STANDARD DETECTOR DEWAR SERIES

SPECIFICATIONS

Performance ....BLIP @ 300K background, standard FOV, unfiltered

Quantum Efficiency .... ≥ 75% at wafer test wavelength near 4.5 microns (excluding window transmission losses)

Responsivity .... ≥ 2.9 amps/watt at 4.8 microns is typical

Other descriptions: Photovoltaic InSb; "buried metallization" (for sizes < 1.25 mm dia.); passivated for longevity; spectral response: 1 to 5.5 μm (peak 4.8 to 5.0 μm); P-type mesas on N-type monolithic substrate

SINGLE-ELEMENT DETECTOR DEWARS

Dewar Dimensions ....7" high, 2.5" dia., side-look base 2.625" dia.; side-look optical center 1.45" above base
Dewar Hold Time...............12 hours (liquid nitrogen)
Weight ....1 lb empty, 1.25 lb filled
Optical Window ....Sapphire, 5/8" clear aperture
Power Requirements............± 15 volts, approx. 4 mA
Preamplifier ....Nominal output: -1/2 V DC (background flux) @ BNC
Cold Shield/Aperture ....60° nominal FOV is standard (30° FOV and Narrow FOV also provided)

MULTIPLE-ELEMENT ARRAY DETECTOR DEWARS

Dewar Dimensions ....8" tall x 3.5" diameter (side-look only), optical center 2.0" above base
Electronics Box Size ....6.8" long x 4.1" tall x 2.7" wide
Overall Length ....12"
Dewar Hold Time...............> 12 hours (liquid nitrogen)
Weight ....5.5 lb empty, 6.5 lb filled
Optical Window ....Sapphire, 1.5" dia. clear aperture 1 cm nominal from focal plane
Cold Shield/Aperture ....30° nominal FOV, slot shaped 0.10" wide x 0.90" long 0.140" from focal plane (approx.)
Power Requirements............± 15 volts, approx. 50 mA per 8 channel board
AM-1000's preamp..........Nominal output: -1/2 V DC (background flux)
AM-1000's postamp.........10x, AC coupled standard; gain changeable, DC output capable

DATA PROVIDED TO CUSTOMER WITH UNIT

Optical tests on customer's specific unit:
- Responsivity wavelength, responsivity blackbody
- D* wavelength, D* blackbody
- Quantum efficiency wavelength (Wavelength tests made near 4.5 microns)

Representative information supplied:
- Responsivity versus wavelength curve
- Quantum efficiency versus wavelength curve

Standard Detector Dewar and amplifier applications notes.

WARRANTY

Covers defective material or workmanship for one year after shipment by CE.

Since Cincinnati Electronics continually improves its products, specifications are subject to change without notice.

STANDARD DETECTOR SIZES AVAILABLE

InSb SINGLE-ELEMENT STANDARD DETECTOR DEWARS

Model No.	Diameter or Side (mm)	Shape	Feedback resistor (R_f) (Ohms)
SDD-0019	.043	square	22M
SDD-0066	.081	square	11M
SDD-0410	.203	square	1.8M
SDD-0491	.250	circle	1.5M
SDD-1963	.500	circle	360K
SDD-4418	.750	circle	160K
SDD-5027	.800	circle	150K
SDD-7854	1.000	circle	91K
SDD-12E0	1.250	circle	56K
SDD-32E0	2.032	circle	22K
SDD-20E1	5.080	circle	3.6K

InSb MULTIPLE-ELEMENT ARRAY STANDARD DETECTOR DEWARS

Model No.	Element Size (mm)	Center Line Spacing	R_f (Ohms)	Array Sizes, No. of Elements
SDD-0019	.043 x .043	.061	50M	08, 16, 24, or 32
SDD-0066	.081 x .081	.100	10M	08, 16, 24, or 32
SDD-0085	.081 x .104	.100	6.8M	08, 16, 24, or 32
SDD-0103	.081 x .127	.100	5.6M	08, 16, 24, or 32
SDD-0410	.203 x .203	.234	1.5M	08, 16, 24, or 32
SDD-2000	.25 x .80	.275	270K	08, 16, 24, or 32
SDD-2296	.47 x .49	.49	240K	08, 16, or 24
SDD-2304	.48 x .48 (outside rows .44 x .48)	.5 x .5 (4xn matrix)	240K	16, 24, or 32 (4x4, 4x6, 4x8)

ORDERING INSTRUCTIONS

Specify model desired as follows:

SINGLE-ELEMENT STANDARD DETECTOR DEWARS

SDD-xxxx-S1 ....for side-looking dewar
SDD-xxxx-D1 ....for down-looking dewar
Add -NP......for no preamp with unit*

"xxxx" designates detector size/shape from above list

Example: SDD-0066-S1
Selects the .081 mm square, side-looking

*Without integral matched preamp, optimum detector performance cannot be assured to the customer.

