DSS- SERIES

SOLID STATE DETECTORS

Part Number 80135 Rev. A

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Instruments S.A., Inc.

About the Manuals . . .

You may have more than one manual, depending on your system configuration. To find the manual that has the information you need, these guidelines may help.

- Each manual generally covers a product and the features and accessories peculiar to and/or contained within that product.
- Accessories that can be applied to other products are normally covered by separate documentation.
- Software that is exclusively used with one instrument or system is covered in the manual for that product.
- Software that can be used with a number of other products is covered in its own manual.
- If you are reading about a product that interacts with other products, you will be referred to other documentation as necessary.

Table of Contents:

Overview:

Solid State detectors are opto-electronic devices used to convert photon flux to electronic signals. Available with wavelength ranges from below 200 nm to beyond 20μm, solid state detectors offer a combination of sensitivity, dependability, cost and efficiency not available in other devices.

Reviewing the glossary section starting on page 33 is recommended. It contains definitions of terms as used in this manual. Also included is information about essential topics relating to detection of spectra.

Components:

The detector subsystem is generally comprised of three components, an optical interface, the detector head and a power supply.

Optical Interface:

The 1427B series detector interface is a housing with optics which attaches to the exit slit of a spectrometer. An elliptical mirror is employed to collect the diverging light from the exit slit and focus it onto the active area of the detector. A six times demagnification concentrates the slit image area to a smaller image to fit in the detector active area. Because a front surface mirror is used rather than a lens system, the image position will be fixed for the entire range of wavelengths. (Lens systems are prone to focal point shift due to chromatic aberration.)

The DSS-H1020 detector adapter is a simple mechanical mounting for use with primarily with H10, H20, and DH10 monochromators.

Detector Heads:

The two classes of single channel solid state detectors that are generally best suited to spectroscopy are photodiodes and photoconductors.

Photodiode detectors generate a voltage or current as a result of absorbing incident photons. Interfacing to support electronics is straightforward, as they often require only amplification to boost the current or voltage to a level sufficient for accurate digitization. Photoconductive detectors change resistance in response to photon flux. These detectors require a biasing voltage and lock-in amplifier signal processing to extract the signal from the inherent noise that is characteristic of this class of detectors. In either case, the DSS- Series of detector heads are provided with a built in preamplifier to boost the signal to a level of 10 volts, full scale.

The DSS- series of detectors can be interfaced to the exit slits of most SPEX and J-Y spectrometers, including those in fluorometers and Raman instruments. The catalog numbers of the detectors can be broken down to determine the type of sensor, size of the active area, and cooling technique, if any.

The **DSS** prefix means Detector, Solid State
Next comes the type designation:

- **-S** refers to a Silicon (Si) sensor
- **-IGA** refers to an Indium Gallium Arsenide (InGaAs) sensor
- **-IA** refers to an Indium Arsenide (InAs) sensor
- **-IS** refers to an Indium Antimonide (InSb) sensor
- **-G** refers to a Germanium (Ge) sensor
- **-PS** refers to a Lead Sulfide (PbS) sensor
- **-PSE** refers to a Lead Selenide (PbSe) sensor
- **-MCT** refers to Mercury Cadmium Telluride (HgCdTe)
- **-S(X)** refers to a two color detector with the Silicon in front of the (X) IR detector

The next 3 digits refer to the size of the sensor in tenths of a millimeter.

- **020** denotes a 2.0 mm size
- **025** denotes a 2.5 mm size

The suffix specifies the detector as cooled or ambient temperature

- **A** refers to Ambient
- **T** refers to Thermoelectric cooling
- **L** refers to Liquid Nitrogen cooling

Power Supplies:

Ambient temperature and LN_2 cooled detectors (see A and L suffix above) in the DSS- series require stable ±15 volt power with minimal noise and ripple. This is normally supplied by the DataScan 2 controller / photometer or the DSS-15V/TEP power supply. For applications where a lock-in amplifier or other signal processing is used in place of the DataScan, the DSS-15VP power supply is utilized to provide low noise power to the preamplifier.

The thermoelectrically cooled heads (T suffix) are provided with the DSS-15V/TEP which performs two support functions: low noise ± 15 Volts DC power for the detector preamplifier, and thermoelectric cooler drive to reduce and stabilize the detector temperature.

The **DSS-15V/TEP** controller works with a thermistor integrated to the sensor mounting cold plate in the detector head. The temperature is maintained to ±0.2°C around the set point. The set point of the controller is continuously variable using the front panel potentiometer. The range of temperature settings possible is from room temperature to -80°C, dependent on the cooler type and heat sinking. A DC ammeter is provided for current monitoring along with a green LED temperature status indicator. The unit has internal current limiting to protect the cooler from damage.

The **DSS-15VP** power supply is optionally provided with ambient and liquid nitrogen cooled heads that are used in systems without a DataScan controller. It provides the ± 15 volt power in place of the DataScan. Note that the heads ordered with the DSS-15VP are specially wired with a short 18 inch power cable to connect to the DSS-15VP.

