Instruction Manual

Model 7038
75Ω 2GHz Multiplexer Card

Contains Operating and Servicing Information

KEITHLEY

7038-901-01 Rev. A / 6-98

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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.

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Instruction Manual

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Manual Print History

The print history shown below lists the printing dates of all Revisions and Addenda created for this manual. The Revision Level letter increases alphabetically as the manual undergoes subsequent updates. Addenda, which are released between Revisions, contain important change information that the user should incorporate immediately into the manual. Addenda are numbered sequentially. When a new Revision is created, all Addenda associated with the previous Revision of the manual are incorporated into the new Revision of the manual. Each new Revision includes a revised copy of this print history page.

Revision A (Document Number (7038-901-01) ..... June 1998

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, 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) measuring circuits 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.

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 the 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.

7038 75Ω 2.0GHz Multiplexer

Specifications

CHARACTERISTIC IMPEDANCE: 75Ω nominal.

MULTIPLEXERS PER CARD: Three (with isolated ground).

CHANNELS PER MULTIPLEXER: Four.

CONTACT CONFIGURATION: 1-pole, 1 of 4 tree. Channels 1, 5 and 9 normally closed.

RELAY DRIVE CURRENT: 154mA per channel.

CONNECTOR TYPE: 75Ω miniature SMB receptacle.

ACTUATION TIME: 6ms.

MAXIMUM VOLTAGE: Any terminal (center or shield) to any other terminal or chassis: 24V.

MAXIMUM CURRENT: 10mA DC.

MAXIMUM POWER: 10W @ 1.2GHz.

ISOLATION:
Multiplexer to Multiplexer: >1GΩ.
Center to Shield: >1GΩ, 60pF.
Channel to Channel: >100MΩ.

SIGNAL DELAY: <1ns.

CONTACT POTENTIAL: 15µV.

CONTACT RESISTANCE: <1Ω.

CONTACT LIFE:
3×10^5 closures @ 24VDC, 10mA DC;
1×10^5 closures @ 10W, 1.2GHz signal;
5×10^6 closures @ cold switching.

AC PERFORMANCE:

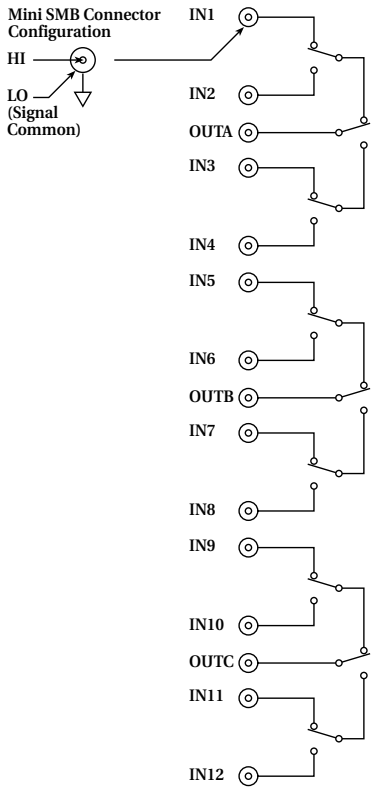
For $Z_L = Z_S = 75\Omega$	≤10 MHz	≤100 MHz	≤500 MHz	≤900 MHz	≤2 GHz
Insertion Loss (dB)	<0.25	<0.5	<1.0	<1.5	<3.0
Crosstalk (dB)					
Channel-Channel	<–90	<–80	<–65	<–55	<–40
Mux. to Mux.	<–90	<–80	<–70	<–60	<–55
VSWR	<1.2	<1.25	<1.5	<1.5	<2.2

ENVIRONMENT: **Operating:** 0° to 50°C, up to 35°C at <80% RH.
Storage: –25°C to 65°C.

EMC: Conforms with European Union Directive 89/336/EEC EN 55011, EN 50082-1, EN 61000-3-3, FCC part 15 class B.

SAFETY: Conforms with European Union Directive 73/23/EEC EN 61010-1.

ACCESSORIES SUPPLIED: Bank interconnection cables.



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4 Servicing

5 Replaceable Parts

1
General Information

1.1 Introduction

This section contains general information about the Model 7038 75Ω 2GHz Multiplexer Card. The Model 7038 is equipped with three four-channel multiplexers and is designed for both Model 7001 and 7002 Switch Systems.

1.2 Features

Key Model 7038 features include:

- Three independent four-channel multiplexers.
- 75Ω characteristic impedance.
- 2GHz bandwidth.
- Low insertion loss (<1dB @ 500MHz; <1.5dB @ 900MHz; <3dB @ 2GHz).
- Low VSWR assures good high-frequency performance.

1.3 Warranty information

Warranty information is located on the inside front cover of this instruction manual. Should your Model 7038 require warranty service, contact the Keithley representative or authorized repair facility in your area for further information. When returning the card for repair, be sure to fill out and include the service form at the back of this manual in order to provide the repair facility with the necessary information.

1.4 Manual addenda

Any improvements or changes concerning the card or manual will be explained in an addendum included with the card.

1.5 Safety symbols and terms

The following symbols and terms may be found on an instrument or used in this manual.

The  symbol on equipment indicates that you should refer to the operating instructions located in the instruction manual.

The **WARNING** heading used in this 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 used in this manual explains hazards that could damage the multiplexer card. Such damage may invalidate the warranty.

1.6 Specifications

Model 7038 specifications are located at the front of this manual.

1.7 Unpacking and inspection

1.7.1 Inspection for damage

The Model 7038 is packaged in a re-sealable, anti-static bag to protect it from damage due to static discharge and from contamination that could degrade its performance. Before removing the card from the bag, observe the precautions on handling discussed below.

1.7.2 Handling precautions

- Always grasp the card by the side edges and covers. Do not touch the board surfaces or components.
- After removing the card from its anti-static bag, inspect it for any obvious signs of physical damage. Report any such damage to the shipping agent immediately.
- When the card is not installed in a switching mainframe, keep the card in its anti-static bag, and store it in the original packing carton.

1.7.3 Shipment contents

The following items are included with every Model 7038 order:

- Model 7038 75Ω 2GHz Multiplexer Card
- Model 7038 Instruction Manual
- Additional accessories as ordered
- 2 SMB 10” jumpers (CA-193-1A)

1.8 Instruction manual

If an additional Model 7038 Instruction Manual is required, order the manual package, Keithley part number 7038-901-00. The manual package includes an instruction manual and any pertinent addenda.

1.9 Repacking for shipment

Should it become necessary to return the Model 7038 for repair, carefully pack the unit in its original packing carton or the equivalent, and include the following information:

- Call the Repair Department at 1-800-552-1115 for a Return Material Authorization (RMA) number.
- Advise as to the warranty status of the card.
- Write ATTENTION REPAIR DEPARTMENT and the RMA number on the shipping label.
- Fill out and include the service form located at the back of this manual.

1.10 Recommended cables and connectors

Recommended Cable: RG-179, 75Ω characteristic impedance

Connector Type: miniature SMB

When choosing cables, consider key parameters such as maximum outside diameter, attenuation over the desired frequency range, flexibility, and shield type. See *Switching considerations* in *Section 3* for more information on cable parameters and how they affect performance.

2

Connections and Installation

2.1 Introduction

WARNING

The procedures in this section are intended only for qualified service personnel. Do not perform these procedures unless you are qualified to do so. Failure to recognize and observe normal safety precautions could result in personal injury or death.

This section includes information on making connections to the Model 7038 and installing the card in the Model 7001/ 7002 Switch System.

2.2 Handling precautions

To maintain high-impedance isolation between channels, care should be taken when handling the card to avoid contamination from such foreign materials as body oils. Such contamination can reduce isolation resistance. To avoid possible contamination:

- Always grasp the card by the side edges or covers.
- Do not touch board surfaces, components, or connector insulators.
- Operate the card in a clean environment. If the card becomes contaminated, it should be thoroughly cleaned as explained in *Section 4*.

2.3 Connections

This paragraph provides the information necessary to connect cables and your external test circuitry to Model 7038.

2.3.1 Simplified schematic

Figure 2-1 shows a simplified schematic diagram of the Model 7038. The card is arranged into three separate multiplexers, each with four channels. Note that channels 1, 5, and 9 are normally closed.

2.3.2 Card configuration

Figure 2-2 shows the general configuration of the Model 7038. Connectors include:

IN 1-12 (channels 1-12): Each input is equipped with a miniature SMB coaxial connector. The center conductor is the signal path, while the outer shell is connected to signal common.

OUT A, OUT B, and OUT C: Each multiplexer output is equipped with a miniature SMB coaxial connector. The center conductor is the signal path, and the shell is connected to signal common.

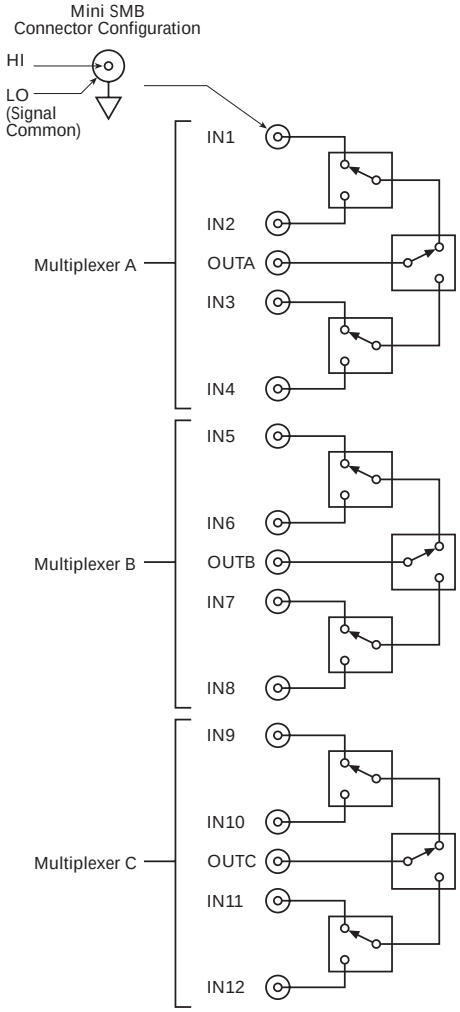


Figure 2-1
Model 7038 simplified schematic

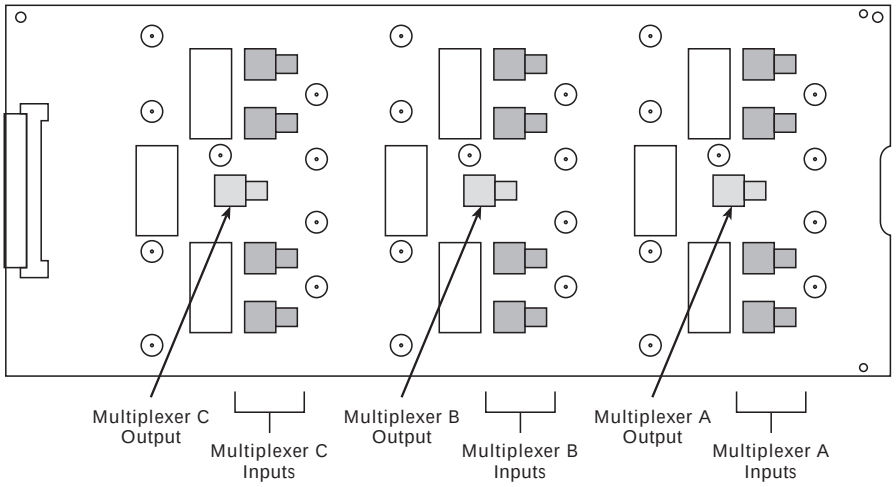


Figure 2-2
Model 7038 card configuration

2.3.3 Input/output connecting cables

All connections to the multiplexer card input and output jacks should be made using RG-179 75Ω coaxial cable equipped with miniature SMB connectors.

