

ARTISAN®
TECHNOLOGY GROUP

Your **definitive** source for quality pre-owned equipment.

Artisan Technology Group
(217) 352-9330 | sales@artisantg.com | artisantg.com

Full-service, independent repair center
with experienced engineers and technicians on staff.

We buy your excess, underutilized, and idle equipment
along with credit for buybacks and trade-ins.

Custom engineering
so your equipment works exactly as you specify.

- Critical and expedited services
- In stock / Ready-to-ship
- Leasing / Rentals / Demos
- ITAR-certified secure asset solutions

Expert team | Trust guarantee | 100% satisfaction

All trademarks, brand names, and brands appearing herein are the property of their respective owners.

Visit our website - *Click HERE*

KEITHLEY INSTRUMENTS

Model 7057A
Thermocouple Scanner Card
Instruction Manual

Contains Operating and Servicing Information

Publication Date: January 1992
Document Number: 7057A-901-01 Rev. D

WARRANTY

Keithley Instruments, Inc. warrants this product to be free from defects in material and workmanship for a period of 1 year from date of shipment.

Keithley Instruments, Inc. warrants the following items for 90 days from the date of shipment: probes, cables, rechargeable batteries, diskettes, and documentation.

During the warranty period, we will, at our option, either repair or replace any product that proves to be defective.

To exercise this warranty, write or call your local Keithley representative, or contact Keithley headquarters in Cleveland, Ohio. You will be given prompt assistance and return instructions. Send the product, transportation prepaid, to the indicated service facility. Repairs will be made and the product returned, transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days.

LIMITATION OF WARRANTY

This warranty does not apply to defects resulting from product modification without Keithley's express written consent, or misuse of any product or part. This warranty also does not apply to fuses, software, non-rechargeable batteries, damage from battery leakage, or problems arising from normal wear or failure to follow instructions.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE. THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES.

NEITHER KEITHLEY INSTRUMENTS, INC. NOR ANY OF ITS EMPLOYEES SHALL BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OF ITS INSTRUMENTS AND SOFTWARE EVEN IF KEITHLEY INSTRUMENTS, INC., HAS BEEN ADVISED IN ADVANCE OF THE POSSIBILITY OF SUCH DAMAGES. SUCH EXCLUDED DAMAGES SHALL INCLUDE, BUT ARE NOT LIMITED TO: COSTS OF REMOVAL AND INSTALLATION, LOSSES SUSTAINED AS THE RESULT OF INJURY TO ANY PERSON, OR DAMAGE TO PROPERTY.

KEITHLEY INSTRUMENTS

Instruments Division, Keithley Instruments, Inc. • 28775 Aurora Road • Cleveland, Ohio 44139 • (216) 248-0400 • Fax: (216) 248-6168

AUSTRIA:	Keithley Instruments GesmbH • Rosenhugelstrasse 12 • A-1120 Wien • 0222-804-6548 • Fax: 0222-804-3597
FRANCE:	Keithley Instruments SARL • 3 Allee des Garays • B.P. 60 • 91121 Palaiseau Cedex • 01-60-11-51-55 • Fax: 01-60-11-77-26
GERMANY:	Keithley Instruments GmbH • Landsberger Str. 65 • D-8034 Germering • 089-849307-0 • Fax: 089-84930759
GREAT BRITAIN:	Keithley Instruments, Ltd. • The Minster • 58 Portman Road • Reading, Berkshire RG3 1EA • 0734-575666 • Fax: 0734-596469
ITALY:	Keithley Instruments SRL • Viale S. Gimignano 38 • 20146 Milano • 02-48303008 • Fax: 02-48302274
JAPAN:	Keithley Instruments Far East KK • Sumiyoshi 24 Bldg., Room 201 • 2-24-2 Sumiyoshi-Cho • Naka-Ku, Yohohama 231 • 81-45-201-2246 • Fax: 81-45-201-2247
NETHERLANDS:	Keithley Instruments BV • Avelingen West 49 • 4202 MS Gorinchem • Postbus 559 • 4200 AN Gorinchem • 01830-35333 • Fax: 01830-30821
SWITZERLAND:	Keithley Instruments SA • Kriesbachstrasse 4 • 8600 Dubendorf • 01-821-9444 • Fax: 01-820-3081
TAIWAN:	Keithley Instruments Taiwan • Room 1105, 11th Floor, No. 147 • Section 2, Chien Kuo North Road • Taipei, Taiwan R.O.C. • 886-2-509-4465 • Fax: 886-2-509-4473

Safety Precautions

The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read the operating information carefully before using the product.

The types of product users are:

Responsible body is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

Operators use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

Maintenance personnel perform routine procedures on the product to keep it operating, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the manual. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

Service personnel are trained to work on live circuits, and perform safe installations and repairs of products. Only properly trained service personnel may perform installation and service procedures.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60VDC are present. **A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.**

Users of this product must be protected from electric shock at all times. The responsible body must ensure that users are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product users in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000 volts, **no conductive part of the circuit may be exposed.**

As described in the International Electrotechnical Commission (IEC) Standard IEC 664, digital multimeter measuring circuits (e.g., Keithley Models 175A, 199, 2000, 2001, 2002, and 2010) are Installation Category II. All other instruments' signal terminals are Installation Category I and must not be connected to mains.

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or

removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

The instrument and accessories must be used in accordance with its specifications and operating instructions or the safety of the equipment may be impaired.

Do not exceed the maximum signal levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument or test fixture panels, or switching card.

When fuses are used in a product, replace with same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth ground connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

If a ⏚ screw is present, connect it to safety earth ground using the wire recommended in the user documentation.

The ⚠ symbol on an instrument indicates that the user should refer to the operating instructions located in the manual.

The ⚠ symbol on an instrument shows that it can source or measure 1000 volts or more, including the combined effect of normal and common mode voltages. Use standard safety precautions to avoid personal contact with these voltages.

The **WARNING** heading in a manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading in a manual explains hazards that could damage the instrument. Such damage may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits, including the power transformer, test leads, and input jacks, must be purchased from Keithley Instruments. Standard fuses, with applicable national safety approvals, may be used if the rating and type are the same. Other components that are not safety related may be purchased from other suppliers as long as they are equivalent to the original component. (Note that selected parts should be purchased only through Keithley Instruments to maintain accuracy and functionality of the product.) If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

To clean an instrument, use a damp cloth or mild, water based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument. Products that consist of a circuit board with no case or chassis (e.g., data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

SPECIFICATIONS

CHANNELS PER CARD: 9 plus temperature reference.

CONTACT CONFIGURATION: 2 Pole Form A with common guard.

CONNECTOR TYPE: Screw terminals in isothermal block, No. 18 AWG wire maximum.

RELAY DRIVE CURRENT: 12mA (per relay).

TEMPERATURE OFFSET: ±0.05°C maximum from HI to LO of any input or between any two adjacent channels in one column on the isothermal block. ±0.1°C maximum between any two terminals on the isothermal block. Maximum additional dynamic offset due to 10°C step change in environment: ±0.1°C after one hour settling.

TEMPERATURE REFERENCE: Thermistor in a linearized bridge.

REFERENCE OUTPUT: −1mV/°C, (0mV at +30°C).

REFERENCE ACCURACY: ±0.25°C (10°C to 35°C), ±0.5°C (0°C to 10°C and 35°C to 50°C).

WARM UP TIME: 1 Hour to rated accuracy.

CONTACT OFFSET VOLTAGE: 1μV.

ACTUATION TIME: < 5ms, exclusive of mainframe.

CONTACT LIFE: $> 10^8$ closures.

CONTACT RESISTANCE: < 2Ω (< 0.7Ω initial).

CHANNEL ISOLATION: $> 10^8\Omega$, 10pF.

INPUT ISOLATION: $> 10^7\Omega$, 150pF.

COMMON MODE VOLTAGE: 200V peak.

ENVIRONMENT, SPECIFIED: 10°C to 35°C, up to 70% R.H.

ENVIRONMENTAL, OPERATING: 0°C to 50°C, up to 35°C at 70% R.H.

ENVIRONMENTAL, STORAGE: −25°C to +65°C.

DIMENSIONS, WEIGHT: 32mm high × 114mm wide × 272mm long (1¼" × 4½" × 10¾") net weight 0.64kg (1lb. 6.5oz.).

Signal Level: 42V, 100mA, 2VA maximum (non-inductive load only).

