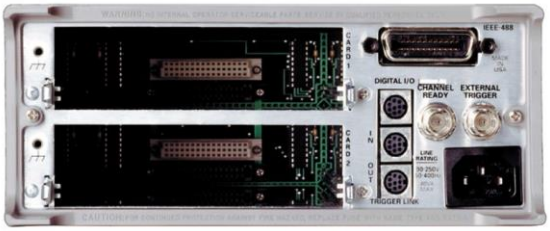
Keithley 7001 Switch/Control Mainframe

07-15-2018

近日在 Rowley flea market 收集到这台 Keithley 7001 Switch System 仪器，见图 1. 该机前面有設置面板;后面有带高频 BNC 的多个输入输出接插口及电脑 IEEE-488 插口;看来不是台简单的設备.数天内我都不清楚它的用途. 起先以为该机是电話系統的开关电路,但后面高频 BNC 的多个接插口否定了这个想法: 电話系統不用高频 BNC 接插口. 直到昨天在网上找到了这篇文章 “Switching and Control”, edited by Keithley in 2001. 我才弄清楚了它的用途: 它是台**通用的电子設备的自动綜合測試仪**,可称為 Switch Matrix 或者 Switch Mainframe,产于 2001-2003 年前后.

KEITHLEY
A Tektronix Company

图 1 . Keithley 7001 Switch System



始果您有一台新制成的电子設备需要測試.这台設备有多个输入信号和多个输出信号,不同输入信号的組合会产生不同的输出信号. 測試这台新設备时就需要用人工的方法設定不同的输入号信并且在输出仪器上观察不同输入信号下的綜合反应. 这样的测試很费时, 在工业生产上是不許可的.于是在早年就出现了继电器矩陣把多种输入输出信号用来組合以求得綜合测設效果.見图 2.

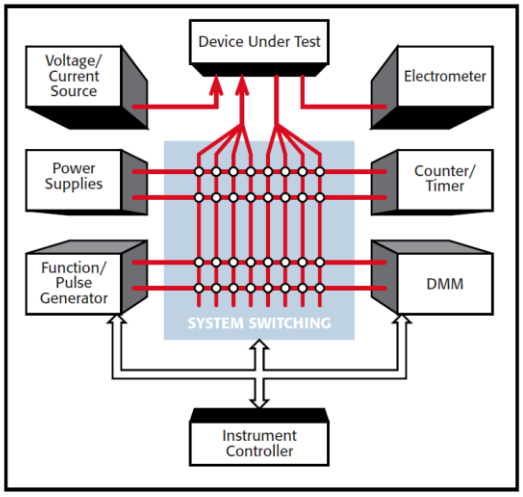


Figure 1. General Purpose Test System

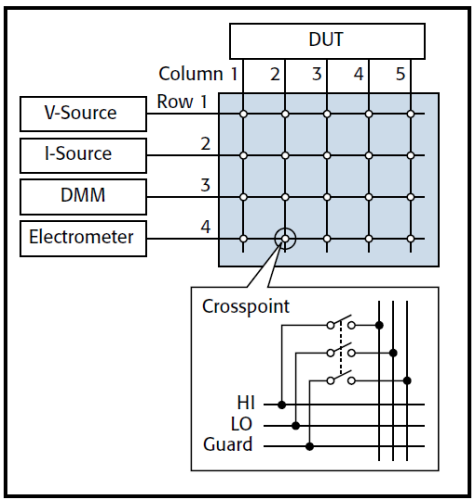


Figure 3. Matrix Switch

当 PC 面世以后这个用继电器做矩阵的开关陣就被电脑控制的电子开关阵取代. 这就是为何出现了象 **Keithley 7001, Keithley 3700A** 等 **Switch Mainframe** 样一类的产品.

相比继电器矩阵它们有很大的优点. 继电器矩阵是半机械式的, 要修改测試方案须改接线; 电子开关由电脑控制, 只要修改存放在内存中的测試方案(Test Pattern)即可办到. 另外电子开关速度极快可以减少测試中的时差问题, 也可直接现代的数字测量仪.

实际上 **Keithley Switch System** 内部的 I/O 插件是可换的. 根据您测試的要求(例如高压, 大电流, 直流/交流, 音频/高频等)可有许多选择. 例如 **Keithley 7001** 就提供 20 多种插件供用户选. 测试方案(Test Pattern)可在面板上設定也可以用背面的 IEEE-488 接口经电脑软件設定.

1. Keithley 7001 Switch/Control Mainframe 简介

1.1 下面是 **Keithley 7001** 的主要指标:

GENERAL

DISPLAY: Dual-line vacuum fluorescent.
1st line:20-character alphanumeric.
2nd line:32-character alphanumeric.

REAR PANEL CONNECTORS:
IEEE-488
8-pin micro-DIN connector for digital I/O
8-pin micro-DIN for Trigger Link
8-pin micro-DIN for Trigger Link expansion
BNC for External Trigger
BNC for Channel Ready

POWER: 100V to 240Vrms, 50/60Hz, 50VA maximum.

EMC: Conforms to European Union Directive 89/336/EEC, EN61326-1.

SAFETY: Conforms to European Union Directive 73/23/EEC, EN61010-1.

EMI/RFI: Meets VDE 0871B and FCC Class B.

ENVIRONMENT:
Operating: 0°–50°C, <80% relative humidity (0°–35°C).
Storage: –25° to +65°C.

DIMENSIONS, WEIGHT: 89mm high × 216mm wide × 375mm deep (3½ in × 8½ in × 14¾ in). Net weight 3.4kg (7½ lbs).

System

CAPACITY: 2 plug-in cards per mainframe.

MEMORY: Battery backed-up storage for 100 switch patterns.

SWITCH SETTLING TIME: Automatically selected by the mainframe for each card. Additional time from 0 to 99999.999 seconds can be added in 1ms increments.