MULTIPLE-ELEMENT ARRAY STANDARD DETECTOR DEWARS

SDD-xxxx-##-H.........for horizontal orientation of array
SDD-xxxx-##-V.........for vertical orientation of array

"xxxx" designates detector size/shape from above list

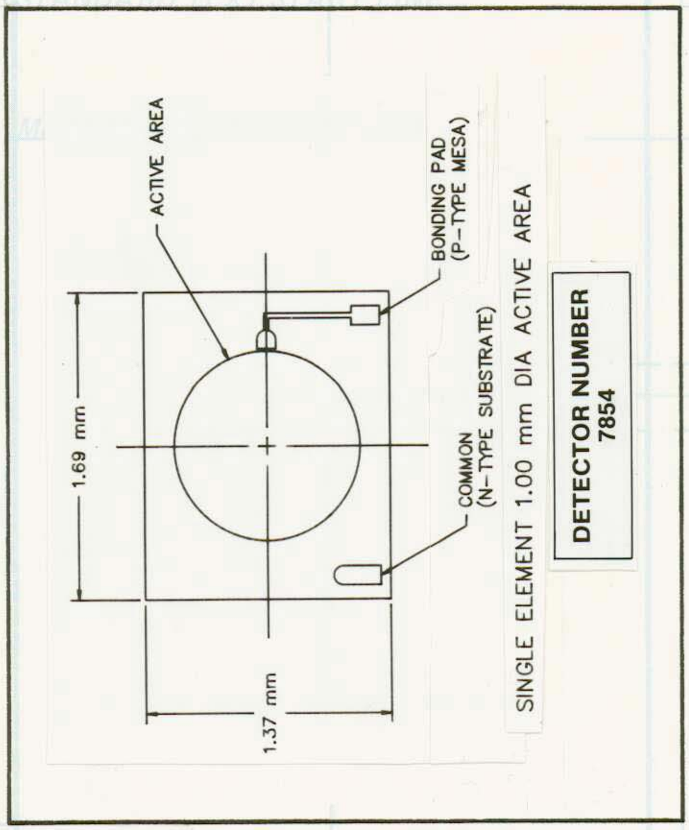
"##" designates the number of elements in the array (-08, -16, -24, or -32 elements; see list)

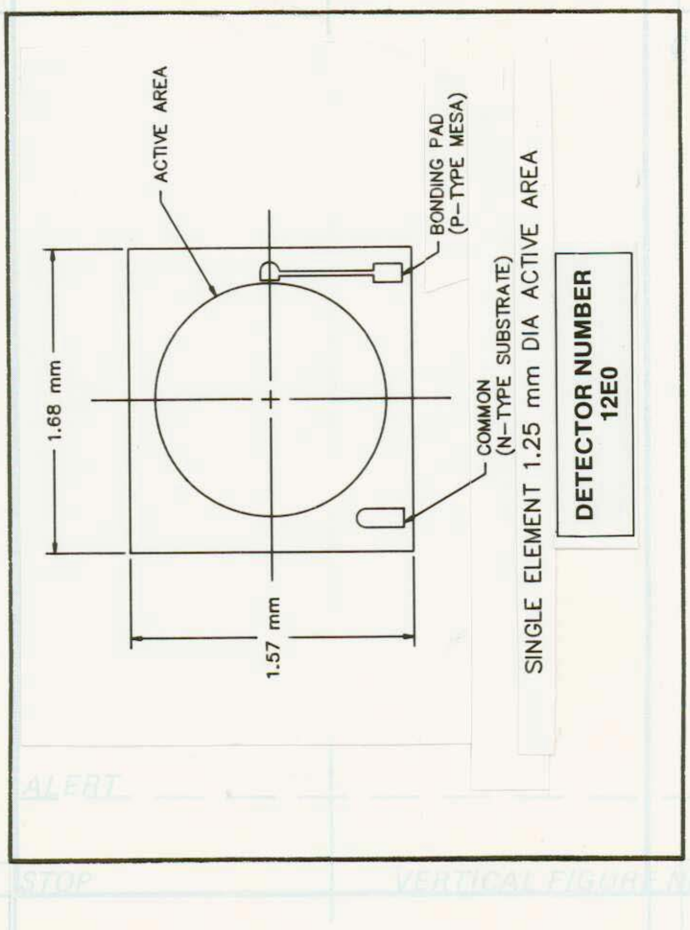
Example: SDD-0019-24-H
Selects .043 mm square, 24 diodes, horizontal array orientation.

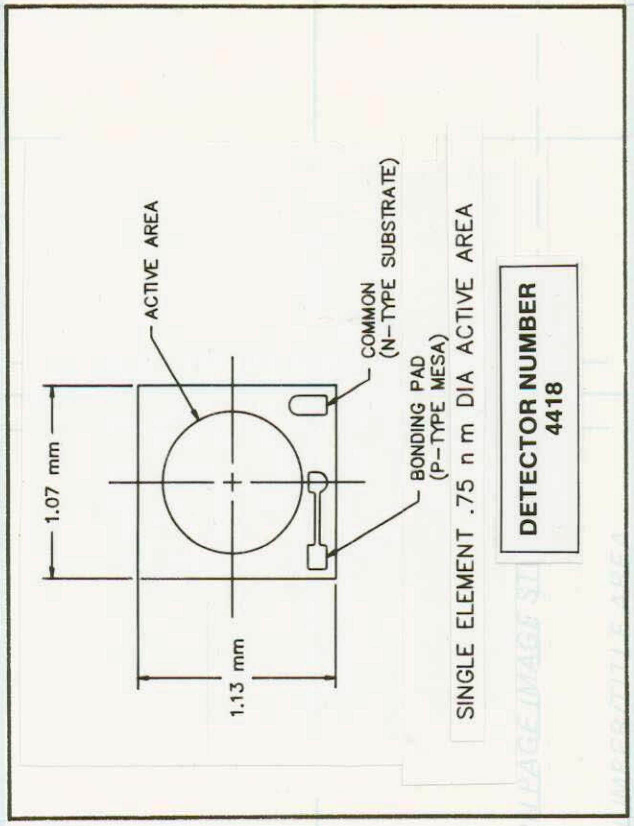
It is the policy of Cincinnati Electronics to formally accept and acknowledge orders only when they are confirmed in writing; therefore, it is best to simply send a written purchase order. Telex of the PO information or FAX versions of a PO are typically accepted. Advising CE by phone that an order is about to be placed is helpful and may help avoid delays or identify situations where the purchase order has not arrived in a reasonable time. CE will verify by phone the current list price for a standard model Standard Detector Dewar.