TABLE OF CONTENTS

SECTION 1—GENERAL INFORMATION

1.1 Introduction 1
1.2 Warranty Information 1
1.3 Manual Addenda 1
1.4 Safety Symbols and Terms 1

SECTION 2—OPERATION

2.1 Introduction 3
2.2 Wiring 3
2.3 Operating Considerations 4
2.4 Operating Hints 4
2.5 Thermocouple Measurement Considerations 5
2.6 Measurement Procedure 6
2.7 Switch Terminology 7

SECTION 3—SERVICING INFORMATION

3.1 Calibration Procedure 21
3.2 Calibration Procedures 21
3.3 Test of Calibration 21
3.4 Channel Isolation 21
3.5 Input Isolation, Common Mode 22

SECTION 4—REPLACEABLE PARTS

4.1 Introduction 23
4.2 Replaceable Parts 23
4.3 Ordering Information 23
4.4 Factory Service 23
4.5 Component Layout and Schematic Diagram 23

LIST OF FIGURES

1 Typical Thermocouple Connections 3
2 Plug-In Board Assembly 4
3 Using GUARD Connection 5
4 Typical Multiple Channel Analog Connections 5
5 Typical Thermocouple Measurements 6
6 Switch Terminology 7
7 Channel Isolation Test Setup 22
8 Common Mode Isolation Test Setup 22
9 Model 7057A, Component Location Drawing 25
10 Model 7057A, Schematic Diagram 27

LIST OF TABLES

1 Summary of Temperature Measurement Procedure 7
2 NBS Quartic Coefficients for Types S, R, B, E, J, K and T 8
3 Recommended Test Equipment 21
4 Model 7057A Replaceable Parts 23
5 Model 7057A Replaceable Parts (Mechanical) 24

SECTION 1
GENERAL INFORMATION

1.1 INTRODUCTION

The Model 7057A is a thermocouple scanner card which is field-installable in an appropriate scanner mainframe (e.g. Model 705). Since it combines the functions of a thermocouple scanner and uniform temperature reference, it is especially useful for scanning thermocouples. The input terminals are #110 alloy-copper set in an isothermal block to minimize temperature differences. A thermistor sensor within the isothermal block is used with a bridge network located on the Model 7057A to give an indication of the temperature reference or cold junction. The temperature of the heat sink is used to calculate the corrected thermocouple output. The output voltages of each thermocouple must be converted to temperature (°C or °F) using appropriate thermocouple tables or polynomial equations. In addition any channel may be used for monitoring low-level signals. The Model 7057A uses 2-pole form A contacts for switching of signals up to 35V peak or 100mA peak. Input and output connections are made through the rear panel of the scanner mainframe using #4 screw terminals on the Model 7057A.

1.2 WARRANTY INFORMATION

Warranty information is stated on the inside front cover of the manual. If there is a need for service, contact the Keithley representative or authorized repair facility in your area. Check the back cover of this manual for addresses. The service form supplied at the end of this manual should be used to provide the repair facility with adequate information concerning any difficulty.

1.3 MANUAL ADDENDA

Any improvements or changes to this manual will be explained on an addendum included with this manual.

1.4 SAFETY SYMBOLS AND TERMS

The symbol  denotes that the user should refer to the operating instructions.

The symbol  denotes that a high voltage may be present on the terminal(s).

The **WARNING** used in this manual explains dangers that could result in personal injury or death.

The **CAUTION** used in this manual explains hazards that could damage the instrument.

SECTION 2
OPERATION

2.1 INTRODUCTION

This section provides information needed to use the Model 7057A with an appropriate scanner mainframe.

2.2 WIRING AND INSTALLATION

1. Wiring Configuration—The Model 7057A has a 2-pole switching configuration. It may be used to connect one of nine signals to the output. The tenth scanner position (Channel 1) is used to monitor the temperature of the input terminals with a thermistor bridge. Bridge power is derived from a non-isolated internal supply with jumper provisions for an external isolated supply.
   A. Input and output connections are made to the screw terminals shown in Figure 1.
   B. Signal path resistance, including both poles of a channel relay, is typically less than 1.4Ω, less than 2Ω at end of life.
   C. A guard surrounds all signal paths and is connected to the heat sink surrounding the input terminals. Connection to the guard is made at the isothermal block.
2. Installation—Refer to the scanner mainframe instruction manual for scanner card installation instructions.

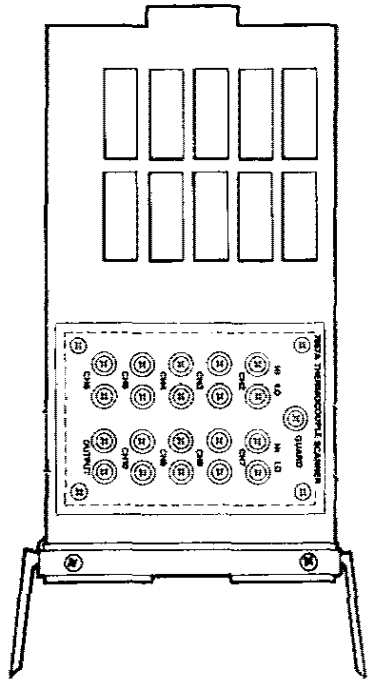


Figure 1. Typical Thermocouple Connections.

2.3 OPERATING CONSIDERATIONS

1. Signal Level—10V peak, 10mA peak with a resistive load for expected life. Maximum peak instantaneous rating is 35V.
2. Contact Potential (Laboratory Environment)—Less than 1μV from input to output when copper wires are used.
3. Isolation—Guarded interchannel resitance is nominally $10^8\Omega$. Guarded capacitance is less than 100pF between any two channels.
4. Maximum Levels—A 200V peak between channels or from channel to guard or mainframe (digital) common.
5. Operating Environment—0°C-50°C, up to 35°C at 70% relative humidity.

2.4 OPERATING HINTS

1. The clamp-type screw terminals will accept #18 to #36 AWG (0.044 to 0.005 inch) wire. Figure 2 shows the mechanical features of the Model 7057A which prevent lead movement after the board is wired.

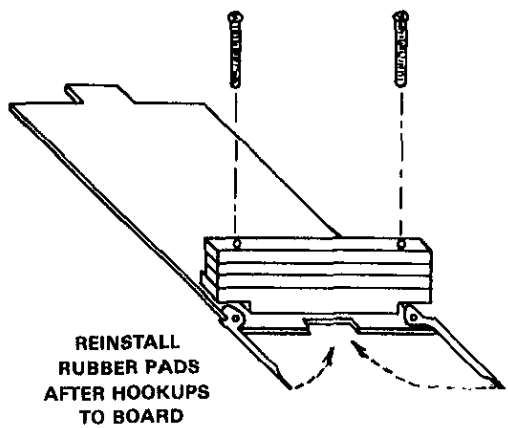


Figure 2. Plug-In Board Assembly

2. Thermal offset on any given channel is typically repeatable to within a few hundred nanovolts each time the channel is selected. That is, every time a channel is selected and allowed to stabilize for a period of time, the channel will exhibit the same thermal offset to within a few hundred nanovolts. This offset may be accounted for in the measurement and subtracted from each reading, to obtain a more precise measurement.

3. To effectively eliminate error voltages produced by leakage current, the GUARD terminal should be connected to the reference connection on the channel which is most sensitive to error (that is, the one which has the lowest source voltage versus the highest resistance). For instance, two sources are connected to the Model 7057A; one having an equivalent source voltage of 1V with a series resistance of 100kΩ, and the other having a source voltage of .1V with a 1kΩ series resistance. The 100kΩ source resistance will develop 100 times the error voltage as the 1kΩ source resistance. Its source voltage however, is only 10 times as great, which means that the percentage error is 10 times as large on the 1V/100kΩ chan-

nel. The GUARD would therefore be connected to the reference point of this channel. (See Figure 3).

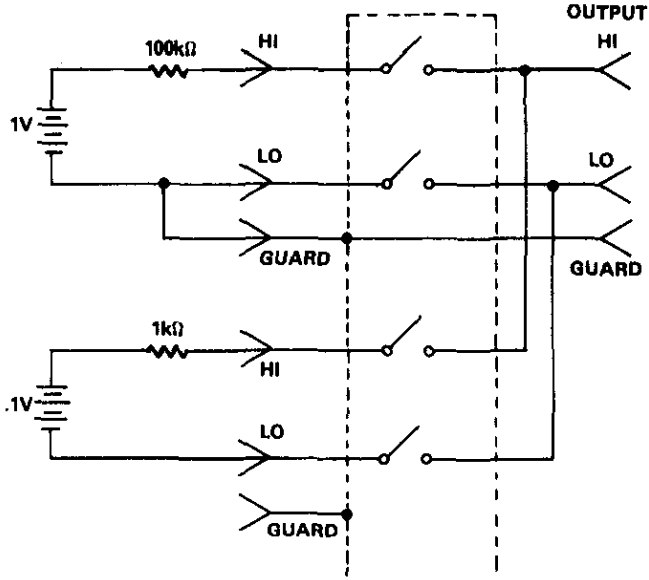


Figure 3. Using GUARD Connection

4. The relay switching time includes a 50μs time interval between releases and operate conditions. The actuation time is less than 5msec.
5. Reactances in the system cause transients during switching.
6. For scanner systems using two or more plug-in boards output HI and LO on all Model 7057A plug-in boards should be made using continuous copper wires. This ensures that the number of copper-to-copper junctions is at a minimum and therefore unnecessary thermal effects are avoided. Figure 4 shows the method of continuous board-to-board connections.