WARNING

Make sure that power is off and external energy sources are discharged before connecting or disconnecting cables.

NOTE

75Ω cables must be used to assure good high-frequency performance. See *Switching considerations* **in** *Section 3* **for more information.**

2.3.4 Typical connecting scheme

Figure 2-3 shows a typical connecting scheme for the Model 7038. In this arrangement, sources are connected to the multiplexer A inputs while the measuring instrument is connected to the output.

CAUTION

Maximum voltage from any terminal (center conductor or shield) to any other terminal or chassis is 24V. Exceeding this value may result in card damage.

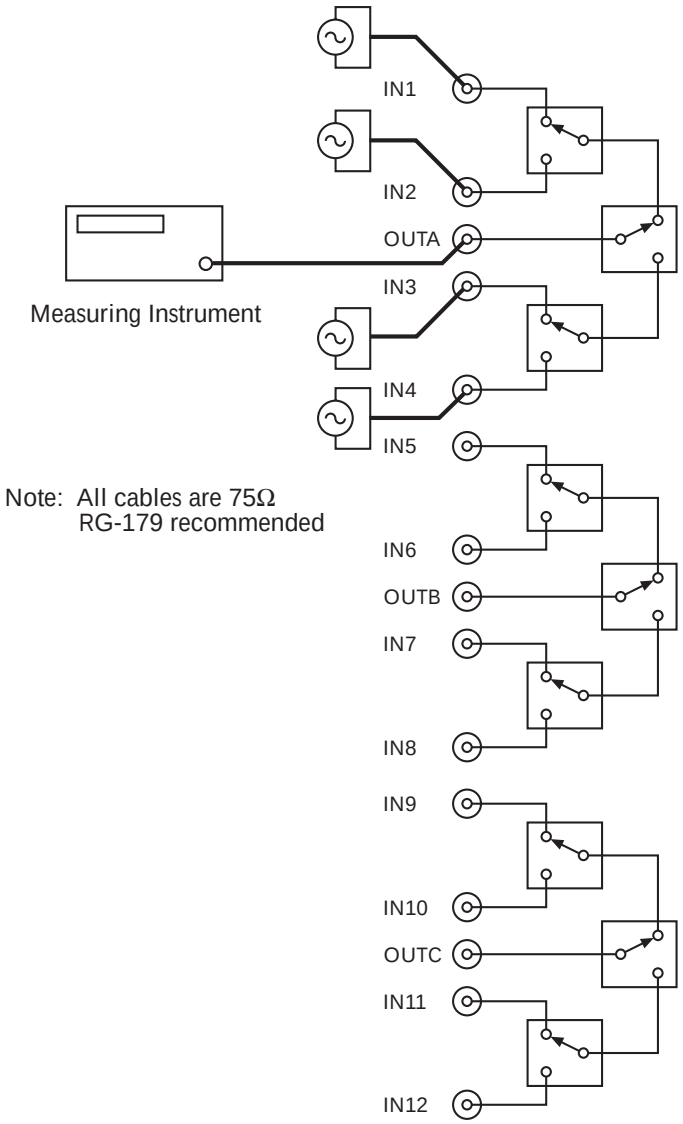


Figure 2-3
Typical connection scheme

2.4 Card installation and removal

This paragraph explains how to install and remove the Model 7038 card assembly from the Model 7001/7002 mainframe.

WARNING

Installation or removal of the Model 7038 should be performed only by qualified service personnel. Failure to recognize and observe standard safety precautions could result in personal injury or death.

NOTE

To prevent performance degradation caused by contamination, handle the card only by the edges and covers.

2.4.1 Card installation

After connecting the input/output cables, perform the following steps, and refer to Figure 2-4 or Figure 2-5 to install the card assembly in the Model 7001 or 7002 mainframe.

WARNING

Turn off power to all instrumentation (including the Model 7001/7002), and disconnect all line cords. Make sure all power is removed and any stored energy in external circuitry is discharged.

1. Open the ejector arms at the back edge of the card.
2. Slide the card edges into the guide rails inside the mainframe.
3. Carefully push the card all the way forward until the ejector arms engage the mounting cups.
4. Push in on the card edge and ejector arms until the card is properly seated.
5. Make sure the ejector arms are properly latched.

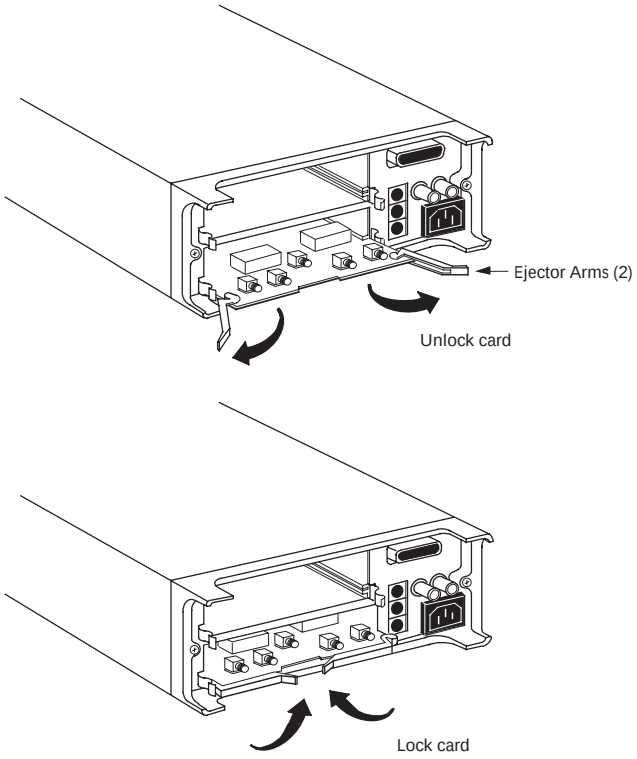


Figure 2-4
Card installation in Model 7001

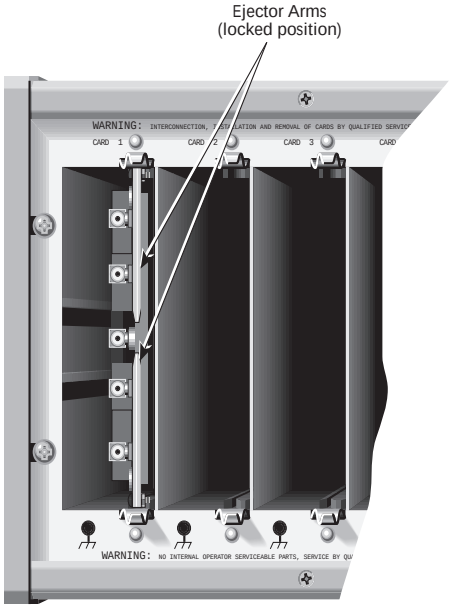


Figure 2-5
Card installation in Model 7002

2.4.2 Card removal

Follow the steps below to remove the multiplexer card from the mainframe:

WARNING

Turn off power to all instrumentation (including the Model 7001/7002), and disconnect all line cords. Make sure all power is removed and any stored energy in external circuitry is discharged.

1. Pull out on the ejector arms until the card pulls free from the internal connector.
2. Carefully slide the card out of the switching mainframe.

3
Operation

3.1 Introduction

This section contains basic information on using the Model 7038 including signal limitations, switching considerations, and multiplexer expansion. For detailed mainframe operating information, refer to the Model 7001 or Model 7002 Instruction Manual.

3.2 Signal limitations

CAUTION

To prevent damage to the Model 7038, do not exceed the maximum signal level specifications of the card.

To prevent over-heating or damage to the relays, never exceed the following maximum signal levels when using the Model 7038:

- **Maximum voltage:** Any terminal (center or shield) to any other terminal or chassis: 24V.
- **Maximum current:** 10mA DC
- **Maximum power:** 10W @ 1.2GHz

3.3 Front panel control

3.3.1 Closing and opening channels

Model 7038 channels are organized into three multiplexer banks as follows:

Multiplexer bank A: channels 1 to 4
Multiplexer bank B: channels 5 to 8
Multiplexer bank C: channels 9 through 12

NOTE

On power-up, the Model 7001 display will not show that channels 1, 5, and 9 are normally closed. If the instrument is to be operated manually, close channels 1, 5, and 9 so that the Model 7001 display reflects the actual state of the Model 7038. Executing a scan list will also ensure that the display reflects the actual state of the relays.

Closing channels

To close a Model 7038 multiplexer channel, simply key in the CHANNEL assignment, then press the Model 7001/7002 CLOSE key. For example, to close channel 11 of a Model 7038 installed in slot 2, key in the following channel list, and press CLOSE:

```
SELECT CHANNELS 2!11
```

You can also simultaneously close one channel in each multiplexer by including all channels in the channel list. For example, to close channels 2, 6, and 10 of a card in slot 1, enter the following channel list at the prompt:

```
SELECT CHANNELS 1!2, 1!6, 1!10
```

(Note that channels are separated by a comma, which can be inserted by pressing either the ENTER or right cursor key.)

NOTE

To maintain 75Ω characteristic impedance, close only one channel per multiplexer bank simultaneously. Closing more than one channel per multiplexer may cause unexpected results. Program the Model 7001/7002 for restricted operation to avoid closing more than one channel at a time.