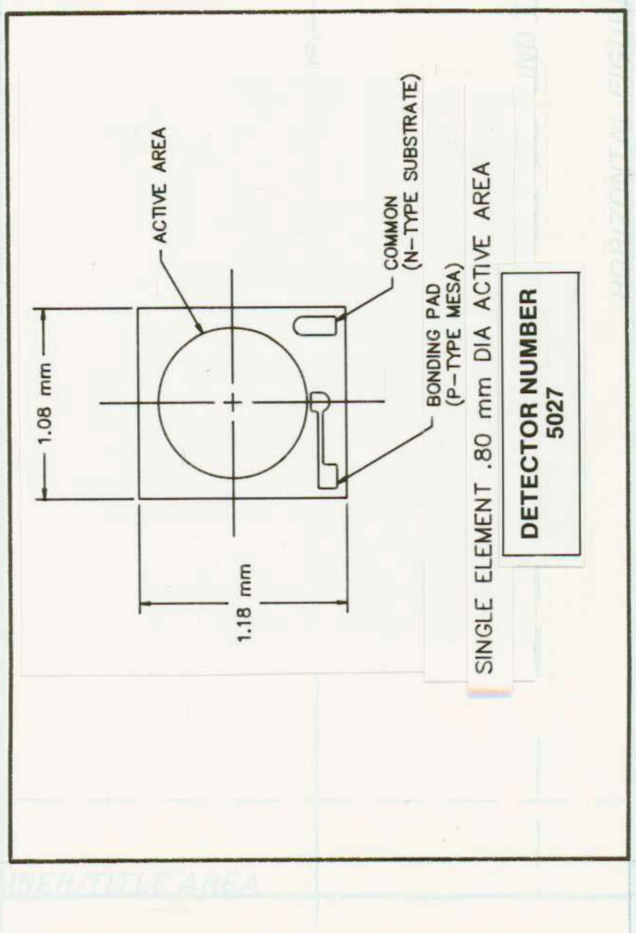
For more specific information or to discuss your application, please contact DMDL Marketing.

FOR MORE INFORMATION CONTACT: DETECTOR & MICROCIRCUIT DEVICES LABORATORIES (DMDL) MARKETING (513) 573-6275


ACTIVE AREA
BONDING PAD
(P-TYPE MESA)
COMMON
(N-TYPE SUBSTRATE)
1.69 mm
1.37 mm
SINGLE ELEMENT 1.00 mm DIA ACTIVE AREA
DETECTOR NUMBER
7854


ACTIVE AREA
BONDING PAD
(P-TYPE MESA)
COMMON
(N-TYPE SUBSTRATE)
1.68 mm
1.57 mm
SINGLE ELEMENT 1.25 mm DIA ACTIVE AREA
DETECTOR NUMBER
12E0


ACTIVE AREA
COMMON
(N-TYPE SUBSTRATE)
BONDING PAD
(P-TYPE MESA)
1.07 mm
1.13 mm
SINGLE ELEMENT .75 n m DIA ACTIVE AREA
DETECTOR NUMBER
4418


ACTIVE AREA
COMMON
(N-TYPE SUBSTRATE)
BONDING PAD
(P-TYPE MESA)
1.08 mm
1.18 mm
SINGLE ELEMENT .80 mm DIA ACTIVE AREA
DETECTOR NUMBER
5027

DETECTOR & MICROCIRCUIT DEVICES LABORATORIES

CINCINNATI ELECTRONICS CORP

APPLICATION NOTE FOR THE AM-05M AMPLIFIER USED IN STANDARD DETECTOR DEWARS OF 5MHz FOR PHOTOVOLTAIC DETECTORS

I. INTRODUCTION

The AM-05M is an amplifier option available in the single-element SDD product line. This amp offers moderately wide bandwidth (> 5 MHz) and considerable versatility. There are provisions for tailoring amplifier performance to provide an optimized trade-off between bandwidth and noise. The AM-05M is DC coupled, and has a low 1/f noise corner despite its wide bandwidth capabilities. Detector bias is held to 0 ± 100 µV without external adjustments.

II. THEORY OF OPERATION

Photodiode is best modeled as a current source with shunt capacitance. The most efficient means of reading out photon induced signal current is with a transimpedance amplifier (figure 1). In an attempt to maximize the high frequency response of this circuit one will encounter a limitation caused by the destabilizing effect of C_j on the feedback circuit's phase margin. A wider bandwidth op-amp will improve this, but most wideband op-amps are not unity gain stable, complicating the stability requirements further.

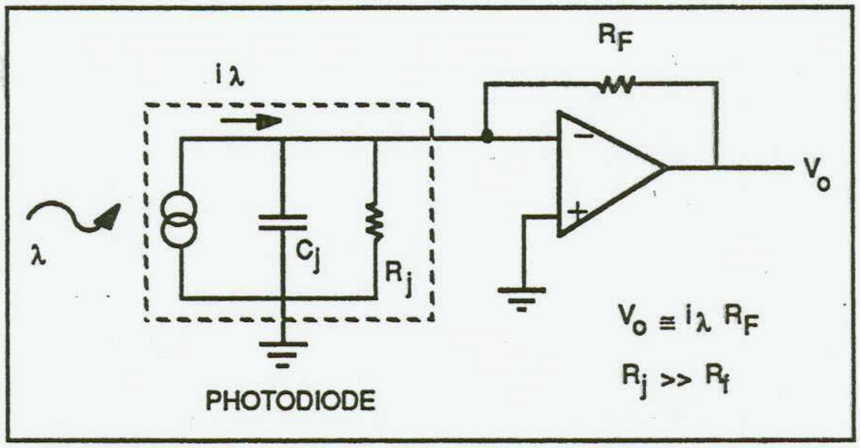


Figure 1

Transimpedance amplifier (TIA)

The AM-05M offers a solution to this problem using a 2-stage amplifier and a "bandwidth boosting" technique (figure 2). The first stage is a TIA with controlled bandwidth and damping factor. This is followed by a "booster" voltage amplifier whose frequency response rises to cancel the TIA roll-off (figure 3). The crossover frequency (F_C) is the -3 dB frequency of the TIA, and must coincide with the +3 dB frequency of the boost amplifier for effective cancellation. The crossover frequency in the AM-05M is fixed at 100 kHz.