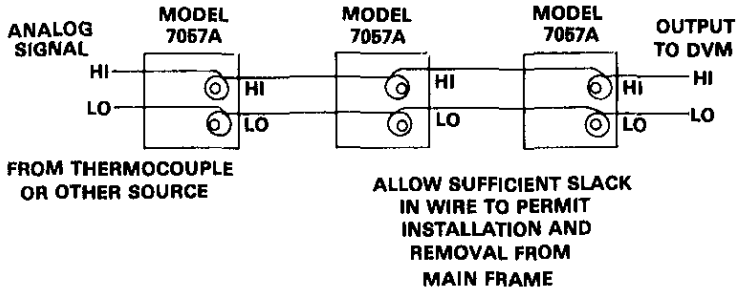


Figure 4. Typical Multiple-Channel Analog Connections

2.5 THERMOCOUPLE MEASUREMENT CONSIDERATIONS

A thermocouple is a junction formed between two dissimilar metals. If the junction temperature is T_1 a voltage E_1 will be developed between leads A and B. When connected to a voltmeter two more junctions are formed with meter terminals, which are usually copper as shown in Figure 5.

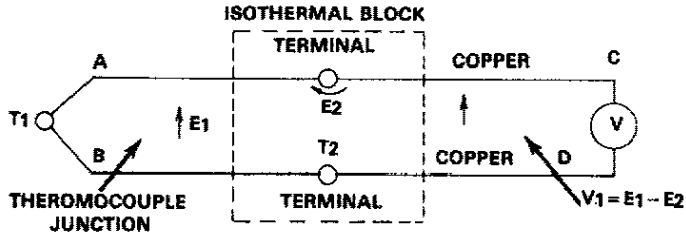


Figure 5. Typical Thermocouple Measurement

The voltage measured by the voltmeter is proportional to the difference between temperature T_1 and T_2. To determine T_1, T_2 the thermoelectric properties of the thermocouple are needed. Data is available to determine the voltage versus temperature relationship based on a reference temperature (T_2) of 0°C. Thus, if the thermocouple-to-copper junctions were maintained at 0°C it would be possible to determine T_1 directly by referring to thermocouple reference tables*, which give temperature as a function of the meter reading V_1. If these junctions are different from 0°C a voltage E_2 will be introduced, where $V_1 = E_1 - E_2$.

2.6 MEASUREMENT PROCEDURE

In the Model 7057A the reference temperature T is measured by a dual thermistor in a bridge circuit. The temperature of a thermocouple connected to Channels 2 through 10 is determined by the following procedure:

1. Measure the voltage for the reference junction V and calculate T_2. $T_2 = 30 - (V_2 \times 10^3)$.
2. Determine the reference junction voltage, E_2, either from thermocouple reference tables* or by the calculation**:
   $E_2 = a_0 + A_1 T + a_2T^2 + a_3T^3 + a_4T^4$ where $T = T_2$ as determined in step 1 above. E_2 is expressed in microvolts. The constant a_0 through a_4 are a function of the thermocouple type connected to the channel. The coefficients, a_0, a_1, a_2, a_3 and a_4 are dependent on the thermocouple type and temperature range under consideration.
3. Measure the thermocouple voltage V_1 at the channel output. Convert to microvolts.
4. Add E_2 to V_1 to determine E_1. $E_1 = V_1 + E_2$ (where V_1 is expressed in microvolts).
5. Determine the thermocouple temperature, T_1, either from thermocouple reference tables* or by calculation**:
   $T_1 = a_0 + a_1E_1, + a_2E_12_1 + a_3E_1{}^3 + a_4E_14_1$ (where E_1 is expressed in microvolts).
6. For example, consider a type J iron-constantan thermocouple at 300°C (T_1). The reference junction temperature will be 8 to 10°C above ambient, say 36°C (T_2).

   A. The bridge output (channel 1) will be -.006V. Since the bridge output is zero when $T_2 = 30$°C this indicates $T_2 = 36$°C.
   B. Using NBS Monograph 125 to determine the reference voltage for a type J thermocouple gives $E_2 = 1849.0\mu V$. Using the most accurate quartic approximation formula (Table 2) for this range gives $1849.085\mu V$.
   C. The voltage at Channel 1, which is V_1, will be $14476.0\mu V$. ($V_1 = E_1 - E_2$).
   D. Add E_2 to V_1 and get $E_1 = 16325.0\mu V$.

E. Using Table A6.2.1 to find the thermocouple temperature gives 300.00°C. Using the formula (Table 2) gives 299.995°C.

* Thermocouple Reference Tables, Based on the IPTS-68 National Bureau Standards Monograph 125. (SD Catalog No. C13.44:125)

** See also Table 2 which summarizes the quartic coefficients.

Table 1. Summary of Temperature Measurement Procedure

Action	Measured Quantity	Relationship Required	Calculated Quantity
Measured reference channel output V_2.	V_2 (volts)	--	--
Determine equivalent temperature T_2.	--	$T_2 = 30 - (V_2 \times 10^3)$	T_2 (°C)
Measured desired channel V_1.	V_1 (volts)	--	--
Calculate correction voltage E_2	--	$E_2 = a_0 + a_1T_2 + a_1T^2_2 + a_3T^3_2 + a_4T^4_2$	E_2 microvolts
Calculate voltage E_1.	--	$E_1 = E_2 + V_1 \times 10^{-6}$	E_1 microvolts
Calculate equivalent temperature T_1.	--	$T_1 = a_0 + a_1E_1 + a_2E^2_1 + a_3E^3_1 + a_4E^4_1$	T_1 (°C)

2.7 SWITCH TERMINOLOGY

Throughout this manual the terminology Form A is used. The term Form A is used in switch terminology and is described as follows:

1. Form A is simply a single pole normally open (SPNO) switch (refer to Figure 6). A 2-pole switch normally open is classified as 2 Form A.
2. Form B is similar to Form A except that its contacts are normally closed (refer to Figure 6). A 2-pole switch normally closed is classified as a 2 Form B.
3. Form C is shown in Figure 6 as a single pole double throw switch. It could also be a multipole switch such as a 2-pole which would be classified as a 2 Form C.

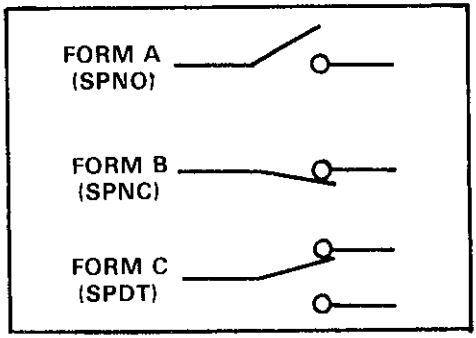


Figure 6. Switch Terminology

Table 2. NBS Quartic Coefficients for Types S, R, B, E, J, K, and T.

Type S Thermocouples[1] Temperature Range (°C)	a_0		a_1		a_2		a_3		a_4		Error Range (μV)
I. Quartic Equation	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Exact-Approx.
−50 to 900			5.5439639	+0	1.0103667	−2	−1.0944499	−5	4.9628963	−9	−7 to 14
0 to 1100			5.8791282	+0	7.9098118	−3	−6.7450002	−6	2.5247577	−9	−16 to 12
0 to 1400			6.2516859	+0	5.8347856	−3	−3.4351369	−6	9.4022202	−10	−35 to 25
0 to 1650			6.5554932	+0	4.4519908	−3	−1.6378513	−6	2.4140360	−10	−55 to 35
0 to 1768			6.6834421	+0	3.9334084	−3	−1.0384046	−6	3.4244511	−11	−60 to 35
400 to 1100	−3.8051591	+2	8.7228147	+0	6.2984807	−4	9.0526670	−7	−2.9241601	−10	−.7 to .5
400 to 1400	−5.2412524	+2	9.5827994	+0	−1.2077351	−3	2.5723104	−6	−8.3681057	−10	−1.6 to 1.5
400 to 1650	−5.0061921	+2	9.4591354	+0	−9.7986687	−4	2.3967559	−6	−7.8837971	−10	−1.8 to 1.9
1050 to 1400	1.4352322	+3	2.9873073	+0	6.9951678	−3	−1.8986036	−6	6.5006637	−11	−.05 to .05
1050 to 1650	1.3054176	+3	3.4129348	+0	6.4741403	−3	−1.6163524	−6	7.9103746	−12	−.05 to .05
1400 to 1550	1.8695098	+2	6.4091373	+0	3.4664812	−3	−2.7553724	−7	−2.1606150	−10	−.05 to .05
1400 to 1650	1.0863331	+3	3.9952876	+0	5.8939317	−3	−1.3595782	−6	−3.4675031	−11	−.05 to .05
1400 to 1768	−7.4180405	+4	2.0043202	+2	−1.8607781	−1	8.1899566	−5	−1.3556030	−8	−1.0 to 1.3
1666 to 1768	8.2703440	+4	−1.3532278	+2	8.0243878	−2	−1.0633404	−5	−1.7212343	−9	−.05 to .05
Reference Junction Correction											
0 to 50			5.3994446	+0	1.2467754	−2	−1.9934168	−5			−0.01 to +0.01

[1]Quadratic, cubic, and quartic approximations to the data as a function of temperature (°C) in selected temperature ranges. The expansion is of the form $E = a_0 + a_1T + a_2T^2 + a_3T^3 + a_4T^4$ where E is in microvolts and T is in degrees Celsius.