TRIGGER SOURCES:

External Trigger (TTL-compatible, programmable edge, 600ns minimum pulse, rear panel BNC).

IEEE-488 bus (GET, *TRG)

Trigger Link

Manual (front panel)

Internal Timer, programmable from 1ms to 99999.999 seconds in 1ms increments.

STATUS OUTPUT: Channel Ready (TTL-compatible signal, rear panel BNC). Low going pulse (10μs typical) issued after relay settling time. For two different switch cards, 7001 will be set to the slowest relay settling time.

SWITCHING SEQUENCE: Automatic break-before-make.

MAINFRAME DIGITAL I/O: 4 open-collector outputs (30V maximum pull-up voltage, 100mA maximum sink current, 10Ω output impedance), 1 TTL compatible input, 1 common.

RELAY DRIVE: 700mA maximum for both card slots.

CARD SIZE: 32mm high × 114mm wide × 272mm long (1¼ in × 4½ in × 10¾ in).

CARD COMPATIBILITY: Fully compatible with all 7XXX cards.

Analog Backplane

SIGNALS: Four 3-pole rows (Hi, Lo, Guard). These signals provide matrix and multiplexer expansion between cards within one mainframe.

MAXIMUM VOLTAGE: 250V DC, 250V rms, 350V AC peak, signal path to signal path or signal path to chassis.

MAXIMUM CURRENT: 1A peak.

PATH ISOLATION:

$>10^{10}\Omega$, <50pF path to path (any Hi, Lo, Guard to another Hi, Lo, Guard).

$>10^{10}\Omega$, <50pF differential (Hi to Lo or Hi, Lo to Guard).

$>10^{9}\Omega$, <75pF path to chassis.

CHANNEL CROSSTALK: <–65dB @ 1MHz (50Ω load).

BANDWIDTH: <3dB loss at 100MHz (50Ω load).

IEEE-488 BUS IMPLEMENTATION

STANDARDS CONFORMANCE: Conforms to SCPI-1990, IEEE-488.2, and IEEE-488.1.

MULTILINE COMMANDS: DCL, LLO, SDC, GET, GTL, UNT, UNL, SPE, SPD.

UNILINE COMMANDS: IFC, REN, EOI, SRQ, ATN.

INTERFACE FUNCTIONS: SH1, AH1,T5, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, C0, E1.

1.2 Keithley 7001 内部的 I/O 插件是可换的，可有许多选择

Selector guide: Switch cards for 7001, 7002

Selector Guide — Switch Cards for 7001, 7002

	No. of Channels	Card Config.	Contact Config.	Max. Voltage	Max. Current	Max. Power	Contact Potential	Max. Offset Current	Recomm. Frequency	Connection Type	CE	Comments
HIGH DENSITY												
7011-C	40	Multiplexer	2 form A	110V	1A	60VA	<1μV	<100pA	2MHz	Connector	Yes	Four independent 1×10 multiplexers, connection to backplane
7011-S	40	Multiplexer	2 form A	110V	1A	60VA	<500nV	<100pA	2MHz	Screw term.	Yes	Four independent 1×10 multiplexers, connection to backplane
7012-C	4×10	Matrix	2 form A	110V	1A	60VA	<1μV	<100pA	2MHz	Connector	Yes	Rows connect to analog backplane
7012-S	4×10	Matrix	2 form A	110V	1A	60VA	<500nV	<100pA	2MHz	Screw term.	Yes	Rows connect to analog backplane
7013-C	20	Isolated Switch	2 form A	110V	1A	60VA	<1μV	<100pA	10MHz	Connector	Yes	
7013-S	20	Isolated Switch	2 form A	110V	1A	60VA	<500nV	<100pA	10MHz	Screw term.	Yes	
7015-C	40	Multiplexer	2 form A	175V	34mA	0.3VA	<5μV	<1nA	500kHz	Connector	Yes	Solid state switch for high reliability
7015-S	40	Multiplexer	2 form A	175V	34mA	0.3VA	<5μV	<1nA	500kHz	Screw term.	Yes	Solid state switch for high reliability
7018-C	28	Multiplexer	3 form A	110V	1A	60VA	<5μV	<100pA	2MHz	Connector	Yes	3 pole switching
7018-S	28	Multiplexer	3 form A	110V	1A	60VA	<5μV	<100pA	2MHz	Screw term.	Yes	3 pole switching
7035	36	Multiplexer	2 form A	60V	1A	30VA	<1μV	<100pA	10MHz	Connector	Yes	9 independent 1×4 multiplexers
7036	40	Isolated Switch	1 form A	60V	1A	30VA	<4μV	<100pA	10MHz	Connector	Yes	40 independent channels of 1-pole switching
7111-S	40	Multiplexer	1 form C	110V	1A	60VA	<500nV	<100pA	2MHz	Screw term.	Yes	Four independent 1×10 multiplexers, connection to backplane
Control												
7020 7020-D*	80	Digital I/O								Connector	Yes	40 inputs/40 outputs
7037-D*	30/20	Isolated/ Digital I/O	1 form A	110V	1A	30VA	<4μV	<100pA	10MHz	Connector	Yes	30 independent channels of 1-pole switching, 10 digital inputs, 10 digital outputs
7065					See page 211 for details.							Hall Effect measurement buffer card
HIGH CURRENT												
7053	10	Multiplexer	2 form A	300V	5A	100VA	<1mV		1MHz	Screw term.		
HIGH VOLTAGE												
7154	10	Multiplexer	2 form A	1100V	500mA	10VA	<35μV		1MHz	Screw term.	Yes	
LOW CURRENT												
7152	4×5	Matrix	2 form A	200V	500mA	10VA	<20μV	<1pA	60MHz	Connector	Yes	
7153	4×5	Matrix	2 form A	1300V	500mA	10VA	<50μV	<1pA	60MHz	Connector	Yes	
7158	10	Multiplexer	1 form C	30V	100mA		<200μV	<1pA	1MHz	BNC	Yes	
LOW VOLTAGE												
7168	8	Multiplexer	2 form A	10V	50mA		<30nV		1kHz	Screw term.	Yes	
7153	4×5	Matrix	2 form A	1300V	500mA	10VA	<50μV	<1pA	60MHz	Connector	Yes	
7158	10	Multiplexer	1 form C	30V	100mA		<200μV	<1pA	1MHz	BNC	Yes	
LOW VOLTAGE												
7168	8	Multiplexer	2 form A	10V	50mA		<30nV		1kHz	Screw term.	Yes	

