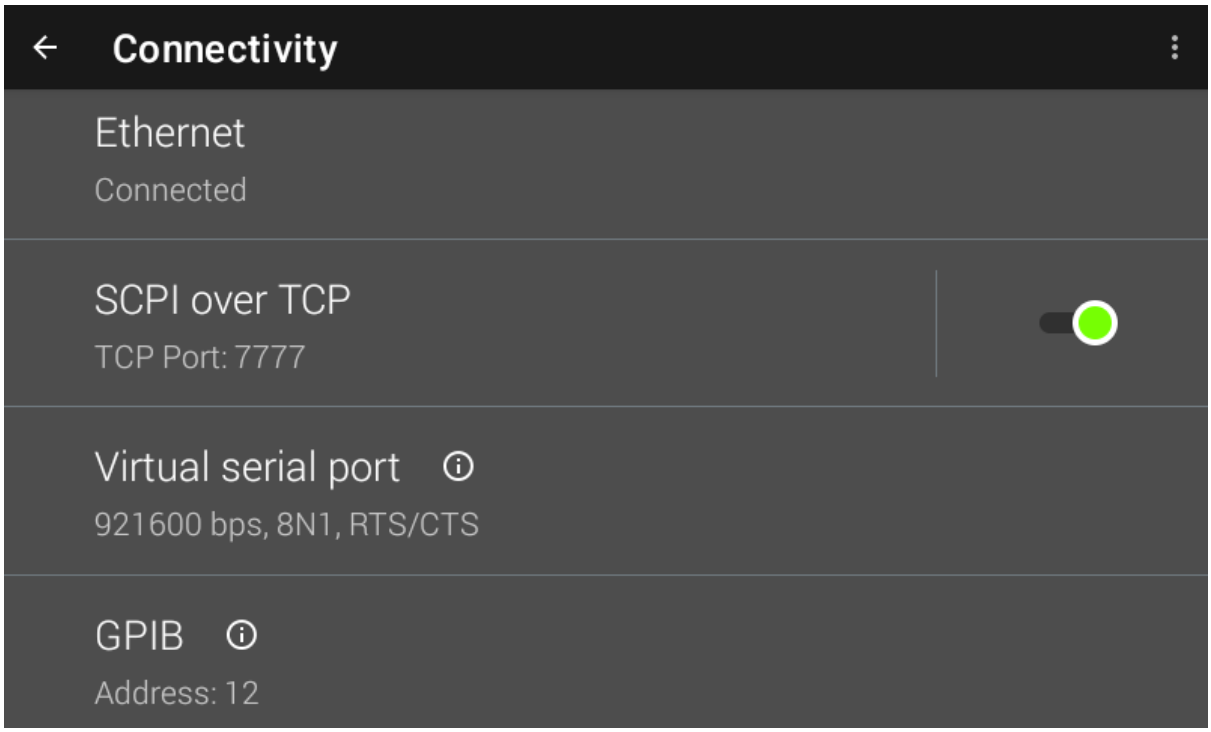


Figure 5.3: GPIB settings

5.5 Model 346 Command Summary

This section provides a summary of the commands and queries available for the Model 346. The commands are organized into the following categories:

Below is the key to explain the syntax used for each command/query description

Symbol	Description
*	Begins common interface command
?	Required to identify queries
s[n]	String of alphanumeric characters with length n. Send these string using surrounding quotes. Quotes enable characters such as commas and spaces to be used without the instrument interpreting them as delimiters.
[term]	Terminator characters
<...>	Indicates a command specific parameter field.
(+)nn...	numeric string that can include a decimal point
a	Indicates an alphanumeric designator

5.5.1 Input Related Commands & Queries

The Model 346 supports a variety of temperature input configurations across the ten built in inputs, plus additional option card inputs. The two dedicated inputs, A and B, have a 10 Hz update rate, while the remaining inputs C1 to D4, can have a variable update rate, ranging from 10 Hz with only one input per card enabled, to 2.5 Hz with all four inputs enabled. This update rate variance is mirrored for any additional installed scanner option cards.

SRDG? Sensor input Reading Query

```
SRDG? <input>[term]
```

Parameters

Name	Type	Description
input	a	Specifies input to query: A, B, C1, C2, C3, C4, D1, D2, D3, D4, E1, E2, E3, E4, F1, F2, F3, F4, G1, G2, G3, G4, H1, H2, H3, H4, ALL

Returns

```
<sensor reading>[term]
```

Remarks

If the mnemonic ALL is provided for the <input> term the Model 346 will return readings for all the active temperature inputs. While a value will always be returned by this query if the input is present, the reading integrity may vary based on the input state and should be queried using RDGST?.

KRDG? Kelvin Reading Query

```
KRDG? <input>[term]
```

Parameters

Name	Type	Description
input	a	Specifies input to query: A, B, C1, C2, C3, C4, D1, D2, D3, D4, E1, E2, E3, E4, F1, F2, F3, F4, G1, G2, G3, G4, H1, H2, H3, H4, ALL

Returns

```
<temperature reading>[term]
```

Remarks

A valid curve must be loaded and assigned to the input in order for a valid temperature response to be generated, and if a curve is not assigned, absolute zero (0 K) will be returned. If the mnemonic ALL is provided for the <input> term, the Model 346 will return readings for all the active temperature inputs. While a value will always be returned by this query if the input is present, the reading integrity may vary based on the input state and should be queried using RDGST?.

CRDG? Celsius Reading Query

```
CRDG? <input>[term]
```

Parameters

Name	Type	Description
input	a	Specifies input to query: A, B, C1, C2, C3, C4, D1, D2, D3, D4, E1, E2, E3, E4, F1, F2, F3, F4, G1, G2, G3, G4, H1, H2, H3, H4, ALL

Returns

<temperature reading>[term]

Remarks

A valid curve must be loaded and assigned to the input in order for a valid temperature response to be generated, but if a curve is not assigned, absolute zero will be returned (-273.15). If the mnemonic ALL is provided for the <input> term, the Model 346 will return readings for all the active temperature inputs. While a value will always be returned by this query if the input is present, the reading integrity may vary based on the input state and should be queried using RDGST?.

INTYPE Temperature Input Type Command

INTYPE <input>, <sensor type>, <autorange>, <range>, <compensation>, <units>[term]

Parameters

Name	Type	Description
input	a	Specifies input to query: A, B, C1, C2, C3, C4, D1, D2, D3, D4, E1, E2, E3, E4, F1, F2, F3, F4, G1, G2, G3, G4, H1, H2, H3, H4
sensor type	n	Specifies input sensor type: 0 = Disabled 1 = Diode 2 = PTC RTD e.g., platinum or RhFe 3 = NTC RTD e.g., Cernox or Rox 4 = Thermocouple
autorange	n	Specifies autoranging: 0 = off 1 = on
range	n	Specifies input range when autorange is off
compensation	n	For resistive sensors, compensation refers to EMF compensation and is achieved through current reversal. For thermocouples, compensation refers to room temperature compensation. Always 0 if input is a diode. 0 = off 1 = on.
units	n	Specifies the temperature units when a curve is assigned to the input: 0 = Kelvin 1 = Celsius

range values are based on the sensor type:

Diode	0 = 2.5 V
PTC RTD	0 = 10 Ω
	1 = 100 Ω
	2 = 1 kΩ
NTC RTD	0 = 100 Ω
	1 = 300 Ω
	2 = 1 kΩ
	3 = 3 kΩ
	4 = 10 kΩ
	5 = 30 kΩ
	6 = 100 kΩ
Thermocouple	0 = 50 mV

Example

```
INTYPE A,2,1,0,1,0[term]
```

Sets Input A sensor type to PTC RTD, autorange on, compensation on, temperature units to kelvin.

Remarks

The <range> and <autorange> parameters do not apply to the thermocouple sensor type, and the <range>, <autorange> and <compensation> parameters do not apply to the diode sensor type. When configuring these sensors, the parameters must be included, and should be set to 0.

INTYPE? Temperature Input Type Query

```
INTYPE? <input>[term]
```

Parameters

Name	Type	Description
input	a	Specifies input to query: A, B, C1, C2, C3, C4, D1, D2, D3, D4, E1, E2, E3, E4, F1, F2, F3, F4, G1, G2, G3, G4, H1, H2, H3, H4

Returns

`<sensor type>,<autorange>,<range>,<compensation>,<units>[term]` (see command for description)

Remarks

If autorange is on, the returned range parameter is the present auto-selected range.

INNAME Thermometry Custom Input Name Command

```
INNAME <input>, <name>[term]
```

Parameters

Name	Type	Description
input	a	Specifies input to configure: A, B, C1, C2, C3, C4, D1, D2, D3, D4, E1, E2, E3, E4, F1, F2, F3, F4, G1, G2, G3, G4, H1, H2, H3, H4
name	s	Specifies the custom name for the input. Maximum length is 32 characters.

Example

```
INNAME A,"Sample Chamber"[term]
```

Sets Input A name to "Sample Chamber".

Remarks

Input names are used for identification purposes and can be retrieved using the INNAME? query. Names are limited to 32 characters and can include ASCII characters when sent over the remote interface. When configured from the front panel, names can include any unicode character, but will not query back correctly as unicode encoding over the remote interface is not supported.

INNAME? Thermometry Custom Input Name Query

```
INNAME? <input>[term]
```

Parameters

Name	Type	Description
input	a	Specifies input to query: A, B, C1, C2, C3, C4, D1, D2, D3, D4, E1, E2, E3, E4, F1, F2, F3, F4, G1, G2, G3, G4, H1, H2, H3, H4

Returns

<name>[term] (see command for description)

Remarks

If no custom name has been assigned to the input, a default blank string ("") will be returned.

TLIMIT Temperature Limit Command

TLIMIT <input>, <limit>[term]

Parameters

Name	Type	Description
input	a	Specifies input to query: A, B, C1, C2, C3, C4, D1, D2, D3, D4, E1, E2, E3, E4, F1, F2, F3, F4, G1, G2, G3, G4, H1, H2, H3, H4
limit	+n.nn	The temperature in Kelvin at which outputs will be shut off

Remarks

The Temperature Limit parameter provides a means of protecting your equipment from damage by shutting down all control outputs when the assigned temperature limit is exceeded on any sensor input. This limit is on an input by input basis, but does not require the input to be tied to any output to function. The limit will not be used if it is set to 0 K, or if the input is not configured with a valid curve.

Example

TLIMIT A, 100[term]

Set the temperature limit for input A to 100 K.

TLIMIT? Temperature Limit Query

`TLIMIT? <input>[term]`

Parameters

Name	Type	Description
input	a	Specifies input to query: A, B, C1, C2, C3, C4, D1, D2, D3, D4, E1, E2, E3, E4, F1, F2, F3, F4, G1, G2, G3, G4, H1, H2, H3, H4

Returns

`<limit>[term]` (see command for description)

FILTER Temperature Input Filter Command

`FILTER <input>, <enabled>, <points>, <window>[term]`

Parameters

Name	Type	Description
input	a	Specifies input to query: A, B, C1, C2, C3, C4, D1, D2, D3, D4, E1, E2, E3, E4, F1, F2, F3, F4, G1, G2, G3, G4, H1, H2, H3, H4
enabled	n	Enables or disables the filter 0 = Disabled 1 = Enabled
points	n	The number of points (2 to 64) to use in the filter
window	n	Specifies what percent of full scale reading limits the filtering function. Reading changes greater than this percentage reset the filter. Valid range = 1 to 10%.

Example

```
FILTER A,1,10,5[term]
```

Enables the filter on input A with 10 points and a window size of 5%. For example, If input A is a diode, the filter will reset if the reading is 125 mV or more from the filtered value.

Remarks

The reading filter applies exponential smoothing to the sensor input readings. If the filter is turned on for a sensor input, all reading values for that input are filtered. The filter is a running average, so it does not change the update rate of an input. The filtered reading is used for everything except closed loop control loop calculations, which use the unfiltered reading.

FILTER? Temperature Input Filter Query

```
FILTER? <input>[term]
```

Parameters

Name	Type	Description
input	a	Specifies input to query: A, B, C1, C2, C3, C4, D1, D2, D3, D4, E1, E2, E3, E4, F1, F2, F3, F4, G1, G2, G3, G4, H1, H2, H3, H4

Returns

`<enabled>, <points>, <window>[term]` (see command for description)

Remarks

Returns the filter settings for the provided input.

ALARM Input Alarm Command

```
ALARM <input>, <enabled>, <high limit>, <low limit>, <deadband>,
<latch>, <audible>, <visible>[term]
```

Parameters

Name	Type	Description
input	a	Specifies input to query: A, B, C1, C2, C3, C4, D1, D2, D3, D4, E1, E2, E3, E4, F1, F2, F3, F4, G1, G2, G3, G4, H1, H2, H3, H4
enabled	n	Enables or disables the alarm 0 = Disabled 1 = Enabled
high limit	+n.nn	High limit for the alarm
low limit	+n.nn	Low limit for the alarm
deadband	+n.nn	Deadband for the alarm
latch	n	Latch the alarm when triggered 0 = No latch 1 = Latch
audible	n	Enable or disable the audible alarm 0 = Disabled 1 = Enabled
visible	n	Enable or disable the visual alarm 0 = Disabled 1 = Enabled

Example

```
ALARM A,1,100,0,10,0,1,1[term]
```

Enables the alarm on input A with a high limit of 100 K, low limit of 0 K, deadband of 10 K, latching disabled, and both audible and visual alarms enabled.

Remarks

The example above assumes that input A has a valid curve assigned to it, otherwise the limits will be in sensor units. If a curve is applied, the Model 346 will interpret the limits based on the <units> value, as specified in the INTYPE command.

Alarms are often used for process automation when connected to a relay, and can be used to trigger actions when a temperature is reached. This is discussed in more depth in the RELAY command.

ALARM? Input Alarm Query

`ALARM? <input>[term]`

Parameters

Name	Type	Description
input	a	Specifies input to query: A, B, C1, C2, C3, C4, D1, D2, D3, D4, E1, E2, E3, E4, F1, F2, F3, F4, G1, G2, G3, G4, H1, H2, H3, H4

Returns

`<enabled>, <high limit>, <low limit>, <deadband>, <latch>, <audible>, <visible>[term]` (see command for description)

Remarks

Returns the alarm settings for the provided input.

ALMRST Input Alarm Reset Command

`ALMRST [term]`

Parameters

none

Remarks

Clears both the high and low status of all alarms, including latching alarms. This mirrors the effect of pressing the alarm reset toast on the front panel, or the reset all alarms action button.

ALARMST? Input Alarm Status Query

```
ALARMST? <input> [term]
```

Remarks

This is a query available on the Model 336. Because the Model 346 has additional input operational information to report, alarm status can be found using the RDGOPR? query.

THRESHOLD Reading Threshold Command

```
THRESHOLD <input>, <id>, <value>, <comparison>[term]
```

Parameters

Name	Type	Description
input	a	Specifies input to configure: A, B, C1, C2, C3, C4, D1, D2, D3, D4, E1, E2, E3, E4, F1, F2, F3, F4, G1, G2, G3, G4, H1, H2, H3, H4
id	n	Threshold identifier (1 to 4)
value	n.nn	Threshold value
comparison	n	Comparison operator 0 = Less than (<) 1 = Greater than (>)

Example

```
THRESHOLD A,0,50.5,1[term]
```

Sets threshold 0 on input A to trigger when temperature is greater than 50.5 K.

Remarks

The threshold feature allows monitoring of up to four independent temperature thresholds per input. When the input reading crosses a threshold based on the configured comparison operator, a corresponding bit is set in the input's operational register (RDGOPR?).

If a curve is assigned to the input, the threshold value is interpreted in temperature units (K or °C) as configured by the INTYPE command. If no curve is assigned, the value is in sensor units.

Thresholds are useful for monitoring multiple temperature points without requiring alarm functionality, and can be used for process control or data logging triggers.

THRESHOLD? Reading Threshold Query

```
THRESHOLD? <input>, <id>[term]
```

Parameters

Name	Type	Description
input	a	Specifies input to query: A, B, C1, C2, C3, C4, D1, D2, D3, D4, E1, E2, E3, E4, F1, F2, F3, F4, G1, G2, G3, G4, H1, H2, H3, H4
id	n	Threshold identifier (1 to 4)

Returns

`<value>, <comparison>[term]` (see command for description)

Remarks

Returns the threshold configuration for the specified input and threshold ID.

MDAT? Minimum/Maximum Data Query

```
MDAT? <input>[term]
```

Parameters

Name	Type	Description
input	a	Specifies input to query: A, B, C1, C2, C3, C4, D1, D2, D3, D4, E1, E2, E3, E4, F1, F2, F3, F4, G1, G2, G3, G4, H1, H2, H3, H4

Returns

```
<minimum value>, <maximum value>[term]
```

Remarks

Returns the minimum and maximum sampled input readings since the last time the min/max readings were reset. If a curve is not assigned, the values will be in sensor units. If a curve is assigned, the values will be units in K. If there has not been a valid (non-questionable) reading since the last reset, this command will return NaN.

Some events tied to input setup can cause these values to reset as the values may no longer be valid. These events include:

- Changing the sensor type
- Changing curve

MNMXRST Minimum and Maximum Function Reset Command

```
MNMXRST <input>[term]
```

Parameters

Name	Type	Description
input	a	Specifies input to query: ALL, A, B, C1, C2, C3, C4, D1, D2, D3, D4, E1, E2, E3, E4, F1, F2, F3, F4, G1, G2, G3, G4, H1, H2, H3, H4

Remarks

Resets the minimum and maximum reading data for the give input, or all inputs if ALL.

TCCOMPOFFSET? Thermocouple Compensation Offset Query

```
TCCOMPOFFSET? <input>[term]
```

Parameters

Name	Type	Description
input	a	Specifies thermocouple input to query: E1, E2, F1, F2, G1, G2, H1, H2

Returns

```
<offset>[term]
```

Example

```
TCCOMPOFFSET? E1[term]
```

Returns: `-0.5`

Remarks

Returns the current thermal block compensation offset value in Kelvin for the specified thermocouple input. If no offset has been applied, the query returns 0.0.