Type S Thermocouples[2]

Temperature Range (°C)	a_0		a_1		a_2		a_3		a_4		Error Range (μV)
I. Quartic Equation	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Exact-Approx.
−50 to 900			1.6414048	−1	−2.0241757	−5	2.7849728	−9	−1.4172102	−13	−11 to 3
0 to 1100			1.5445376	−1	−1.3349067	−5	1.3626587	−9	−5.3270847	−14	−3 to 6
0 to 1400			1.4713897	−1	−9.0783455	−6	6.5660913	−10	−1.8499175	−14	−5 to 9
0 to 1650			1.4260554	−1	−7.0073775	−6	3.8981279	−10	−8.3047780	−15	−6 to 11
0 to 1768			1.4087955	−1	−6.3195007	−6	3.1267454	−10	−5.7422562	−15	−6 to 12
400 to 1100	4.1137317	+1	1.1599785	−1	−1.8642979	−6	1.2643267	−11	8.4828836	−16	−.05 to .07
400 to 1400	4.4507790	+1	1.1373998	−1	−1.3349811	−6	−3.9224680	−11	2.6563405	−15	−.08 to .08
400 to 1650	4.1670535	+1	1.1543356	−1	−1.6782780	−6	−1.0845801	−11	1.8379726	−15	−.2 to .2
1050 to 1400	−3.0938374	+1	1.4106560	−1	−4.9794442	−6	1.7334256	−10	−1.9262160	−15	−.003 to .003
1050 to 1650	1.2226507	+1	1.2706383	−1	−3.2873314	−6	8.3038098	−11	−1.3019379	−16	−.010 to .010
1400 to 1550	1.3866867	+2	9.3486676	−2	4.8592708	−8	−6.3885209	−11	2.2896541	−15	−.0005 to .0005
1400 to 1650	1.3923740	+2	9.3267401	−2	7.7266682	−8	−6.5458208	−11	2.3208160	−15	−.0005 to .0005
1400 to 1768	4.5133695	+3	−1.0046437	+0	1.0322002	−4	−4.3637046	−9	6.9361610	−14	−.13 to .10
1666 to 1768	2.3131446	+4	−5.4122671	+0	4.9347196	−4	−1.9681943	−8	2.9430179	−13	−.0005 to .0005

[2]Quadratic, cubic, and quartic approximations to the data as a function of voltage in selected temperature ranges (°C). The expansion is of the form $T = a_0 + a_1E + a_2E^2 + a_3E^3 + a_4E^4$ where E is in microvolts and T is in degrees Celsius.

Type R Thermocouples[3]

Temperature Range (°C)	a_0		a_1		a_2		a_3		a_4		Error Range (μV)
I. Quartic Equation	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Exact-Approx.
−50 to 900			5.4295008	+0	1.1446885	−2	−1.1295306	−5	5.0020496	−9	−7 to 15
0 to 1100			5.7622558	+0	9.2715271	−3	−7.1346883	−6	2.5877458	−9	−16 to 12
0 to 1400			6.1429772	+0	7.1515857	−3	−3.7539447	−6	9.6963832	−10	−35 to 25
0 to 1650			6.4615269	+0	5.7010917	−3	−1.8683292	−6	2.3636365	−10	−55 to 35
0 to 1768			6.5962120	+0	5.1559203	−3	−1.2385309	−6	1.8827643	−11	−65 to 35
400 to 1100	−4.0674108	+2	8.7490294	+0	1.7115155	−3	7.5039035	−7	−3.0096280	−10	−.4 to .5
400 to 1400	−5.6047484	+2	9.6731111	+0	−2.6994046	−4	2.5536988	−6	−8.9155491	−10	−1.7 to 1.6
400 to 1650	−5.4505828	+2	9.5942872	+0	−1.2813352	−4	2.4468512	−6	−8.6286756	−10	−2.1 to 1.8
1050 to 1400	1.6618159	+3	2.3048526	+0	8.7635426	−3	−2.3016819	−6	7.4284923	−11	−.05 to .05
1050 to 1650	1.5132838	+3	2.7958847	+0	8.1571403	−3	−1.9701159	−6	6.5568964	−12	−.05 to .05
1400 to 1550	2.4008703	+3	4.1604579	−1	1.0549178	−2	−3.0383621	−6	1.8540516	−10	−.05 to .05
1400 to 1650	1.5787334	+3	2.6321144	+0	8.3100314	−3	−2.0332036	−6	1.6260416	−11	−.05 to .05
1400 to 1768	−7.1904948	+4	1.9442383	+2	−1.7913090	−1	7.9264764	−5	−1.3187245	−8	−1.0 to 1.3
1666 to 1768	8.8532076	+4	−1.5014129	+2	9.5376167	−2	−1.6644901	−5	−8.3062870	−10	−.05 to .05
Reference Junction Correction											
0 to 50	5.2891411	+0	1.3844426	−2	−2.0889531	−5	−0.01 to +0.01				

[3]Quadratic, cubic, and quartic approximations to the data as a function of temperature (°C) in selected temperature ranges. The expansion is of the form $E = a_0 + a_1T + a_2T^2 + a_3T^3 + a_4T^4$ where E is in microvolts and T is in degrees Celsius.

Type R Thermocouples[4]

Temperature Range (°C)	a_0		a_1		a_2		a_3		a_4		Error Range (μV)
I. Quartic Equation	**Argument**	**Exp.**	**Argument**	**Exp.**	**Argument**	**Exp.**	**Argument**	**Exp.**	**Argument**	**Exp.**	**Exact-Approx.**
−50 to 900			1.6251434	−1	−2.0454379	−5	2.5404935	−9	−1.1767904	−13	−13 to 3
0 to 1100			1.5239494	−1	−1.3755675	−5	1.2610922	−9	−4.4281251	−14	−4 to 7
0 to 1400			1.4441607	−1	−9.5014952	−6	6.2073358	−10	−1.5622497	−14	−6 to 10
0 to 1650			1.3944190	−1	−7.4485484	−6	3.8266182	−10	−7.4517277	−15	−7 to 13
0 to 1768			1.3752883	−1	−6.7651171	−6	3.1420473	−10	−5.4254872	−15	−7 to 14
400 to 1100	4.5509556	+1	1.1284875	−1	−2.8603978	−6	8.5173702	−11	−1.1440038	−15	−.04 to .04
400 to 1400	4.9160016	+1	1.1054589	−1	−2.3559046	−6	3.9276248	−11	3.3369324	−16	−.08 to .09
400 to 1650	4.8343651	+1	1.1098270	−1	−2.4353890	−6	4.5164488	−11	1.8172612	−16	−.10 to .12
1050 to 1400	−4.1134459	+0	1.2738464	−1	−4.3132296	−6	1.3863582	−10	−1.5283798	−15	−.002 to .002
1050 to 1650	3.7487318	+1	1.1519304	−1	−2.9827002	−6	7.4538667	−11	−3.7809957	−16	−.011 to .011
1400 to 1550	8.0559850	+1	1.0442877	−1	−1.9827500	−6	3.3603790	−11	2.4513433	−16	−.0005 to .0005
1400 to 1650	1.4180146	+3	9.0181346	−2	−7.4068329	−7	−1.4487255	−11	9.4290495	−16	−.0005 to .0005
1400 to 1768	3.1759093	+3	−5.8922431	−1	5.6190639	−5	−2.1303241	−9	3.0369250	−14	−.11 to .08
1666 to 1768	1.2883437	+4	−2.6747958	+0	2.2334214	−4	−8.0565860	−9	1.0882779	−13	−.0007 to .0007

[4]Quadratic, cubic, and quartic approximations to the data as a function of voltage in selected temperature ranges (°C). The expansion is of the form $T = a_0 + a_1E + a_2E^2 + a_3E^3 + a_4E^4$ where E is in microvolts and T is in degrees Celsius.