Opening individual channels

To open a closed channel, simply key in the desired channel(s), then press OPEN. Closing channels 1, 5, and 9 will open all other channels. OPEN ALL performs the same function.

Using OPEN ALL

OPEN ALL will open all channels except channels 1, 5, and 9. Since those three channels are normally closed, OPEN ALL will close channels 1, 5, and 9.

NOTE

If channels 1, 5, and 9 are closed, all remaining channels will open, but the display will not update reflecting these current open channels. Conversely, if OPEN ALL is used to open all channels, channels 1, 5, and 9 will close automatically, but the display will not update to reflect these closed channels. Executing a scan list will update the display to reflect the current state of the relay card.

3.3.2 Scanning channels

To scan through channels, first configure a scan list, then program the Model 7001/7002 to perform a scan sequence. You can create a scan list in the same manner as you would a channel list. First, however, press the SCAN LIST key to select the "SCAN CHANNEL" mode, then enter the desired channels to be included in the scan list. For example, the following list scans channels 2, 3, 6, and 10 through 12 of a Model 7038 installed in slot 2:

SCAN CHANNELS 2!2, 2!3, 2!6, 2!10-2!12

Note that channels are scanned in the order they appear in the scan list.

To perform a manual scan, first select the RESET default conditions in the SAVESETUP selection of the main MENU. Press STEP to take the mainframe out of the idle state, then manually scan through channels by pressing the STEP key.

For information on more complex scan sequences, refer to the Model 7001 or 7002 Instruction Manual.

3.4 IEEE-488 bus control

3.4.1 Closing and opening channels

Closing channels

Use the following SCPI command to close channels:

:CLOS <list>

For example, the following command will close channels 2 and 6 of a Model 7038 installed in slot 1:

:CLOS (@ 1!2, 1!6)

Again, be sure not to close more than one channel per multiplexer to maintain 75Ω characteristic impedance.

Opening individual channels

Use the following command to open selected channels:

:OPEN <list>

For example, the command below will open previously closed channels 2 and 6:

:OPEN (@ 1!2, 1!6)

Using :OPEN ALL

Sending :OPEN ALL will open all channels except channels 1, 5, and 9. Since those three channels are normally closed, they will close when the :OPEN ALL command is sent.

3.4.2 Scanning channels

There are a number of commands associated with scanning. However, you can perform a simple scan using only the following four commands:

```
*RST
:TRIG:SEQ:COUN:AUT ON
:ROUT:SCAN <list>
:INIT
```

The *RST command selects the default scan configuration, while the second command automatically sets the channel count to the number of channels in the scan list. The :ROUT:SCAN command programs the scan list, and the :INIT command takes the mainframe out of the idle state.

For example, send the following commands to scan through all 12 channels of a Model 7038 installed in slot 1:

```
*RST
:TRIG:SEQ:COUN:AUT ON
:ROUT:SCAN (@ 1!1:1!12)
:INIT
```

3.5 Switching considerations

Signals passing through the Model 7038 Multiplexer Card are subject to various effects that can influence their characteristics. The following paragraphs discuss some of these effects and ways to minimize them.

3.5.1 Card characteristics

Insertion loss

Insertion loss indicates signal power lost while passing through the card. This loss occurs in the various signal path components through the card (connectors, PC board traces, and relays). The amount of power lost will, of course, depend on the particular insertion loss specification as well as the applied power. For example, with an insertion loss of 1dB, and a 10W source signal applied to the card, about 2W will be dissipated in the card, and approximately 8W will appear at the load. Note that, as with most transmission lines, Model 7038 insertion loss values increase with increasing frequency.

Crosstalk

Crosstalk figures indicate the amount of signal leakage between channels or switches on the card. With similar power levels applied to the various channels, crosstalk will be of little consequence. With widely different power levels, however, crosstalk may produce undesired results. For example, assume that 10W is applied to channel 1, and 1mW is applied to channel 2. Assuming a -60dB crosstalk figure, the unwanted signal coupled from channel 1 to channel 2 will be only 20dB below the desired channel 2 signal.

VSWR

The term VSWR (Voltage Standing Wave Ratio) is defined as the ratio of the maximum and minimum voltages along a transmission path, and it indicates the degree of impedance mismatch. In a perfectly matched system, the VSWR is 1:1, while open and shorted paths have infinite VSWR values. Since VSWR is related to both the return loss and reflection coefficient, VSWR figures indicate the degree of signal loss and reflection; the lower the VSWR figure, the less signal attenuation that occurs along the transmission path.

Isolation resistance

The isolation resistance is simply the equivalent resistance between two given connecting points on the card and is of importance primarily for DC and low-frequency AC signals switched by the card. The effects of this characteristic depend on the particular isolation specification. Center-to-shield isolation resistance, for example, may cause loading problems with signals having high source resistance. Channel-to-channel isolation resistance may result in leakage currents generated in one channel caused by a voltage source connected to another channel.

3.5.2 Cable characteristics

Characteristic impedance (Z_O)

Characteristic impedance is the value of cable impedance obtained by an RF measurement at either end. For example, a cable with a 75Ω characteristic impedance is $\sqrt{\frac{L}{C}}$ per unit length. (The characteristic impedance of a cable depends on the relative diameters of the inner and outer conductors, as well as on the dielectric constant of the insulating material.) Since the Model 7038 is designed to work with 75Ω cables, you must use 75Ω cables to assure proper impedance matching (RG-179 recommended). Mismatching anywhere along the transmission path will increase VSWR and signal reflections, decrease return loss, and consequently result in signal attenuation.

Cable attenuation

Cable attenuation is analogous to insertion loss of the card itself in that it defines the degree of attenuation of the signal as it passes through the cable. Cable attenuation factors are generally given in dB per 100 ft. and generally increase with rising frequency. For optimum performance, choose a high-quality 75Ω cable with a minimal insertion loss.

Cable termination

Proper cable termination is imperative to ensure maximum signal transfer and to minimize VSWR and signal reflections. In the case of Model 7038 operation, both source and load impedances should be as close to 75Ω as possible to assure optimum matching and thus maximum power transfer. For example, if a 75Ω cable is terminated with 150Ω, the reflection coefficient is 0.33, the VSWR increases to 2, and the return loss is reduced to less than -10dB.

Cable connectors and adapters

Although miniature SMB connectors are optimized for best performance, some small impedance mismatch at connecting points is virtually inevitable. For that reason, it is considered good practice to minimize the number of connectors used in a transmission path, especially at higher frequencies. Where possible, avoid using adapters to convert between various connector types.

3.6 Multiplexer expansion

3.6.1 Double T configuration

The simplest way to connect the three Model 7038 multiplexers together for expansion is to use the double "T" configuration shown in Figure 3-1. Note that this configuration results in a 1-of-12 multiplexer. Although this configuration is useful in many applications, the ideal 75Ω characteristic impedance will not be maintained. Consequently, VSWR will increase, affecting card insertion loss, particularly at higher frequencies. Also, considerable transmission path reflections will occur, an important consideration when switching pulse signals.

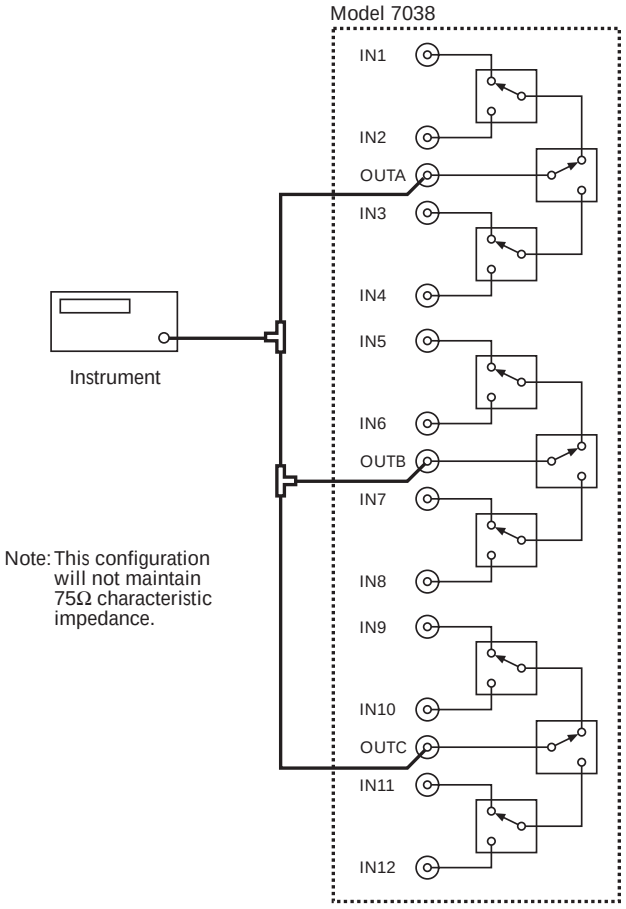
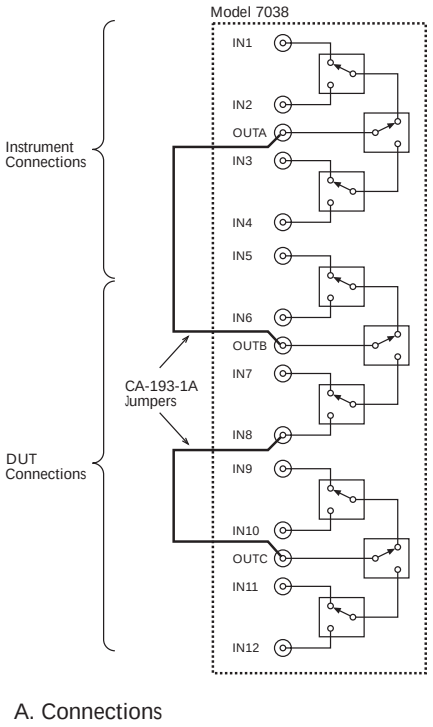


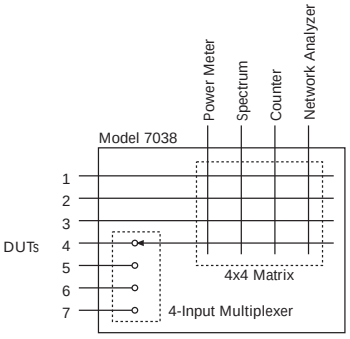
Figure 3-1
"T" connector multiplexer expansion

3.6.2 Matrix expansion

The proper way to connect the three Model 7038 multiplexers together is shown in Figure 3-2. Here, two of the three outputs are connected together using short coaxial cables, while the remaining output is connected to one of the other multiplexer bank inputs. Note that this connection scheme effectively forms a 4 × 4 matrix with a 4-input multiplexer on one of the matrix rows. This method provides a convenient way to connect seven DUTs to four different test instruments. Also, this method maintains the proper 75Ω characteristic impedance for optimum bandwidth and minimal signal loss and reflections. Two jumpers are provided for bank interconnect (CA-193-1A).