TEMP? Thermocouple Junction Temperature Query

```
TEMP? <slot>[term]
```

Parameters

Name	Type	Description
slot	a	Specifies thermocouple option-card slot to query: E, F, G, H

Returns

```
<junction temperature>[term]
```

Example

```
TEMP? H[term]
```

Returns: `297.53`

Remarks

Temperature is in kelvin. This query returns the temperature of the ceramic thermocouple block used in the room temperature compensation calculation. Note, there is only a single temperature sensor for a given thermocouple card.

5.5.2 Curve Related Commands

The Model 346 supports a variety of temperature sensor types and associated calibration curves to convert the raw sensor readings of ohms and volts into temperature readings that can be used for display and control. From the front panel, users can configure their sensors in one click by selecting a curve from the list of loaded curves and the instrument will automatically configure the input to match. On the remote interface, the user must first configure their input using the INTYPE command. At that point, a curve that matches the configured sensor type can be assigned to the input using the INCRV command. When configuring in this way, non-matching curves are rejected. An example of this is being unable to assign a diode curve to an input configured as an NTC resistor.

When selecting curves, a number of the fields in the curve header are used to help identify the curve. The name is displayed on the front panel for selection, and the format field is used to determine if the curve is valid for a given sensor type. Once the curve is selected, the setpoint limit is used to prevent control outside of a given upper limit.

Once the curve is applied, the breakpoint table is used to convert the raw sensor reading into a temperature reading using linear interpolation between the two nearest points. If the sensor reading is outside of the range of the curve, the instrument will extrapolate using the two nearest points up to a maximum of 50% lower than the lowest point or 5% higher than the highest point. When in this state, a chip is displayed on the input card on the front panel, and the *extrapolated* bit is set in RDGST?.

Standard curves (1 to 20) are provided for common sensor types and cannot be modified. They are as follows:

Curve ID	Type	Name
2	Diode	DT-670
6	PTC	PT-100
8	NTC	RX-102A-AA
9	NTC	RX-202A-AA
10	NTC	RX-103A-AA
12	Thermocouple	Type K
13	Thermocouple	Type E

User curves, numbered 21 to 60, can be loaded in using the ColdSync tool provided by Lake Shore. User curves must have at least two non-zero points to be valid. Once loaded, user curves can be deleted using the CRVDEL command.

CRVHDR Curve Header Command

```
CRVHDR <curve>, <name>, <serial num>, <format>, <limit value>,
<coeff> [term]
```

Parameters

Name	Type	Description
curve	nn	Specifies a user curve to configure. Valid entries: 21 to 60.
name	s[32]	The name of the curve. Limited to 32 characters.
serial num	s[16]	The serial number of the curve. Limited to 16 characters.
format	n	The format of the curve. 1 = mV/K 2 = V/K 3 = Ω/K 4 = log Ω/K
limit value	+nnn.n	The setpoint limit of the curve in Kelvin.
coeff	nn	The coefficient of the curve. 1 = negative 2 = positive

Example

```
CRVHDR 21,"DT-670","00011134",2,325.0,1[term]
```

configures user curve 21 with a name of DT- 670, serial number of 00011134, data format of V/K, setpoint limit of 325 K, and negative temperature coefficient.

Remarks

The coefficient parameter will be calculated automatically based on the first 2 curve datapoints. It is included as a parameter for compatibility with the CRVHDR? query. All parameter fields must be filled with a value. If the sensor does not have a serial number, it is still recommended to enter a non-empty string in this field. The format parameter is a function of sensor type. For example, diodes are V/K, platinums are Ω/K, Cernox are log Ω/K, and thermocouples are mV/K. This sensor format parameter is what's used to group the curves on the front panel curve selection screen.

CRVHDR? Curve Header Query

`CRVHDR? <curve> [term]`

Parameters

Name	Type	Description
curve	nn	Specifies a curve header to query. Valid entries: 1–60.

Returns

`<name>, <serial num>, <format>, <limit value>, <coeff> [term]` (see command for description)

CRVPT Curve Data Point Command

`CRVPT <curve>, <index>, <units value>, <temp value>[term]`

Parameters

Name	Type	Description
curve	nn	Specifies a user curve to configure. Valid entries: 21 to 60.
index	nnn	The index of the data point. Valid entries: 1 to 200.
units value	+/- nnnnnn	Specifies sensor units for this point to 6 digits.
temp value	+nnnnnn	Specifies the corresponding temperature in kelvin for this point to 6 digits.

Example

`CRVPT 21,4,0.13650,479.500,N[term]`

sets user curve 21 fourth data point to 0.13650 sensor units and 479.500 K

Remarks

If a sensor reading is measured beyond the last point, or below the first point, the instrument will extrapolate the curve. An extrapolated chip will be present on the front panel, and the extrapolated bit will be set in RDGST?. This extrapolation extends to 50% of the lowest point and 5% above the highest point. For example, if the lowest point is 4 K, the extrapolated range would extend down to 2 K.

CRVPT? Curve Data Point Query

`CRVPT? <curve>, <index> [term]`

Parameters

Name	Type	Description
curve	nn	Specifies a curve to query. Valid entries: 1 to 60.
index	nnn	The index of the data point. Valid entries: 1 to 200.

Returns

`<units value>, <temp value> [term]` (see command for description)

INCRV Input Curve Number Command

`INCRV <input>, <curve number>[term]`

Parameters

Name	Type	Description
input	a	Specifies input to query: A, B, C1, C2, C3, C4, D1, D2, D3, D4, E1, E2, E3, E4, F1, F2, F3, F4, G1, G2, G3, G4, H1, H2, H3, H4
curve number	nn	Specifies which curve a given input uses. If specified curve type does not match the configured input type, the curve number. Defaults to 0. Valid entries: 0 = none 1 to 20 = standard curves 21 to 60 = user curves

Example

```
INCRV A,23[term]
```

specifies that input A uses user curve 23 for temperature conversion.

Remarks

If a curve is not assigned to an input, control and display will be in sensor units. When a curve is assigned to an input, control and display readings change to be in temperature units. If the sensor type in the curve header does not match the configured input type, the command is rejected and the curve number returns to 0 (none).

INCRV? Input Curve Number Query

```
INCRV? <input> [term]
```

Parameters

Name	Type	Description
input	a	Specifies input to query: A, B, C1, C2, C3, C4, D1, D2, D3, D4, E1, E2, E3, E4, F1, F2, F3, F4, G1, G2, G3, G4, H1, H2, H3, H4

Returns

`<curve number> [term]` (see command for description)

CRVDEL Curve Delete Command

`CRVDEL <curve> [term]`

Parameters

Name	Type	Description
curve	nn	The curve number to delete. Must be between 21 and 60.

Example

`CRVDEL 21[term]` deletes curve 21 from the instrument.

CRVNUMPTS? Input Curve Number of Points Query

`CRVNUMPTS? <curve> [term]`

Parameters

Name	Type	Description
curve	nn	Specifies the curve to query. Valid entries: 1 to 60.

Remarks

Returns the number of breakpoints defined in the specified curve before encountering a 0K reading, if the curve is empty this will return 0.

5.5.3 Output Related Commands

Heater Outputs 1, 2, 3, and 4 are traditional control loop heater outputs for a cryogenic temperature controller. The 4 outputs are identical current sources, with a maximum current output of 2 A and a compliance voltage limit of 50 VDC. For a maximum power output of 100 W, the heaters are optimally designed to drive 25 Ω loads. However, the heaters can drive loads ranging from 10 Ω to 100 Ω.

When setting up the heaters using the HTRSET command, they can be configured in terms of output power, or output current. The *heater resistance* and *max output* parameters work together to limit the maximum available power into the resistive heater. This is useful for preventing heater damage or limiting the maximum heater power into the system. The *max output* setting allows for a current or power limit that keeps the output operating within the voltage compliance limit to ensure the best possible resolution. These parameters work with the Heater Range parameter *range* to provide safety and flexibility across up to 100 W and 1 W max outputs.

While operating the outputs on a 346 in closed loop control, three major components are necessary. First, an input must be selected to operate on and depending on whether or not a curve is applied, will use either the sensor reading (without a curve), or temperature reading (with a curve). Second, a setpoint matching the units provided by the input is chosen to calculate error. Finally, gains of P, I, and D are used to convert the calculated error to heater power.

If any of these three parts of an output are changed, it is possible that it could have effects on the others. For example, changing the input can reset the setpoint if the units do not match. This is to prevent changing from setpoints in ohms (usually in the 10 Ω to 100 kΩ range) to a setpoint in volts (-50 mV to 2.5 V range). Other changes include:

- Applying or removing a curve to an input
- Applying the input to another output
- Applying a new input to the output

OUTGROUP Output Heater Group Command

```
OUTGROUP <output>, <group>
```

Parameters

Name	Type	Description
output	n	The heater number to configure: 1 to 4
group	n	The heater group to assign the output to: 9 or 10; 0 = do not assign output to a group

Example

```
OUTGROUP 2,9[term]
```

Heater output 2 will be assigned to heater group 9.

Remarks

The OUTGROUP command allows for the grouping of heater outputs for coordinated control. This can be useful for applications where multiple heaters need to be controlled together, such as in a stage where multiple heaters are required to control at a power greater than 100 W. When outputs are grouped, they will share the same control parameters (P, I, D, Setpoint, Ramp Rate) and will be controlled as a single entity. The power output of each heater in the group will be adjusted proportionally based on their individual HTRSET max power settings and will output power according to the OUTMODE setting of the heater group channel.

If any individual heater in a group has a fault condition (short/open), the entire group will be disabled to ensure safety. The group will remain disabled until the fault condition is cleared and the heaters are manually re-enabled.

When using heater groups, it is important to ensure that all physical heaters in the group are configured correctly and that their respective HTRSET parameters are set appropriately for the desired control behavior. In addition, once a heater output is assigned to a heater group, its output mode settings (OUTMODE) cannot be configured individually, and any attempt to do so will result in an error (-203 command protected).

OUTGROUP? Output Heater Group Query

`OUTGROUP? <output> [term]`

Parameters

Name	Type	Description
output	n	The heater number to query: 1 to 4

Returns

`<group> [term]` (see command for description)

OUTMODE Output Mode Command

`OUTMODE <output>, <mode>, <input>, <powerup enable>, <warmup> [term]`

Parameters

Name	Type	Description
output	n	The output number to configure: 1 to 10
mode	n	Specifies the control mode. Valid entries: 0 = Off 1 = Closed Loop PID 2 = Zone 3 = Open Loop 4 = Monitor Out
input	a	Specifies input to use for control: A, B, C1, C2, C3, C4, D1, D2, D3, D4, E1, E2, E3, E4, F1, F2, F3, F4, G1, G2, G3, G4, H1, H2, H3, H4, NONE
powerup enable	n	Specifies whether the output restarts or remains off after power cycle. Valid entries: 0 = Powerup enable off 1 = Powerup enable on
warmup	n	Specifies if the output will be used for warmup. Valid entries: 0 = Off 1 = On

Example

```
OUTMODE 1,1,A,0,0[term]
```

Output 1 is configured for closed-loop control mode, using Input A

Remarks

Monitor out mode is only valid for analog outputs 5 to 8. Zone and warmup is only valid for heater outputs 1 to 4, and heater groups 9 and 10. None can be used for open-loop control. In addition, none will be assigned automatically if an output's prior input was assigned to another output. For example: OUTMODE 1,1,A,0,0; followed by OUTMODE 2,1,A,0,0; will result in output 1 being assigned to NONE. Closed-loop mode will *not* allow the range to be set if the input is NONE.

OUTMODE? Output Mode Query

`OUTMODE? <output> [term]`

Parameters

Name	Type	Description
output	n	The output number to query: 1 to 10

Returns

`<mode>, <input>, <powerup enable>, <warmup> [term]` (see command for description)

HTRSET Heater Setup Command

`HTRSET <output>, <resistance>, <max output>, <current/power>[term]`

Parameters

Name	Type	Description
output	n	The output number to configure: 1 to 4, 9 or 10
resistance	nnn	Specifies the resistance of the heater load in ohms. 10 Ω to 100 Ω (25 Ω default)
max output	+n.nn	Represents 100% output as either power or current depending on the <current/power> setting on HIGH range.
current/power	n	Specifies whether the max output is in current or power. Valid entries: 0 = Power 1 = Current

Example

```
HTRSET 2, 25, 40, 0[term]
```

Heater output 2 will be configured to know that a 25 Ω heater is attached and the 346 heater output will treat 100% out as 4 W.

Remarks

The *current/power* parameter determines how the output percentage is applied to the heater. When in units of current, the heater output percentage is a percentage of the full-scale current, as specified in the *max output* parameter. When in units of power, the output percentage is a percentage of full-scale power, also specified by the *max output* parameter.

For example, if the full-scale output is 100 W and in power mode and 50% output is requested, the internal current source will provide 1.41 A to your 25 Ω load for a total of 50 W.

It should also be noted that this max output value is applicable only for the HIGH heater range. If the low range is selected, the Model 346 automatically scales down the max output setting accordingly. For example, in power mode, if the max output is set to 50 W, then 50 W will be the maximum output when the HIGH range is selected, while the LOW range maximum output will be 500 mW, since the LOW range hardware is designed to output 1/100th of the HIGH range power. The same idea applies to current. If the max output is set to 1 A, then 1 A will be used for the HIGH range max output, while 100 mA will be used for the low range, since the LOW range hardware is designed to output 1/10th of the HIGH range current.

For use with heater groups (9 and 10), the *max output* parameter and *resistance* parameter are unused, as the physical channels are used to determine the max output and resistance of their respective heater loads. Because of this, valid entries must be provided, but are recommended to be set to 25 Ω and 100 W.

Note, if the value provided in *max output* exceeds the *current/power* hardware limits of the output, based on the resistance, the instrument will adjust the max output accordingly. For example, a command of HTRSET 1, 50, 100, 0 will cause the instrumetn to only be able to output 50 W max across a 50 Ω load)

HTRSET? Heater Setup Query

`HTRSET? <output> [term]`

Parameters

Name	Type	Description
output	n	The output number to query: 1 to 4, 9 or 10

Returns

`<resistance>, <max output>, <current/power> [term]` (see command for description)

Remarks

As mentioned in the HTRSET command description, the instrument will limit *max output* if a max current/power value exceeds the hardware limits, for a given heater resistance. The *max output* query will return the actual max output being applied.

HTRLIM Heater Short/Open Command

`HTRLIM <output>, <enabled>, <short resistance>, <open resistance> [term]`

Parameters

Name	Type	Description
output	n	The heater number to configure: 1 to 4
enabled	n	Configures if a detected short or open will shut off the heater (On = 1), or will be ignored (Off = 0)
short resistance	+nnn.n	Resistances below this value are a short
open resistance	+nnn.n	Resistances above this value are an open

Example

```
HTRLIM 3, 1, 25, 250[term]
```

Heater output 3 will have short/open protection enabled with a short circuit being any measured heater resistance below 25 Ω and an open circuit being any measured heater resistance above 250Ω.

Remarks

To ensure as few false positives as possible, a short or open condition must be present for at least 5 s before shutting off the heaters. The heater must also be outputting at least 10% of full scale to get an accurate reading of the heater load's resistance. If the output percentage is less than 10%, then the heater limits are not checked nor enforced.

HTRLIM? Heater Short/Open Query

```
HTRLIM? <output> [term]
```

Parameters

Name	Type	Description
output	n	The heater number to configure: 1 to 4

Returns

`<enabled>, <short resistance>, <open resistance> [term]` (see command for description)

RANGE Heater Range Command

```
RANGE <output>, <range> [term]
```

Parameters

Name	Type	Description
output	n	The output number to configure: 1 to 10
range	n	For heater outputs 1 - 4, and heater groups 9 and 10: 0 = Off 1 = Low 2 = High For analog out outputs 5 - 8: 0 = Off 1 = On

Example

```
RANGE 2,2[term]
```

Heater output 2 will be configured to the high range.

Remarks

For heater outputs 1 to 4 and heater groups 9 and 10, the HIGH setting provides the maximum amount of output power, while the low setting provides a full-scale output range of 1/100th of maximum power. From a current perspective, the HIGH setting causes the output to have a full scale output of 2 A, while the LOW setting causes the output to have a full scale output of 200 mA Full scale current/power is determined by the HTRSET command settings.

Note, for the heaters, the OFF range disables the heater by shorting the heater leads together and floating them from the heater circuit. This is the fallback state an output enters if it detects fault conditions.

RANGE? Heater Range Query

```
RANGE? <output> [term]
```

Parameters

Name	Type	Description
output	n	The output number to query: 1 to 10

Returns

`<range> [term]` (see command for description)

HTRAUTO Heater Autorange Command

`HTRAUTO <output>, <autorange> [term]`

Parameters

Name	Type	Description
output	n	The output number to configure: 1 to 4, 9 or 10
autorange	n	For heater outputs 1 to 4, 9 or 10 0 = Disabled 1 = Enabled

Example

`HTRAUTO 2,1[term]`

Heater output 2 will be configured to autorange.

Remarks

This feature is designed to be used with PID gains configured for the high range, and automatically swaps the heater range between high and low based on the output percentage. When enabled, if the output percentage drops below 8% of current or .8% of power the range will switch to low. If the output percentage goes above 10% of current or 1% of power, the range will switch to high.

This command works together with the RANGE command. The RANGE command is used to de-energize the heaters to OFF. It is also used to energize the heater by setting it to an

initial range. When heater autorange is enabled, the Model 346 will automatically adjust the range to either HIGH or LOW as necessary.