Type B Thermocouples[5]

Temperature Range (°C)	a_0		a_1		a_2		a_3		a_4		Error Range (μV)
I. Quartic Equation	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Exact-Approx.
0 to 900			−2.3614224	−1	5.7496551	−3	−5.6339756	−7	−1.1808558	−10	−.22 to .14
0 to 1100			−2.3893338	−1	5.7684447	−3	−5.9963692	−7	−9.7041131	−11	−.18 to .20
0 to 1400			−2.3476301	−1	5.7480761	−3	−5.7165679	−7	−1.0838193	−10	−.7 to 1.0
0 to 1650			−1.9185893	−1	5.5578879	−3	−3.3057924	−7	−2.0018428	−10	−4 to 5
0 to 1820			−1.3749133	−1	5.3446673	−3	−9.1094186	−8	−2.8098361	−10	−8 to 9
400 to 1100	1.3740347	+1	−3.2914888	−1	5.9766638	−3	−8.0141311	−7	−2.7203972	−11	−.05 to .05
400 to 1400	−2.5321108	+1	−9.9736579	−2	5.4976533	−3	−3.6623964	−7	−3.6969100	−10	−2.0 to 1.8
400 to 1650	−1.1708354	+2	3.9860894	−1	4.5539656	−3	3.6623964	−7	−3.6969100	−10	−2.0 to 1.8
1050 to 1400	−9.8446259	+2	3.3670688	+0	8.2282215	−4	2.4061224	−6	−7.7901142	−10	−.05 to .05
1050 to 1650	−1.3702395	+3	4.6252371	+0	−7.0976836	−4	3.2325686	−6	−9.4548852	−10	−.05 to .05
1400 to 1550	−4.7644591	+2	2.2890832	+0	1.5749253	−3	2.2417410	−6	−7.8471224	−10	−.05 to .05
1400 to 1650	−6.4878929	+2	2.7380621	+0	1.1375302	−3	2.4305578	−6	−8.1518033	−10	−.05 to .05
Reference Junction Correction											
0 to 50			−2.4673839	−1	5.9050303	−3	−1.2267180	−6			−0.01 to +0.01

[5]Quadratic, cubic, and quartic approximations to the data as a function of temperature (°C) in selected temperature ranges. The expansion is of the form $E = a_0 + a_1T + a_2T^2 + a_3T^3 + a_4T^4$ where E is in microvolts and T is in degrees Celsius.

Type B Thermocouples[a]

Temperature Range (°C)	a_0		a_1		a_2		a_3		a_4		Error Range (μV)
I. Quartic Equation	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Exact-Approx.
0 to 900			8.9244743	−1	−5.7447033	−4	1.8053618	−7	−1.9719121	−11	−30 to 75
0 to 1100			7.2874066	−1	−3.1771931	−4	6.8254996	−8	−5.1002233	−12	−35 to 90
0 to 1400			5.7822214	−1	−1.6039309	−4	2.2187592	−8	−1.0678514	−12	−45 to 110
0 to 1650			4.9929130	−1	−1.0349686	−4	1.0792281	−8	−3.9111456	−13	−50 to 120
0 to 1820			4.6255054	−1	−8.2176262	−5	7.3717195	−9	−2.2913665	−13	−50 to 130
400 to 1100	1.8946288	+2	3.0966136	−1	−5.8100680	−5	8.2483967	−9	−4.7591774	−13	−.09 to 1.0
400 to 1400	2.0949015	+2	2.7222162	−1	−3.6930932	−5	3.6830239	−9	−1.4483702	−13	−3 to 3
400 to 1650	2.2354664	+2	2.4988761	−1	−2.7160312	−5	2.1299660	−9	−6.4220755	−14	−5 to 5
1050 to 1400	3.2188156	+2	1.8282378	−1	−1.1561743	−5	6.4320083	−10	−1.4544375	−14	−.003 to .003
1050 to 1650	3.4418084	+2	1.7031473	−1	−8.9696912	−6	4.0789445	−10	−6.6410259	−15	−.025 to .020
1400 to 1550	3.7140306	+2	1.5828913	−1	−7.0050689	−6	2.6714849	−10	−2.9082072	−15	−.001 to .001
1400 to 1650	3.9253848	+2	1.4979551	−1	−5.7276293	−6	1.8192801	−10	−7.8042686	−16	−.001 to .001

[a]Quadratic, cubic, and quartic approximations to the data as a function of voltage in selected temperature ranges (°C). The expansion is of the form $T = a_0 + a_1E + a_2E^2 + a_3E^3 + a_4E^4$ where E is in microvolts and T is in degrees Celsius.

Type E Thermocouples[7]

Temperature Range (°C)	a_0		a_1		a_2		a_3		a_4		Error Range (μV)
I. Quartic Equation	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Exact-Approx.
−270 to 0			5.9287179	+1	7.0983783	−2	5.2421843	−5	3.8137875	−7	−5 to 5
−200 to 0			5.8754764	+1	5.7443085	−2	−5.0637772	−5	1.3960921	−7	−.5 to .4
−200 to 800			5.8043714	+1	5.6118501	−5	−5.9506584	−5	2.2327737	−8	−60 to 30
−20 to −500			5.8318735	+1	5.4292960	−2	−5.6288941	−5	2.0825828	−8	−8 to 4
0 to 400			5.8327591	+1	5.3761106	−2	−5.2870656	−5	1.5352840	−8	−3 to 4
0 to 1000			5.8734597	+1	5.0789891	−2	−4.7821793	−5	1.4659118	−8	−18 to 17
400 to 1000	−8.5384268	+2	6.5022632	+1	3.4354900	−2	−2.9769494	−5	7.6039401	−9	−2 to 2.5
600 to 800	−1.3839633	+3	6.7211126	+1	3.1669230	−2	−2.9237913	−5	8.1514671	−9	−.03 to .03
850 to 1000	−5.1503130	+4	−1.6691278	+2	4.1877018	−1	−3.1228607	−4	8.5283044	−8	−.06 to .06
Reference Junction Correction											
0 to 50			5.8637565	+1	4.6720025	−2	−1.4438022	−5			−.12 to +.24

[7]Quadratic, cubic, and quartic approximations to the data as a function of temperature (°C) in selected temperature ranges. The expansion is of the form $E = a_0 + a_1T + a_2T^2 + a_3T^3 + a_4T^4$ where E is in microvolts and T is in degrees Celsius.

Type E Thermocouples[a]

Temperature Range (°C)	a_0		a_1		a_2		a_3		a_4		Error Range (μV)
I. Quartic Equation	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Exact-Approx.
−270 to 0			2.8168878	−3	−8.5940057	−6	−1.4930918	−9	−8.7987588	−14	−9 to 6
−200 to 0			1.5726646	−2	−1.2102152	−6	−1.9577799	−10	−1.6696298	−14	−.3 to .3
−200 to 800			1.8432856	−2	−3.2311582	−7	6.9795810	−12	−5.1106852	−17	−8 to 7
−20 to −500			1.6970287	−2	−2.0830603	−7	4.6512717	−12	−4.1805785	−17	−.18 to .12
0 to 400			1.7022525	−2	−2.2097240	−7	5.4809314	−12	−5.7669892	−17	−.05 to .04
0 to 1000			1.6410783	−2	−1.3560189	−7	1.8600342	−12	−8.5537337	−18	−.9 to 1.4
400 to 1000	1.9669452	+1	1.4207735	−2	−5.1844510	−8	5.6361365	−13	1.5646343	−18	−.03 to .03
600 to 800	2.5192188	+1	1.3909529	−2	−4.7201133	−8	5.5638718	−13	−1.7775228	−18	−.0005 to .0005
850 to 1000	−7.1102114	+2	5.6554599	−2	−9.7013068	−7	9.3938146	−12	−3.3333675	−17	−.001 to .001

[a]Quadratic, cubic, and quartic approximations to the data as a function of voltage in selected temperature ranges (°C). The expansion is of the form $T = a_0 + a_1E + a_2E^2 + a_3E^3 + a_4E^4$ where E is in microvolts and T is in degrees Celsius.

Type J Thermocouples*

Temperature Range (°C)	a_0		a_1		a_2		a_3		a_4		Error Range (μV)
I. Quartic Equation	**Argument**	**Exp.**	**Argument**	**Exp.**	**Argument**	**Exp.**	**Argument**	**Exp.**	**Argument**	**Exp.**	**Exact-Approx.**
−200 to 0			5.0408743	+1	3.2009063	−2	−6.3493968	−5	2.5174022	−7	−.2 to .3
−200 to 760			4.9502533	+1	3.2898022	−2	−6.9936031	−5	5.1112729	−8	−100 to 80
−200 to 1200			4.7062907	+1	2.5522650	−2	−2.2198295	−5	7.1373907	−9	−500 to 600
−20 to 500			5.0465304	+1	2.8062596	−2	−6.5666305	−5	5.3587106	−8	−1.5 to 3.0
0 to 400			5.0452399	+1	2.8409137	−2	−6.7556436	−5	5.6382040	−8	−.8 to .5
0 to 760			5.1258213	+1	2.0040854	−2	−4.2235982	−5	3.2819408	−8	−24 to 36
0 to 1200			5.5861877	+1	−1.4207954	−2	3.1325181	−5	−1.5023710	−8	−210 to 160
400 to 760	−5.7931005	+3	9.7718575	+1	−1.1658430	−1	1.3184454	−4	−4.8218788	−8	−2.5 to 2.8
400 to 1200	7.1127371	+3	1.8969007	+1	5.3862730	−2	−2.2171472	−5	1.8445398	−10	−100 to 100
600 to 760	−2.5724435	+4	2.2157898	+2	−4.0418097	−1	4.2749984	−4	1.6174242	−7	−.1 to .1
760 to 1200	3.9064962	+4	−1.4765017	+2	3.6470921	−1	−2.7029005	−4	7.2113090	−8	−11 to 11
Reference Junction Correction											
0 to 50			5.0373743	+1	3.0167011	−2	−7.4293513	−5			−.06 to +.06

*Quadratic, cubic, and quartic approximations to the data as a function of temperature (°C) in selected temperature ranges. The expansion is of the form $E = a_0 + a_1T + a_2T^2 + a_3T^3 + a_4T^4$ where E is in microvolts and T is in degrees Celsius.