A. Connections



B. Matrix/Multiplexer Configuration

Figure 3-2
4 × 4 matrix/multiplexer connections

3.6.3 1 × 8 mux configuration

The three banks of the Model 7038 can also be connected together in the 1 × 8 mux configuration shown in Figure 3-3. Here OUTA and OUTB are connected to IN9 and IN10 of bank C using the supplied CA-193-1A jumpers. IN1 through IN8 are the eight mux inputs, while OUTC is the 1 × 8 mux output. Note that IN11 and IN12 are not used with this configuration.

Aside from providing a 1 × 8 mux, there are a couple other advantages to using this configuration. For one thing, the characteristic impedence is always maintained at 75Ω. Secondly, it is possible to have all channels effectively open simply by selecting an unused channel (IN11 in Figure 3-3).

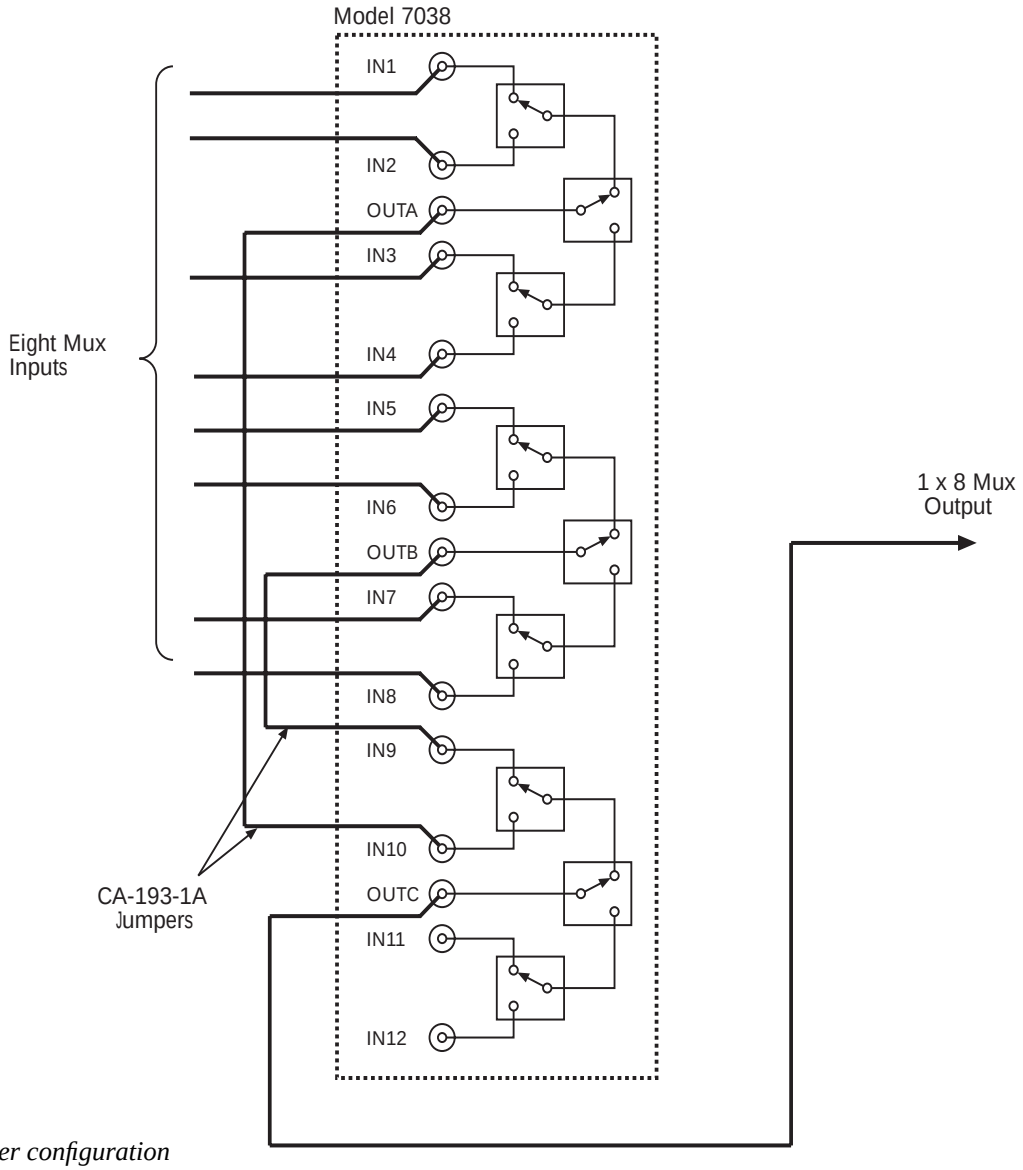


Figure 3-3
1 × 8 multiplexer configuration

4
Servicing

4.1 Introduction

This section contains information necessary to service the Model 7038 and includes information on handling and cleaning, performance verification, as well as principles of operation and troubleshooting.

WARNING

The information in this section is intended only for qualified service personnel. Some of the procedures may expose you to hazardous voltages that could result in personal injury or death. Do not perform these procedures unless you are qualified to do so.

4.2 Handling and cleaning precautions

Because of the high-impedance areas on the Model 7038, care should be taken when handling or servicing the card to prevent possible contamination. The following precautions should be observed when servicing the card.

4.2.1 Handling precautions

Observe the following precautions when handling the multiplexer card:

- Handle the card only by the edges and shields.
- Do not touch connector insulators.
- Do not touch any board surfaces or components not associated with the repair.
- Do not touch areas adjacent to electrical contacts.
- When servicing the card, wear clean cotton gloves.
- Do not store or operate the card in an environment where dust could settle on the circuit board.
- Use dry nitrogen gas to clean dust off the board if necessary.

4.2.2 Soldering considerations

Should it become necessary to use solder on the circuit board, observe the following precautions:

- Use an OA-based (organic activated) flux, and take care not to spread the flux to other areas of the circuit board.
- Remove the flux from the work areas when the repair has been completed. Use pure water along with clean cotton swabs or a clean soft brush to remove the flux.
- Once the flux has been removed, swab only the repaired area with methanol, then blow dry the board with dry nitrogen gas.
- After cleaning, allow the card to dry in a 50°C low-humidity environment for several hours before use.

4.3 Performance verification

The following paragraphs provide performance verification procedures for the Model 7038. These tests include insertion loss and isolation measurements.

4.3.1 Environmental conditions

All performance verification measurements should be made at an ambient temperature of 18°C to 28°C and <70% relative humidity.

Table 4-1
Recommended verification equipment

Description	Manufacturer and Model	Specifications	Test
Network Analyzer	Hewlett Packard 8713C (Option 1EC, 75Ω)	10MHz–2GHz	Insertion loss
Electrometer	Keithley 6517A	100MΩ, ±0.151% 1GΩ, ±0.226%	Isolation

4.3.2 Recommended verification equipment

Table 4-1 summarizes the test equipment recommended for performance verification. Alternate equipment may be used as long as the corresponding specifications are at least as good as those listed.

4.3.3 Insertion loss tests

Insertion loss tests are performed by applying a 10MHz-2GHz signal from a 75Ω network analyzer to the Model 7038 channel inputs and then measuring the amount of attenuation as the signal passes through the card.

Proceed as follows:

1. Set the network analyzer to sweep the 10MHz to 2GHz frequency range.
2. Normalize the analyzer reference channel to 0dB on the display.
3. Connect the network analyzer to the Model 7038 as shown in Figure 4-1. Be sure to use 75Ω cables for all insertion loss tests.
4. Install the Model 7038 in the Model 7001 or 7002 mainframe.
5. Close channel 1 on the Model 7038 card.
6. Verify that the insertion loss values are within the limits shown in Table 4-2.
7. Open the closed channel.
8. Repeat steps 3 through 7 for channels 2 through 12. For each channel:
   - Connect the analyzer signal to the input jack of the channel being tested.
   - Be sure the signal output cable is connected to the correct output jack.
   - Close only the channel being tested.
   - Verify that the insertion loss values at the various frequencies are within the limits stated in Table 4-2.

Table 4-2
Insertion loss values

Frequency	Insertion loss
10MHz	<0.25dB
100MHz	<0.5dB
500MHz	<1.0dB
900MHz	<1.5dB
2GHz	<3.0dB

4.3.4 Isolation resistance tests

These tests check the isolation resistance between various Model 7038 terminals using the ohms function of a Model 6517A Electrometer.

CAUTION

The following tests use the Model 6517A voltage source to measure resistance. Do not apply more than 24V to the Model 7038 to avoid card damage.

4.3.5 Channel isolation tests

Perform the following steps to check channel isolation:

1. Connect the Model 6517A Electrometer to the center conductors of channels 1 and 2, as shown in Figure 4-2.
2. With the power off, install the Model 7038 card in the mainframe.
3. Turn on the mainframe and the Model 6517A power, and allow the electrometer to warm up for at least one hour before making measurements. Make sure the voltage source is turned off.