HTRAUTO? Heater Autorange Query

`HTRAUTO? <output> [term]`

Parameters

Name	Type	Description
output	n	The output number to query: 1 to 4, 9 or 10

Returns

`<autorange> [term]` (see command for description)

HTR? Heater Percentage Query

`HTR? <output> [term]`

Parameters

Name	Type	Description
output	n	The output number to query: 1 to 10

Returns

`<output percentage> [term]`

Remarks

Returns the present heater percentage of full scale for the output. This can be converted into output power or current by using the HTRSET parameters for outputs 1 to 4, or by multiplying by 10 V on outputs 5 to 8. This is the theoretical value and may not reflect the actual output due to load conditions, incorrectly entered HTRSET resistance, or other factors.

AOUT? Analog Output Data Query

```
AOUT? <output> [term]
```

Remarks

This is a query available on the Model 336. Because the Model 346 considers outputs 5 to 8 auxiliary 1 W heaters, the AOUT? query is not implemented. To retrieve the output percentage for analog outputs 5 to 8, use the HTR? query.

HTROUT? Heater Output Query

```
HTROUT? <output> [term]
```

Parameters

Name	Type	Description
output	n	The output number to query: 1 to 10

Returns

```
<output value>, <output power> [term]
```

Remarks

Returns the calculated output value and power for the specified output. For outputs 1 to 4, the output value is the calculated output current in Amperes, while for outputs 5 to 8, the output value is the calculated output voltage in Volts. The power value is calculated as follows:

Outputs 1 to 4: Power (W) = (output current (A)) ^{2} × heater resistance (Ω)

Outputs 5 to 8: Power is not calculated and will return 0.0

For heater groups 9 and 10, the output value is the sum of the output currents of the physical heater outputs in the group, and the power is the sum of their calculated powers.

HTRDIAG? Heater Output Measurement Query

```
HTRDIAG? <output> [term]
```

Parameters

Name	Type	Description
output	n	The output number to query: 1 to 8

Returns

```
<voltage>,<current>,<resistance>,<power> [term]
```

Remarks

These readings are purely for diagnostic purposes and do not have any associated accuracy specifications. Typically, one can expect accuracies in the 3 to 5% range, down to about 10% of the output of the heater (1 to 4) or the analog output (5 to 8). Below 10% of output percentage, the readings are highly inaccurate. Note, for the analog outputs 5 to 8, the voltage is not measured, so the value returned in this query is simply the *commanded* output voltage. For example, if the analog output is overloaded, the voltage will still return what is being commanded, not the actual reduced voltage output as a result of the short. The resistance and power values are simply calculated as a result of the measured voltages and currents. In addition, the voltages and currents measured (and the subsequent power and resistance calculations) are from the perspective of the

internal circuitry, and don't account for any losses outside of the instrument (for example, voltage drops due to lead resistnace). The readings of heaters 1 to 4 are updated every 100 ms, while the analog outputs 5 to 8 are updated every 250 ms.

MOUT Manual Output Command

```
MOUT <output>, <percentage> [term]
```

Parameters

Name	Type	Description
output	n	The output number to configure: 1 to 10
percentage	+nnn	The percentage of full scale output. 0 to 100

Example

```
MOUT 1,22.45[term]
```

Sets output 1 manual output percentage to 22.45%.

Remarks

What the percentage represents is a function of the *current/power* and *max output* settings as specified in the HTRSET command. When in units of current, the output percentage is a percentage of the full scale max output specified. When in units of power, the output percentage is full scale power, with full scale power being defined as (max current output)^2 × heater resistance.

Manual output does not apply in OFF mode

MOUT? Manual Output Query

```
MOUT? <output> [term]
```

Parameters

Name	Type	Description
output	n	The output number to query: 1 to 10

Returns

`<percentage> [term]` (see command for description)

OUTLIMIT Output Percentage Limit Command

```
OUTLIMIT <output>, <max percentage> [term]
```

Parameters

Name	Type	Description
output	n	The output number to configure: 1 to 10
max percentage	+nnr	The maximum output percentage limit. 0 to 100

Example

```
OUTLIMIT 1,75[term]
```

Sets output 1 maximum output percentage limit to 75%.

Remarks

This feature is designed to limit the maximum output percentage of an output. When a limit is set, any command or control loop that attempts to drive the output will be limited to this value, and if the value would be exceeded, a status bit will be set in OUTST? to indicate the output is being limited.

OUTLIMIT? Output Percentage Limit Query

`OUTLIMIT? <output> [term]`

Parameters

Name	Type	Description
output	n	The output number to query: 1 to 10

Returns

`<max percentage> [term]` (see command for description)

PID Control Loop PID Values Command

`PID <output>, <P>, <I>, <D> [term]`

Parameters

Name	Type	Description
output	n	The output number to configure: 1 to 10.
P	+nnn	The proportional gain value. 0.1 to 100,000.
I	+nnn	The integral gain value. 0.1 to 100,000.
D	+nnn	The derivative gain value. 0 to 20,000.

Example

`PID 1,10,50,0[term]`

sets the PID values for output 1 where P is 10, I is 50, and D is 0%

Remarks

Control settings, (P, I, D, and Setpoint) are assigned to outputs, which results in the settings being applied to any loop formed by the output and its control input. Note the I term is internally scaled by the P, and the D value is called by both I and P. This means, you must have a P term entered to use I, and you must have P and I terms entered to use D.

PID? Control Loop PID Values Query

`PID? <output> [term]`

Parameters

Name	Type	Description
output	n	The output number to query: 1 to 10

Returns

`<P>, <I>, <D> [term]` (see command for description)

SETP Control Setpoint Command

`SETP <output>, <setpoint> [term]`

Parameters

Name	Type	Description
output	n	The output number to configure: 1 to 10
setpoint	+nnn.n	The value for the setpoint, in either units of sensor or temperature (see remarks)

Example

`SETP 1,122.5[term]`

sets the setpoint for output 1 to 122.5, based on the units of the input that output 1 is tied to.

Remarks

Control settings, that is, P, I, D, and Setpoint, are assigned to outputs, which results in the settings being applied to the control loop formed by the output and its control input. Regarding the units of this setpoint value, if a curve is **not** assigned to an input, the setpoint will be in sensor units. When a curve is assigned to an input, this causes the instrument to interpret this setpoint in temperature units of either Kelvin or Celsius, as specified in the INTYPE command. For information regarding assigning curves, see the INCRV command.

SETP? Control Setpoint Query

`SETP? <output> [term]`

Parameters

Name	Type	Description
output	n	The output number to query: 1 to 10

Returns

`<setpoint> [term]` (see command for description)

Remarks

Note, if setpoint ramping is enabled and the setpoint is actively ramping, this query returns a 'real-time' sample of wherever the setpoint is in the ramping process, at the moment the query is issued. Otherwise, the query returns the static setpoint setting. When ramping, this setpoint query has an update rate of 10 Hz.

SETPRST Control Setpoint Reset Command

```
SETPRST <output> [term]
```

Parameters

Name	Type	Description
output	n	The output number to reset: 1 to 10

Example

```
SETPRST 1[term]
```

Resets the setpoint for output 1 to the current input reading value.

Remarks

This command is used for quickly snapping a setpoint while ramping, or for convenience when the setpoint is desired to be the same as the input value. However, if the current output has no attached input (ie. OUTMODE 1,3,NONE,0), the setpoint will be set to 0.

RAMP Setpoint Ramp Command

```
RAMP <output>, <enable>, <rate> [term]
```

Parameters

Name	Type	Description
output	n	The output number to configure: 1 to 10
enable	n	Specifies if the ramp rate is enabled. Valid entries: 0 = Off 1 = On
rate	+nn.n	Ramp rate in K/min. 0.1 to 100 (0 disables ramping).

Example

`RAMP 1,1,10.0[term]`

Sets the ramp rate for output 1 to 10 K/min and enables ramping.

Remarks

Disabling the ramp rate will cause the setpoint to jump to any new setpoint instantly, and if the Model 346 was previously ramping, it will complete its ramp instantly. In addition, a transition to disabled causes PID state variables, such as the I accumulator and the D term, to reset, as this is considered a step change in the setpoint. A ramp rate of 0 K/min can be applied, however this simply responds as if ramping was off. This has some automation uses in zone operation, but is not recommended for general use.

RAMP? Setpoint Ramp Query

`RAMP? <output> [term]`

Parameters

Name	Type	Description
output	n	The output number to query: 1 to 10

Returns

`<enable>, <rate> [term]` (see command for description)

RAMPSETP? Ramp Setpoint Query

`RAMPSETP? <output> [term]`

Parameters

Name	Type	Description
output	n	The output number to query: 1 to 10

Returns

```
<setpoint> [term]
```

Remarks

This command will return the setpoint that the output is ramping to, or if the output is not ramping, it will return the current setpoint. This query is available since, when ramping, the SETP? query will return a real-time snapshot of wherever the setpoint is in the ramp cycle, at the moment the query is issued.

RAMPST? Setpoint Ramp Status Query

```
RAMPST? <output> [term]
```

Parameters

Name	Type	Description
output	n	The output number to query: 1 to 10

Returns

```
<status> [term]
```

Name	Type	Description
status	n	0 = not ramping, 1 = ramping

Remarks

This query will report whether the specified output's setpoint is actively ramping or not.

ZONE Zone Settings Command

```
ZONE <output>, <zone>, <upper boundary>, <kp>, <ki>, <kd>, <mout>,
<output limit>, <range>, <input>, <ramp rate> [term]
```

Parameters

Name	Type	Description
output	n	The output number to configure: 1 to 4, 9 or 10
zone	n	The zone number to configure: 1 to 10
upper boundary	+nnn.	The upper boundary of the zone in Kelvin
kp	+nnn	The proportional gain value. 0.1 to 100,000.
ki	+nnn	The integral gain value. 0.1 to 100,000.
kd	+nnn	The derivative gain value. 0 to 20,000.
mout	+nnn	The manual output percentage. 0 to 100.
output limit	+nnn	The output limit percentage. 0 to 100.
range	n	The heater range. Valid entries: 0 = Off 1 = Low 2 = High
input	a	Specifies input to use for control: A, B, C1, C2, C3, C4, D1, D2, D3, D4, E1, E2, E3, E4, F1, F2, F3, F4, G1, G2, G3, G4, H1, H2, H3, H4
ramp rate	+nn.n	Ramp rate in K/min. 0.1 to 100 (0 disables ramping)

Example

```
ZONE 1,1,300,10,50,0,0,100,2,A,10.0[term]
```

Sets the zone settings for output 1, zone 1, with an upper boundary of 300 K, a P term of 10, I term of 50, D term of 0, manual output of 0%, output limit of 100%, high range, input A, and a ramp rate of 10 K/min.

Remarks

Zones are defined by upper bounds with the first zone having an implied lower bound of 0 K. Zones are used to define different control parameters for different temperature ranges and can also be used for automation when combined with ramping. Zones are not compatible with analog outputs 5 to 8.

ZONE? Zone Settings Query

`ZONE? <output>, <zone> [term]`

Parameters

Name	Type	Description
output	n	The output number to query: 1 to 4, 9, or 10
zone	n	The zone number to query: 1 to 10

Returns

`<upper boundary>, <kp>, <ki>, <kd>, <mout>, <output limit>, <range>, <input>, <ramp rate> [term]` (see command for description)

ANALOG Monitor Out Parameter Command

`ANALOG <output>, <high value>, <low value> [term]`

Parameters

Name	Type	Description
output	n	The output number to configure: 5 to 8
high value	+nnnn	The input reading at which the analog output reaches 100% output (+10 V).
low value	+nnnn	The input reading at which the analog output is 0% output (0 V).

Example

```
ANALOG 5,100.0,20[term]
```

Sets the monitor out parameters for output 5 where the high value is 100.0 and the low value is 20.0.

Remarks

The input reading that the analog output monitors is specified by using the OUTMODE command, which allows the tying of an output to an input.

The units of the high value and low value are dependent of if a curve is assigned to the specified input. If a curve is not assigned to the specified input, the high and low values will be in sensor units. When a curve is assigned to an input, this causes the instrument to interpret the high and low values in temperature units, as specified in the INTYPE command. To assign a curve to an input, see the INCRV command. In the example above, it's assumed a curve is assigned to the input tied to output 5. Is also assumes the units are Kelvin, as specified by the INTYPE command.

ANALOG? Monitor Out Parameter Query

```
ANALOG? <output> [term]
```

Parameters

Name	Type	Description
output	n	The output number to query: 5 to 8

Returns

`<high value>, <low value> [term]` (see command for description)

OUTSTABLE Output Control Stability Command

```
OUTSTABLE <output>, <enabled>, <setpoint error>, <settle time>,
<audible>, <visible>[term]
```

Parameters

Name	Type	Description
output	n	The output number to configure: 1 to 10
enabled	n	Specifies if stability detection is enabled. Valid entries: 0 = Off 1 = On
setpoint error	+nn.n	The maximum allowable error from the setpoint in K.
settle time	n.nn	The amount of time in seconds the output must remain within the setpoint error and stabilizing to be considered stable.
audible	n	Specifies if an audible tone sounds when stability is achieved. Valid entries: 0 = Off 1 = On
visible	n	Specifies if a chip is displayed on an output card when stability is achieved. Valid entries: 0 = Off 1 = On

Example

`OUTSTABLE 1,1,0.5,30,1,1[term]` Enables stability detection for output 1 with a setpoint error of 0.5 K, a settle time of 30 s, audible tone enabled, and visible indicator enabled.

Remarks

The output control stability command is used to configure stability detection parameters for a given PID control loop. When enabled, information about the PID control loop will be monitored for stability based on the provided parameters, once the sensor reading has achieved two local maximums above the setpoint, but still in-band, and two local minimums below the setpoint, but still in band, then the output will be considered stabilizing. After the settle time has passed without the input reading leaving the band, it

will be considered stable. When stability is achieved, the STABLE bit will be set in the OUTOPR? status query, and any relays tied using the STABILITY mode will activate.

OUTSTABLE? Output Control Stability Query

`OUTSTABLE? <output> [term]`

Parameters

Name	Type	Description
output	n	The output number to query: 1 to 10

Returns

`<enabled>, <setpoint error>, <settle time>, <audible>, <visible> [term]` (see command for description)

WARM Warmup Command

`WARM <temperature>, <percentage> [term]`

Parameters

Name	Type	Description
temperature	+n.nn	The target temperature for the warmup process. Valid entries of 275 K to 325 K
percentage	+nn.n	The acceptable output level for the system to be considered WARM. 0 to 100%

Example

`WARM 300, 5[term]`

Initiates a warmup to 300 K, which will be consdered WARM at output values below 5%

Remarks

The warmup command is used to set a target temperature for the warmup process. All warmup-enabled outputs will have their setpoints set to this temperature, without ramping, and at a range of high. Upon commencement of the warmup, the warming status bit (bit 6) of the output operation register (OUTOPR?) will be set.

When a output with the warming status bit set reaches above its setpoint and is outputting less than the specified percentage, the warm status bit (bit 7) will be set). When all warming outputs also have their warm bits set, the warmup is completed and a dialog will be displayed on the front panel prompting the user to either turn off all outputs or continue controlling.

5.5.4 Digital IO Related Commands

RELAY Relay Control Parameter Command

```
RELAY <relay number>, <feature>, <instance>, <condition> [term]
```

Parameters

Name	Type	Description
relay number	n	The relay number to configure: 1 or 2
feature	n	Input feature for first value: 0 = Off 1 = On 2 = Thermometry Input (Alarms) 3 = Output Status 4 = Digital Input 5 = System Status
instance	n/a	Input instance for first value. Type depends on feature 1: • For the thermometry input feature: input channel (A, B, C1-C4, D1-D4, E1-E4, F1-F4, G1-G4, H1-H4, or NONE) • For output status feature: numeric output (1-10) • For digital input feature: digital input number (1-2) • For system feature currently only warmup all (0) is implemented • For off and on feature: ignored (use 0)
condition	n	Condition to evaluate for first value. Valid values depend on feature. • For on, off, and system status features: condition is ignored, and should be set to 0. • For thermometry input feature: 0 = Low alarm active, 1 = High alarm active, 2 = Either alarm active, 3 = Both alarms active 4 = Threshold 1, 5 = Threshold 2, 6 = Threshold 3, 7 = Threshold 4, 8 = Sensor fault, 9 = Temperature fault, 10 = Temperature extrapolated • For output status feature: 0 = Output load fault, 1 = Setpoint ramp done, 2 = Output stabilizing, 3 = Output stable, 4 = Output warm • For digital input feature: 0 = Low, 1 = High

Example

`RELAY 1, 1, NONE, 0[term]` relay 1 normally open contacts are closed and normally closed contacts are open.

Remarks

Each relay has both a Normally Closed and Normally Open contact terminal exposed on the rear panel. Although instances are only required for thermometry input, output status, and digital input features, the instance parameter must be specified for all features and should be set to 0 when not used. The condition parameter varies based on feature type - thermometry input features support alarm and threshold conditions, output status features support various output state conditions, and other features use generic true/false conditions. In addition, for backwards compatibility with the Model 336, input channels can be accepted for the 'instance' parameter, and will be treated as 'don't cares' by the Model 346. In addition, in the case of ON and OFF as the feature, the instance and condition parameters will be reset to zero, regardless of what was sent by the user, and will be reported as such, on a subsequent query.

RELAY? Relay Control Parameter Query

`RELAY? <relay number> [term]`

Parameters

Name	Type	Description
relay number	n	The relay number to query: 1 or 2

Returns

`<feature>, <instance>, <condition>` (see command for description)

RELAYST? Relay Status Query

`RELAYST? <relay number> [term]`

Parameters

Name	Type	Description
relay number	n	The relay number to query: 1 or 2

Returns

```
<relay state>
```

Remarks

The relay state is either de-energized (0) or energized (1). When the relay is energized, the normally open contacts are closed and the normally closed contacts are open. When the relay is de-energized, the normally open contacts are open and the normally closed contacts are closed. If issuing a RELAY command followed by RELAYST?, it is recommended to wait at least 100 mS before issuing the query to ensure the relay has had time to change state.