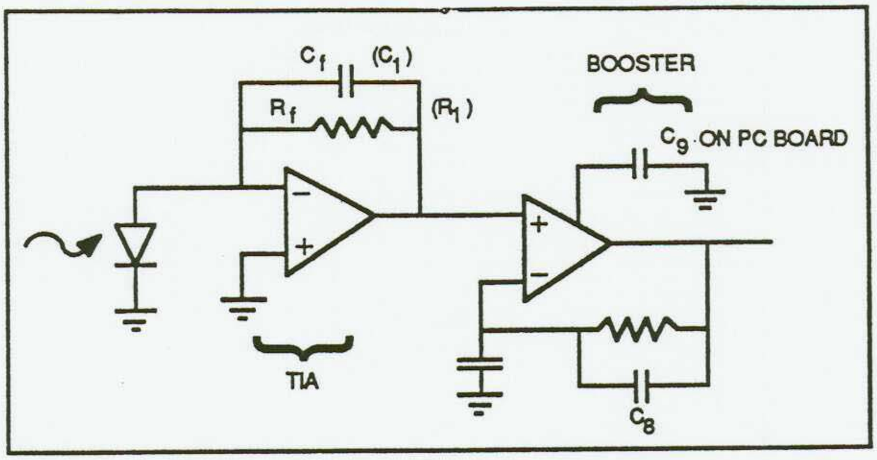


Figure 2

Simplified AM-05M

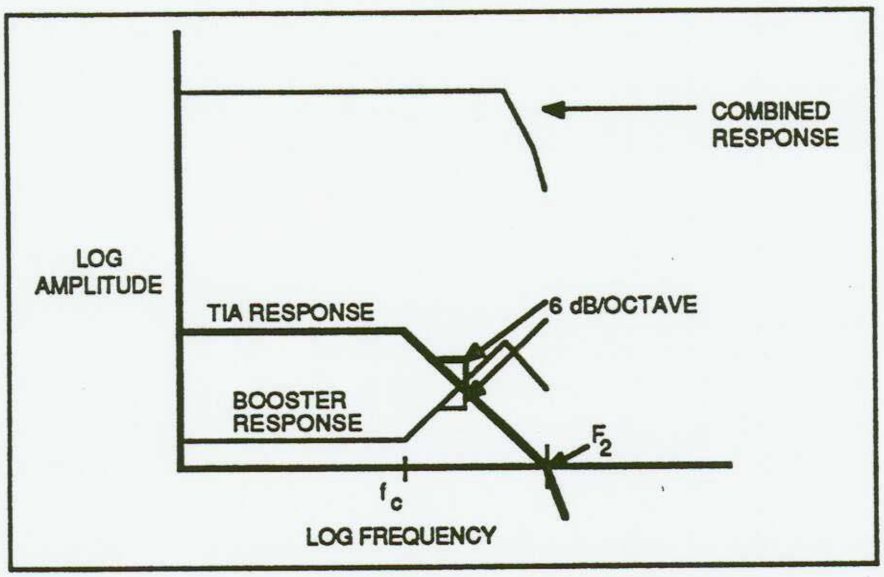


Figure 3

Signal response

The combined frequency response is determined by the failure of the TIA and/or the boost amplifier to maintain a 6 dB/octave slope to infinite frequency. The boost amplifier is designed to maintain a constant +6 dB/octave slope to 7 MHz, although this may be altered to reduce noise bandwidth, and is discussed further in the applications section. The TIA will at some frequency exhibit a second pole (F_2) in its closed loop response. This will increase the slope of the TIA roll-off to -12 dB/octave beginning at the frequency of the second pole. The location of this second TIA pole is a function of damping factor and may be controlled independently of F_c by the relationship:

$$F_2 = F_c\left(\delta + \sqrt{\delta^2 - 1}\right)^2 \qquad (1)$$

where δ = damping factor; F_2 = frequency of second pole; F_c = 100 kHz.

Manipulation of the TIA feedback components will control amplifier damping:

$$R_f \cong \frac{\left(\frac{1.7 \times 10^7}{F_n}\right)^2 - 2\delta\left(\frac{1.7 \times 10^7}{F_n}\right) + 1}{1.07 \times 10^8\, C_{in}} \qquad (2)$$

$$C_f \cong \frac{1.07 \times 10^8}{(2\Pi F_n)^2\, R_F} - C_{in} \qquad (3)$$

where: $$F_n = \frac{F_c}{\left[\sqrt{\left(2\delta^2 - 1\right)^2 + 1} - \left(2\delta^2 - 1\right)\right]^{1/2}}$$

C_{in} = total capacitance at TIA input (Farads)
$\cong$ C_j + 8 pF (8 pF is a typical stray capacitance of wiring and electronics)
C_j = A_j x 6,000 to 8,000 (typical) pF/cm (high speed InSb process devices only, supplied in SDD when AM-05M is specified)
A_j $\cong$ detector area (cm^2); junction area is slightly larger than the active area