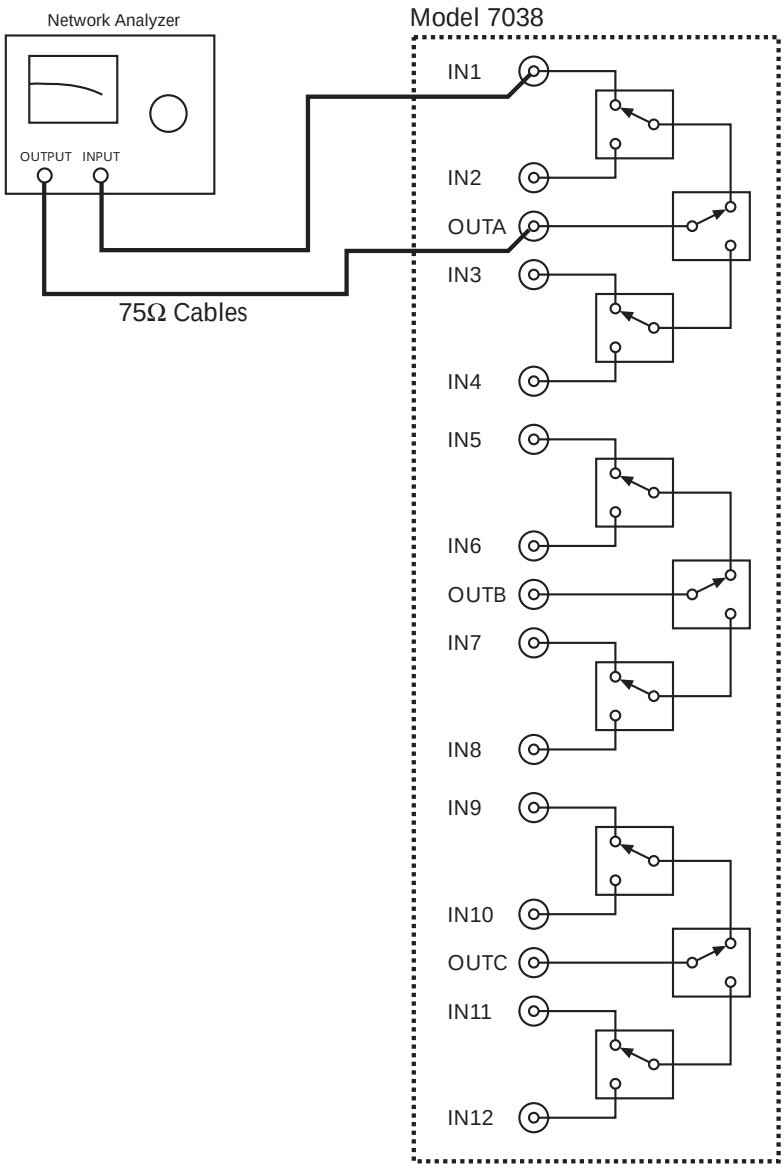


Figure 4-1
Connections for insertion loss tests

4. Select the Model 6517A ohms function, choose the 200MΩ range, and make certain zero check is disabled.
5. Close channel 1 on the Model 7038.
6. Program the Model 6517A voltage source for 20V, and make sure the internal voltage source connection mode is selected.
7. Turn on the Model 6517A voltage source, and allow the reading to settle.
8. Verify that the Model 6517A resistance reading is >100MΩ.
9. Turn off the voltage source, and open channel 1.
10. Repeat the procedure for channels 2 through 4, measuring the resistance between the center conductor of each channel and the center conductors of all other channels of multiplexer A. For each test:
    - Connect the electrometer to the center conductors of the two channels being tested.
    - Close only one of the channels being tested.
11. Repeat the entire procedure to test channel isolation between all multiplexer B channels (5-8) and multiplexer C channels (9-12).

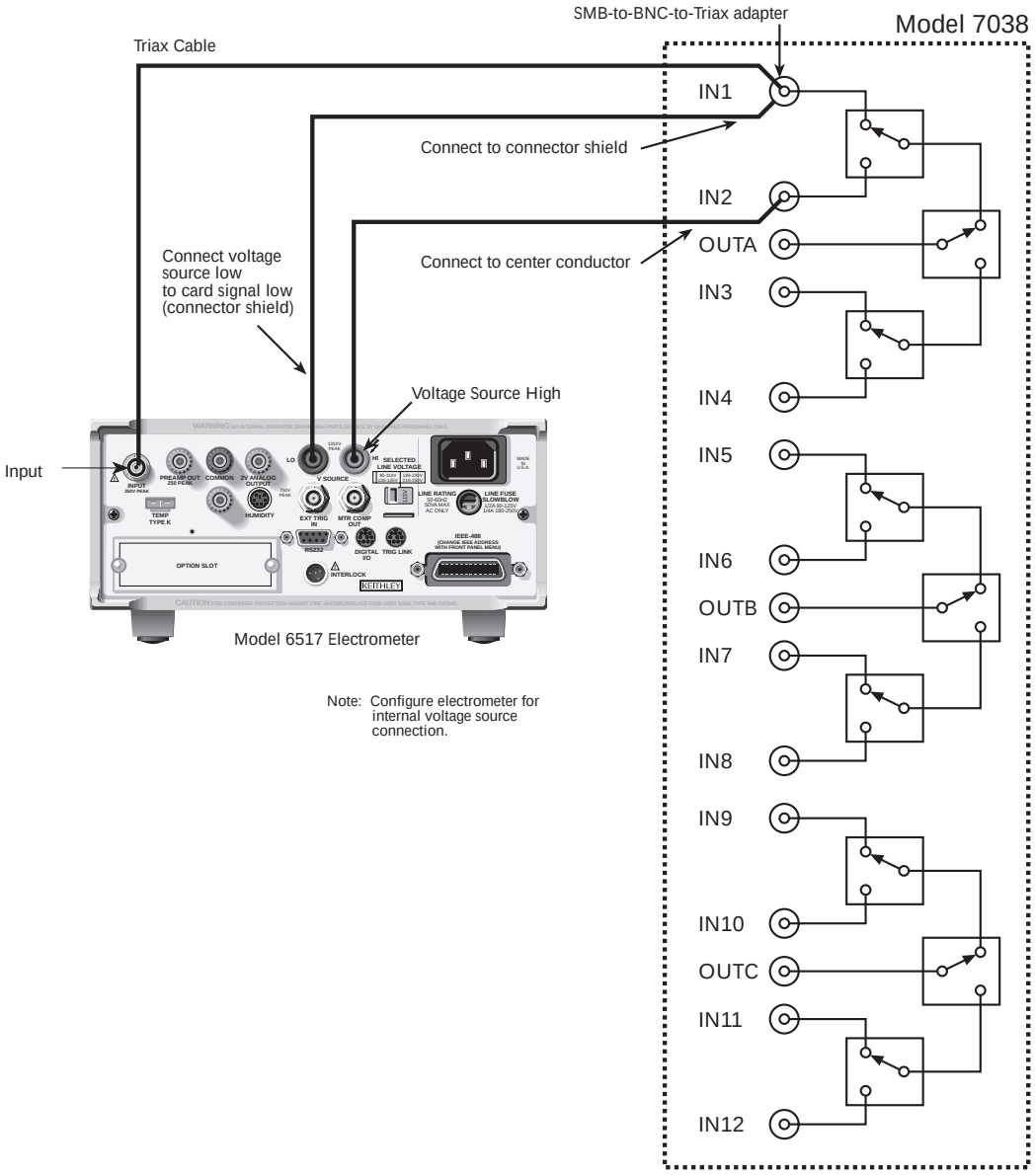


Figure 4-2
Connections for channel isolation tests

Center-to-shield isolation

Perform the following steps to check center-to-shield isolation:

1. Connect the Model 6517A Electrometer to the center conductor and shield output, as shown in Figure 4-3.
2. With the power off, install the Model 7038 card in the mainframe.
3. Turn on the mainframe and the Model 6517A power, and allow the electrometer to warm up for at least one hour before making measurements. Make sure the voltage source is turned off.
4. Select the Model 6517A ohms function, choose the 2GΩ range, and make certain zero check is disabled.
5. Close channel 1 on the Model 7038.
6. Program the Model 6517A voltage source for 20V, and make sure the internal voltage source connection mode is selected.
7. Turn on the Model 6517A voltage source, and allow the reading to settle.
8. Verify that the Model 6517A resistance reading is >1GΩ.
9. Turn off the voltage source, and open channel 1.

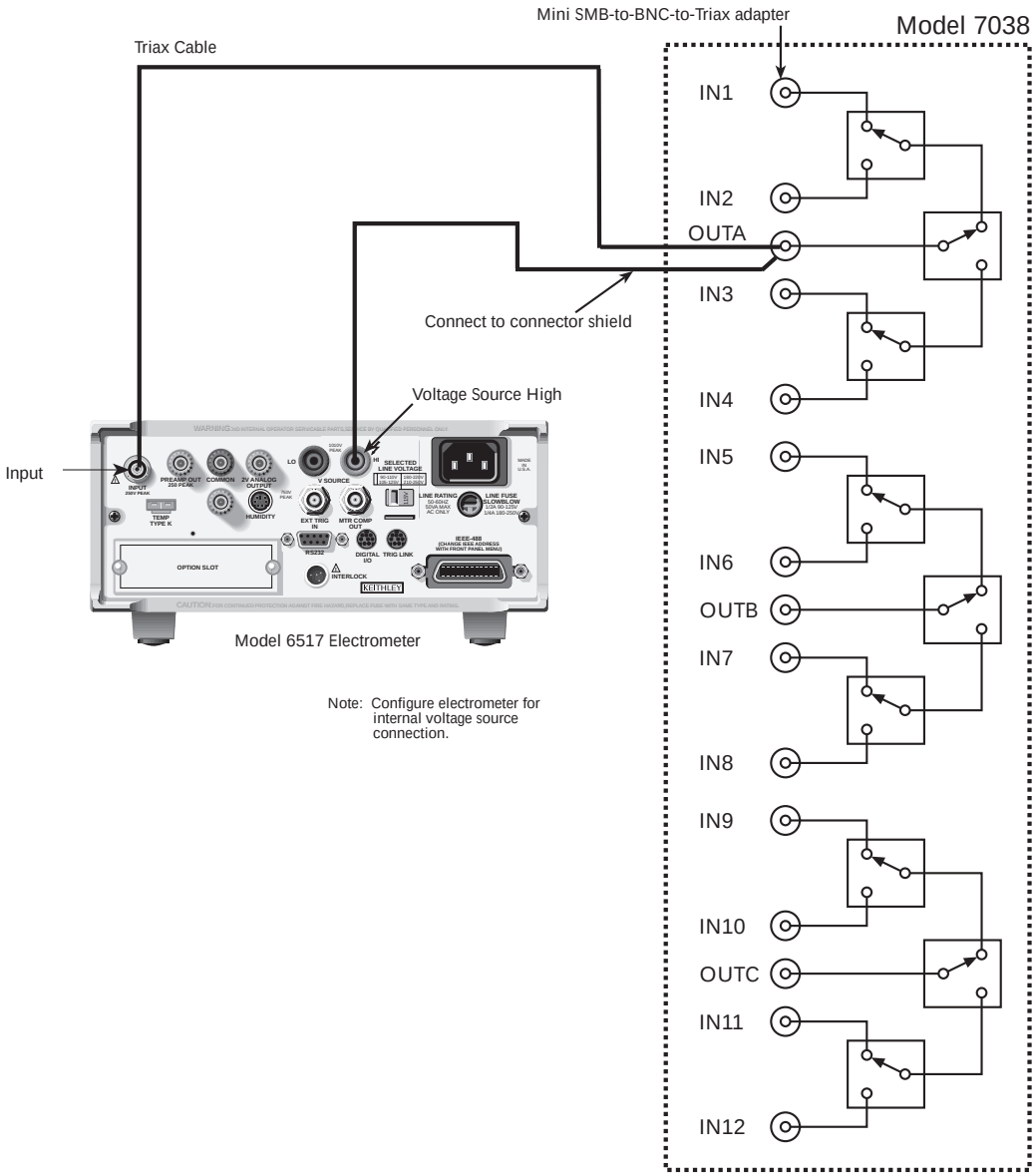


Figure 4-3
Connections for center-to-shield isolation tests

10. Repeat the procedure for channels 2 through 12, measuring the resistance between the center conductor and shield of each channel. For each test:
    - Connect the electrometer to the center conductor and shield of the output bank being tested.
    - Close only the channel being tested.