DIGIN? Digital Input State Query

```
DIGIN? [term]
```

Returns

```
<digital in 1 state>,<digital in 2 state>[term]
```

Name	Type	Description
digital in 1 state	n	0 = low, 1 = high
digital in 2 state	n	0 = low, 1 = high

5.5.5 Status and Error Reporting

Status System Overview

The Model 346 implements a status system compliant with the IEEE-488.2 standard. The status system provides a method of recording and reporting the status of the instrument, readings, and installed option cards. At the center of the status system is the status byte register. This register contains summary bits from other status registers, providing the user one register to periodically query to determine if further interrogation of the instrument is required.

In addition to the status byte and its complementary service request enable register, the status system is made up of standard, questionable, and operation status register sets. Each one of those register sets comprises three types of registers: condition, event, and enable. In addition, the status system contains an output buffer and error queue. A diagram of the status system is shown below.

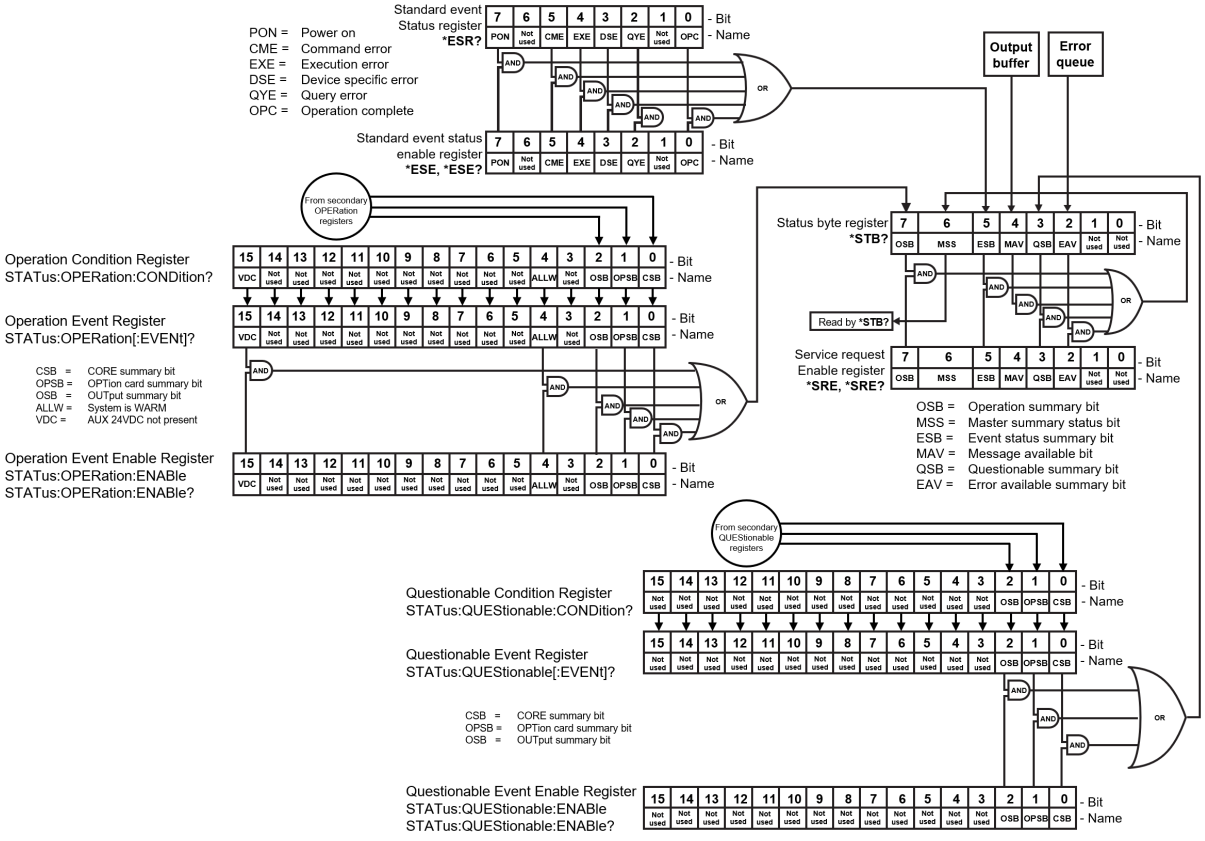


Figure 5.4: Top-level status diagram

Along with the registers shown in the diagram above, both the operation and questionable registers are further divided into a tree of secondary registers:

1. **CORE**: the core thermometry inputs available on every Model 346. Each bit represents summary information for inputs A, B, C1 to C4 and D1 to D4.

2. **OPTion**: Because an input option can contain no more than 4 channels, this 16-bit register contains summary data for each input option card E, F, G, and H. The meaning of the information depends on the type of input card installed.
3. **OUTput**: contains summary data for heater outputs 1 to 4, analog outputs 5 to 8, and heater groups 9 and 10.

Overview of register types

Status Byte Register

The status byte register, typically referred to as the status byte, is a non-latching, read-only register that contains all of the summary bits from the register sets. The status of the summary bits are controlled from the register sets as explained below. The status byte also contains the Master Summary Status (MSS) bit. This bit is used to report if any of the summary bits are set via the **STB?* command. The status of the MSS bit is controlled by the summary bits and the service request enable register.

Service Request Enable Register

The service request enable register determines which summary bits in the status byte will set the MSS bit of the status byte. The user may write to or read from the service request enable register. Each status byte summary bit is logically ANDed to the corresponding enable bit of the service request enable register. When a service request enable register bit is set by the user, and the corresponding summary bit is set in the status byte, the MSS bit of the status byte will be set.

Conditional Registers

Each register set (except the standard event register set) includes a condition register. The condition register constantly monitors the instrument status. The data bits are real-time and are not latched or buffered. The register is read-only.

Event Registers

Each register set includes an event register. Bits in the event register correspond to various system events and latch when the event occurs. Once an event bit is set, subsequent events corresponding to that bit are ignored. Set bits remain latched until the register is cleared by a query command (such as **ESR?*) or a **CLS* command. The register is read-only.

Enable Registers

Each register set includes an enable register. An enable register determines which bits in the corresponding event register will set the summary bit for the register set in the status byte. The user may write to or read from an enable register. Each event register bit is logically ANDed to the corresponding enable bit of the enable register. When an enable register bit is set by the user, and the corresponding bit is set in the event register, the

output (summary) of the register will be set, which in turn sets the master summary status bit of the status byte register.

Reading Registers

Any register in the status system may be read using the appropriate query command. The response to a query will be a decimal value that corresponds to the binary-weighted sum of all bits in the register.

Bit	Decimal	Weighting
0	1	2^0
1	2	2^1
2	4	2^2
3	8	2^3
4	16	2^4
5	32	2^5
6	64	2^6
7	128	2^7
8	256	2^8
9	512	2^9
10	1024	2^{10}
11	2048	2^{11}
12	4096	2^{12}
13	8192	2^{13}
14	16384	2^{14}
15	32768	2^{15}

Programming Registers

The only registers that may be programmed by the user are the enable registers. All other registers in the status system are read-only registers. To program an enable register, send a decimal value that corresponds to the desired binary-weighted sum of all bits in the register

Standard event register definitions

Status Byte Register

The summary messages from the event registers and the output buffer set or clear the summary bits of the status byte register. These summary bits are not latched. Clearing an event register will clear the corresponding summary bit in the status byte register. Reading all messages in the output buffer, including any pending queries, will clear the

message available bit. Reading all errors out of the queue will clear the error available bit. The bits of the status byte register are described as follows:

- **Operation Summary (OSB), Bit 7**: This bit is set when an enabled operation event has occurred
- **Master Summary Status (MSS), Bit 6**: This bit is set when a summary bit and the summary bit's corresponding enable bit in the service request enable register are set. A **STB?* will read the status of the MSS bit (along with all of the summary bits), but also will not clear it. To clear the MSS bit, either clear the event register that set the summary bit or disable the summary bit in the service request Enable register.
- **Event Summary (ESB), Bit 5**: This bit is set when an enabled standard event has occurred
- **Message Available (MAV), Bit 4**: This bit is set when a message is available in the output buffer
- **Questionable Summary (QSB), Bit 3**: This bit is set when an enabled questionable event has occurred
- **Error Available (EAV), Bit 2**: This bit is set when an error is available in the error queue

Service Request Enable Register

The service request enable register is programmed by the user and determines which summary bits of the status byte may set bit 6 (MSS). Enable bits are logically ANDed with the corresponding summary bits. Whenever a summary bit is set by an event register and its corresponding enable bit is set by the user, bit 6 will be set. The Service Request Enable command (**SRE*) programs the Service Request Enable Register and the query command (**SRE?*) reads it.

Standard Event Status Register Set

The standard event status register reports the following interface-elated instrument events: power on detected, command syntax errors, command execution errors, query errors, and operation complete. Any or all of these events may be reported in the standard event summary bit through the enable register. The standard event status enable command (**ESE*) programs the enable register and the query command (**ESE?*) reads it. **ESR?* reads and clears the standard event status register.

- **Power On (PON), Bit 7**: This bit is set to indicate an instrument off-on transition
- **Command Error (CME), Bit 5**: This bit is set if a command error has been detected since the last reading. This means that the instrument could not interpret the

command due to a syntax error, an unrecognized header, unrecognized terminators, or an unsupported command

- **Execution Error (EXE), Bit 4**: This bit is set if an execution error has been detected. This occurs when the instrument is instructed to do something not within its capabilities. A typical example of this are command parameters that are outside the instrument's acceptable bounds.
- **Device Specific Error (DSE), Bit 3**: This bit is set if an error occurs that does not fall into another category defined as a standard event. Examples include if the Model 346 is unable to set its date/time or time zone.
- **Query Error (QYE), Bit 2**: This bit indicates a query error. It occurs rarely and involves loss of data because the output queue is full.
- **Operation Complete (OPC), Bit 0**: When **OPC* is sent, this bit will be set when the instrument has completed all pending operations. The operation of this bit is not related to the **OPC?* command, which is a separate interface feature.

Operational register definitions

The operation event register set reports the instrument events that are considered part of normal operation. Any or all of these events may be reported in the operation event summary bit through the enable register. The operation event enable command (STATus:OPERation:ENABle) programs the enable register and the query command (STATus:OPERation:ENABle?) reads it. STATus:OPERation[:EVENt]? reads and clears the operation event register. STATus:OPERation:CONDition? reads the operation condition register.

In addition to the primary operation register, there are several secondary registers with their own summary bits, which in turn, feed into the primary operation register. The following diagram illustrates the breakdown of the secondary operational registers.

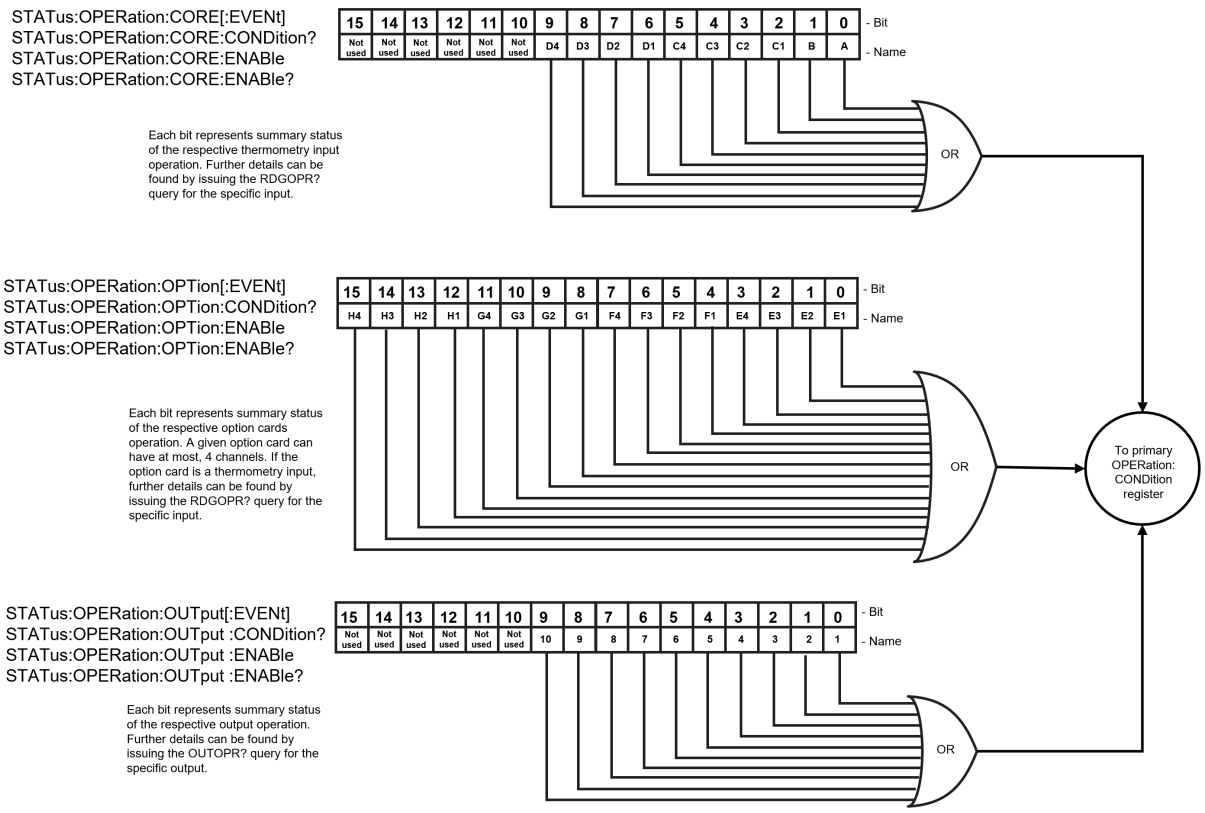


Figure 5.5: Operational register breakdown

STATus:OPERation

This is primary operation status register. Each bit can be logically ORed together to set the operation summary bit (bit 7)in the status byte register (**STB?*).

The bits of this register are described as follows:

- **AUX 24VDC not present (VDC), Bit 15**: This bit is set when the auxiliary 24VDC power is not present. This can occur when the power supply is not connected, or if the supply is not providing the required voltage, or the polarity is inverted.
- **System is WARM (ALLW), Bit 4**: This bit is set when using Warm-up mode. When all the outputs report as warm, this bit will be set.
- **Output card summary (OPSB), Bit 2**: This is a summary bit that is set when a bit is set in the STATus:OPERation:OUTput[:EVENt] register and its corresponding :ENABle bit is set.
- **Option card summary (OPSB), Bit 1**: This is a summary bit that is set when a bit is set in the STATus:OPERation:OPTion[:EVENt] register and its corresponding :ENABle bit is set.
- **CORE Summary (CSB), Bit 0**: This is a summary bit that is set when a bit is set in the STATus:OPERation:CORE[:EVENt] register and its corresponding :ENABle bit is set.

STATus:OPERation:CORE

This is a secondary operation status register. Each bit can be logically ORed together to set the core summary bit (bit 0) in the primary STATus:OPERation register.

Each bit is a summary of the operational status of one of the core thermometry inputs available on every Model 346. The inputs are A, B, C1 to C4 and D1 to D4. The mapping of bits to inputs is as follows:

Bit	Bit weighting	Input designator
0	1	A
1	2	B
2	4	C1
3	8	C2
4	16	C3
5	32	C4
6	64	D1
7	128	D2
8	256	D3
9	512	D4

If a bit is set, more operational status information can be found by issuing the RDGOPR? query for the input.

STATus:OPERation:OPTion

This is a secondary operation status register. Each bit can be logically ORed together to set the option summary bit (bit 1) in the primary STATus:OPERation register.

Each bit is a summary of the operational status of the input channels of option cards E, F, G, and H. An option card can have at most, 4 channels. Because an input option can contain no more than 4 channels, this 16-bit register contains summary data for each input option card E, F, G, and H.

The meaning of the information depends on the type of input card installed. Presently, there are only two types of input option cards, the 3401 scanner, and the 3402 thermocouple. Similar to the CORE behavior, if a given channel summary bit is set, further details can be found by issuing the RDGOPR? query for the specific input channel.

The mapping of bits to inputs is as follows:

Bit	Bit weighting	Input channel designator
0	1	Option Card E channel 1
1	2	Option Card E channel 2
2	4	Option Card E channel 3
3	8	Option Card E channel 4
4	16	Option Card F channel 1
5	32	Option Card F channel 2
6	64	Option Card F channel 3
7	128	Option Card F channel 4
8	256	Option Card G channel 1
9	512	Option Card G channel 2
10	1024	Option Card G channel 3
11	2048	Option Card G channel 4
12	4096	Option Card H channel 1
13	8192	Option Card H channel 2
14	16384	Option Card H channel 3
15	32768	Option Card H channel 4

STATus:OPERation:OUTput

This is a secondary operation status register. Each bit can be logically ORed together to set the output summary bit (bit 2) in the primary STATus:OPERation register.

Each bit is a summary of the operational status of each output. Outputs are made up of heater outputs 1 to 4, analog outputs 5 to 8, and heater groups 9 and 10.

The mapping of bits to outputs is as follows:

Bit	Bit Weighting	Output Designator
0	1	Output 1
1	2	Output 2
2	4	Output 3
3	8	Output 4
4	16	Output 5
5	32	Output 6
6	64	Output 7
7	128	Output 8
8	256	Output 9
9	512	Output 10

If a bit is set, more operational status information can be found by issuing the OUTOPR? query for the output.

Questionable register definitions

The questionable status register reports various states of the instrument that could indicate the quality of the output signal may be compromised. Any or all of these events may be reported in the questionable event summary bit through the enable register. The questionable event enable command (STATus:QUEStionable:ENABle) programs the enable register and the query command (STATus:QUEStionable:ENABle?) reads it. STATus:QUEStionable[:EVENt]? reads and clears the questionable event register. STATus:QUEStionable:CONDition? reads the questionable condition register.

In addition to the primary questionable register, there are several secondary registers with their own summary bits, which in turn, feed into the primary questionable register. The following diagram illustrates the breakdown of the secondary questionable registers.