Type J Thermocouples[10]

Temperature Range (°C)	a_0		a_1		a_2		a_3		a_4		Error Range (μV)
I. Quartic Equation	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Exact-Approx.
−200 to 0			1.8843850	−2	−1.2029733	−6	−2.5278593	−10	−2.5849263	−14	−.4 to .5
−200 to 760			2.1155170	−2	−3.3513149	−7	1.2443997	−11	−1.5227150	−16	−6 to 7
−200 to 1200			2.1676850	−2	−2.1844464	−7	3.9094347	−12	−2.4303017	−17	−14 to 10
−20 to 500			1.9745056	−2	−1.8094256	−7	7.8777919	−12	−1.1897222	−16	−.07 to .06
0 to 400			1.9750953	−2	−1.8542600	−7	8.3683958	−12	−1.3280568	−16	−.03 to .05
0 to 760			1.9323799	−2	−1.0306020	−7	3.7084018	−12	−5.1031937	−17	−.9 to .7
0 to 1200			1.8134974	−2	−5.6495930	−8	−2.4644023	−12	2.1141718	−17	−3 to 4
400 to 760	9.2808351	+1	5.4463817	−3	6.5254537	−7	−1.3997013	−11	9.9364476	−17	−.03 to .03
400 to 1200	−1.1075293	+2	2.8651303	−2	−2.9758175	−7	2.5945419	−12	−4.9012035	−18	−1.3 to 1.6
600 to 760	1.8020713	+2	−4.5284199	−3	1.0769294	−6	−2.1962321	−11	1.5521511	−16	−.001 to .001
760 to 1200	−6.3828680	+2	7.4068749	−2	−1.7177773	−6	2.1771293	−11	−9.9502571	−17	−.15 to .11

[10]Quadratic, cubic, and quartic approximations to the data as a function of voltage in selected temperature ranges (°C). The expansion is of the form $T = a_0 + a_1E + a_2E^2 + a_3E^3 + a_4E^4$ where E is in microvolts and T is in degrees Celsius.

Type K Thermocouples[11]

Temperature Range (°C)	a_0		a_1		a_2		a_3		a_4		Error Range (μV)
I. Quartic Equation	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Exact-Approx.
−270 to 0			3.9575518	+1	3.1063355	−2	−9.1607995	−5	3.0006628	−8	−1.1 to 1.2
−200 to 0			3.9478446	+1	2.8256412	−2	−1.1488433	−4	−2.8153447	−8	−.08 to .05
−200 to 800			3.6762217	+1	2.4544587	−2	−4.3081993	−5	2.5127588	−8	−180 to 200
−20 to 500			4.0999640	+1	−3.2619221	−3	8.5714137	−6	−1.6912373	−9	−25 to 45
0 to 400			4.0981103	+1	−1.5992510	−4	−1.2525700	−5	3.2784725	−8	−25 to 20
0 to 1370			3.9443859	+1	5.8953822	−3	−4.2015132	−6	1.3917059	−10	−60 to 110
400 to 1000	1.3223524	+3	3.0191663	+1	2.7508912	−2	−2.4734437	−5	6.9799332	−9	−.9 to 1.4
400 to 1370	−3.5456236	+1	3.8349319	+1	9.9993329	−3	−8.7444446	−6	1.7108618	−9	−12 to 11
600 to 800	2.1326086	+3	2.5608012	+1	3.7091744	−2	−3.3517324	−5	9.9607405	−9	−.05 to .07
850 to 1000	−9.0373549	+2	4.0577145	+1	9.5092149	−3	−1.0989249	−5	3.0753213	−9	−.05 to .03
1050 to 1150	−2.5972816	+3	5.2075276	+1	−1.4576419	−2	9.4854151	−6	−3.1178779	−9	−.05 to .05
Reference Junction Correction											
0 to 50			3.9448872	+1	2.4548362	−2	−9.0918433	−5			−.06 to +.14

[11]Quadratic, cubic, and quartic approximations to the data as a function of temperature (°C) in selected temperature ranges. The expansion is of the form $E = a_0 + a_1T + a_2T^2 + a_3T^3 + a_4T^4$ where E is in microvolts and T is in degrees Celsius.

Type K Thermocouples[1,2]

Temperature Range (°C)	a_0		a_1		a_2		a_3		a_4		Error Range (μV)
	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Exact-Approx.
I. Quartic Equation											
−270 to 0			1.2329875	−2	−1.4434305	−5	−4.2824995	−9	−4.2028679	−13	−11 to 8
−200 to 0			2.3783697	−2	−2.4382217	−6	−6.8203073	−10	−9.4854031	−14	−.5 to .5
−200 to 800			2.8346886	−2	−5.8008526	−7	2.5720615	−11	−3.6813679	−16	−8 to 10
−20 to 500			2.4363851	−2	5.6206931	−8	−3.8825620	−12	3.9120208	−17	−1.2 to .6
0 to 400			2.4383248	−2	9.7830251	−9	3.6276965	−12	−2.5756438	−16	−.5 to .6
0 to 1370			2.5132785	−2	−6.0883423	−8	5.5358209	−13	9.3720918	−18	−2.4 to 1.2
400 to 1000	−2.4707112	+1	2.9465633	−2	−3.1332620	−7	6.5075717	−12	−3.9663834	−17	−.02 to .02
400 to 1370	6.2300671	+0	2.4955374	−2	−7.8788333	−8	1.3269743	−12	1.5580541	−18	−.3 to .3
600 to 800	−3.9480992	+1	3.1425797	−2	−4.0905633	−7	8.5482602	−12	−5.5696636	−17	−.001 to .001
850 to 1000	−3.1617495	+0	2.7115517	−2	−2.1941995	−7	4.8782826	−12	−2.9316611	−17	−.0012 to .0012
1050 to 1150	2.3615582	+2	1.1066277	−3	8.2516607	−7	−1.3558849	−11	9.1638500	−17	−.001 to .001

[1]Quadratic, cubic, and quartic approximations to the data as a function of voltage in selected temperature ranges (°C). The expansion is of the form $T = a_0 + a_1E + a_2E^2 + a_3E^3 + a_4E^4$ where E is in microvolts and T is in degrees Celsius.

Type T Thermocouples[13]

Temperature Range (°C)	a_0		a_1		a_2		a_3		a_4		Error Range (μV)
	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Exact-Approx.
I. Quartic Equation											
−270 to 0			3.9439919	+1	6.2407452	−2	8.0773568	−5	2.6845647	−7	−9 to 7
−200 to 0			3.8749056	+1	4.5149809	−2	−4.7759448	−5	−2.5773959	−8	−.14 to .13
−200 to 400			3.8621703	+1	4.5433050	−2	−3.4731838	−5	1.4661300	−8	−7 to 3.5
0 to 400			3.8468407	+1	4.6651731	−2	−3.7375793	−5	1.5999833	−8	−9 to .9
Reference Junction Correction											
0 to 50			3.8680238	+1	4.1277001	−2					−0.04 to +0.08

[13]Quadratic, cubic, and quartic approximations to the data as a function of temperature (°C) in selected temperature ranges. The expansion is of the form $E = a_0 + a_1T + a_2T^2 + a_3T^3 + a_4T^4$ where E is in microvolts and T is in degrees Celsius.

Type T Thermocouples[14]

Temperature Range (°C)	a_0		a_1		a_2		a_3		a_4		Error Range (μV)
	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Argument	Exp.	Exact-Approx.
I. Quartic Equation											
−270 to 0			4.3553379	−3	−2.0325426	−5	−5.4720813	−9	−5.0865527	−13	−8 to 6
−200 to 0			2.3837090	−2	−2.9878839	−6	−7.1945810	−10	−1.0041943	−13	−.3 to .3
−200 to 400			2.6792411	−2	−1.0370271	−6	6.1330327	−11	−1.3988385	−15	−6 to 5
0 to 400			2.5661297	−2	−6.1954869	−7	2.2181644	−11	−3.5500900	−16	−.15 to .17

[14]Quadratic, cubic, and quartic approximations to the data as a function of voltage in selected temperature ranges (°C). The expansion is of the form $T = a_0 + a_1E + a_2E^2 + a_3E^3 + a_4E^4$ where E is in microvolts and T is in degrees Celsius.

SECTION 3
SERVICING INFORMATION

3.1 RECOMMENDED TEST EQUIPMENT

The recommended test equipment for calibration and performance verification is given in Table 3. Test equipment other than recommended may be substituted if specifications at least equal those given in Table 3.

Table 3. Recommended Test Equipment

Item	Description	Specifications	Mfg.	Model
A	DMM	10μV resolution	Keithley	195
B	Voltage Source	100V DC	Keithley	230
C	Electrometer	1μA resolution	Keithley	614
D	Scanner Mainframe	—	Keithley	705

3.2 CALIBRATION PROCEDURES

To calibrate the Model 7057A do the following procedure:

1. Remove the green wire on the Model 7057A.
2. Connect DMM across R104 (6.151kΩ resistor).
3. Adjust R101 for 175.92mV ±0.1mV.
4. Remove DMM and reconnect the green wire.

