DATA SHEET

DS-11107

Matrix Modules [CPM-N & PAM-16N]

- **6 by 8 Analog Switching Matrix**
- **Fully Guarded Kelvin Sensing**
- **Analog Ground Relay Protection**
- **2A Carry Current**
- **600V Standoff Voltage**
- **Integrated 16-Bit Picoampere Meter**

System Versatility

With the exception of very high currents and voltages, crosspoint matrix (CPM-N) and picoammeter matrix (PAM-16N) modules connect any instrument to any DUT pin. Relays are controlled through Reedholm driver software, which enables safe connection of any combination of eight pins with six analog instrumentation nodes. Node 0 is designated as analog ground, with hardware and software that augment earlier Reedholm software that reduces the probability of hot-switching relay contacts; that is prevent relay switching while voltage and current are present that could lead to arcing of reed switch contacts. The other five nodes are fully guarded pathways with separate force and sense lines for accurate delivery of precision voltages up to |600V| at |2A|. Each module is separately addressable, thereby allowing multiple matrix modules.

Self-Calibration Corrections

Reedholm self-calibration software is now used in conjunction with the PAM-16N through use of 1GΩ resistors mounted on the loopback card. Offset and gain factor corrections are generated after the resistors are measured by the DMM-16 and VFIF-16 modules previously put through self-calibration. This provides traceability of the PAM measurements to a standards lab through an inexpensive, precision bench DMM.

CPM & PAM-16 Matrix Specifications

Standoff Voltage	600V Max	
Carry Current	2A Max	
Series Resistance	200mΩ Max CPM 350mΩ Max PAM	
Bandwidth	5MHz Typical	
Node Loading	No Pins Connected	30pF Max/Module
	Pins Connected	30pF per Pin
Leakage Resistance	Any Pin to a PAM Pin	$1x10^{15}\Omega$
	Pin-to-Pin	$1x10^{12}\Omega$/ System Pin Count
Switching Time	1 ms Max	
Pin Pair Thermal EMF	100µV Max	

PAM-16 Specifications

Mode	Range	Measure Error		Resolution
		Offset	% of Value	
Current	100pA	100fA	0.15	6.25fA
	1nA	125fA	0.15	62.5fA
	10nA	1.25pA	0.1	625fA
	100nA	12.5pA	0.1	6.25pA

Accuracy	Specifications apply for 24 hours and ±1Cº after manual calibration is performed.
A/D Conversion Time	50ms
Input Reference Voltage	Fixed at Virtual Ground
Pin Injection Capacitance	0.15pF
Maximum Injection Step Without Overload	100pA, 1nA Ranges: $[9/(C_{DUT}^* +0.15)]$V
	10nA, 100nA Ranges: $[585/(C_{DUT}^* +0.15)]$V
	$^*C_{DUT}$ expressed in pF
Amplifier Overload	Recovery Time: 50ms
Step Response Time to within ±0.1%	See Figure 5
Normal Mode Noise Rejection	60dB at 50Hz and 60Hz
Noise Bandwidth	20Hz
Input Current	75fA Max
Input Current Temperature Coefficient	10fA/C°
Input Referred Noise	7fA RMS (<35fA p-p, 99% of the time)

Minimum Effects on Test Results

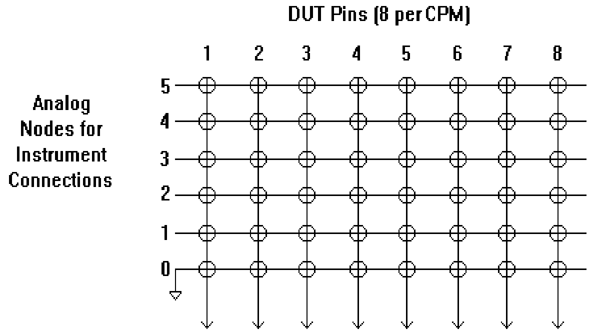

Figure 1 - Crosspoint Matrix Block Diagram

Matrix modules are transparent to device testing. Each node-to-pin crosspoint dry reed relay is independent of all others. These high-quality relays are built to Reedholm specifications to provide an excellent combination of signal transmission, pin isolation, and life expectancy.