For a given TIA configuration damping factor can be predicted by:

$$\delta \cong 0.5\left[R_f\, C_f + 9.4 \times 10^{-9}\right]\sqrt{\frac{1.07 \times 10^8}{R_f\left(C_f + C_{in}\right)}} \qquad (4)$$

The high frequency noise performance of the AM-05M is no different from a TIA of identical bandwidth (figure 4). Thermal noise, shot noise and op-amp input current noise sources are amplified to the output as white (spectrally uniform) noise at frequencies below F_c (figure 5). The op-amp input voltage noise, e_n, is amplified by the circuit's non-inverting voltage gain (noise gain) whose value below F_c is frequency dependent. Depending on circuit parameters, e_n will be the dominant noise source at approximately 1 MHz. Dashed lines in figure 5 indicate the effect of either increased TIA bandwidth or bandwidth boosting post amplifier. In the bandwidth range of the AM-05M, low e_n is a more important attribute than low i_n.

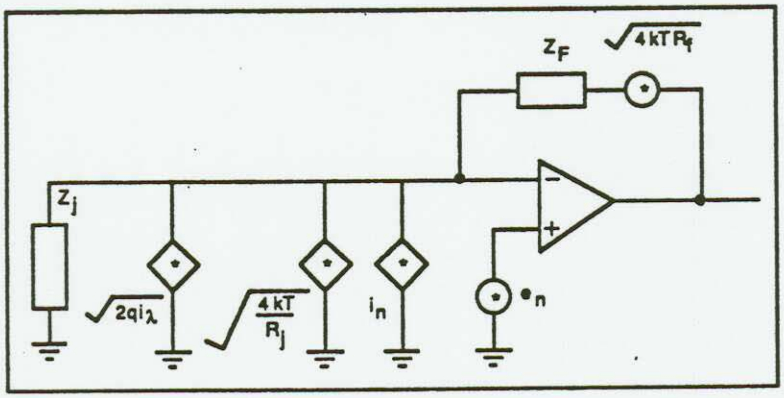


Figure 4

TIA noise model

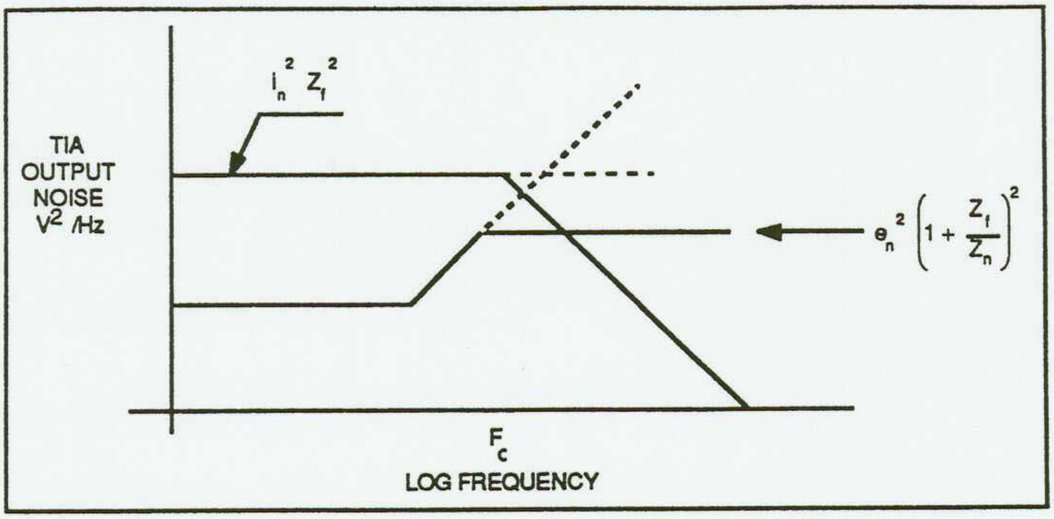


Figure 5

TIA noise response

III. APPLICATIONS

Single-element SDD's equipped with the AM-05M are delivered with TIA feedback components selected for 5 MHz (guaranteed minimum) bandwidth. The AM-05M circuit board is equipped with bifurcated stand-off terminals for easy replacement of components (figure 6) which are used to optimize AM-05M performance. This allows the user maximum versatility in adjusting performance to meet individual system needs.

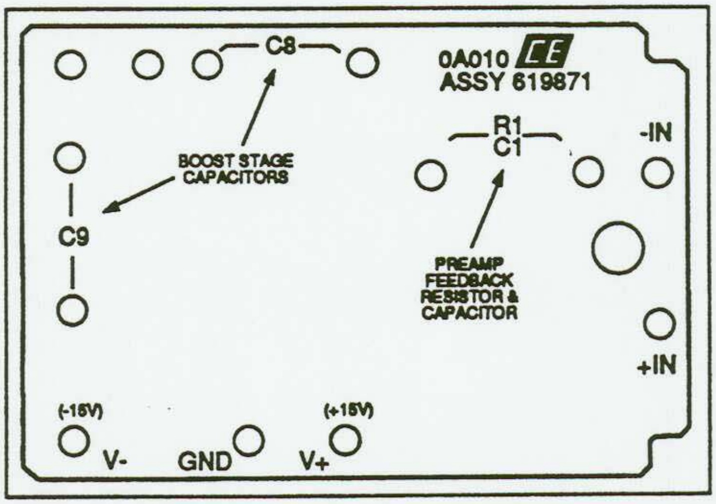


Figure 6

Modifying Bandwidth Alone

In most applications, AM-05M bandwidth will be controlled by the combined effect of TIA second pole, F_2 Eq. (1) and boost amplifier roll-off, (F_B) (figure 7). It is possible to use F_2 alone to control bandwidth, if F_2 << 7 MHz (boost amplifier curve A). The drawback to this is that the boost amp +6 dB/octave slope beyond the desired bandwidth, while contributing nothing to amplifier signal response, continues to boost the TIA noise gain.