3.3 TEST OF CALIBRATION

Using RFL industries oil bath (or equivalent), submerge thermistor (on 7057A) with temperature standard measuring device (Thermometrics S-10 probe or equivalent) into the oil. Allow to stabilize and note the difference (at 30°C). The difference should be less than .2°C.

3.4 CHANNEL ISOLATION

A. This test measures the leakage resistance between two channels on the board. One channel is to be open and the other closed. Set up the test circuit shown in Figure 7.
B. Short the HI and LO connections of each channel on the Model 7057A. Do not connect the channels together, just short the HI and LO terminals.
C. Set the Model 705 to the Channel mode, Channel 2 and the Step mode. Set the electrometer to Amps and program the Model 230 to output 100V. Take the electrometer out of ZERO CHECK. Program the channel under test as open and other channels as closed.
D. Take the reading on the electrometer. The reading should be less than 1×10^{-6}A. Using Ohm's Law calculate the channel isolation. For example: $R = E/I = 100V/1 \times 10^{-6}A = 1 \times 10^{8}\Omega$. Due to the capacitance of the circuit, the offset current may be high until the capacitance of the circuit is charged up. Wait until the readings settle out.
E. Manually scan through channels 2 through 10 repeating step C and D for each channel.

NOTE

Channel 1 is the temperature reference channel.

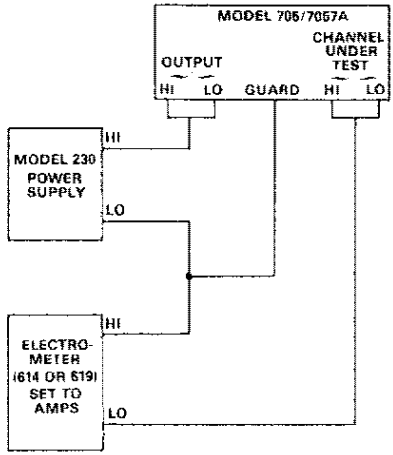


Figure 7. Channel Isolation Test Set Up

3.5 INPUT ISOLATION, COMMON MODE

A. This test measures the leakage resistance between signal lines and power line ground. Set up the test circuit shown in Figure 8.
B. Short the input HI and LO terminals of each channel with a short piece of solid copper wire. Do not connect the channels together, just short the HI and LO terminals.
C. Insert the Model 7057A into the mainframe and set the Model 705 to the Channel mode, Channel 2 and the Step mode.
D. Set the electrometer to Amps and program the Model 230 to output 100V. Take the electrometer out of ZERO CHECK.
E. Take the reading on the electrometer. The reading should be less than 1×10^{-5}A. Using Ohm's Law calculate the isolation (leakage resistance). For example: $R = E/I = 100V/1 \times 10^{-5}A = 10^{7}\Omega$. Due to the capacitance of the circuit, the offset current may be high until the capacitance is charged up. Wait until the readings settle out.
F. Manually scan Channels 2 through 10 repeating step D and E for each channel.

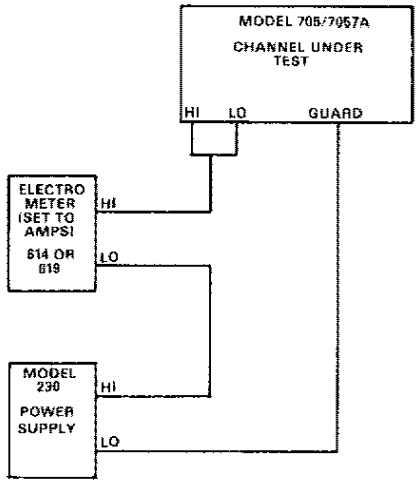


Figure 8. Common Mode Isolation Test Setup

SECTION 4
REPLACEABLE PARTS

4.1 INTRODUCTION

This section contains replacement parts information, a schematic diagram and component layout for the Model 7057A.

4.2 REPLACEABLE PARTS

Parts are listed alpha-numerically in order of their circuit designation. Table 4 contains parts list information for the Model 7057A. Table 5 contains a mechanical parts list for the Model 7057A.

4.3 ORDERING INFORMATION

To place an order, or to obtain information concerning replacement parts, contact your Keithley representative of the factory. See the inside front cover for addresses. When ordering include the following information:

1. Instrument Model Number
2. Instrument Serial Number
3. Part Description
4. Circuit Description (if applicable)
5. Keithley Part Number

4.4 FACTORY SERVICE

If the instrument is to be returned to the factory for service, please complete the service form which follows this section and return it with the instrument.

4.5 COMPONENT LAYOUT AND SCHEMATIC DIAGRAM

The component layout for the Model 7057A is shown in Figure 9, while Figure 10 contains the Model 7057A schematic diagram.

Table 4. Model 7057A Replaceable Parts

Table 4. Model 7057A Replaceable Parts

Circuit Desig.	Description	Keithley Part No.
C101	Capacitor, .1μF, 500V, Polystyrene	C-238-.1
C102-C111	Capacitor, 10μF, 25V, Aluminum Electrolytic	C-314-10
K101	Relay, 2 Pole Form A	RL-77
K102	Relay, 2 Pole Form A	RL-77
K103	Relay, 2 Pole Form A	RL-77
K104	Relay, 2 Pole Form A	RL-77
K105	Relay, 2 Pole Form A	RL-77
K106	Relay, 2 Pole Form A	RL-77
K107	Relay, 2 Pole Form A	RL-77
K108	Relay, 2 Pole Form A	RL-77
K109	Relay, 2 Pole Form A	RL-77
K110	Relay, 2 Pole Form A	RL-77
R101	Pot, 100Ω	RP-97-100
R102	Resistor, 77.77k, 0.02%, ¼W, Wirewound	R-260-77.77k
R103	Resistor, 953.4Ω, 0.02%, ¼W, Wirewound	R-260-953.4
R104	Resistor, 6.15kΩ, 0.02%, ¼W, Wirewound	R-260-6.151k
R105	Resistor, 46.59Ω, 0.02%, ¼W, Wirewound	R-260-46.59
R106	Resistor, 12kΩ, .1%, 1/8W, Metal Film	R-168-12k
R107-R116	Resistor, 270Ω, 5%, ¼W, Composition	R-76-270
RT101	Thermistor	RT-4
U101	Low Drift Voltage Reference, AD5803	IC-151

Table 5. Model 7057A Replaceable Parts Mechanical

Description	Part Number
Isothermal Block	7057A-303
Isothermal Block, Cover	7057A-305
Clamp Assembly, Upper	7055-303-06
a. Clamp, Upper	7055-305
b. Strip, Rubber	26621
Clamp Assembly, Lower	7055-308
a. Clamp Cable, Lower	7055-307
b. Strip, Rubber	26621
Handle (2 required)	FA-119
Rivet (2 required)	FA-121
Standoff (21 required)	ST-139-7
#6-32 × 5/16 Phillips Pan Head Screw (2 required)	
#6-32 × 1 inch Phillips Pan Head Screw (2 required)	
#6-32 × ¼ Phillips Pan Head Screw (Heat Sink) (4 required)	
#6-32 × ¼ Phillips Pan Head Screw (Heat Sink Cover) (4 required)	
#6-32 × 3/8 Phillips Pan Head Screw	