The PAM is a superset of the CPM having a very low current node connected to a feedback ammeter.

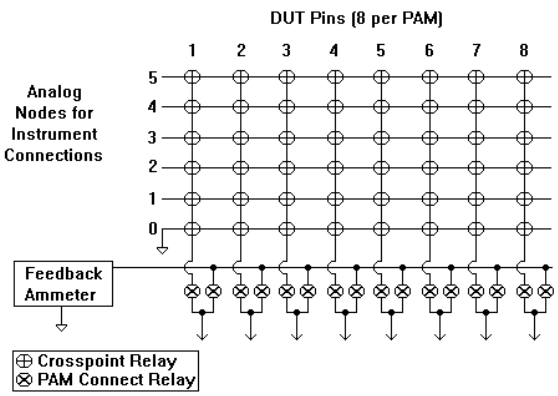

Figure 2 - Picoammeter Block Diagram

Notable Features of Both Matrix Types:

- Form A, three-pole relays allow routing of force, sense, and driven guard signals from any instrument to the DUT for low noise parameter testing on nodes 1 - 5.
- Form A, single-pole relays for force and sense connections on node 0.
- Fast relay closure (settling times) of <1ms.
- High relay life expectancy (>10^8 cycles).
- <200mΩ static resistance over life of relay.

Matrix with Node 0 Protection

Reedholm addressed hot switching damage to node zero relays with new matrix designs. Migrating to the new PAM-16N and CPM-N does not eliminate scrambling or all hot switching, but does minimize damage to node 0 switches, which bear the brunt of hot switching from sneak paths.

The node 0 triple pole, single throw relays (force, sense, and guard contacts) have been replaced with independent single pole relays for the force and sense lines as shown in figure 2. Connecting guard to ground has no value except for low leakage PAM measurements, so that contact was eliminated. A resistor to ground accomplishes the same thing, and eliminates guard switch welding.

Resistance added to the node 0 sense path prevents welding of the sense relay, but provides a discharge path if there is voltage present. The force relay is not allowed to close until voltage is <|1V|, which is below the arcing voltage. Thus, even if there is switch bounce, the voltage is too low to transfer material, which leads to welding, or sticking, of contacts.

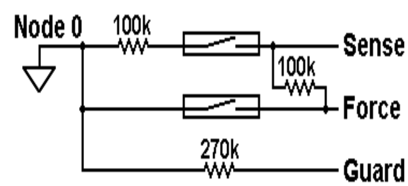

Figure 3 – Node 0 Layout

PAM Current Measurement Capability

In very simplified form, the feedback ammeter (Figure 4) consists of an electrometer class amplifier whose input voltage is held at virtual ground via the feedback path of R_F and C_F. The unknown current I_X flows through R_F, creating a voltage equal to I_XR_F at the amplifier output.

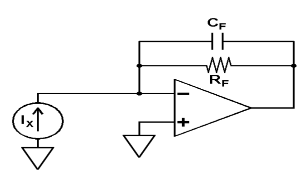

Figure 4 - Feedback Ammeter

Current Span

A PAM has four current ranges with full-scale values of 100pA, 1nA, 10nA, and 100nA. An integrating ADC with a crystal-controlled clock converts DC output of the feedback ammeter to a digital signal. Integration times are selected to reduce always-present power line noise (50 or 60Hz) by >60dB. Resolution on the lowest range is 6.25fA.

Matrix Analog Cabling

Proprietary analog cables connect PAM pins to low leakage probe cards using fabrication methods that minimize tribo-electric and piezo-electric noise. A fully guarded PAM cable provides force/sense routing for system matrix measurements up to |600V| and |2A|.