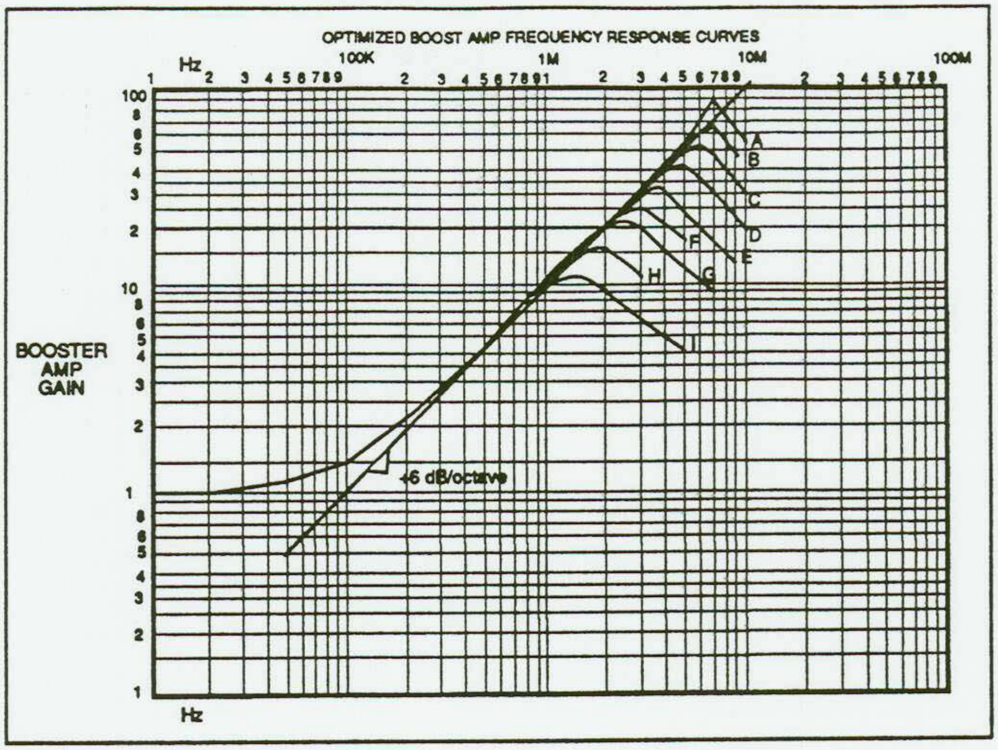


Figure 7

Controlling boost amplifier roll-off (F_B)

Nominal values of electronic components C_8 and C_9 to control F_B alone are shown in Figure 8.

Line	A	B	C	D	E	F	G	H	I
C_8	120 pF	140 pF	150 pF	170 pF	188 pF	220 pF	240 pF	300 pF	340 pF
C_9	0 pF	4 pF	7 pF	12 pF	24 pF	35 pF	48 pF	82 pF	150 pF

Figure 8

Nominal values of electronic components C_8 and C_9

Alternatively it is also possible to use Eq. (1), (2), (3) to set F_2 arbitrarily large and control AM-05M bandwidth using boost amplifier roll-off (F_B) alone. A larger-than-necessary F_2 requires a less than maximum value of R_F (gain of the TIA). This will degrade signal/noise ratio but may be an acceptable solution when large signals are available, or low R_F is necessary ($i\lambda \leq 10/R_F$).

Optimizing Signal to Noise and Bandwidth

In circumstances where both wide bandwidth and high sensitivity are required a compromise is necessary where F_B and F_2 should be set approximately equal, and greater than the desired bandwidth.

The desired AM-05M bandwidth (F_{3dB}) is then described by:

$$2 = \left[1 + \left(\frac{F_{3dB}}{F_2}\right)^2\right]\left[1 + \left(\frac{F_{3dB}}{F_B}\right)^2\right] \tag{5}$$

or, when $F_2 = F_B$

$$F_{3dB} = 0.64\ F_2 \tag{6}$$

For these circumstances, start with Eq. (6) to determine F_2 and F_B. Use Eq. (1), (2), (3) to determine TIA component values, and figures 7 and 8 for boost amplifier components.

Due to variations in wiring and stray capacitance, component tolerances, etc., some experimentation with component values may be necessary to achieve predicted performance (see Figure 9). Best results can be expected when using ceramic or mica dielectric capacitors. Avoid inductive (i.e. wirewound) resistors. Keep lead lengths as short as practical, and do not permit components on terminals to touch adjacent circuitry.

Since effective signal to noise performance is dependent on both the TIA gain and the output noise, the performance improvement depends on both the R_f and V_{rms} values.

As described previously, strays and component tolerances cause deviations from predicted performance. Hence, figure 9 performance values are for reference only and cannot be guaranteed.