Multiplexer-to-multiplexer isolation

Perform the following steps to check multiplexer-to-multiplexer isolation:

1. Connect the Model 6517A Electrometer to the center conductors of channels 1 and 5, as shown in Figure 4-4.
2. With the power off, install the Model 7038 card in the mainframe.
3. Turn on the mainframe and the Model 6517A power, and allow the electrometer to warm up for at least one hour before making measurements. Make sure the voltage source is turned off.
4. Select the Model 6517A ohms function, choose the 2GΩ range, and make certain zero check is disabled.
5. Close channels 1 and 5 on the Model 7038.

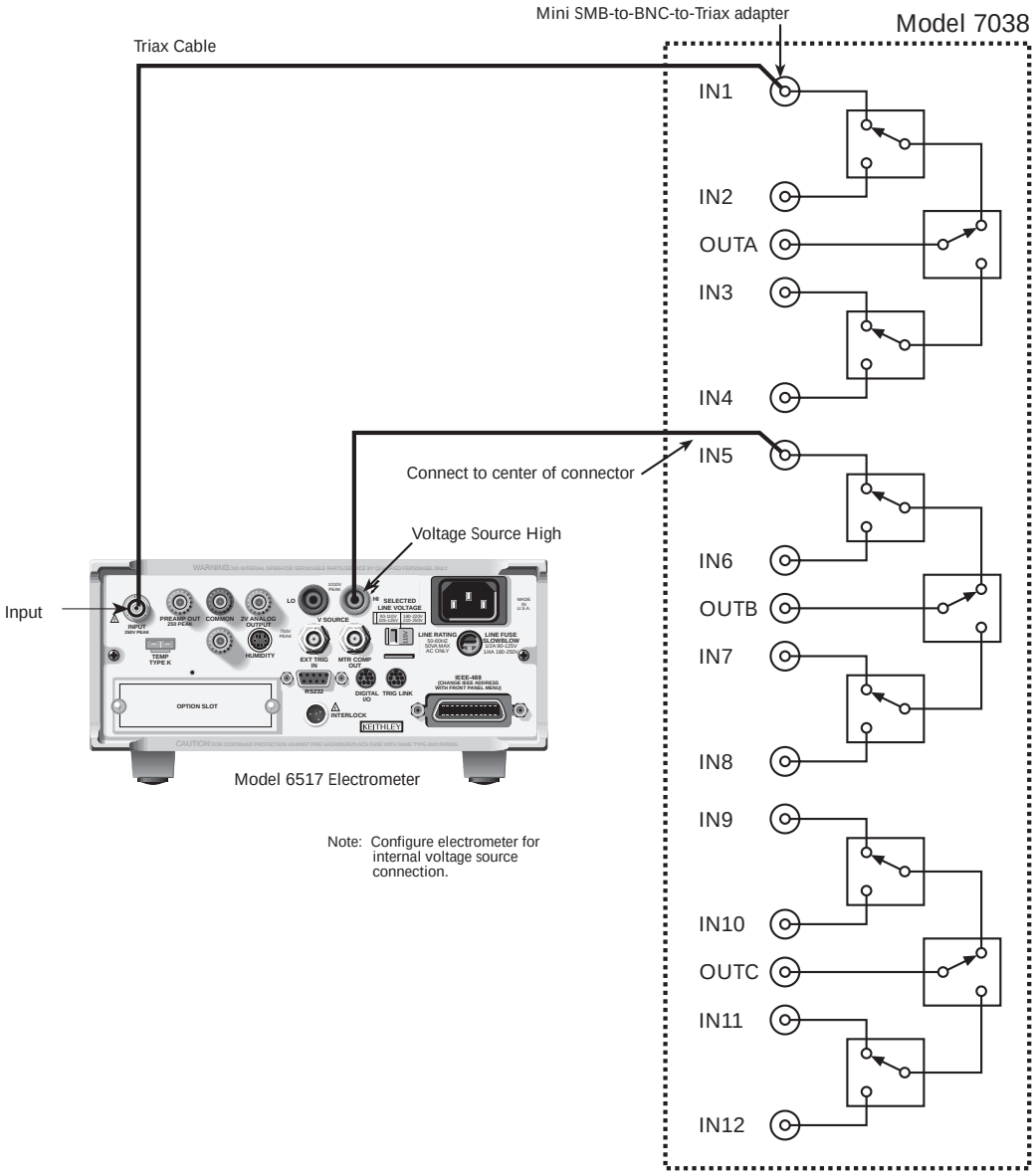


Figure 4-4
Connections for multiplexer-to-multiplexer isolation tests

6. Program the Model 6517A voltage source for 20V, and make sure the internal voltage source connection mode is selected.
7. Turn on the Model 6517A voltage source, and allow the reading to settle.
8. Verify that the Model 6517A resistance reading is >1GΩ.
9. Turn off the voltage source, and open channels 1 and 5.
10. Repeat steps 1 through 9 for isolation between multiplexers A and C and between B and C:
    - Multiplexers A and C: use channels 1 and 9.
    - Multiplexers B and C: use channels 5 and 9.

4.3.6 Special handling of static-sensitive devices

CMOS and other high-impedance devices are subject to possible static discharge damage because of the high-impedance levels involved. When handling such devices, observe the precautions listed below.

NOTE

To prevent damage, assume that all parts are static-sensitive.

- Such devices should be transported and handled only in containers specially designed to prevent or dissipate static build-up. Typically, these devices will be received in anti-static containers made of plastic or foam.
- Keep these parts in their original containers until ready for installation or use.
- Remove the devices from their protective containers only at a properly grounded workstation. Also, ground yourself with an appropriate wrist strap while working with these devices.
- Handle the devices only by the body; do not touch the pins or terminals.
- Any printed circuit board into which the device is to be inserted must first be grounded to the bench or table.
- Use only anti-static type de-soldering tools and grounded-tip soldering irons.

4.4 Principles of operation

The following paragraphs discuss the basic Model 7038 operating principles that can be used as an aid in troubleshooting the card. The schematic diagram of the card is located at the end of Section 5.

4.4.1 Block diagram

Figure 4-5 shows a simplified block diagram of the Model 7038. Key sections include the relay data control and driver ICs, the relays, and the card configuration memory. These various elements are discussed in the following paragraphs.

4.4.2 Relay control

Card relays are controlled by serial data transmitted from the host switching mainframe via the DATA line. Each control byte is shifted in serial fashion into latches located in the card relay driver IC (U101, U102, U103). The serial data is clocked in by the CLK (clock) line.

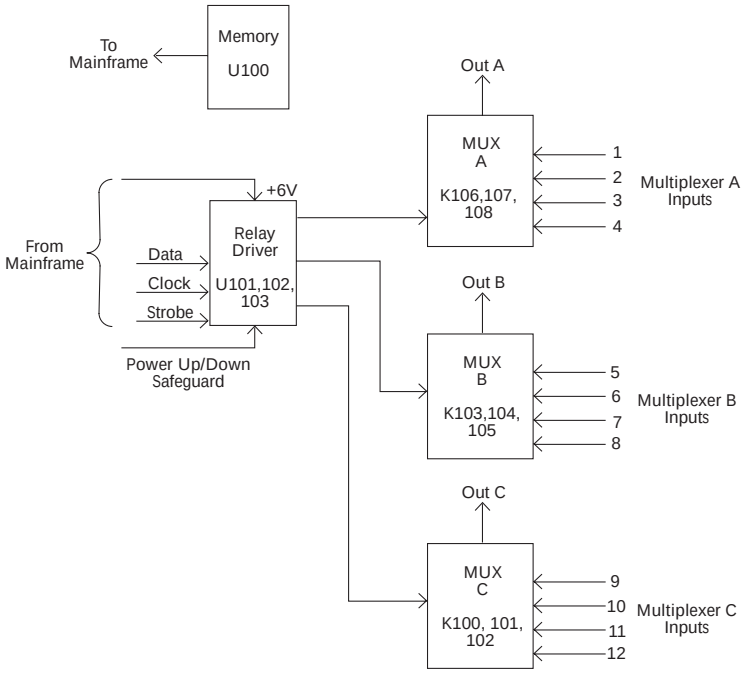


Figure 4-5
Block diagram

Once the relay control byte has been shifted into the card, the STR line is set high to latch the relay information into the Q outputs of the relay drivers, and the appropriate relays are energized (assuming the driver outputs are enabled, as discussed below). Note that a relay driver output goes low to energize the corresponding relay. Channels 1, 5, 9 are selected by deenergizing the relay coils. Q100-105 perform this function.

The output enable (OE) lines of U101, U102, and U103 are controlled by the power-up/power-down safeguard circuit located in the mainframe. This circuit assures that no card relays are inadvertently energized when the mainframe power is turned on or off.

Steering and clamping circuits are also included on the driver outputs. Each driver IC includes two transistors and four diodes to perform these functions.

4.4.3 Switching circuits

Signal switching is performed by relays K101 through K109. K106 through K108 switch channels 1 through 4, K103 through K105 switch channels 5 through 8, and K100 through K102 switch channels 9 through 12.

4.4.4 Card configuration memory

Card configuration information is stored in U100. This information is serially read by the mainframe during power-up and allows the unit to determine the card model number and card relay configuration information so that the mainframe can control the appropriate relays accordingly.

4.5 Troubleshooting

4.5.1 Troubleshooting equipment

Table 4-3 summarizes recommended equipment for troubleshooting the Model 7038.

Table 4-3
Recommended troubleshooting equipment

Description	Manufacturer and Model	Application
Multimeter	Keithley 2000	DCV checks
Oscilloscope	TEK 2243	View logic waveforms

4.5.2 Troubleshooting procedure

Table 4-4 summarizes multiplexer card troubleshooting steps. Refer to the schematic diagram and component layout drawing at the end of Section 5 for component locations.