每个 7001 Switch Mainframe 可带 2 个插件. 在我那台 **7001 Switch Mainframe** 上带有一个低电流扫描卡插件 **(Keithley 7158, Low Current Scanner Card)**, 见图 7.

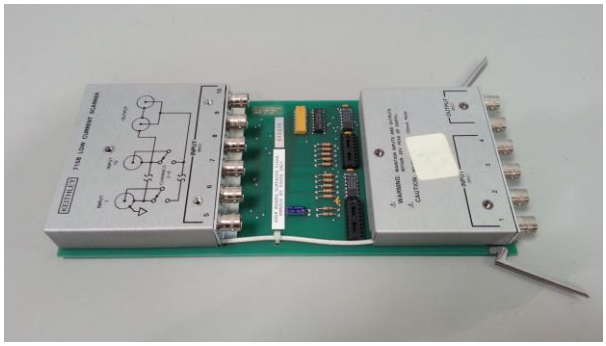
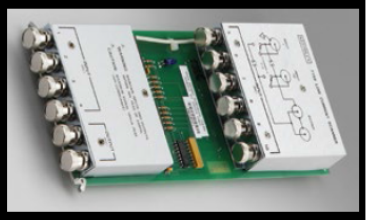


图 7. Keithley 7158 插件

7158



- **Sub-picoamp offset current**
- **Maintains current path for unselected channel**
- **BNC connectors**

Ordering Information

7158	**Low Current Scanner Card**

Accessories Supplied

4801	**Low Noise Male to Male BNC Input Cable**

Low Current Scanner Card

10-channel

The Model 7158 provides quality low-current switching at an affordable price. The offset current error generated is specified <1pA, with typical performance at <30fA. When used with a voltage source and electrometer or picoammeter, this card can easily automate insulation resistance tests, reverse leakage tests on semiconductor junctions, or gate leakage tests on FETs.

The Model 7158 is designed to maintain the current path even when the channel is deselected. Input connectors are BNC for shielding of the sensitive measurements and for compatibility with low noise coaxial cables such as Keithley accessory cables Models 4801 and 4803. Two outputs are provided to allow for chaining several scanner cards to one measurement instrument, and an isolation relay in the output HI minimizes interaction between cards.

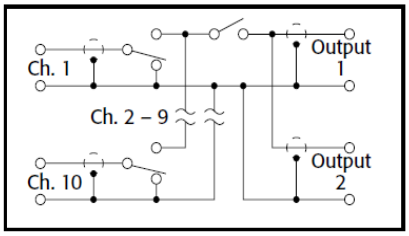
CHANNELS PER CARD: 10.
CONTACT CONFIGURATION: Single pole, simultaneous break and make for signal HI input. Signal LO is common for all 10 channels and output. When a channel is off, signal HI is connected to signal LO.
CONNECTOR TYPE: BNC.
RELAY DRIVE CURRENT: 100mA per card typical (regardless of channel closures selected).
MAXIMUM SIGNAL LEVEL: 30V, 100mA peak (resistive load).
CONTACT LIFE: >10^6 closures at maximum signal levels; >10^7 closures at low signal levels.
CONTACT RESISTANCE: <1Ω.
CONTACT POTENTIAL: <200μV.
OFFSET CURRENT: <1pA (<30fA typical).
3dB BANDWIDTH: 1MHz typical.
ACTUATION TIME: <1ms, exclusive of mainframe.
CHANNEL ISOLATION: >10^{14}Ω.
INPUT ISOLATION: Differential: >10^9Ω, <50pF.
Common Mode: >10^9Ω, <150pF.
COMMON MODE VOLTAGE: <30V maximum.

ACCESSORIES AVAILABLE

4801	Low Noise Male to Male BNC Input Cable
4802-10	Low Noise BNC to Unterminated Cable, 10 ft.
4803	Low Noise BNC Cable Kit for 7158

SERVICES AVAILABLE

7158-3Y-EW	1-year factory warranty extended to 3 years from date of shipment



Use with 7001 and 7002 switch mainframes

图 8 Keithley 7158, Low Current Scanner Card 简介

图 9. 7158 插件输入(1-4)和输出

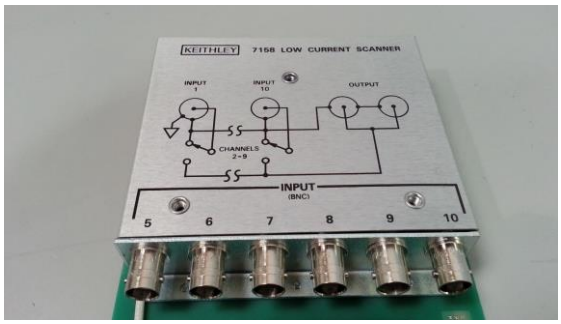


图 10. 7158 插件输入(5-10)

1.3 Keithley 7001 的原理

7001 型主机包含六个主要电路板，最多可接受两个插入式继电器插件. 图 10. 显示了 **Keithley 7001** 的原理方框图.