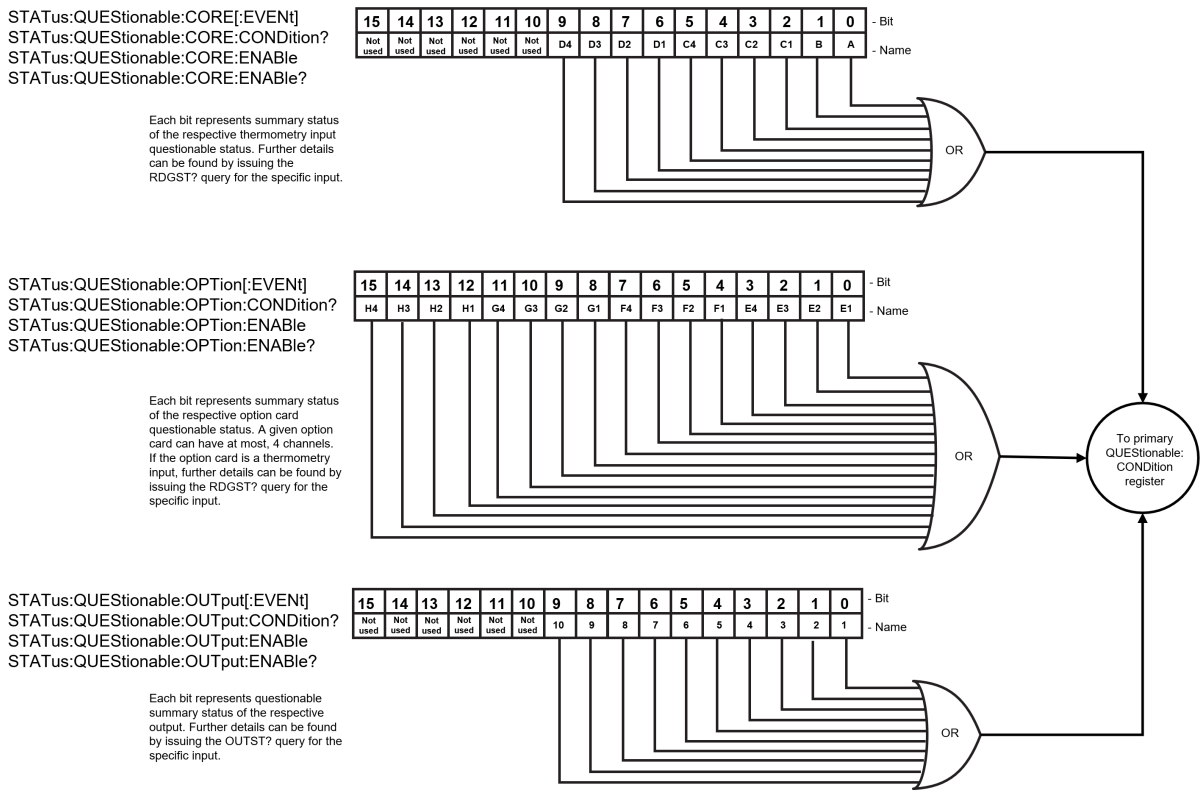


Figure 5.6: Questionable register breakdown

STATus:QUEStionable

This is primary questionable status register. Each bit can be logically ORed together to set the questionable summary bit (bit 3) in the status byte register (*STB?).

The bits of this register are described as follows:

- **Output card summary (OPSB), Bit 2**: This is a summary bit that is set when a bit is set in the STATus:QUEStionable:OUTput[:EVENt] register and its corresponding :ENABle bit is set.
- **Option card summary (OPSB), Bit 1**: This is a summary bit that is set when a bit is set in the STATus:QUEStionable:OPTion[:EVENt] register and its corresponding :ENABle bit is set.
- **CORE Summary (CSB), Bit 0**: This is a summary bit that is set when a bit is set in the STATus:QUEStionable:CORE[:EVENt] register and its corresponding :ENABle bit is set.

STATus:QUEStionable:CORE

This is a secondary questionable status register. Each bit can be logically ORed together to set the core summary bit (bit 0) in the primary STATus:QUEStionable register.

Each bit is a summary of the questionable status of one of the core thermometry inputs available on every Model 346. The inputs are A, B, C1 to C4 and D1 to D4. The mapping of bits to inputs is as follows:

Bit	Bit weighting	Input designator
0	1	A
1	2	B
2	4	C1
3	8	C2
4	16	C3
5	32	C4
6	64	D1
7	128	D2
8	256	D3
9	512	D4

If a bit is set, more questionable status information can be found by issuing the RDGST? query for the input.

STATus:QUEStionable:OPTion

This is a secondary questionable status register. Each bit can be logically ORed together to set the option summary bit (bit 1) in the primary STATus:QUEStionable register.

Each bit is a summary of the questionable status of the input channels of option cards E, F, G, and H. An option card can have at most, 4 channels. Because an input option can contain no more than 4 channels, this 16-bit register contains summary data for each input option card E, F, G, and H.

The meaning of the information depends on the type of input card installed. Presently, there are only two types of input option cards, the 3401 scanner, and the 3402 thermocouple. Similar to the CORE behavior, if a given channel summary bit is set, further details can be found by issuing the RDGST? query for the specific input channel.

The mapping of bits to inputs is as follows:

Bit	Bit weighting	Input channel designator
0	1	Option Card E channel 1
1	2	Option Card E channel 2
2	4	Option Card E channel 3
3	8	Option Card E channel 4
4	16	Option Card F channel 1
5	32	Option Card F channel 2
6	64	Option Card F channel 3
7	128	Option Card F channel 4
8	256	Option Card G channel 1
9	512	Option Card G channel 2
10	1024	Option Card G channel 3
11	2048	Option Card G channel 4
12	4096	Option Card H channel 1
13	8192	Option Card H channel 2
14	16384	Option Card H channel 3
15	32768	Option Card H channel 4

STATus:QUEStionable:OUTput

This is a secondary questionable status register. Each bit can be logically ORed together to set the output summary bit (bit 2) in the primary STATus:QUEStionable register.

Each bit is a summary of the questionable status of each output. Outputs are made up of heater outputs 1 to 4, analog outputs 5 to 8, and heater groups 9 and 10.

The mapping of bits to outputs is as follows:

Bit	Bit Weighting	Output Designator
0	1	Output 1
1	2	Output 2
2	4	Output 3
3	8	Output 4
4	16	Output 5
5	32	Output 6
6	64	Output 7
7	128	Output 8
8	256	Output 9
9	512	Output 10

If a bit is set, more questionable status information can be found by issuing the OUTST? query for the output.

Other status related queries

*CLS Clear Status Command

```
*CLS[term]
```

Parameters

None

Remarks

Clears the bits in the status byte register and the standard event status register, clears the error queue and terminates all pending operations. It does not clear the enable registers. The related controller command is *RST.

RDGST? Input Reading Status Query

```
RDGST? <input>[term]
```

Parameters

Name	Type	Description
input	a	Specifies input to query: A, B, C1, C2, C3, C4, D1, D2, D3, D4, E1, E2, E3, E4, F1, F2, F3, F4, G1, G2, G3, G4, H1, H2, H3, H4

Returns

```
<status bit weighting>[term]
```

The integer returned represents the sum of the bit weighting of the input status flag bits. A `0` response indicates a valid reading is present. This is a non-latching, real-time status of the input.

Bit	Bit weighting	Status indicator
0	1	Hardware settling
2	4	Temperature extrapolated
3	8	Current source in compliance
4	16	Temperature underrange
5	32	Temperature overrange
6	64	Sensor units reading under range
7	128	Sensor units reading over range

Example

Query the status of input A.

```
RDGST? A;33
```

33 = 32 + 1 = temperature overrange + hardware settling

RDGOPR? Input Reading Operation Status Query

```
RDGOPR? <input>[term]
```

Parameters

Name	Type	Description

Returns

```
<status bit weighting>[term]
```

The integer returned represents the sum of the bit weighting

Bit	Bit weighting	Status indicator
0	1	Curve applied to input
1	2	Input reading and settings in Celsius
6	64	Input low alarm active
7	128	Input high alarm active

HTRST? Heater Status Query

```
HTRST? <output> [term]
```

Parameters

Name	Type	Description
output	n	The output to query: 1 to 8

Returns

```
<status bit weighting>[term]
```

Bit	Bit weighting	Status indicator
0	1	Open circuit detected (heater) or overload detected (analog out)
1	2	Short circuit detected (heater)

Remarks

These results do not take into account the continuous time requirement for heater shutdown as laid out in HTRLIM, but instead instantly report when the resistance is exceeded.

OUTOPR? Output Operation Query

```
OUTOPR? <output> [term]
```

Parameters

Name	Type	Description
output	n	The output to query: 1 to 10

Returns

```
<status bit weighting>[term]
```

Bit	Bit Weighting	Status Indicator
1	2	RAMPST? is non-zero
4	16	Output is stabilizing
5	32	Output is stable
6	64	Output is in warmup mode (heaters only)
7	128	Output is warm (heaters only, see WARM command for details)

OUTST? Output Status Query

```
OUTST? <output> [term]
```

Parameters

Name	Type	Description
output	n	The output to query: 1 to 10

Returns

```
<status bit weighting>[term]
```

Bit	Bit weighting	Status indicator
0	1	HTRST? is non-zero
1	2	Output is percentage limited
2	4	Output current source is zeroed to prevent transience while changing ranges

Error Messages

As called out in the SCPI-99 specification, the Model 346 implements an error queue that contains coded error and status messages thrown during operation. SCPI 99 defines error messages with a negative (-) prefix as standard errors, common to all SCPI compliant instruments. Error messages with a positive prefix (+) are allocated to instrument manufacturers for instrument specific messages. Presently, the Model 346 does not implement any instrument specific messages. All Model 346 specific errors and status are captured in the status register system.

Coded error and status messages can be retrieved and cleared over the remote interface using the following commands:

```
SYSTem:ERRor:ALL?
SYSTem:ERRor:CLEar
SYSTem:ERRor:COUNt?
SYSTem:ERRor[:NEXT]?
```

The queue is implemented with a "First In, First Out" (FIFO) approach. This means, if the Model 346 adds multiple messages to the queue in a given period of time, issuing the SYSTem:ERRor[:NEXT]? query will return the message that was added to the queue first, and, subsequently remove it from the queue.

SCPI 99 categorizes its standard errors into logical groups that match bit definitions in the standard event status register. When the Model 346 adds an error message to the queue, a bit in the standard event status register will be set as well. The error code range table shown below lists the error code ranges, title, and the corresponding bit in the standard event status register that gets set when the error or status is added to the queue.

Error code range	Description	Standard event register bit
-100 to -184	Command errors	5
-200 to -294	Execution errors	4
-300 to -365	Device specific errors	3
-400 to -440	Query errors	2

A comprehensive list of standard SCPI error codes descriptions can be found in chapters 21.8.9 through 21.8.16 of the official SCPI 99 standard, located on the IVI website.

Note: The Model 346 does not implement every error code listed in the standard.

5.5.6 Utility Commands

These commands are used to query the Model 346 for various information not covered by the other sections. This includes the SCPI error queue, settings lock, and option card query.

DFLT Factory Defaults Command

```
DFLT <code>[term]
```

Parameters

Name	Type	Description
code	n	Must be 99 to confirm the reset.

Example

`DFLT 99` resets the Model 346 to factory default settings.

Remarks

This process returns all power-cycle persistent settings to their factory default values. This includes PID gains, sensor curve selection, sensor configuration, and option card settings. The process does not affect the instrument's loaded curves or calibration data.

*IDN? Identification Query

```
*IDN? [term]
```

Returns

Returns the instrument identification string in the format:
`<manufacturer>,<model number>,<serial number>,<firmware version>`

Field	Description
<manufacturer>	Manufacturer identification
<model number>	Instrument model number
<serial number>	Instrument serial number
<firmware version>	Instrument firmware version

Example

*IDN? returns the identification string LSCI,MODEL346,LSA1234,1.1.2025102214

*RST Power-On Reset Command

*RST [term]

Example

*RST returns the Model 346 to a power-on state.

Remarks

This command is equivalent to a power cycle of the Model 346 but will not require a restart of the front panel application. Readings may become invalid after this command is issued, so it is recommended to wait at least 5 s for the readings to stabilize before using them again. Note, issuing the command string *RST;*OPC? will not return a response, therefore an open loop delay of 5 s is recommended in client software after issuing the command, before resuming communications.

TST? Self-Test Query

*TST? [term]

Returns

<status>[term]

0 = no errors found, 1 = errors found

SYSTem:KLOCk Settings Lock Command

SYSTem:KLOCk <state>[term]

Parameters

Name	Type	Description
state	n	Valid entries: 0 = Unlocked 1 = Locked

Example

SYSTem:KLOCk 1 locks the front panel settings.

Remarks

When the front panel settings are locked, the front panel will display "Settings Locked" when attempting to edit settings and display a lock icon in the lower left of the home screen.

SYSTem:LOCal GPIB Local Command

SYSTem:LOCal[term]

Parameters

none

Example

`SYSTem:LOCal` sets the GPIB interface to local mode.

Remarks

This method sets the instrument to local mode, returning control to the front panel. However, if a GPIB device is connected, the device may return to the locked state if communications are issued over GPIB.

SYSTem:KLOCk? Settings Lock Query

`SYSTem:KLOCk? [term]`

Returns

`<state>` (see command for description)

CARDS? Option Cards Query

`CARDS? [term]`

Returns

`<E>, <F>, <G>, <H> [term]`

Card ID	Card type
0	Not installed or not responding
1	Scanner card
2	Unpublished
3	Unpublished
4	Thermocouple

Example

CARDS? returns "0, 1, 0, 0" if the Model 346 has nothing in slots E, G, and H, and a scanner in slot F.

SYSTem:ERRor[:NEXT]? Error Queue Next Query

SYSTem:ERRor[:NEXT]? [term]

Returns

<error code>,<error message> [term]

Remarks

Returns the next item from the error queue and removes it from queue. If the queue is empty, the error code is 0 and the error message is "No error".

SYSTem:ERRor:CLEAR Error Queue Clear Command

SYSTem:ERRor:CLEAR [term]

Remarks

Removes all errors from the error queue.

SYSTem:ERRor:COUNt? Error Queue Count Query

SYSTem:ERRor:COUNt? [term]

Returns

<count> [term]

Remarks

Returns the number of unread items in the error queue. If the queue is empty, the response is 0.

SYSTem:ERRor:ALL? Error Queue All Query

```
SYSTem:ERRor:ALL? [term]
```

Returns

```
<error code>,<error message> [term]
```

Example

Query

SYST:ERR:ALL?

Query Response

-113,"Undefined header",221,"Settings conflict",-221,"Data out of range"

Remarks

Queries the error/event queue for all the unread items and removes them from the queue. If there are multiple errors queued, the response returns a comma separated list of code, error message pairs, in FIFO order. If the queue is empty, the error code is 0 and the error message is "No error". If more than 16 errors are recorded, the error queue will overflow and all future errors will be lost and the queue will end with -350,"Queue overflow".

SYSTem:ERRor:STARtup? Error Startup Query

```
SYSTem:ERRor:STARtup? [term]
```

Parameters

none

Returns

<error code> [term]

Remarks

Returns the critical startup error code from the last power-on or reset. If no critical errors occurred during startup, the response is 0. The error code is a bitfield with the following bit definitions:

Bit	Bit weighting	Description
0	1	Main NOVRAM corrupt
1	2	Model ID not communicating
2	4	Revision ID not communicating
3	8	Input NOVRAM corrupt
7	128	Option card C NOVRAM corrupt
8	256	Option card C ID not communicating
9	512	Option card C revision ID not communicating
10	1024	Option card C hardware fault
11	2048	Option card D NOVRAM corrupt
12	4096	Option card D ID not communicating
13	8192	Option card D revision ID not communicating
14	16384	Option card D hardware fault
15	32768	Option card E NOVRAM corrupt
16	65536	Option card E ID not communicating
17	131072	Option card E revision ID not communicating
18	262144	Option card E hardware fault
19	524288	Option card F NOVRAM corrupt
20	1048576	Option card F ID not communicating
21	2097152	Option card F revision ID not communicating
22	4194304	Option card F hardware fault
23	8388608	Option card G NOVRAM corrupt
24	16777216	Option card G ID not communicating
25	33554432	Option card G revision ID not communicating
26	67108864	Option card G hardware fault
27	134217728	Option card H NOVRAM corrupt
28	268435456	Option card H ID not communicating
29	536870912	Option card H revision ID not communicating
30	1073741824	Option card H hardware fault

SYSTem:AUTODATETIME Auto Date/Time Command

```
SYSTem:AUTODATETIME <state>[term]
```

Parameters

Name	Type	Description
state	n	Valid entries: 0 = Disabled 1 = Enabled

Example

`SYSTem:AUTODATETIME 1` enables automatic date and time zone adjustment.

Remarks

When enabled, the instrument will automatically adjust its date and time based on the configured time zone and network time protocols.

SYSTem:AUTODATETIME? Auto Date/Time Query

`SYSTem:AUTODATETIME? [term]`

Returns

`<state>` (see command for description)

SYSTem:TIME Time Setting Command

`SYSTem:TIME <hour>, <minute>, <second>[term]`

Parameters

Name	Type	Description
hour	n	Hour in 24-hour format (0 to 23)
minute	n	Minute (0 to 59)
second	n	Second (0 to 59)

Example

`SYSTem:TIME 14, 30, 45` sets the time to 2:30:45 PM.

Remarks

Time settings will not be accepted if SYSTem:AUTODATETIME is enabled.

SYSTem:TIME? Time Query

`SYSTem:TIME? [term]`

Returns

`<hour>, <minute>, <second>` (see command for description)

Example

`SYSTem:TIME?` returns `14, 30, 45` for 2:30:45 PM.

SYSTem:DATE Date Setting Command

`SYSTem:DATE <year>, <month>, <day>[term]`

Parameters

Name	Type	Description
year	n	Year (2000 to 2100)
month	n	Month (1 to 12)
day	n	Day (1 to 31)

Example

`SYSTem:DATE 2024, 3, 15` sets the date to March 15, 2024.