CAUTION

Use care when removing relays from the PC board to avoid pulling traces away from the circuit board. Before attempting to remove a relay, use an appropriate desoldering tool to clear each mounting hole completely free of solder. Each relay pin must be free to move in its mounting hole before removal. Also, make certain that no burrs are present on the ends of the relay pins.

Table 4-4
Troubleshooting procedure

Step	Item/component	Required condition	Comments
1	Digital common P2001, pin 3 & 16		All voltages referenced to digital common.
2	P2001, pin 2	+6V	Card +6V relay supply voltage.
3	P2001, pin 14	+5V	Card +5V logic supply.
4	U101, U102, U103, pin 2	CLK pulses	During relay update sequence only.
5	U101, U102, U103, pin 3	DATA pulses	During relay update sequence only.
6	U101, U102, U103, pin 7	STR pulses	During relay update sequence only.
7	U101, U102, U103, pins 15–17	Low with relay on, hi with relay off.	Relay driver outputs.

5
Replaceable Parts

5.1 Introduction

This section contains replacement parts information, schematic diagrams, and component layout drawings for the Model 7038.

5.2 Parts list

The parts for the multiplexer are listed at the end of this section. Parts are listed alphabetically in order of circuit designation in Table 5-1.

5.3 Ordering information

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

- Card model number (7038)
- Card serial number
- Part description
- Circuit description, if applicable
- Keithley part number

5.4 Factory service

If the card is to be returned to Keithley Instruments for repair, perform the following:

- Call the Repair Department at 1-800-552-1115 for a Return Material Authorization (RMA) number.
- Complete the service form at the back of this manual and include it with the card.
- Carefully pack the card in the original packing carton.
- Write ATTENTION REPAIR DEPT and the RMA number on the shipping label.

NOTE

It is not necessary to return the switching mainframe with the card.

5.5 Component layout and schematic diagram

A component layout drawing and schematic diagram are included in the following pages.

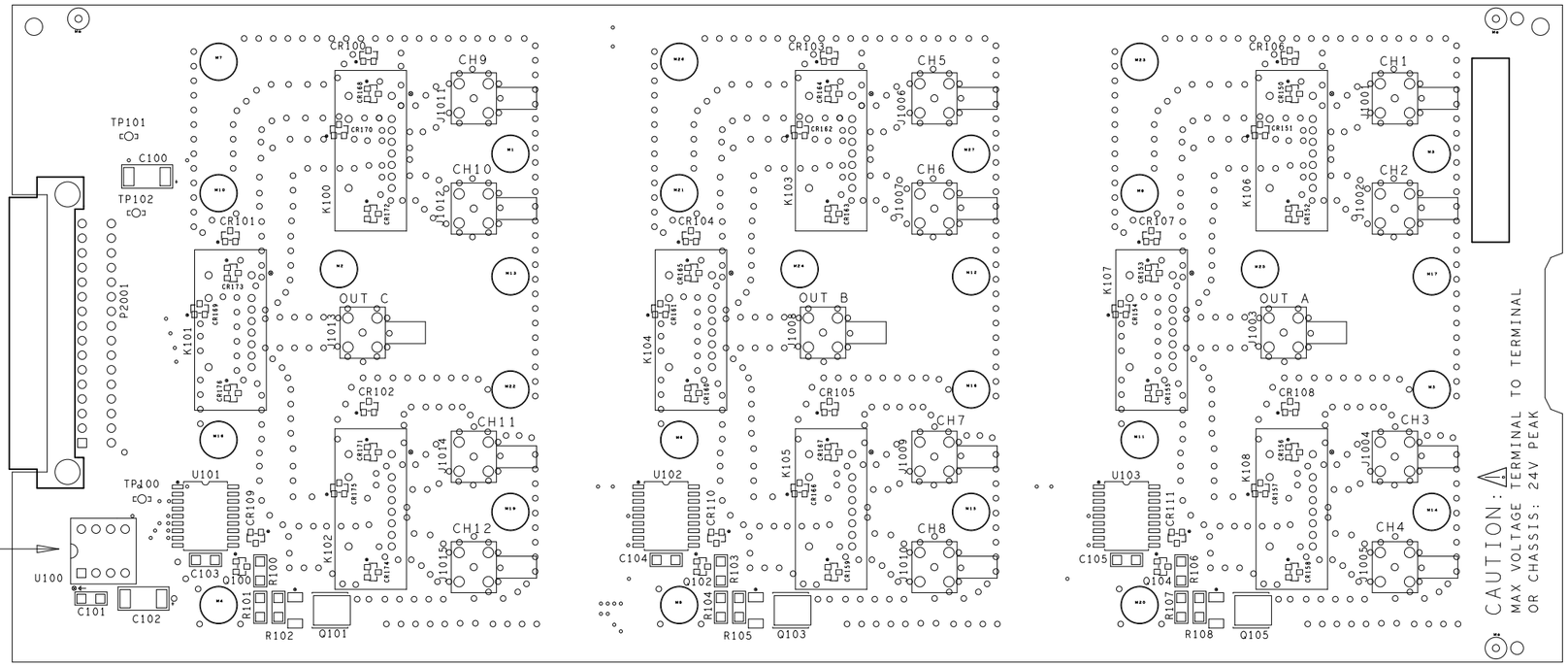
Table 5-1
Model 7038 parts list

Circuit designation	Description	Keithley part no.
C100, C102	CAP, 10UF, 20%, 25V, TANTALUM	C-440-10
C101, C103, C104, C105	CAP, .1UF, 20%, 50V, CERAMIC	C-418-.1
CR 100-CR111, CR150-CR176	DIODE, SWITCHING, MMBD914	RF-83
J1001-1015	CONNECTOR, MINI SMB	CS-1028
K100-108	RELAY HI FREQ, RM2-5V	RL-212
P2001	CONNECTOR, 32-PIN, 2-ROWS	CS-775-1
Q100, Q102, Q104	TRANS, NPN, MMBT3904	TG-238
Q101, Q103, Q105	P CHANNEL ENHANCEMENT POWER FET	TG-362
R100, R102, R103, R105, R106, R108	RES, 470, 5%, 125MW, METAL FILM	R-375-470
R101, R104, R107	RES, 4.7K, 5%, 125MW, METAL FILM	R-375-4.7K
TP100, TP101, TP102	CONN, TEST POINT	CS-553
U100	PROGRAMMED ROM	7038-800*
U101, U102, U103	IC, 8 STG/SHFT/STR REG, UCN5841LW	IC-857
	SMB CABLE.ASSY, 75 OHM (QTY. 2)	CA-193-1A

* Order current firmware revision (for example, A01).

NO. 7038-100

LTR.	ECA NO.	REVISION	ENG.	DATE
B	21407	RELEASED	P.S.	4/14/97
C	25839	CHANGES ARTWORK FROM B TO C CHANGED U100 FROM IC-918 TO TC17-100.	ELS	5/19/01



TC17-100 BOARD ASSEMBLY
ORIENT ARROW OF THIS ASSEMBLY
TOWARD PIN 1 ON 7038-100
ASSEMBLY

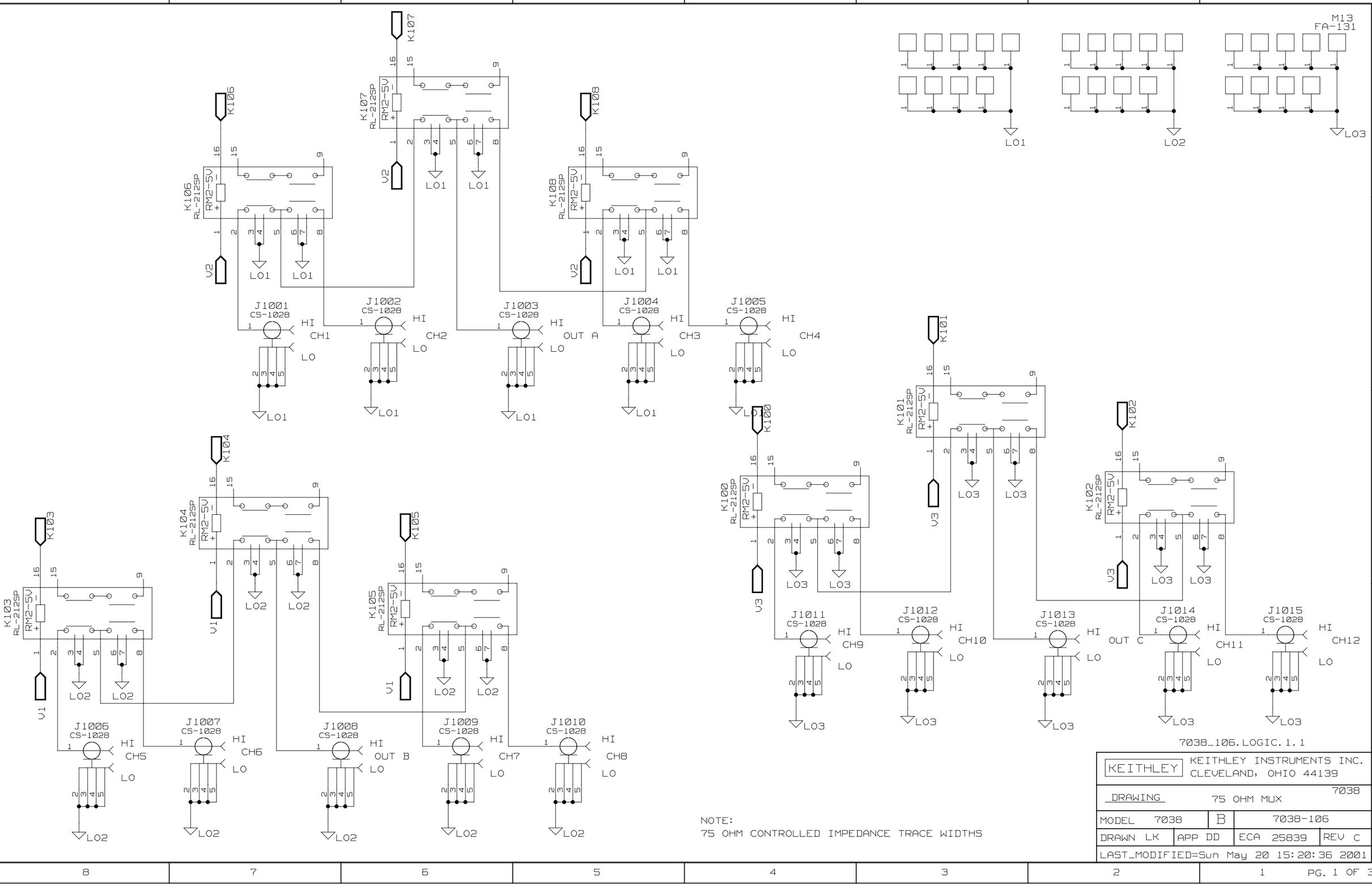
NOTE: FOR COMPONENT INFORMATION, SEE PRODUCT STRUCTURE