六个主要电路板功能可归纳如下：

1)主数字板(Digital Board)
包含微处理器(MC 68302)，操作系统，存储器，IEEE-488 接口和支持电路。
2)后板(Backplane)
提供机械和电气数字板和任何卡之间的接口, 7001 型插入卡插槽。
3)显示板(Display Board)
包括真空荧光显示器（VFD），用于控制的辅助微处理器显示屏，显示驱动程序和前面板键矩阵。
4) BNC 板(BNC Board)
主机械板,它用作控制信号的分配点和交流电源。
5) Micro-DIN 板
接口的数字板,后面板数字 I/O 和 Trigger Link micro-DIN 连接到数字板。
6) 电源板(Power Supply Board)
开关型电源板,提供 +6VDC 和 +14.6VDC 到其他板和显示器。

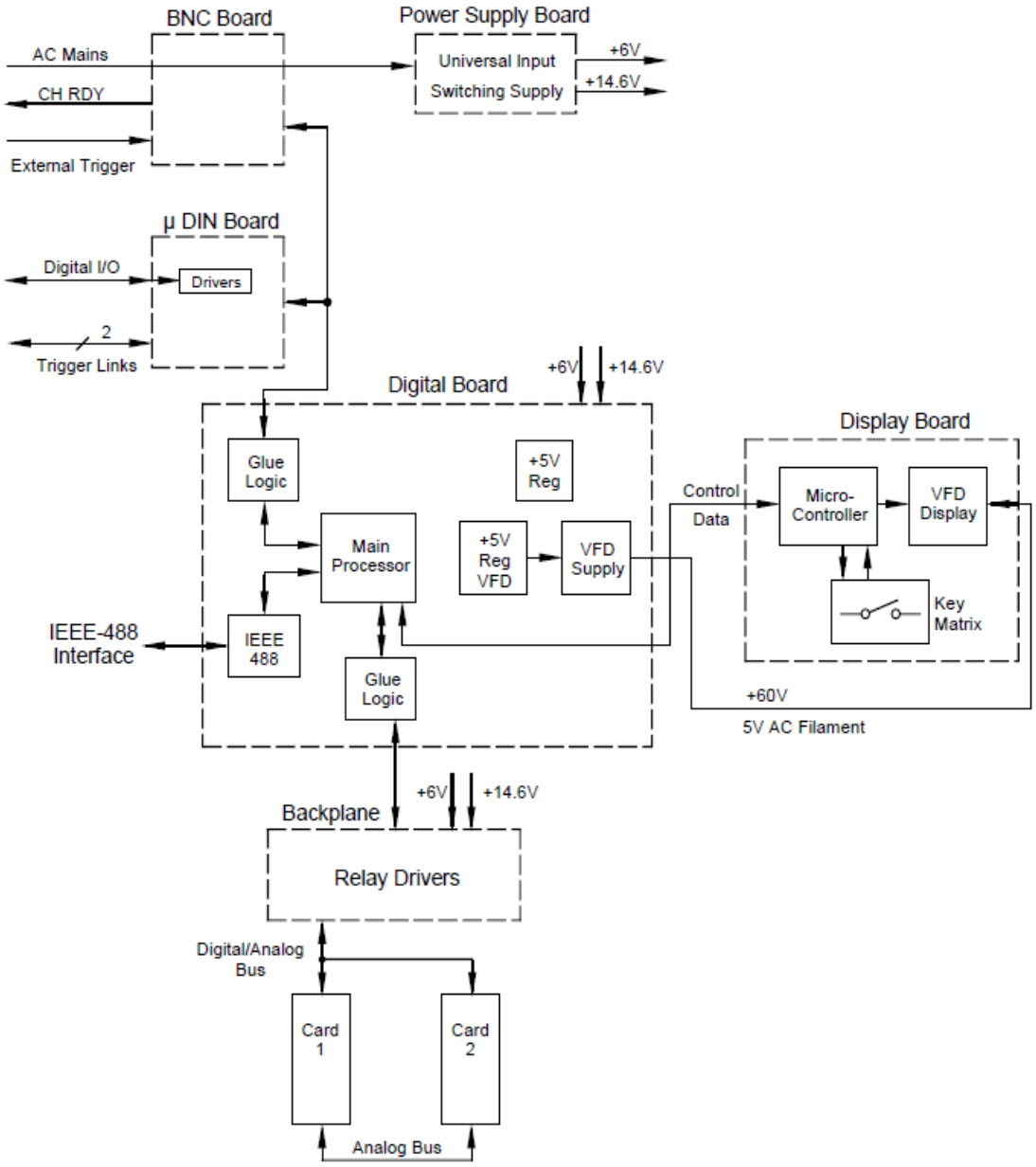


图 10. **Keithley 7001 的原理方框图.**

Figure 6-1
Model 7001 system block diagram

2. Keithley 7001 的简易测试

2.1 运行 Keithley 7001 内置的自检测试

1) MENU -> TEST -> ENTER
2) BUILD-IN-TEST -> ENTER
3) AUTO -> ENTER -> REPEAT? -> YES -> ENTER
   自检测试开始,直到按 EXIT

2.2 显示 Keithley 7001 研发团队名单

1) POWER OFF
2) 同时按下 MEMORY 和 6
3) POWER ON

2.3 模拟操作演示

Keithley 7001 带有内置的供演示使用的 40 路通道复用模拟器(Device 9990),允许您做模拟操作无需外加 I/O 插件.它提供了一个简便的方法让您快速熟悉面板基本操作.

模拟操作可做以下操作:

1) 关闭和打开通道 (Close and open channels)
2) 扫描通道 (Scan channels)

2.3.1 模拟操作 1 - Reset System to Manufacture Default Setting

1) MENU -> SAVESETUP -> ENTER
2) RESET -> ENTER -> See message “RESET COMPLETE”
3) ENTER -> EXIT

2.3.2 模拟操作 2 - Select Simulator Device “9990” Installed at lot 2

1) CARD CONFIGURATION -> TYPE ->ENTER
2) SLOT-2 -> ENTER -> 这时显示“SLOT-2 CARD:XXXX”
3) Select “9990” -> ENTER
4) EXIT -> EXIT.