Remarks

Time settings will not be accepted if SYSTem:AUTODATETIME is enabled.

SYSTem:DATE? Date Query

`SYSTem:DATE? [term]`

Returns

`<year>, <month>, <day>` (see command for description)

Example

`SYSTem:DATE?` returns `2024, 3, 15` for March 15, 2024.

SYSTem:TZONe Time Zone Setting Command

`SYSTem:TZONe <hours>, <minutes>[term]`

Parameters

Name	Type	Description
hours	n	UTC offset in hours (-14 to 14)
minutes	n	UTC offset in minutes (-59 to 59)

Example

SYSTem:TZONe -5, 0 sets the time zone to UTC-5 (Eastern Standard Time).

Remarks

The time zone offset is used for automatic date and time adjustment when SYSTem:AUTODATETIME is enabled.

SYSTem:TZONe? Time Zone Query

SYSTem:TZONe? [term]

Returns

<hours>, <minutes> (see command for description)

Example

SYSTem:TZONe? returns -5, 0 for UTC-5 time zone.

CHAPTER

SIX

OPTIONS AND ACCESSORIES

6.1 General

This chapter provides information on the models, options, and accessories available for the Model 346 temperature controller.

6.2 Models

The list of Model 346 model numbers is provided as follows:

Table 6.1: Model description

Model	Description of Models
346	Standard temperature controller with 10 diode/RTD inputs and 8 control outputs

6.3 Options

Table 6.2: Option description

Model	Description of Options
3401	4 channel RTD / Diode option card
3402	Dual thermocouple option card

6.4 Accessories

Accessories are devices that perform a secondary duty as an aid or refinement to the primary unit. Refer to the Lake Shore Temperature Measurement and Control Catalog for details. Please refer to the Lake Shore website for more information https://www.lakeshore.com/346.

Note: CE / NRTL certifications are pending for Model 346 accessories

6.5 Rack Mounting

The Model 346 can be installed into a 483 mm (19 in) rack mount cabinet using the optional Lake Shore Model RM-1 full-rack mount kit. The kit contains the necessary parts to mount the into mount space, 483 mm (19 in) wide by 88.9 mm (3.5 in) high. See https://www.lakeshore.com/rack-kit/ for full details.

Note: Ensure that there is a 25 mm (1 in) clearance on both sides of the instrument after rack mounting.

6.6 Input Option Card Installation

The field installable option cards add extended input functionality to inputs E to H. Calibration for the options are stored on the card so you can install it in the field and use it with multiple Model 346 temperature controllers without recalibration.

The Model 346 input option cards are field-installable. You will need a small Phillips head screwdriver. Follow this procedure to install an input option card.

WARNING To avoid potentially lethal shocks, turn off the controller and disconnect it from AC power before performing these procedures.

AVERTISSEMENT Pour éviter les chocs potentiellement mortels, éteignez le contrôleur et débranchez-le de l'alimentation secteur avant d'effectuer ces procédures.

CAUTION The components on this board are electrostatic discharge sensitive (ESDS) devices. Follow ESD procedures in the Service section to avoid inducing an electrostatic discharge (ESD) into the device.

ATTENTION Les composants de cette carte sont des dispositifs sensibles aux décharges électrostatiques (ESDS). Suivez les procédures ESD de la section Service pour éviter de provoquer une décharge électrostatique (ESD) dans l'appareil.

1. Turn off the Model 346 power switch. Unplug the power cord from the wall outlet, then from the instrument.
2. Using a #1 Phillips screwdriver, remove the screws from the top panel. Remove the top panel
3. Remove the rear panel cover for the desired option card slot (screws shown in red circles below). Input G is shown in the example below.
4. Slowly and carefully, insert the option card plus bracket into the rear slot loosely. Ensure not to scrape the main board.
5. Attach the ribbon cable to the main board (blue arrow).
6. Orient and secure the option card to the rear panel using the screws from step 3.
7. Re-install the top cover.
8. Replace the power cord in the rear of the unit and set the power switch to On.
9. To verify option card installation, tap I/O from then navigation panel, then navigate to the Input summary page. Scroll down and verify the input cards are displayed for the slot you installed the option card in. For example, if you installed a 3401 card in slot G, verify that cards Input G1, Input G2, Input G3 and Input G4 are displayed.

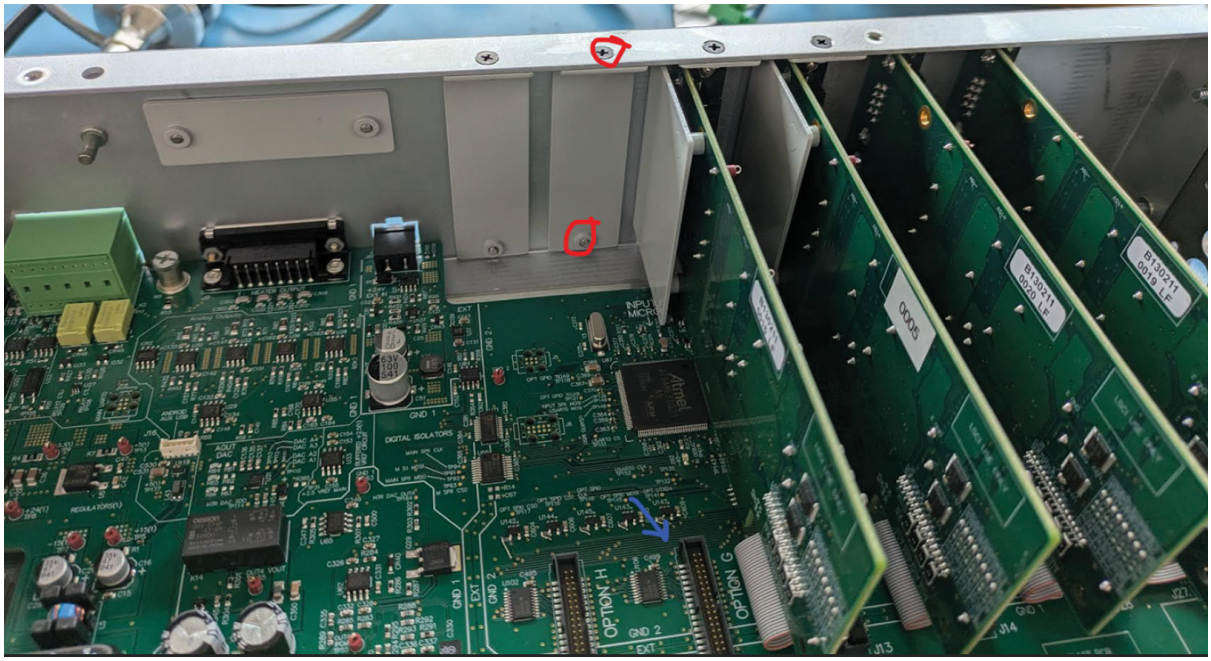


Figure 6.1: Option card slots

CHAPTER

SEVEN

SERVICE

7.1 General

This chapter provides basic service information for the Model 346 temperature controller. Customer service of the product is limited to the information presented in this chapter. Factory trained service personnel should be consulted if the instrument requires repair.

7.2 USB Troubleshooting

This section provides USB interface troubleshooting for issues that arise with new installations, existing installations, and intermittent lockups.

7.2.1 New installation

1. Check that the USB driver is installed properly and that the device is functioning. In Microsoft Windows®, the device status can be checked using Device Manager by right-clicking Lake Shore Model 346 Temperature Controller under Ports (COM & LPT) or Other Devices and then clicking Properties.
2. Check that the correct com port is being used. In Microsoft Windows®, the com port number can be checked using Device Manager under Ports (COM & LPT).
3. Check that the correct settings are being used for communication.
4. Check cable connections and length.
5. Send the message terminator.
6. Send the entire message string at one time including the terminator. (Many terminal emulation programs do not.)
7. Send only one simple command at a time until communication is established.
8. Be sure to spell commands correctly and use proper syntax.

7.2.2 Existing installation no longer working

1. Power the instrument off, then on again to see if it is a soft failure.
2. Power the computer off, then on again to see if communication port is locked up.
3. Check all cable connections.
4. Check that the com port assignment has not been changed. In Microsoft Windows®, the com port number can be checked using Device Manager under Ports (COM & LPT).
5. Check that the USB driver is installed properly and that the device is functioning. In Microsoft Windows®, the device status can be checked using Device Manager by right-clicking Lake Shore Model 346 Temperature Controller under Ports (COM & LPT) or Other Devices and then clicking Properties.

7.2.3 Intermittent lockups

1. Check cable connections and length.
2. Increase the delay between all commands to 100 ms to make sure the instrument is not being overloaded. If possible, append *OPC? to the end of a command string It is highly recommended to append the Operation Complete Query (*OPC?) to the end of any given command string. The operation complete query is a SCPI mandated IEEE 488.2 query that will cause the instrument to send a "1" back to the user program when all commands have been processed. This scheme closes the timing loop and provides the proper balance for a user program to maximize command throughput yet not risk overrunning the instrument SCPI buffer. *OPC? can be appended onto a single command or a chained SCPI message.
3. Ensure that the USB cable is not unplugged and that the Model 346 is not powered down while the com port is open. The USB driver creates a com port when the USB connection is detected, and removes the com port when the USB connection is no longer detected. Removing the com port while in use by software can cause the software to lock up or crash.

7.3 Calibration Information

Instrument calibration can be obtained through Lake Shore Support. Refer to the Technical Inquiries section for contact information.

The Model 346 contains calibration constants, programmed into the instrument during assembly and test, that are stored in non-volatile memory (NOVRAM) in various printed circuit boards (PCBs) within the instrument. These memories are checked on power up,

and if the calibration state is determined to be invalid on any of the PCBs, the instrument will display a warning message on the front panel.

In these cases, the instrument cannot be guaranteed to be within published specifications. The user is allowed to continue operation of the Model 346, despite it being out of calibration.

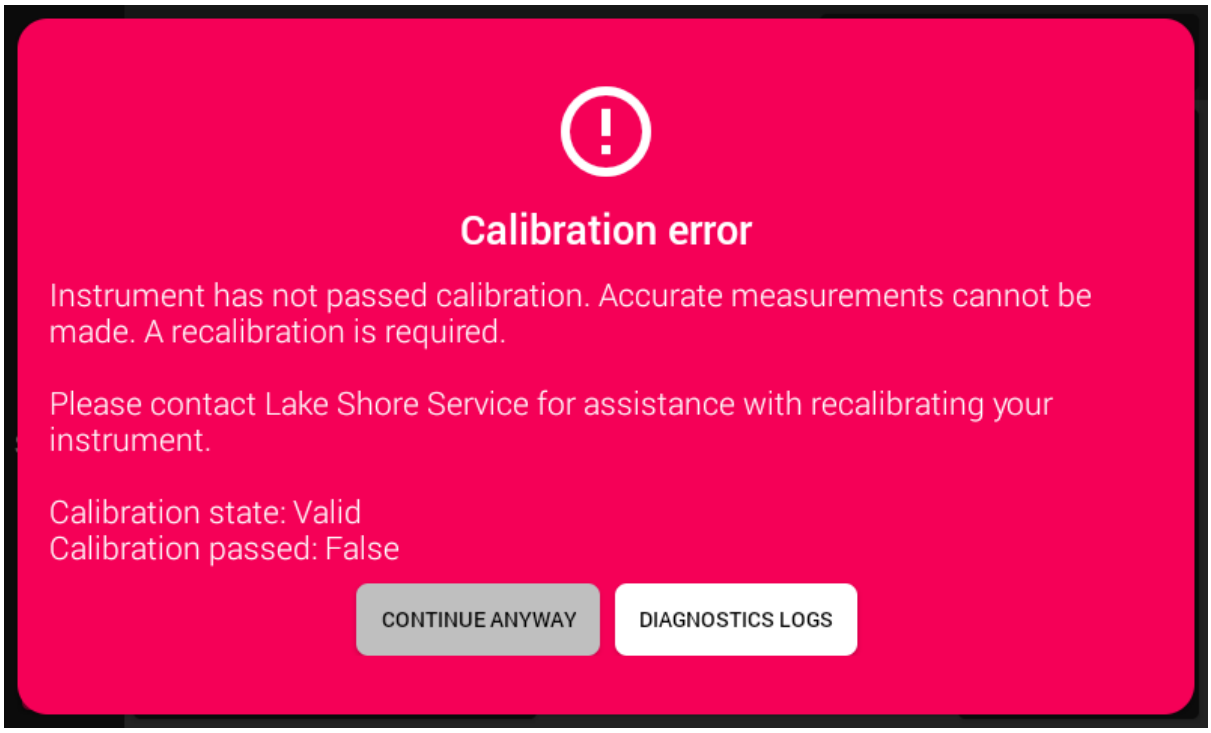


Figure 7.1: Calibration error screen

7.4 Rear Panel Connectors

The connectors on the rear panel of the Model 346 are defined below.

7.4.1 Diode / Resistor Sensor Inputs (includes 3401 option card)

Sensor Inputs A through D are DE-9 style connectors. There are two sensor inputs per connector. The diagram on the left (labeled SENSOR INPUTS) shows the general sensor pin grouping per DE-9 connector. Pins 8,9,4,5 belong to one input, and pins 6,7,1,2 belong to the other input. You can use either the C1 to C4 or D1 to D4 pin outs to determine 3401 sensor wiring.

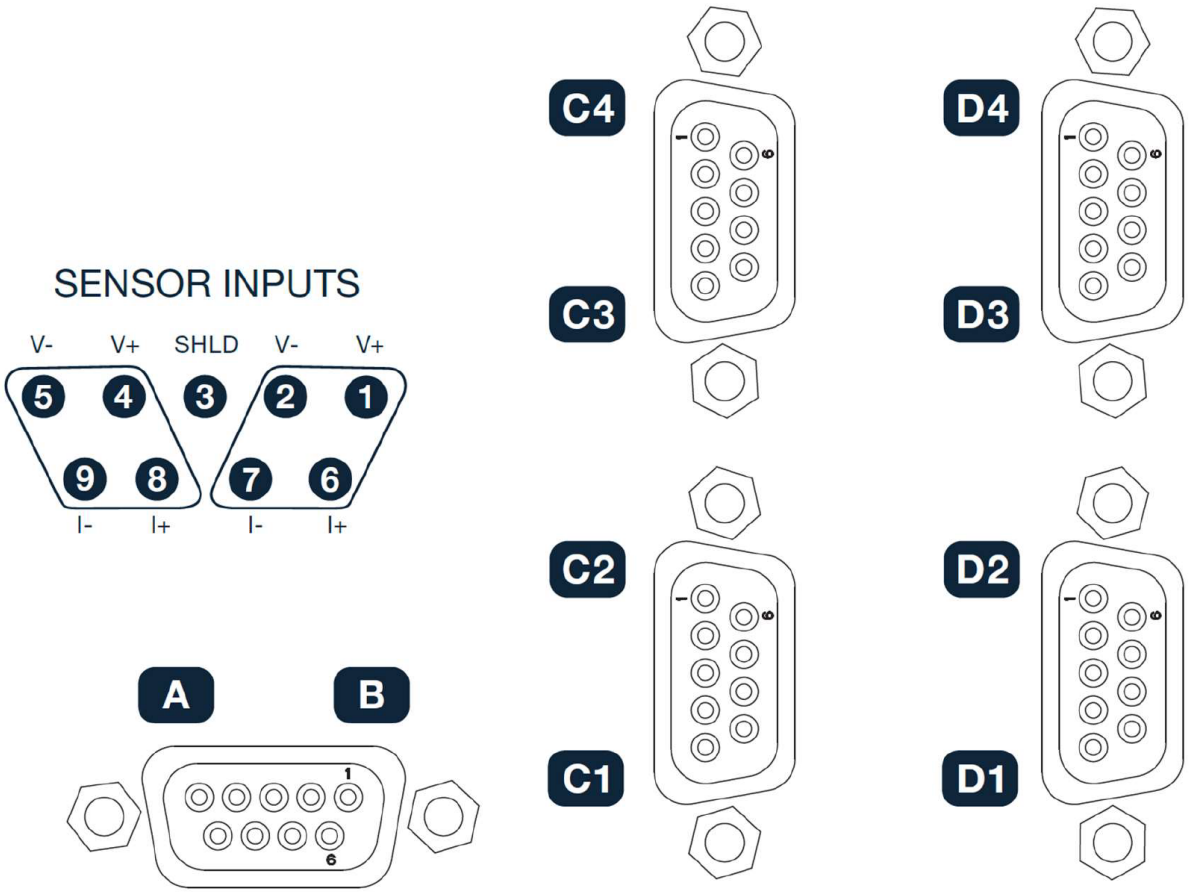


Figure 7.2: Diode / Resistor Sensor Inputs

Pin	Inputs	Sym-bol	Description
8	A, C1, C3, D1, D3	I+	+ current out
9		I-	- current out
4		V+	+ voltage in
5		V-	- voltage in
6	B, C2, C4, D2, D4	I+	+ current out
7		I-	- current out
1		V+	+ voltage in
2		V-	- voltage in
3	n/a	shield	Sensor measurement common (isolated from chassis)

7.4.2 Heater Output

A 15-pin DA-15 style connector is used for the heater outputs. Each heater return is at the same potential as chassis/earth ground. The compliance voltage of each heater output is 50 V minimum, but can reach as high as approximately 53 V, if the heater resistance is higher than the nominal setting. The maximum current that can be sourced from each heater output is approximately 2 A.