MODEL	NEXT ASSEMBLY	QTY.
USED ON		

KEITHLEY

KEITHLEY INSTRUMENTS INC.
CLEVELAND, OHIO 44139

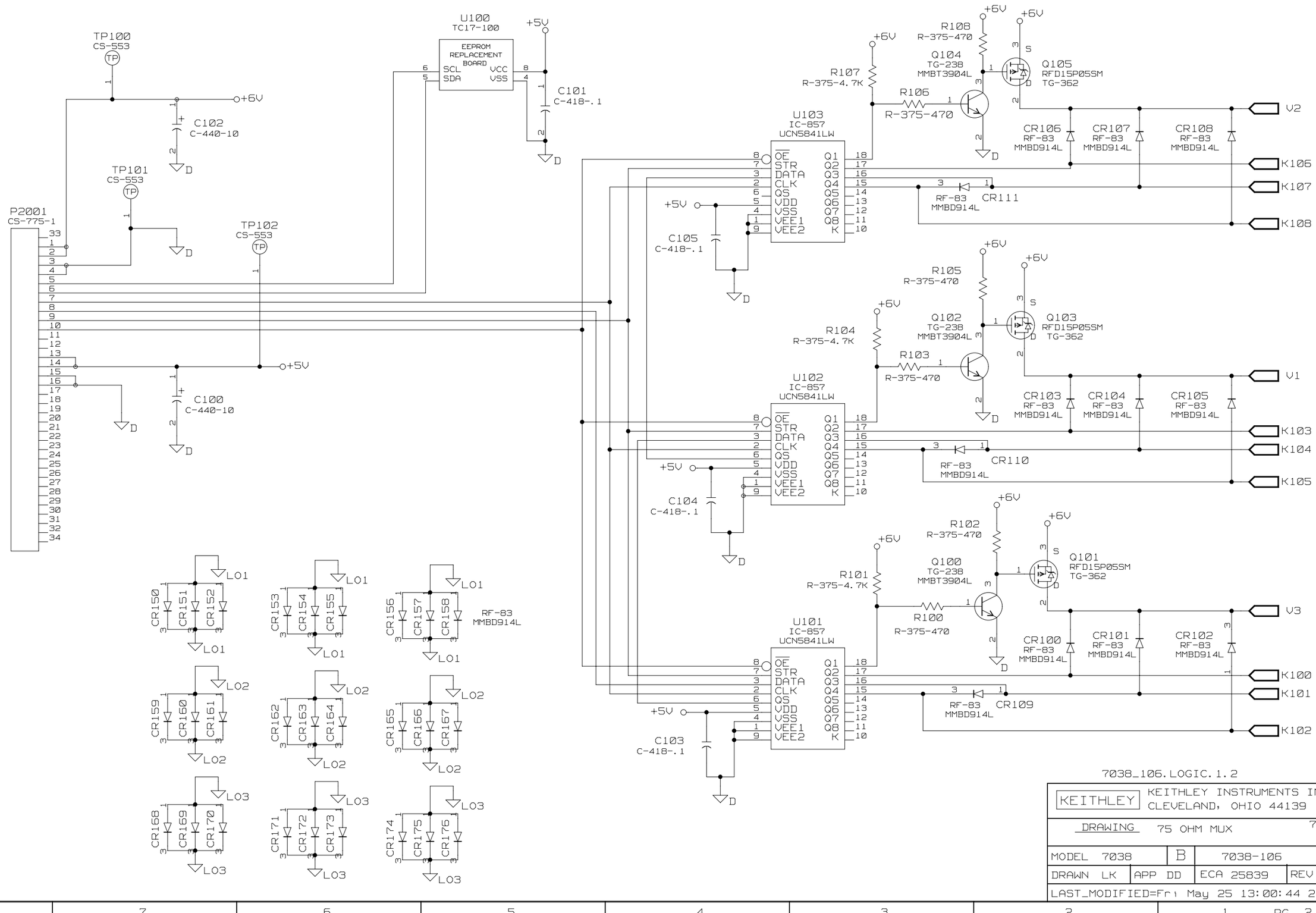
DIM ARE IN IN. UNLESS OTHERWISE NOTED	DATE 4/13/98	SCALE 1:1	TITLE COMPONENT LAYOUT, 75ohm 2Ghz MULTIPLEXER
DIM. TOL. UNLESS OTHERWISE SPECIFIED	DRN MRS	APPR. P.S.	
XX=+.01 ANG.=+1 XXX=+.005 FRAC.=+1/64	DO NOT SCALE THIS DRAWING	B	NO. 7038-100



NOTE:
75 OHM CONTROLLED IMPEDANCE TRACE WIDTHS

7038_105.LOGIC.1.1

KEITHLEY	KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139		
DRAWING	75 OHM MUX		7038
MODEL 7038	B	7038-105	
DRAWN LK	APP DD	ECA 25839	REV C
LAST_MODIFIED=Sun May 20 15:20:36 2001			



7038_106.LOGIC.1.2

KEITHLEY	KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139		
DRAWING	75 OHM MUX		7038
MODEL 7038	B	7038-106	
DRAWN LK	APP DD	ECA 25839	REV C
LAST_MODIFIED=Fri May 25 13:00:44 2001			

*** Signal Cross-Reference ***
--- for the entire design --

K100	1B4 2A1
K101	1C3 2A1
K102	1B2 2A1
K103	1B8 2B1
K104	1B7 2B1
K105	1B6 2B1
K106	1D7 2D1
K107	1D6 2C1
K108	1D5 2C1
V1	1A6 1A8 1B7 2C1
V2	1C5 1C7 1D6 2D1
V3	1B2 1B3 1B4 2A1

*** Unit Cross-Reference ***
--- for the entire design --

C100	ELCAP	2B7
C101	CAPACITOR	2D5
C102	ELCAP	2D7
C103	CAPACITOR	2A4
C104	CAPACITOR	2B4
C105	CAPACITOR	2C4
CR100	RF-83	2A2
CR101	RF-83	2A2
CR102	RF-83	2A1
CR103	RF-83	2B2
CR104	RF-83	2B2
CR105	RF-83	2B1
CR106	RF-83	2D2
CR107	RF-83	2D2
CR108	RF-83	2D1
CR109	RF-83	2A2
CR110	RF-83	2B2
CR111	RF-83	2C2
CR150	RF-83	2B7
CR151	RF-83	2B7
CR152	RF-83	2B7
CR153	RF-83	2B6
CR154	RF-83	2B6
CR155	RF-83	2B6
CR156	RF-83	2B6
CR157	RF-83	2B6
CR158	RF-83	2B5
CR159	RF-83	2A7
CR160	RF-83	2A7
CR161	RF-83	2A7
CR162	RF-83	2A6
CR163	RF-83	2A6
CR164	RF-83	2A6
CR165	RF-83	2A6
CR166	RF-83	2A6
CR167	RF-83	2A5
CR168	RF-83	2A7
CR169	RF-83	2A7
CR170	RF-83	2A7
CR171	RF-83	2A6
CR172	RF-83	2A6
CR173	RF-83	2A6
CR174	RF-83	2A6
CR175	RF-83	2A6
CR176	RF-83	2A5
J1001	CS-1028	1C7
J1002	CS-1028	1C6
J1003	CS-1028	1C6
J1004	CS-1028	1C5
J1005	CS-1028	1C4
J1006	CS-1028	1A8
J1007	CS-1028	1A7
J1008	CS-1028	1A7
J1009	CS-1028	1A6
J1010	CS-1028	1A5
J1011	CS-1028	1A4
J1012	CS-1028	1A3
J1013	CS-1028	1A2
J1014	CS-1028	1A2
J1015	CS-1028	1A1
K100	RL-212SP	1B4
K101	RL-212SP	1B3
K102	RL-212SP	1B2
K103	RL-212SP	1A8
K104	RL-212SP	1B7
K105	RL-212SP	1A6
K106	RL-212SP	1C7
K107	RL-212SP	1D6
K108	RL-212SP	1C5
M1	FA-131	1D1
M2	FA-131	1D1
M3	FA-131	1D3
M4	FA-131	1D1
M5	FA-131	1D3
M6	FA-131	1D2
M7	FA-131	1D1
M8	FA-131	1D3
M9	FA-131	1D2
M10	FA-131	1D1
M11	FA-131	1D3
M12	FA-131	1D2
M13	FA-131	1D1
M14	FA-131	1D3
M15	FA-131	1D2
M16	FA-131	1D1
M17	FA-131	1D3
M18	FA-131	1D2
M19	FA-131	1D1
M20	FA-131	1D3
M21	FA-131	1D2
M22	FA-131	1D1
M23	FA-131	1D3
M24	FA-131	1D2
M25	FA-131	1D3
M26	FA-131	1D2
M27	FA-131	1D2
P2001	CS-775-1	2C8
Q100	TG-238	2B3
Q101	TG-362	2B2
Q102	TG-238	2C3
Q103	TG-362	2C2
Q104	TG-238	2D3
Q105	TG-362	2D2
R100	RESISTOR	2A3
R101	RESISTOR	2B3
R102	RESISTOR	2B3
R103	RESISTOR	2C3
R104	RESISTOR	2C3
R105	RESISTOR	2C3
R106	RESISTOR	2D3
R107	RESISTOR	2D3
R108	RESISTOR	2D3
TP100	CS-553	2D7
TP101	CS-553	2D7
TP102	CS-553	2C6
U100	TC17-100	2D5
U101	IC-857	2A4
U102	IC-857	2C4
U103	IC-857	2D3

CREFOUT.LOGIC.1.3

KEITHLEY INSTRUMENTS INC.
CLEVELAND, OHIO 44139

DRAWING CROSS REFERENCER 7038

MODEL 7038	B	7038-106	
DRAWN LK	APP	ECA 25839	REV C

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KEITHLEY

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
❑ IEEE failure
❑ Front panel operational
❑ Analog output follows display
❑ Obvious problem on power-up
❑ All ranges or functions are bad
❑ Particular range or function bad; specify _____
❑ Batteries and fuses are OK
❑ Checked all cables

Display or output (check one)

❑ Drifts
❑ Unstable
❑ Overload
❑ Unable to zero
❑ Will not read applied input

❑ Calibration only
❑ Data required
❑ Certificate of calibration 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

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Cleveland, Ohio 44139

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