2.3.3 模拟操作 3 - Close/Open Channels

Close/Open Channels 操作必须先建立被控制的 Channel List.
下列各步建立 Slot 2 的被控制通道为 ch1,ch2 以及 ch6 到 ch9.

1) CLEAR LIST -> 这时显示“SELECT CHANNELS”
2) 2 -> 1 -> ENTER
3) 2 -> 2 -> ENTER
4) 2 -> 6 -> ‘- ‘ -> 9 -> ENTER
   这时显示“SELECT CHANNELS 2!1, 2!2, 2!6-2!9”,表示各通道已建好.

以下运行 打开/关闭 各通道

5) CLOSE -> 关闭上面建立的各通道

6) OPEN -> 打开上面建立的各通道

2.3.4 模拟操作 4 - Scan Channel Manually

1) 先建立 Scan List

(1) CLEAR LIST -> SCAN LIST

(2) 下列各步产生 SCAN LIST 用于扫描 Slot 2 的 ch1 到 ch20.

2 -> 1 -> '- ' -> 2 -> 0 -> ENTER

这时显示 "SCAN CHANNELS 2!1-2!20",表示已建扫描通道 ch1 到 ch20.

2) 运行手动扫描: 每次按 STEP 关闭前一个通道且打开后一个通道.

2.3.5 模拟操作 5 - Scan Channel Automatically

用模拟操作 4 中产生的 SCAN LIST(用于扫描 Slot 2 的 ch1 到 ch20)再定义每个 ch 打开/关闭的间隙时间即可运行自动扫描.

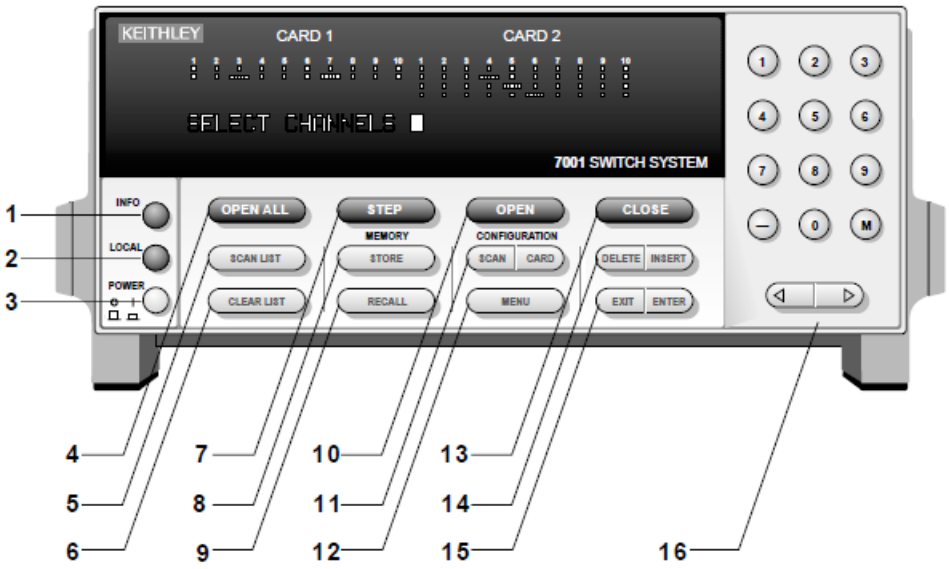
下列操作产生自动扫描 20 个 ch,每个 ch 打开/关闭的间隙是 0.5 秒.

1) OPEN ALL
2) SCAN CONFIGURATION
3) 选 CHAN-CONTROL -> ENTER
4) 选 CHANNEL-SPACING -> ENTER
5) 选 IMMEDIATE -> ENTER
6) EXIT -> EXIT
7) 选 CARD CONFIGURATION -> DELAY -> ENTER
   这时显示 "SET DELAY FOR SLOT ?"
8) 选 SLOT-2 -> ENTER
   这时显示 "(2) DELAY=0000.000"
9) 调节上述数字使它变为"(2) DELAY=0000.500"
10) ENTER -> EXIT -> EXIT
11) 运行自动扫描: 按 STEP 即可运行自动扫描;自动扫描 SLOT-2 的 20 个 ch 间隔是 0.5 秒. 按 OPEN ALL 停自动扫描.

3. References

1) Keithley 7001 Switch System Instruction Manual, Keithley, 2001. https://www.imperial.ac.uk/media/imperial-college/research-centres-and-groups/centre-for-bio-inspired-technology/7293200.PDF
2) Switching and Control, Keithley, 2001. https://www.tek.com/datasheet/switching-and-control
3) Test Equipment Solutions Datasheet, Keithley 7001 Switch System, Test equipment Solutions Ltd. www.testequipmenthq.com/datasheets/KEITHLEY-7001-Datasheet.pdf