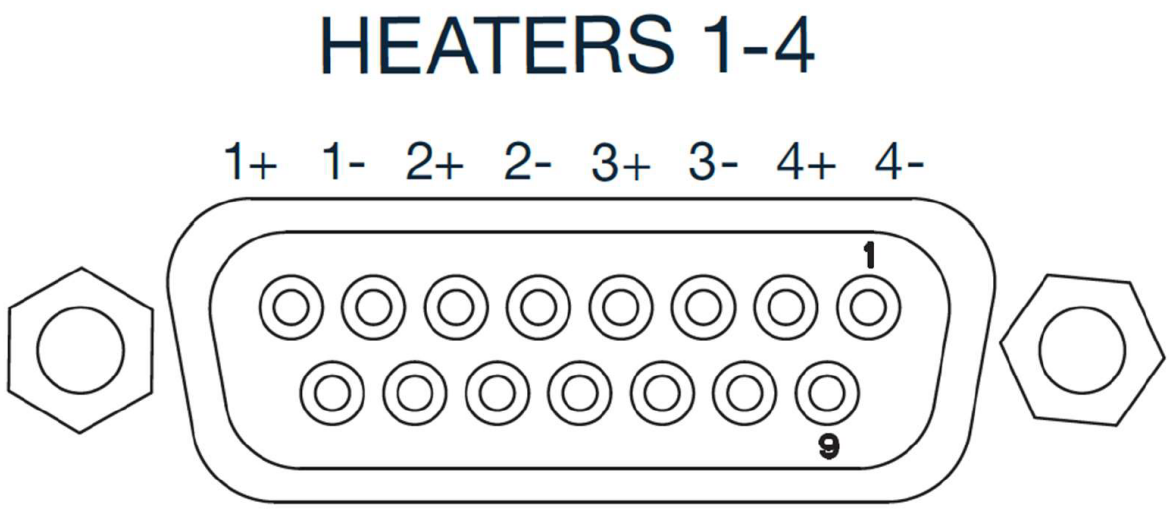


Figure 7.3: Heater Output

Pin	Description
8	Heater 1 HI
7	Heater 1 LO
6	Heater 2 HI
5	Heater 2 LO
4	Heater 3 HI
3	Heater 3 LO
2	Heater 4 HI
1	Heater 4 LO
10, 12, 14	Additional chassis/earth ground connections
9, 11, 13, 15	No connect

7.4.3 Digital In / relays / Analog out

A 2 level, 20 pin, 2.5mm terminal block allows access to the following:

Name	Description
Analog Out / 1W heaters	Identifiable as 'outputs 5-8', these outputs are 0 to +10V voltage sources, capable of sourcing up to 100mA, at 10V, into a 100Ohm load.
Relays	Two relays, each with a normally open, normally closed, and common terminal. Contact rating of 30VDC at 2A.
Digital Input	Optically isolated inputs that have a safe input voltage range of -5V to +35V, with a max low level input voltage of 1V and a minimum high level input voltage of 4V
5V supply	Isolated +5V supply (100mA max). As an example, it can be used with a relay to drive high impedance digital inputs used for process control in a system.

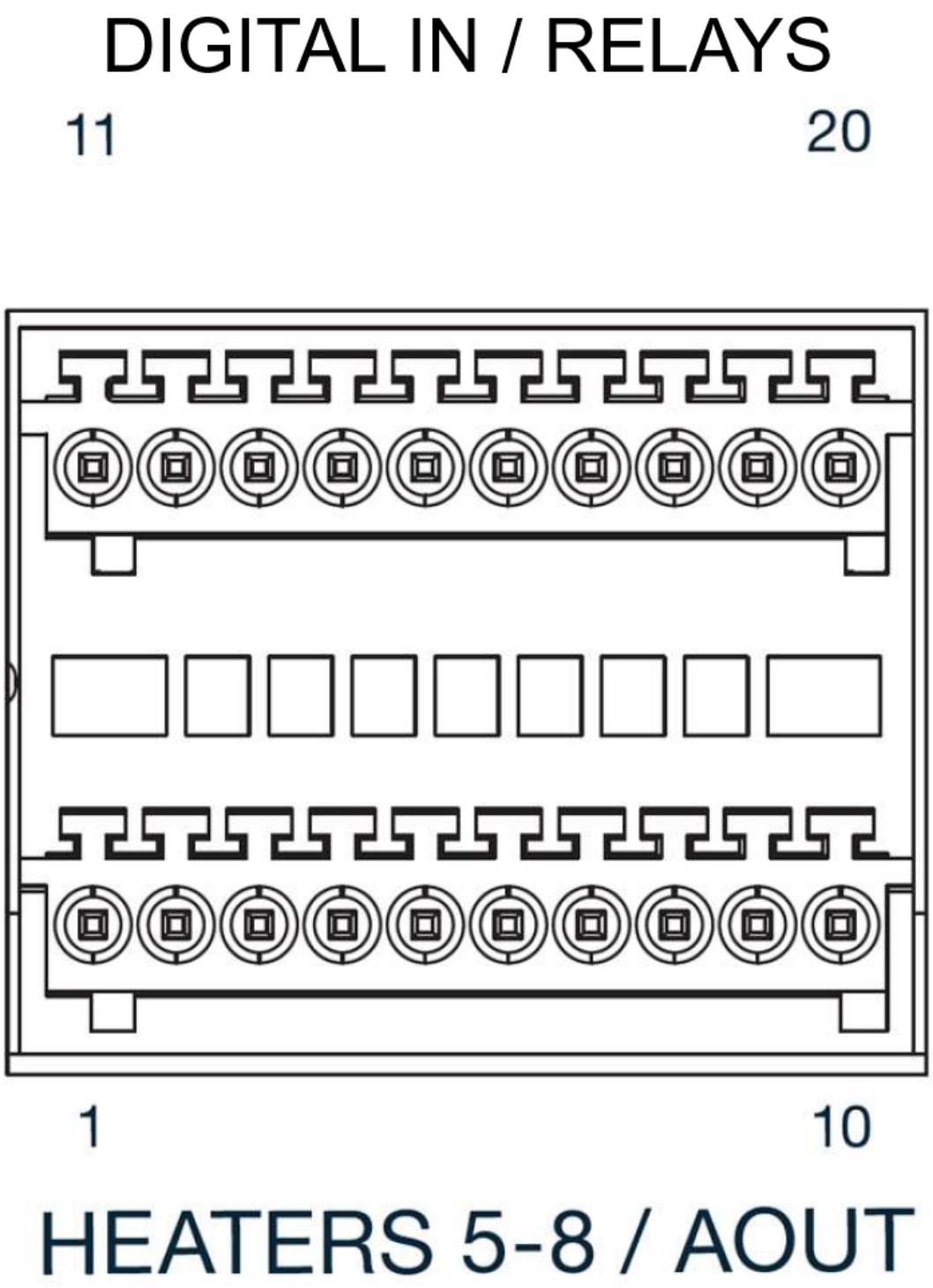


Figure 7.4: Digital In / relays / Analog out

Pin	Description
1	Analog Out 1 +
2	Analog Out 1 -
3	Analog Out 2 +
4	Analog Out 2 -
5	Analog Out 3 +
6	Analog Out 3 -
7	Analog Out 4 +
8	Analog Out 4 +
9	+5V isolated supply
10	+5V isolated supply return
11	Relay 1 normally closed
12	Relay 1 common
13	Relay 1 normally open
14	Relay 2 normally closed
15	Relay 2 common
16	Relay 2 normally open
17	Digital Input 1 +
18	Digital Input 1 -
19	Digital Input 2 +
20	Digital Input 2 -

7.4.4 24VDC Auxiliary Power

A 0.2 in (5.08 mm) 2-pin terminal block allows user-provided 24 VDC to be supplied to the Model 346 to provide auxiliary power to possible future option cards that may require it. The return of this external 24 VDC is connected to the Model 346 chassis ground.

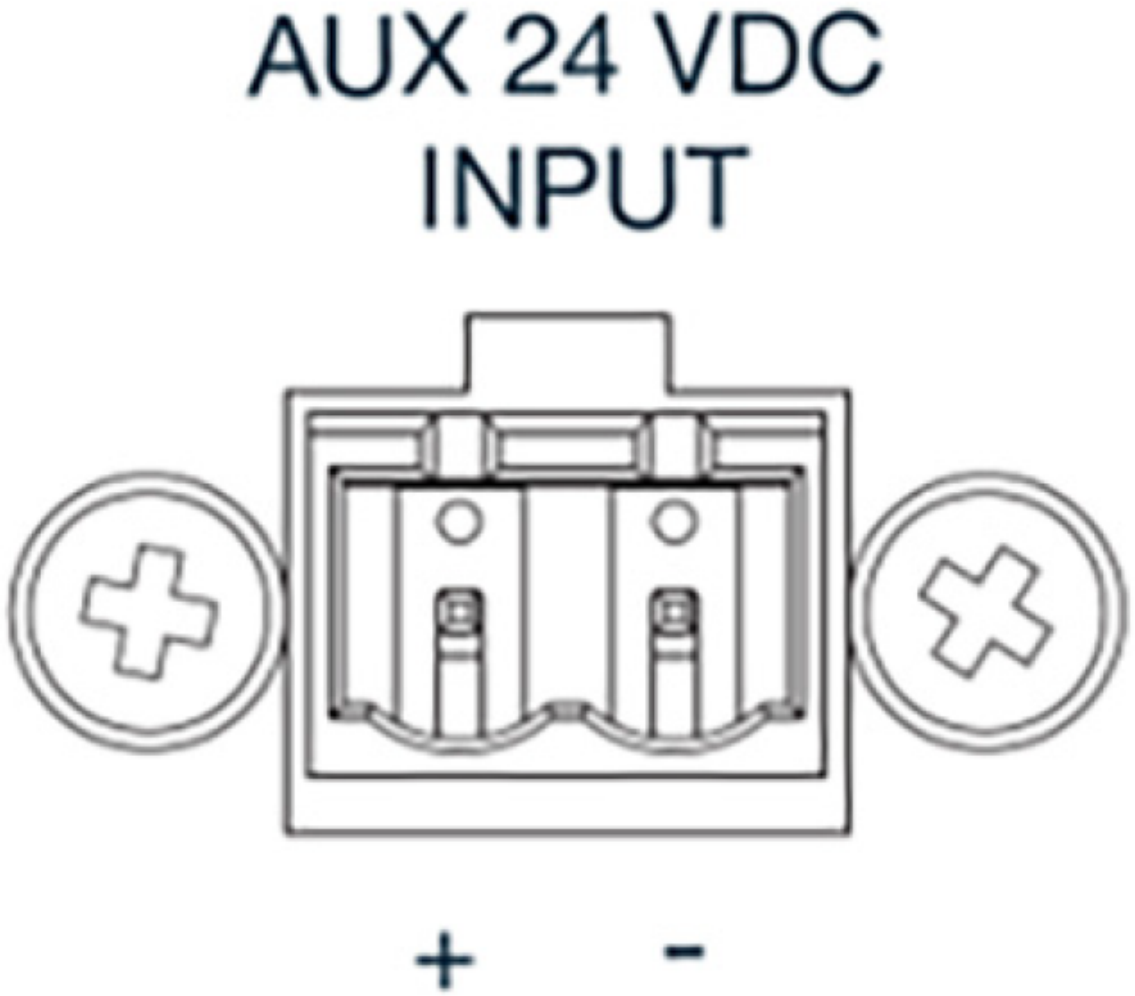


Figure 7.5: AUX 24 VDC Input

7.4.5 USB B Connector

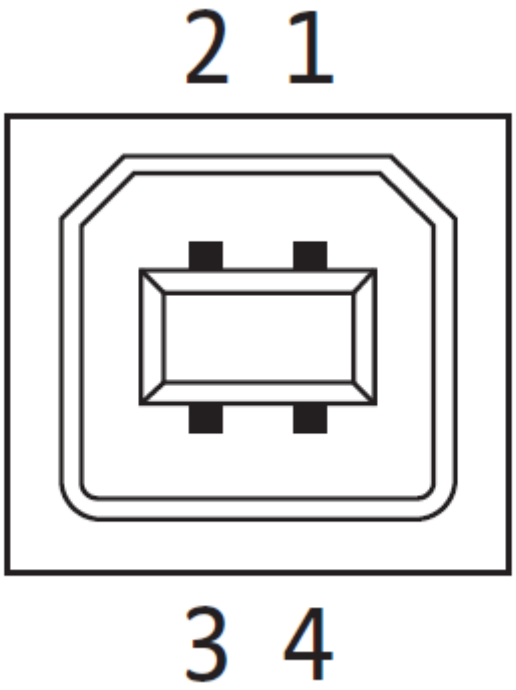


Figure 7.6: USB pin and connector

Pin	Name	Description
1	VCC	+5 VDC
2	D-	Data –
3	D+	Data +
4	GND	Ground

7.4.6 Ethernet Connector

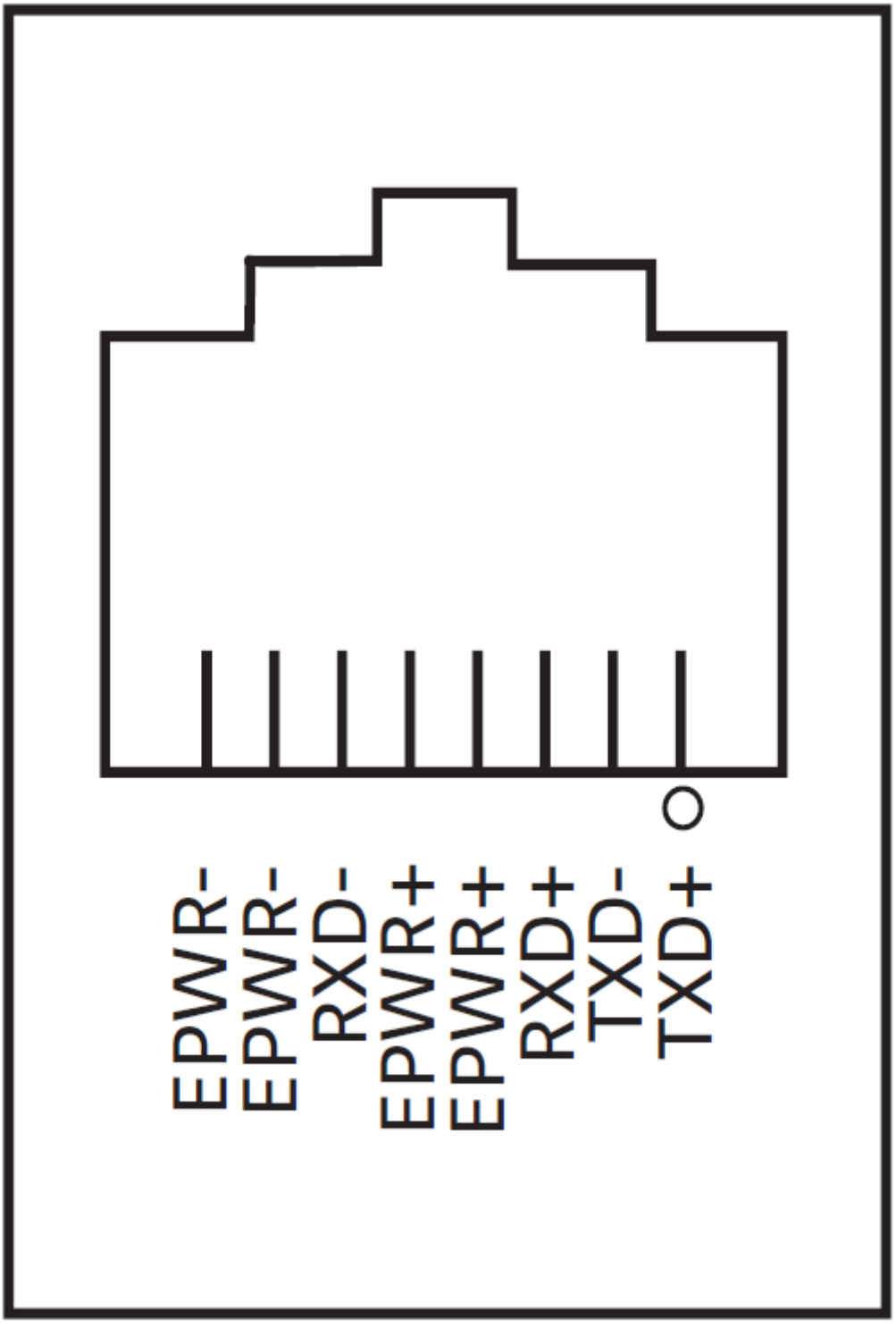


Figure 7.7: Ethernet pin and connector

Pin	Symbol	Description
1	TXD+	Transmit data+
2	TXD-	Transmit data-
3	RXD+	Receive data+
4	EPWR+	Power from switch+ (not used)
5	EPWR+	Power from switch+ (not used)
6	RXD-	Receive data-
7	EPWR-	Power from switch- (not used)
8	EPWR-	Power from switch- (not used)

7.4.7 IEEE-4888 Interface Connector (optional)

Use the cables specified in the IEEE-488 standard. The cable has 24 conductors with an outer shield. The connectors are 24-way Amphenol 57 Series (or equivalent) with piggyback receptacles to allow daisy chaining in multiple device systems.

The total length of cable allowed in a system is 2 m for each device on the bus, or 20 m maximum. The Model 346 can drive a bus of up to 10 devices. The figure below shows the IEEE-488 interface connector pin location and signal names as viewed from the Model 346 rear panel.