When a pin is connected to the PAM node for low current measurement, the shield is connected to analog ground to minimize noise and leakage currents. Dielectric absorption effects are minimized by use of the highest quality dielectrics on the PAM node that are always referenced to ground.

During the PAM-16 redesign that preceded the PAM-16N, the Test Station Cable (TSC) attached to the older PAM was eliminated because the twin-axial connectors have become obsolete. Instead, a very low leakage card edge connector connects the prober analog cable directly to the front of the PAM.

During the CPM-N redesign, the TAC and TAC/PAC card edge connectors were relocated from the top to the front of the cards. These design changes mean that removal and replacement of the matrix modules are as simple as replacing other modules.

Reedholm Probe Cards

Low leakage measurement accuracy and speed are compromised when conventional probe cards are used with the PAM. Reedholm low current probe cards are built with multi-layer techniques that completely guard signal traces against surface and bulk leakage currents. Compared to conventional probe cards, significantly lower dielectric absorption permits faster, and more accurate, measurements.

Step Response

When the PAM is used to measure current from a non-ideal source having finite source resistance R_s, the system loop gain is altered, thereby changing the step response characteristics. Those effects are shown in figure 5.

Those figures contain data for three values of source resistance, each shown with two scales so that large step response can be differentiated from settling to within specified accuracy. The three curves on the left use the left scale and three on the right use the expanded right scale, as denoted in the graphs. Not all of the curves are visible due to overlaid data. Source resistance values, R_s, are provided in graphs.

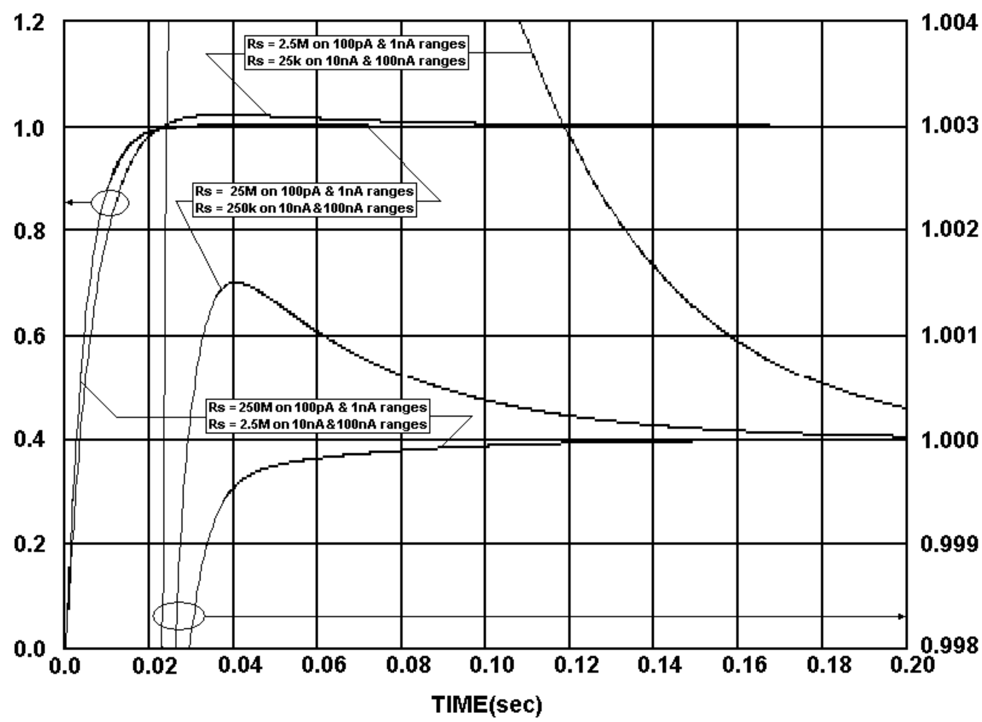

Figure 5 – PAM Step Response