4. Appendix 附录



1 INFO
Displays on-line help information. Press again (or EXIT) to cancel message.

2 LOCAL
Cancels remote, restores front panel control.

3 POWER
0 =off
1 = on

4 OPEN ALL
Opens all channels of both slots. Also, aborts a scan that is in progress and places 7001 in idle state.

5 SCAN LIST
Toggles between Scan List and Channel List

6 CLEAR LIST
Clears the displayed Channel List or Scan List.

7 STEP
Takes 7001 out of idle state and steps through Scan List

8 STORE
Stores channel pattern at a specified memory location.

9 RECALL
Restores 7001 to a channel pattern stored at a specified memory location.

10 OPEN
Opens the specified (displayed) channels in Channel List.

11 SCAN CONFIGURATION
Enables CONFIGURE SCAN MENU :
CHAN-CONTROL
SCAN-CONTROL
ARM-CONTROL
CHAN-RESTRICTIONS

CARD CONFIGURATION
Enables CARD CONFIG MENU :
TYPE
#-OF-POLES
CARD-PAIR
DELAY
READ-I/O-CARD

12 MENU
Enables MAIN MENU:
SAVESETUP
GPIB
DIGITAL-I/O
TEST
LANGUAGE
GENERAL

13 CLOSE
Closes the specified (displayed) channels in Channel List.

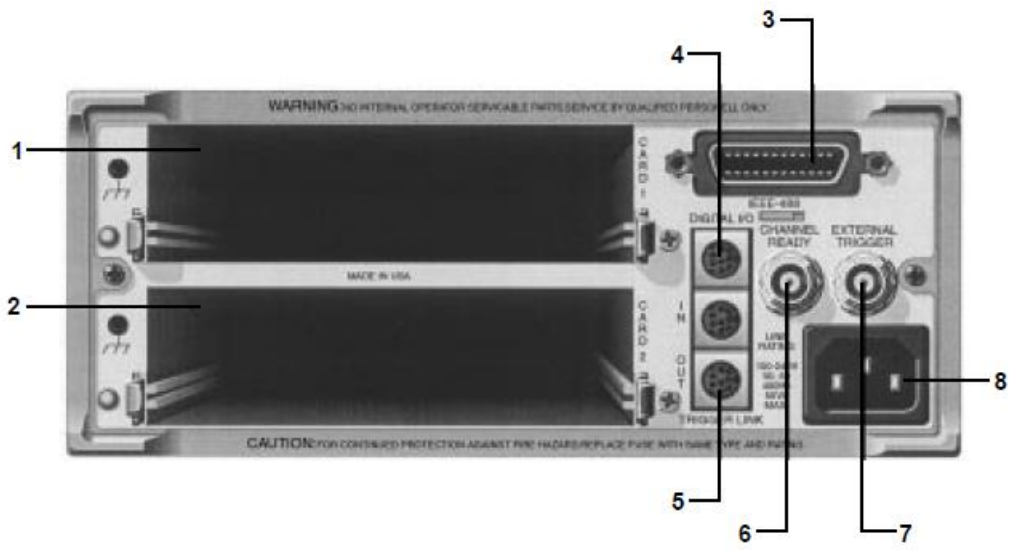
14 DELETE
Delete selected entry from Channel List or Scan List.

INSERT
Insert next entry at selected location in the Channel List or Scan List.

15 EXIT
Back up to previous menu selection, or exit from the menu.

ENTER
Execute the pending operation. Also, separate channels and terminate a Channel List or Scan List.

16 KEYPAD
0 - 9; use to enter numbers.
- ; use to specify a range of channels (i.e. 1!1 - 1!40).
M ; use to precede a specified memory location number.
◁ ; use to move cursor left or
▷ ; use to move cursor right. Also, use to separate channels and terminate a Channel List on Scan List.



1 CARD 1
Slot 1 for switch card. Corresponds to Card 1 channel status display.

2 CARD 2
Slot 2 for switch card. Corresponds to Card 2 channel status display.

3 IEEE-488 CONNECTOR
Use standard IEEE-488 cables.

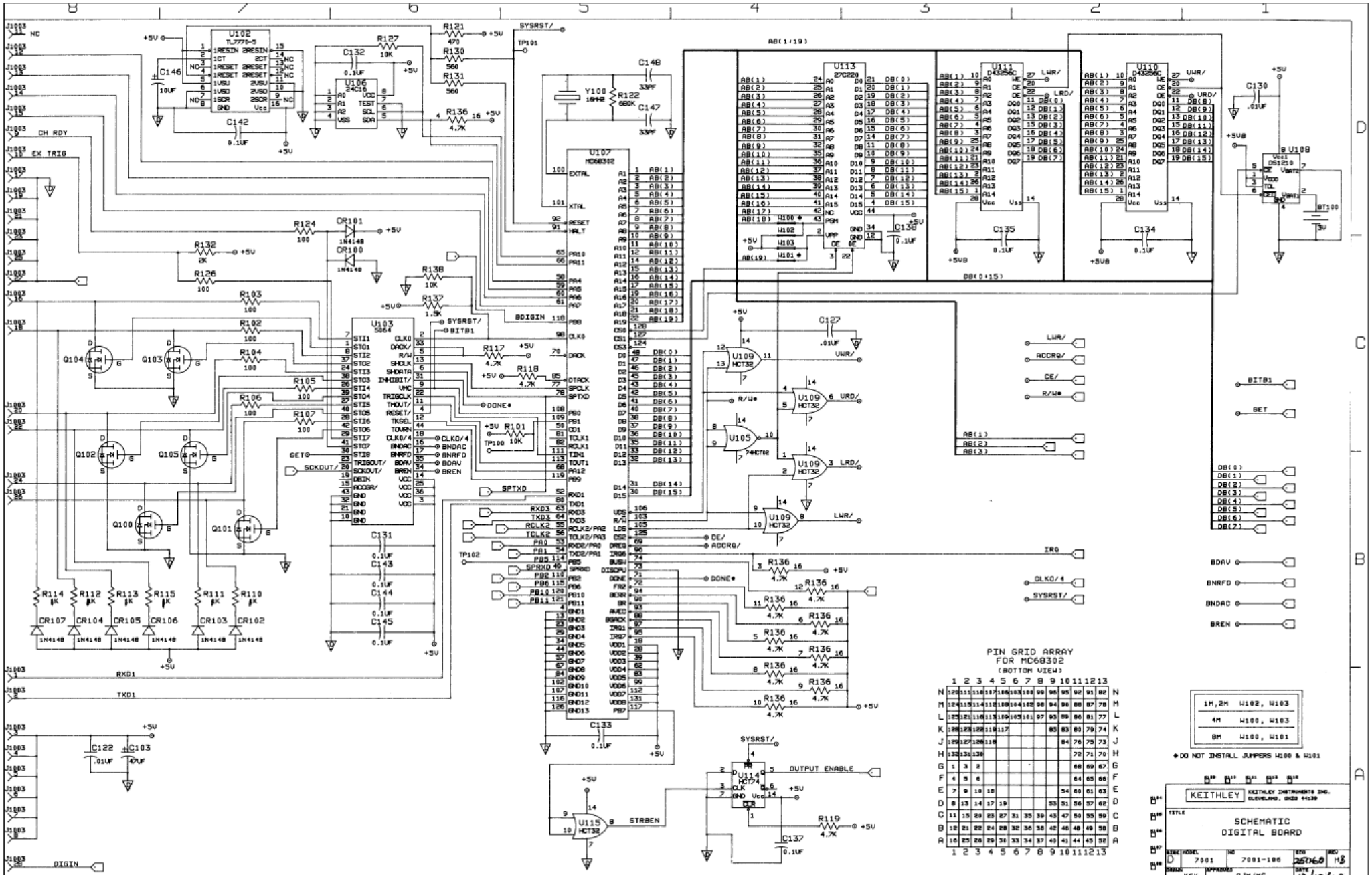
4 DIGITAL I/O
Micro 8-pin DIN connector. Port consists of four TTL output lines and one TTL input line (one common line).