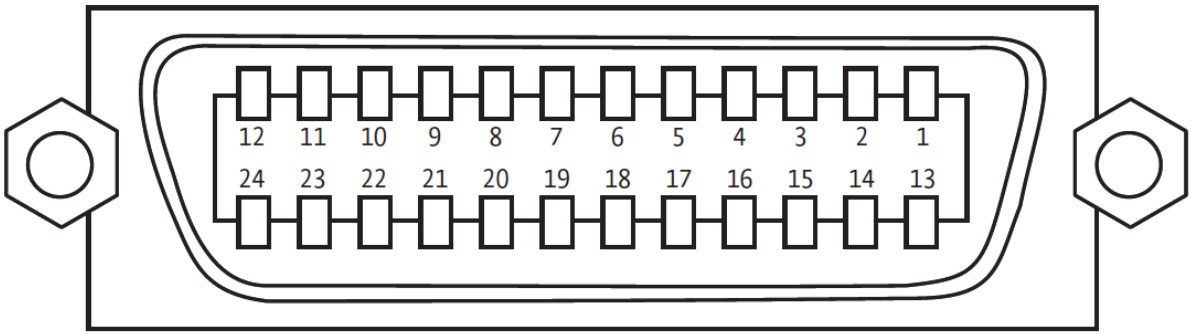


Figure 7.8: IEEE-488 interface

Pin	Symbol	Description
1	DIO 1	Data input/output line 1
2	DIO 2	Data input/output line 2
3	DIO 3	Data input/output line 3
4	DIO 4	Data input/output line 4
5	EOI	End or identify
6	DAV	Data valid
7	NRFD	Not ready for data
8	NDAC	No data accepted
9	IFC	Interface clear
10	SRQ	Service request
11	ATN	Attention
12	SHIELD	Cable shield
13	DIO 5	Data input/output line 5
14	DIO 6	Data input/output line 6
15	DIO 7	Data input/output line 7
16	DIO 8	Data input/output line 8
17	REN	Remote enable
18	GND 6	Ground wire—twisted pair with DAV
19	GND 7	Ground wire—twisted pair with NRFD
20	GND 8	Ground wire—twisted pair with NDAC
21	GND 9	Ground wire—twisted pair with IFC
22	GND 10	Ground wire—twisted pair with SRQ
23	GND 11	Ground wire—twisted pair with ATN
24	GND	Logic ground

7.5 Error Messages

The following are warning and error messages that may be displayed by the Model 346 during operation.

Message	Description
DISABLED	Input is disabled. Refer to Input Setup section.
NO CURVE	Input has no curve assigned. Refer to Input Setup section.
S.OVER	Input is at or over full-scale sensor units.
S.UNDER	Input is at or under negative full-scale sensor units.
T.OVER	Input at or over the high end of the curve.
T.UNDER	Input at or under the low end of the curve.
Input microprocessor communication stopped	The main microprocessor has lost communication with the sensor input microprocessor.
NOVRAM Corrupt	Invalid data or contents in NOVRAM—when this message appears, instrument settings have been reset to default.
All outputs disabled due Sensor X surpassing TLIMIT	The temperature reading on a sensor input has exceeded the Temperature Limit setting. A detailed message will follow, which includes a reference to which sensor input's temperature limit has been exceeded.
Heater X disabled due to load out of range	A short or open circuit condition has been observed on 1 of the heater outputs. A detailed message will follow, which includes a reference to which output caused the condition. The output will be turned off when this occurs.
Output X set to closed loop due to zone error	A zone was entered into where the assocated input did not have a curve attached.
Closed loop control on Output X has been halted	• The input used for closed loop control had a questionable reading. • There is no input assocated with the output. • An attempt was made to control with a disabled output. • The units changed on the input due to a curve no longer being applied, for example
Output on group X has been halted.	A heater group that is actively controlling has a new physical heater added to it.

7.6 Firmware Updates

7.6.1 Overview

The Model 346 can update its firmware manually by attaching a USB Type-C™ stick to the rear panel, or by downloading and installing updates from Lake Shore with a Model 346 source connected to the internet.

Model 346 firmware comprises many files, aggregated together to form a Lake Shore Firmware (LSFW) package. The Model 346 stores versions of its LSFW packages in its internal memory. This local memory location is called the "local repository". This allows you to downgrade firmware should you choose, since older versions will still remain on the Model 346 in the local repository. In addition, Lake Shore maintains LSFW packages on a network server that allows us to deploy those packages to all Model 346 customers. This is called the "remote repository".

Firmware update information can be found via the Model 346 front panel by tapping the **Settings** button, then tapping the **Updates** button. If a valid internet connection is present, the Model 346 will automatically check the remote repository for updates and display information about the latest available firmware.

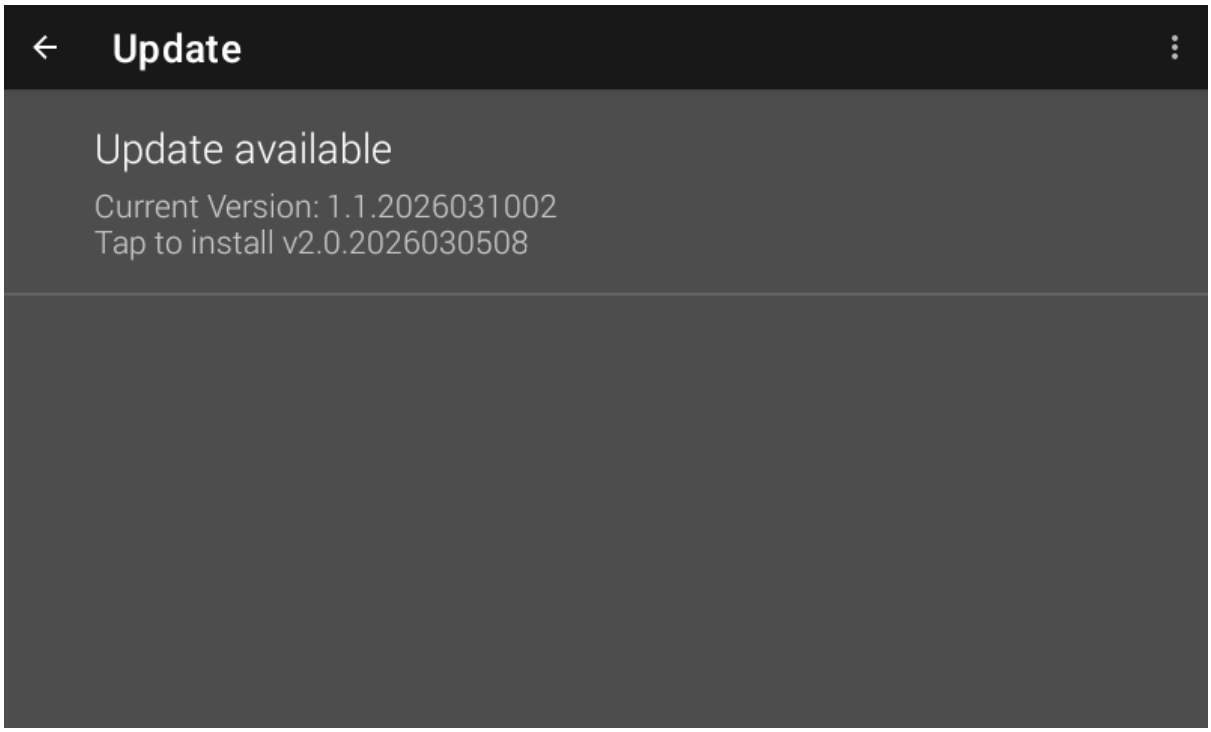


Figure 7.9: Firmware updates: notification

If the Model 346 notifies you that a firmware update is available, tap **Update available**. You'll then be presented with a notification, prompting you to install. Click Install and follow the on screen instructions.

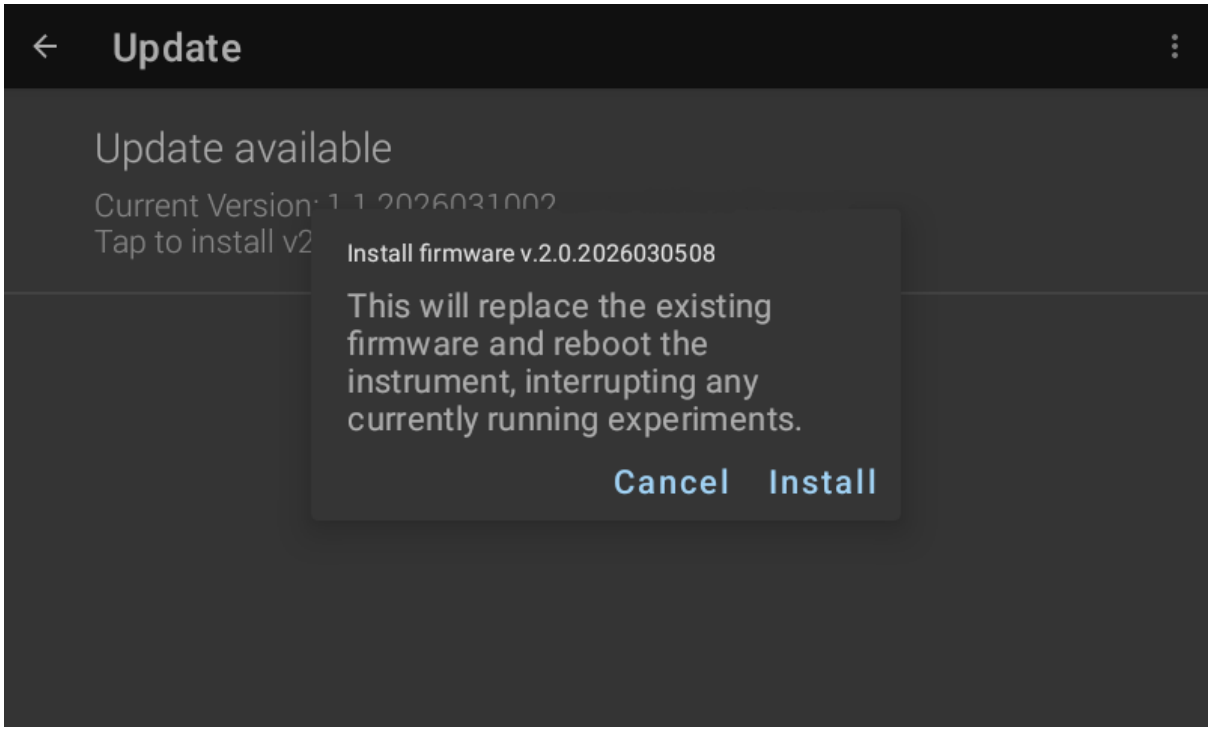


Figure 7.10: Firmware update

7.6.2 Manual Update Procedure using USB Type-C™

The Model 346 firmware can be downloaded from the Lake Shore website and manually installed on the Model 346 using a USB Type-C™ stick:

1. To download the firmware, go to the Downloads tab at https://www.lakeshore.com/346/, then, under the "Software/Firmware" section, select "346 firmware update"
2. Insert the USB stick into your computer and copy the downloaded Model 346 LSFW package to the root directory of the USB stick.
3. Remove the stick from the computer and insert it into the USB Type-C™ port of the Model 346.
4. On the Model 346 front panel by tap the **Settings** button, then tap the **Updates** button.
5. Tap **Update available** and follow the on-screen instructions to update the firmware.

Note: A FAT-32 formatted USB stick is required for this procedure.

7.7 Electrostatic Discharge

Electrostatic Discharge (ESD) may damage electronic parts, assemblies, and equipment. ESD is a transfer of electrostatic charge between bodies at different electrostatic potentials caused by direct contact or induced by an electrostatic field. The human body is the most common cause of damage to electrostatic discharge (ESD) sensitive devices. Simply walking across a carpet in low humidity may generate up to 35,000 V of static electricity.

Modern electronics are increasingly sensitive to ESD. Even a few hundred volts can damage components during testing, handling, repair, or assembly. Discharges below 4,000 V are imperceptible but still hazardous.

7.7.1 Identification of Electrostatic Discharge Sensitive Components

The following are various industry symbols used to label components as ESD sensitive.

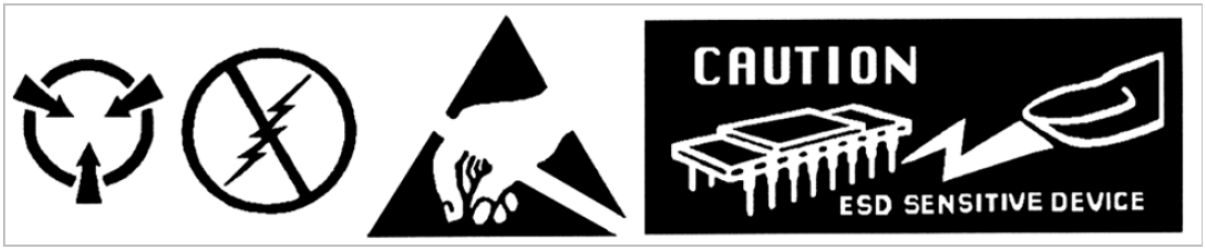


Figure 7.11: Symbols indicating ESD sensitivity

7.7.2 Handling Electrostatic Discharge Sensitive Components

Observe all precautions necessary to prevent damage to ESDS components before attempting installation. Bring the device and everything that contacts it to ground potential by providing a conductive surface and discharge paths. As a minimum, observe these precautions:

- De-energize or disconnect all power and signal sources and loads used with unit.
- Place the unit on a grounded conductive work surface.
- The technician should be grounded through a conductive wrist strap (or other device) using 1 M series resistor to protect operator.
- Ground any tools, such as soldering equipment, that will contact the unit. Contact with the operator's hands provides a sufficient ground for tools that are otherwise electrically isolated.

- Place ESD sensitive devices and assemblies removed from a unit on a conductive work surface or in a conductive container. An operator inserting or removing a device or assembly from a container must maintain contact with a conductive portion of the container. Use only plastic bags approved for storage of ESD material.
- Do not handle ESD sensitive devices unnecessarily or remove them from the packages until they are actually used or tested.

7.8 Summary of Internal Memory Devices

This section outlines the internal memory devices used inside the Model 346 and provides an explanation of the types of data they contain.

Table 7.1: Internal memory devices

Part	Location	Function	Volatility	Field-modifiable
Microchip ATSAME70Q21A Microprocessor	Main U12	Microprocessor code	Non-volatile	No
Microchip ATSAME70Q21A Microprocessor	Main U67	Microprocessor code	Non-volatile	No
Cypress FM24V10 1 Mbit serial F-RAM	Main U12	Calibration, settings	Non-volatile	Yes
Cypress FM24V10 1 Mbit serial F-RAM	Main U16	Calibration, settings	Non-volatile	Yes
Cypress FM24V10 1 Mbit serial F-RAM	Scanner U18	Calibration, settings	Non-volatile	Yes
Cypress FM24V10 1 Mbit serial F-RAM	Thermocouple U18	Calibration, settings	Non-volatile	Yes
Kingston EMMC16G-TB29-PZ90 16 GB eMMC Flash	Digital U6	Operating system, firmware repository, app service, and instrument settings	Non-volatile	Yes
Micron 557-MT53E1G32D2FW 4 GB DDR4 SRAM	Digital U2	Run-time data storage	Volatile	No

1. The Atmel/Microchip ATSAME70Q21A is a microprocessor with 2048 KB of onboard programmable flash memory. The code is loaded by initiating a firmware update over the remote interface.
2. The Cypress FM24V10 is a 128 KB I2C FRAM. It is used to store calibration constants, instrumentation settings. The memory is programmed at Lake Shore and is modified when changing user settings.
3. The Kingston EMMC16G-TB29-PZ90 is a 16 GB eMMC flash memory used to store the instrument operating system. It also contains the local firmware repository and app service, and system level settings like network configuration and date, time, volume and brightness.

4. The Micron 557-MT53E1G32D2FW is a 4 GB DDR4 SRAM. This memory is used by the operating system and applications during runtime as temporary data storage. Data is lost on a power cycle.

7.9 Technical Inquiries

Refer to the following sections when contacting Lake Shore for application assistance or product service. Questions regarding product applications, price, availability and shipments should be directed to sales. Questions regarding instrument calibration or repair should be directed to instrument service. Do not return a product to Lake Shore without a Return Material Authorization (RMA) number.

7.9.1 Contacting Lake Shore

The Lake Shore Service Department is staffed Monday through Friday between the hours of 8:00 AM and 5:00 PM EST, excluding holidays and company shut down days.

The Lake Shore Forum is also a great place to look for solutions, to post issues, and to share successes: forums.lakeshore.com.

Contact Lake Shore Service through any of the means listed below. However, the most direct and efficient means of contacting is to complete the online service request form at www.lakeshore.com/service. Provide a detailed description of the problem and the required contact information. You will receive a response within 24 hours or the next business day in the event of weekends or holidays.

If you wish to contact Service or Sales, use the following:

Lake Shore Cryotronics, Inc.
575 McCorkle Blvd.
Westerville, Ohio
43082-8888 USA

Sales

sales@lakeshore.com
Telephone: (614) 891-2244
Fax: (614) 818-1600

Service

www.lakeshore.com/service
support@lakeshore.com
Telephone: (614) 891-2243, option 4
Fax: (614) 818-1609

7.9.2 Return of Equipment

The Model 346 is packaged to protect it during shipment.

Note: The user should retain any shipping carton(s) in which equipment is originally received, in the event that any equipment needs to be returned.

If the original packaging is not available, a minimum of 76.2 mm (3 in) of shock absorbent packing material should be placed snugly on all sides of the instrument in a sturdy corrugated cardboard box. Please use reasonable care when removing the product from its protective packaging and inspect it carefully for damage. If it shows any sign of damage, please file a claim with the carrier immediately. Do not destroy the shipping container; it will be required by the carrier as evidence to support claims. Call Lake Shore for return and repair instructions.

All equipment returns must be approved by a member of the Lake Shore Service Department. The service engineer will use the information provided in the service request form and will issue an RMA. This number is necessary for all returned equipment. It must be clearly indicated on both the shipping carton(s) and any correspondence relating to the shipment. Once the RMA has been approved, you will receive appropriate documents and instructions for shipping the equipment to Lake Shore.

RMA Valid Period

RMAs are valid for 60 days from issuance; however, we suggest that equipment needing repair be shipped to Lake Shore within 30 days after the RMA has been issued. You will be contacted if we do not receive the equipment within 30 days after the RMA is issued. The RMA will be cancelled if we do not receive the equipment after 60 days.

Shipping Charges

All shipments to Lake Shore are to be made prepaid by the customer. Equipment serviced under warranty will be returned prepaid by Lake Shore. Equipment serviced out-of-warranty will be returned FOB Lake Shore.

Restocking Fee

Lake Shore reserves the right to charge a restocking fee for items returned for exchange or reimbursement.