DETECTOR SIZE	(R_1) R_F	(C_1) C_F	C_8	C_9	F_{3dB}	OUTPUT NOISE (Vrms)
0.25 mm*	91KΩ	18 pF	120 pF	0	5.2 MHz	5.97 mV
0.25 mm	160K	10 pF	170 pF	12 pF	3.7 MHz	3.82 mV
0.25 mm	330K	5 pF	170 pF	12 pF	3.1 MHz	4.48 mV
0.25 mm	820K	2 pF	220 pF	35 pF	1.8 MHz	3.62 mV
0.50 mm*	68K	24 pF	120 pF	0	5.8 MHz	5.81 mV
0.50 mm	110K	15 pF	120 pF	0	5.0 MHz	6.34 mV
0.50 mm	160K	10 pF	170 pF	12 pF	4.0 MHz	3.95 mV
0.50 mm	220K	7 pF	188 pF	24 pF	3.5 MHz	3.72 mV
0.50 mm	422K	4 pF	240 pF	48 pF	2.4 MHz	2.82 mV
0.50 mm	560K	3 pF	340 pF	150 pF	1.7 MHz	1.70 mV
1.00 mm	47K	36 pF	120 pF	0	6.3 MHz	5.44 mV
1.00 mm*	56K	30 pF	120 pF	0	5.7 MHz	5.68 mV
1.00 mm	82K	20 pF	120 pF	0	5.1 MHz	6.11 mV
1.00 mm	110K	15 pF	150 pF	7 pF	4.1 MHz	4.74 mV
1.00 mm	160K	10 pF	170 pF	12 pF	3.3 MHz	4.36 mV
2.00 mm	8.2K	200 pF	120 pF	0	4.9 MHz	4.03 mV
2.00 mm	11K	150 pF	150 pF	7 pF	4.0 MHz	3.21 mV
2.00 mm	16K	100 pF	150 pF	7 pF	3.5 MHz	3.66 mV

*Nominal values as units are provided for detector sizes from CE

Note: Actual values may vary with tolerance of components used and strays.

Figure 9

Examples of performance demonstrated for various combinations of nominal component values

Power Supply

The recommended power supply voltage is fifteen (± 15) volts DC. Eighteen (± 18) volts is the recommended maximum voltage to be supplied. Since the AM-05M is sold with a matched high speed (low capacitance) detector in a dewar, the J-1 power connector for the 2.5" diameter dewar is shown in figure 10.

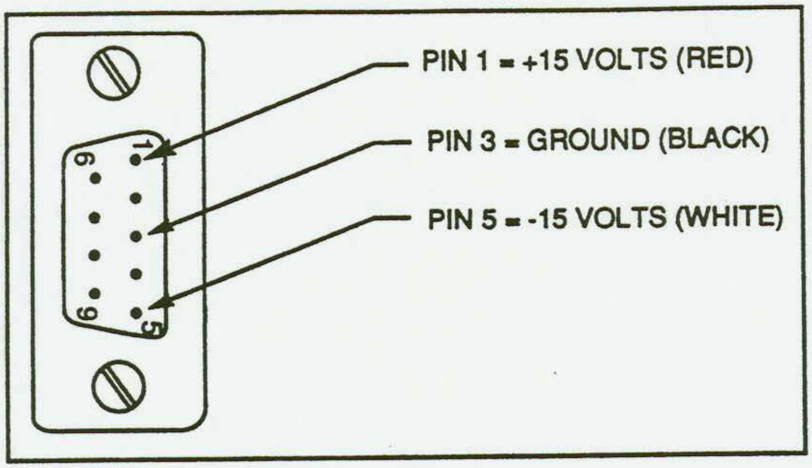


Figure 10

J1 - Power connector (as seen on 2.5" diameter dewar)

USER NOTES AND REFERENCES

CINCINNATI ELECTRONICS CORPORATION
DETECTOR & MICROCIRCUIT DEVICES LABORATORIES
7500 INNOVATION WAY
MASON, OH 45040-9699 U.S.A.

8911

DETECTOR & MICROCIRCUIT DEVICES LABORATORIES

CINCINNATI ELECTRONICS

FAST PREAMPS FOR PHOTOVOLTAIC INFRARED DETECTORS

AM-05M AND AM-35M

Low-noise JFET input transimpedance amplifiers (TIA), such as CE's AM-300, provide high sensitivity for high impedance indium antimonide (InSb) photovoltaic (PV) detectors from DC to a few hundred kilohertz bandwidth. To use capacitive photodiodes at frequencies of 1 megahertz and greater, two additional high speed preamplifier designs are required. These are provided by the AM-05M and AM-35M preamps with specially processed CE InSb detectors in sizes up to 1 mm in diameter.

The AM-05M and AM-35M are DC coupled to allow the user to study both transient and steady-state events.

AM-05M
5 MHz Boosted TIA Preamp

The AM-05M achieves minimum 3 dB bandwidths of 5 MHz by two stage amplification. The first stage is a low e-noise bipolar TIA, which is dampened to maintain stability and steady signal-to-noise ratio at higher frequencies. The second stage is a matched booster that extends the effective 3 dB. Uniform signal gain is provided over the usable bandwidth.

The AM-05M is provided to customers integrated into the Standard Detector Dewar Series (SDD) turnkey unit. The amp is matched to the detector's size and capacitance. It is optimized with the detector for maximum bandwidth.

Bandwidth of 5 MHz or greater (risetime <= 70 nanoseconds) is provided. The amp's design has a bandwidth limit of about 7 MHz.

Flexibility is provided to the user by being able to change special components at bifurcated terminals. Rolling-off of the booster stage's 3 dB response allows lower total noise for those not requiring the maximum speed provided. Corresponding optimizations may be performed to the first stage TIA.

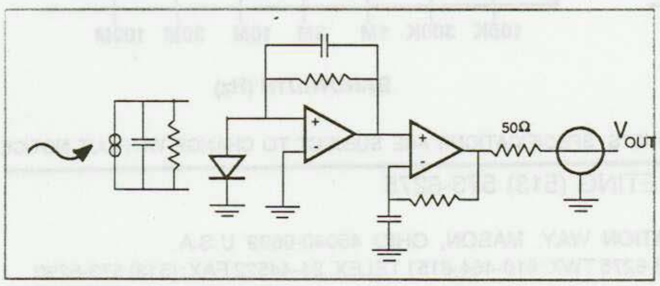
AM-35M
35 MHz Voltage Preamp for PV Detectors

The AM-35M is for those applications where high speeds of 8 MHz to 35 MHz is the user's primary concern with reasonable noise levels. The AM-35M is a type of voltage amplifier that provides a 35 MHz 3 dB bandwidth (rise time <= 10 nanoseconds).