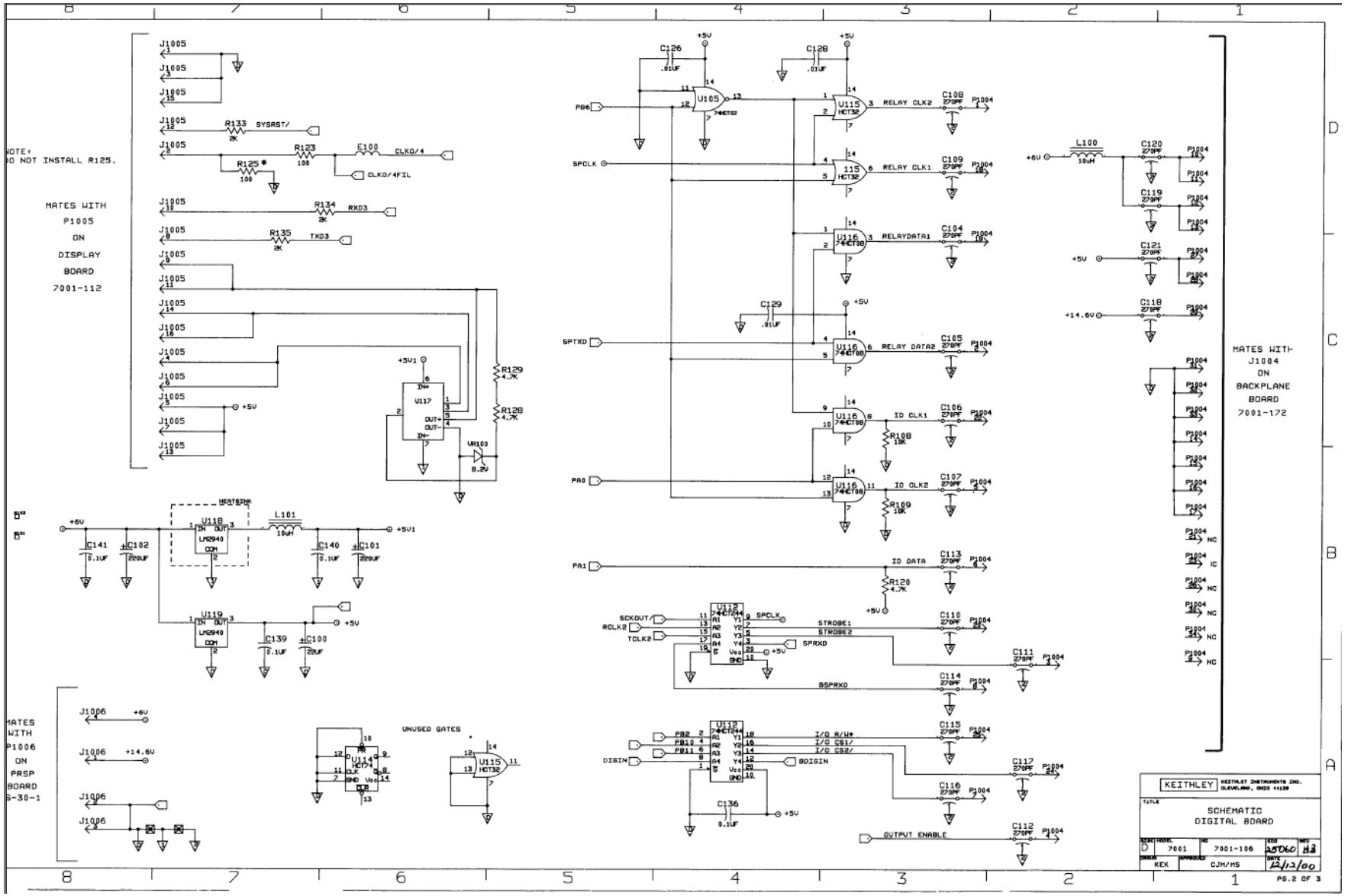
5 TRIGGER LINK IN AND OUT
Two micro 8-pin DIN connectors.