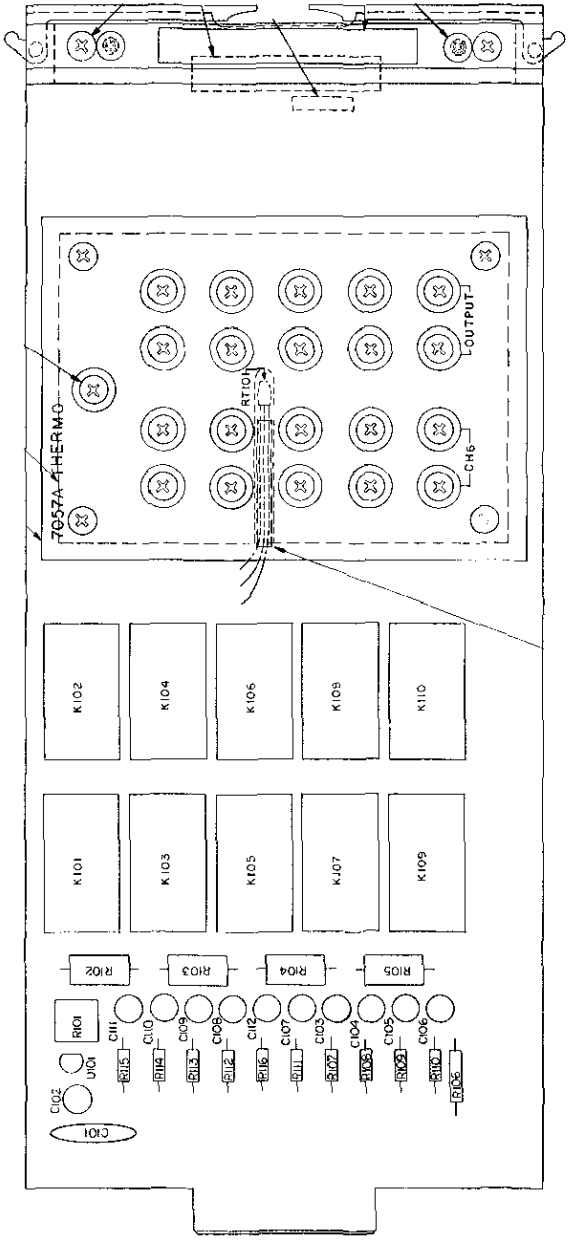
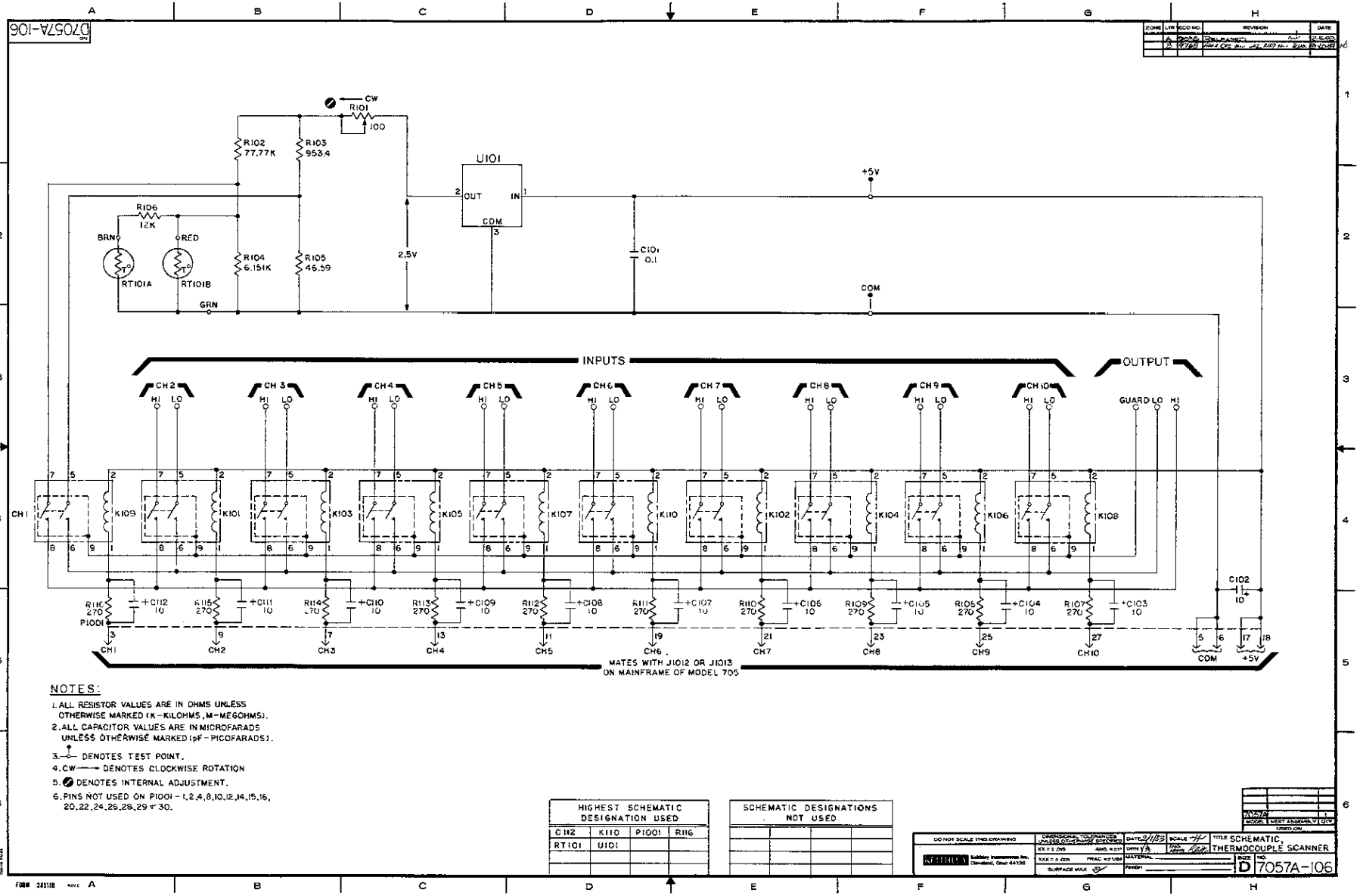


Figure 9. Model 7057A Component Location Diagram



NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS UNLESS OTHERWISE MARKED (K-KILOHMS, M-MEGOHMS).
2. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE MARKED (pF-PICOFARADS).
3. ⊸ DENOTES TEST POINT.
4. CW ⟶ DENOTES CLOCKWISE ROTATION
5. ⊘ DENOTES INTERNAL ADJUSTMENT.
6. PINS NOT USED ON P1001 - 1,2,4,8,10,12,14,15,16, 20,22,24,26,28,29 & 30.

HIGHEST SCHEMATIC DESIGNATION USED			
C112	K110	P1001	R116
RT101	U101		

SCHEMATIC DESIGNATIONS NOT USED			

TITLE	SCHEMATIC, THERMOCOUPLE SCANNER
SIZE	D
NO	7057A-106

Figure 10. Model 7057A Schematic Diagram

KEITHLEY INSTRUMENTS

SERVICE FORM

Model No. _____ **Serial No.** _____ **Date** _____

Name and Telephone No. _____

Company _____

List all control settings, describe problem and check boxes that apply to problem. _____

_____

_____

☐Intermittent ☐Analog output follows display ☐Particular range or function bad; specify _____

☐IEEE failure ☐Obvious problem on power-up ☐Batteries and fuses are OK

☐Front panel operational ☐All ranges or functions are bad ☐Checked all cables

Display or output (circle one)

☐Drifts ☐Unable to zero

☐Unstable ☐Will not read applied input

☐Overload

☐Calibration only ☐Certificate of Calibration required

☐Data required

(attach any additional sheets as necessary.)

Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also, describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.)

_____

_____

What power line voltage is used? _____ Ambient Temperature? _____ °F

Relative humidity? _____ Other? _____

Any additional information. (If special modifications have been made by the user, please describe.) _____

_____

Be sure to include your name and phone number on this service form.

KEITHLEY INSTRUMENTS

Instruments Division, Keithley Instruments, Inc. • 28775 Aurora Road • Cleveland, Ohio 44139 • (216) 248-0400 • Fax: (216) 248-6168

AUSTRIA: Keithley Instruments GesmbH • Rosenhugelstrasse 12 • A-1120 Wien • 0222-804-6548 • Fax: 0222-804-3597
FRANCE: Keithley Instruments SARL • 3 Allee des Garays • B.P. 60 • 91121 Palaiseau Cedex • 01-60-11-51-55 • Fax: 01-60-11-77-26
GERMANY: Keithley Instruments GmbH • Landsberger Str. 65 • D-8034 Germering • 089-849307-0 • Fax: 089-84930759
GREAT BRITAIN: Keithley Instruments, Ltd. • The Minster • 58 Portman Road • Reading, Berkshire RG3 1EA • 0734-575666 • Fax: 0734-596469
ITALY: Keithley Instruments SRL • Viale S. Gimignano 38 • 20146 Milano • 02-48303008 • Fax: 02-48302774
JAPAN: Keithley Instruments Far East Rlt. • Sumiyoshi 24 Bldg., Room 201 • 2-24-2 Sumiyoshi-Cho • Naka-Ku, Yokohama 231 • 81-45-201-2246 • Fax: 81-45-201-2247
NETHERLANDS: Keithley Instruments BV • Avelingen West 45 • 4202 MS Gorinchem • Postbus 559 • 4200 AN Gorinchem • 01830-35333 • Fax: 01830-30821
SWITZERLAND: Keithley Instruments SA • Kriesbachstrasse 4 • 8600 Dubendorf • 01-821-9444 • Fax: 01-820-3081
TAIWAN: Keithley Instruments Taiwan • Room 1105, 11th Floor, No. 147 • Section 2, Chien Kuo North Road • Taipei, R.O.C. • 886-2-509-4465 • Fax: 886-2-509-4473

Artisan Technology Group is an independent supplier of quality pre-owned equipment

Gold-standard solutions

Extend the life of your critical industrial, commercial, and military systems with our superior service and support.

We buy equipment

Planning to upgrade your current equipment? Have surplus equipment taking up shelf space? We'll give it a new home.

Learn more!

Visit us at **artisantg.com** for more info on price quotes, drivers, technical specifications, manuals, and documentation.

Artisan Scientific Corporation dba Artisan Technology Group is not an affiliate, representative, or authorized distributor for any manufacturer listed herein.

We're here to make your life easier. How can we help you today?

(217) 352-9330 | sales@artisantg.com | artisantg.com

ARTISAN® TECHNOLOGY GROUP