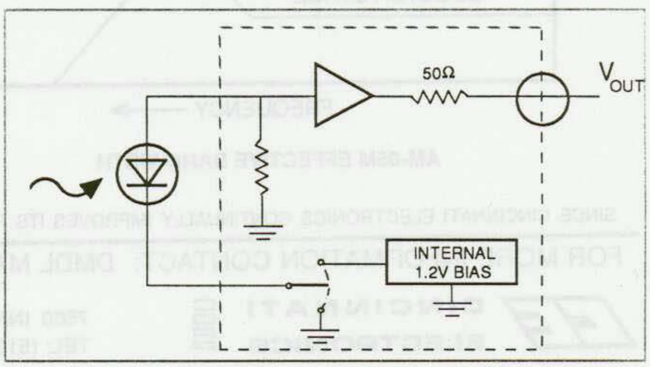
A switchable constant internal reverse bias voltage is available for the detector. The 1.2 volt internal bias voltage is stable with both temperature and supply voltage variations. Utilization of reverse bias helps to extend the frequency and the range of linear photodiode response in high flux applications.

Filtering of wide-band noise has to be performed externally to the AM-35M if this desired by a customer.

The AM-35M is provided in a stand-alone package or integrated into a SDD unit for many of the various standard detector sizes. The stand-alone version is provided in a package that is physically similar to that of the AM-300 preamplifier.



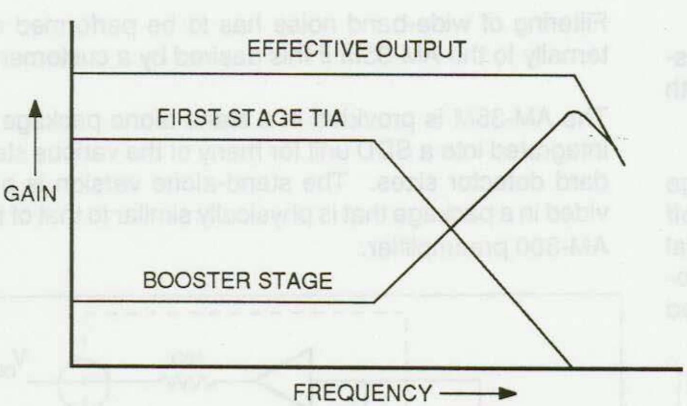
SCHEMATIC OF AM-05M BOOSTED TIA



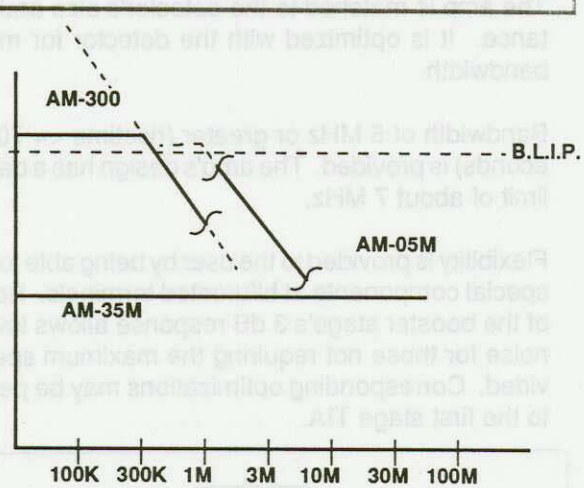
SCHEMATIC OF AM-35M VOLTAGE PREAMPLIFIER

SPECIFICATIONS

DESCRIPTION	AM-05M MIN.	AM-05M TYPICAL	AM-05M MAX.	AM-35M MIN.	AM-35M TYPICAL	AM-35M MAX.
Preamp Type		Boosted TIA			Voltage Amp	
Bandwidth (3 dB) (MHz)	5		7		35	50
Pulse Response (10-90% Risetime)	50 nS		70 nS		10 nS	
Power Supply Required		±15	(Volts DC)		±6	±7
Input Voltage Noise		N/A			1 nV/rtHz	
Output Resistance		50 Ohms			50 Ohms	
Power Consumption		250 mW	350 mW		300 mW	400 mW
Output Voltage Swing	±10	±12			±3.5 (open circuit) ±1.75 (50 ohm load)	
Input Equivalent Broad Band Noise Typical for 1mm:		Measured for unit sold 100 nA RMS @ 5.6 MHz			Measured for unit sold 900 nA RMS @ 50 MHz	
Gain		Determined by diode size (56 Kohms for 1 mm dia.)			Approx. 1700 ohms Equivalent transimpedance	
Noise 1/F Corner		35 Hz			5 KHz	
Detector Sizes		≤1 mm dia. (>1 mm inquire) (Using CE special processed InSb)			≤1 mm dia. (>1 mm inquire)	
Package		CE SDD unit only			With CE SDD unit or stand alone	



AM-05M EFFECTIVE BANDWIDTH



BANDWIDTH (Hz)

SINCE CINCINNATI ELECTRONICS CONTINUALLY IMPROVES ITS PRODUCTS, SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE.

FOR MORE INFORMATION CONTACT: DMDL MARKETING (513) 573-6275

CINCINNATI ELECTRONICS

7500 INNOVATION WAY, MASON, OHIO 45040-9699 U.S.A.
TEL: (513) 573-6275 TWX: 810-464-8151 TELEX: 21-44522 FAX: (513) 573-6290