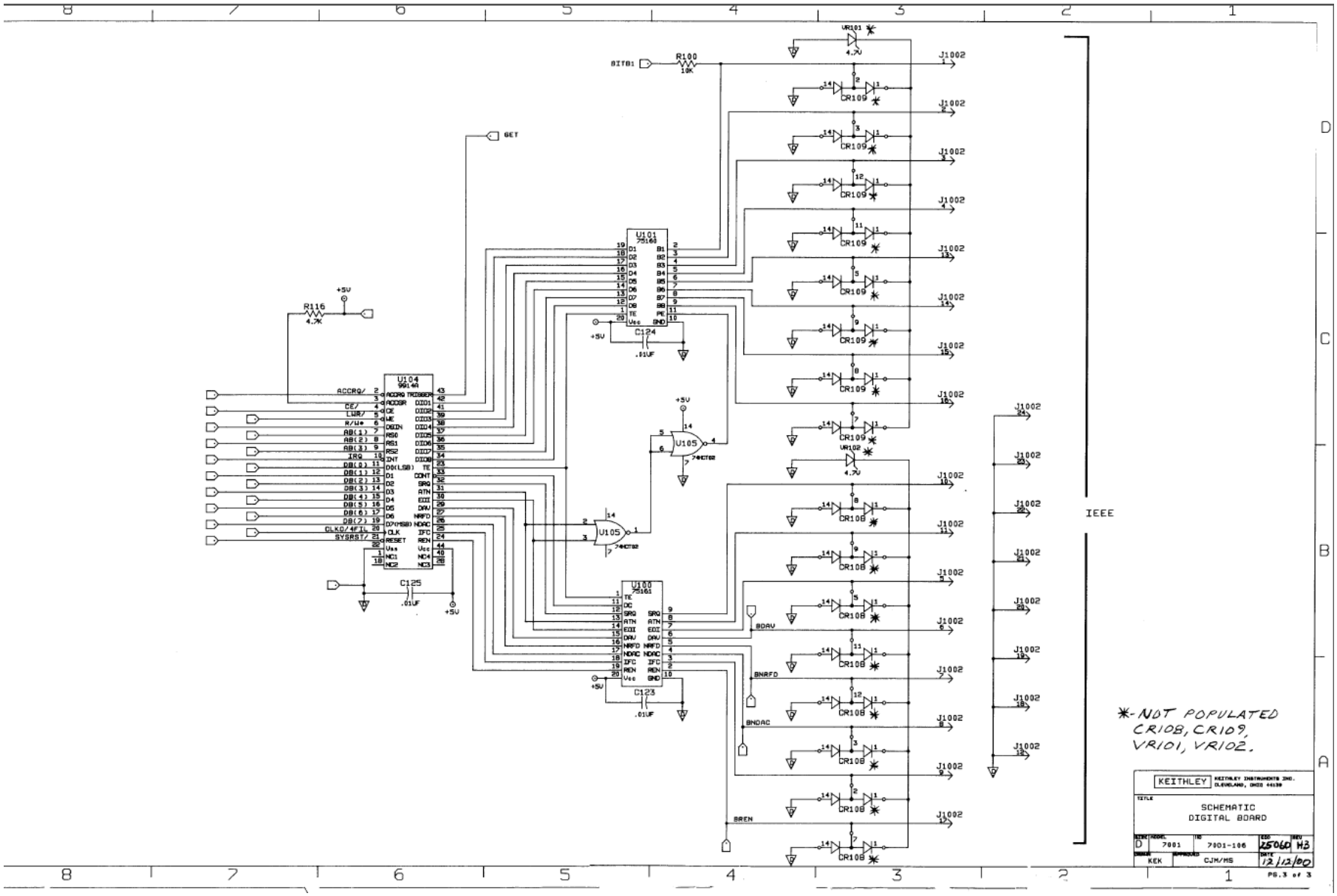
6 CHANNEL READY
Female BNC connector for TTL output trigger pulse.

7 EXTERNAL TRIGGER
Female BNC connector for TTL input trigger pulse.

8 LINE POWER INPUT
WARNING: Connect to grounded outlet using three-wire power cord.


PIN GRID ARRAY
FOR MC68302
(BOTTOM VIEW)
1M,2M W102, W103
4M W100, W103
8M W100, W101
* DO NOT INSTALL JUMPERS W100 & W101
KEITHLEY
KEITHLEY INSTRUMENTS INC.
CLEVELAND, OHIO 44139
SCHEMATIC
DIGITAL BOARD
SIZE D
MODEL 7001
NO 7001-100
REV H3
DRAWN KEK
APPROVED CJM/MS
DATE 12/12/00
PG.1 OF 3


NOTE:
DO NOT INSTALL R125.
MATES WITH P1005 ON DISPLAY BOARD 7001-112
MATES WITH J1004 ON BACKPLANE BOARD 7001-172
MATES WITH P1006 ON PRSP BOARD 8-30-1
UNUSED GATES
KEITHLEY
KEITHLEY INSTRUMENTS INC.
CLEVELAND, OHIO 44139
SCHEMATIC
DIGITAL BOARD
7001
7001-106
25D60
H.3
KEK
CJM/MS
12/12/00
PG.2 OF 3


VR101
4.7V
R100
10K
BITB1
J1002
CR109
GET
U101
75161
R116
4.7K
+5V
C124
.01UF
U104
9914A
ACCRQ/
CE/
LWR/
R/W*
AB(1)
AB(2)
AB(3)
IRQ
DB(0)
DB(1)
DB(2)
DB(3)
DB(4)
DB(5)
DB(6)
DB(7)
CLKO/4FTL
SYSRST/
U105
74HCT02
VR102
4.7V
CR108
IEEE
C125
.01UF
U100
75161
BDAV
BNRFD
BNDAC
BREN
C123
.01UF
*-NOT POPULATED
CR108, CR109,
VR101, VR102.
KEITHLEY
KEITHLEY INSTRUMENTS INC.
CLEVELAND, OHIO 44139
SCHEMATIC
DIGITAL BOARD
D
7001
7001-106
25060
H3
KEK
CJM/MS
12/12/00
PG.3 of 3