Specifications:

Detector Heads:

Type	**Model #** A=Ambient, T=TE, L=LN_2	**λ range** (micron)	**NEP**	**Notes**
Photodiode Detectors: Lock-in and chopper required for low light applications				
Silicon (Si)	304.25.520	0.2-1.1	–	Unamplified, low cost 10 x 10 mm cell. NEP determined by analog input.
Silicon (Si)	DSS-S025A	0.3-1.1	2×10^{-14}	Higher sensitivity Si with preamplifier; requires ±15V.
Germanium (Ge)	DSS-G025A DSS-G025T	0.8-1.8 0.8-1.75	7×10^{-13} 5×10^{-14}	More range than InGaAs. 'A' requires ±15V.
Indium Gallium Arsenide (InGaAs)	DSS-IGA025A DSS-IGA025T DSS-IGA025L	0.8-1.7 0.8-1.65 0.8-1.6	6×10^{-14} 1×10^{-14} 1×10^{-15}	More sensitive than Ge; less range. 'A' and 'L' require ±15V.
Indium Arsenide (InAs)	DSS-IA020A DSS-IA020T	1.0-3.6 1.0-3.55	2×10^{-10} 1×10^{-10}	Allows DC, speed for similar range as PbS. 'A' requires ±15V.
Indium Antimonide (InSb)	DSS-IS020L	2.0-5.5	1×10^{-12}	Liquid Nitrogen cooled version only. Requires ±15V.
Photoconductive Detectors: Require Lock-in and chopper				
Lead Sulfide (PbS)	DSS-PS025A DSS-PS025T	1.0 - 3.0 1.0 - 3.0	2×10^{-12} 1×10^{-12}	100 - 500 Hz chop speed. 'A' requires ± 15V.
Lead Selenide (PbSe)	DSS-PSE025A DSS-PSE025T	1.0 - 5.0 1.0 - 5.0	5×10^{-11} 2×10^{-11}	Faster, less sensitive than PbS. 'A' requires ±15V.
Mercury Cadmium Telluride (MCT)	DSS-MCT020T DSS-MCT020L	1-12 1-12	5×10^{-11} 5×10^{-12}	Wavelength response can be customized at loss in range. Specify peak λ, max λ with order. 'L' requires ±15V.

Type	Model # A=Ambient, T=TE, L=LN_2	λ range (micron)	NEP	Notes
Two Color Detectors: Lock-in required for PbS and PbSe versions, recommended otherwise.				
Silicon over: InGaAs: ambient TE Ge TE PbS TE PbSe TE InAs: ambient TE	 DSS-SIGA020A DSS-SIGA020T DSS-SG020T DSS-SPS020T DSS-SPSE020T DSS-SIA020A DSS-SIA020T	**	**	Silicon becomes transparent near 1.1 microns, at which point the second detector becomes functional. Efficiencies are similar to single detectors, with losses to the first detector approximately 40%. The output of each detector is an individual BNC connector.
** The performance criteria for the two color detectors are similar to the values for individual detectors.				

The preamplifier maximum signal has an output voltage swing of ± 10 V into a 5 k Ω or greater load.

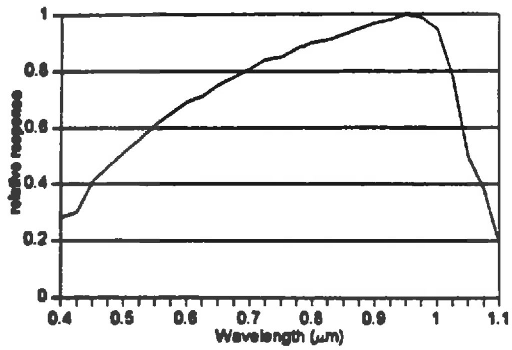
For the photodiode detectors the dual gain preamplifier in the head is DC coupled, therefore, the detector responds to DC light levels, as well as modulated (AC) light signals.

For the photoconductor detectors the dual gain preamplifier is AC coupled, therefore, the detector measures a modulated) light signal. It DOES NOT pass DC dark current and light levels.

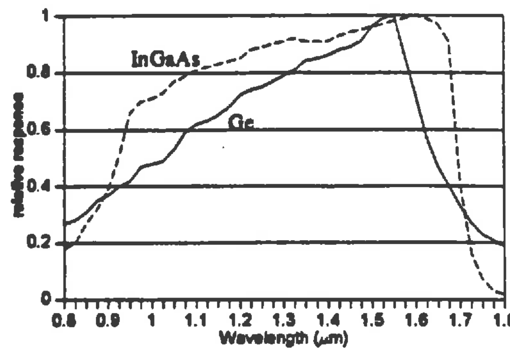
The sensitive area of the Photodiodes is round.
The sensitive area of the Photoconductors is square.

The liquid nitrogen cooled heads have a temperature hold time of over 6 hours.

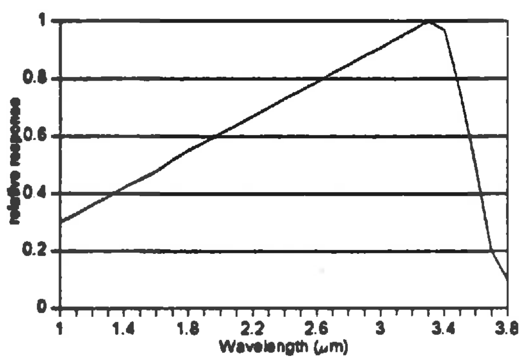
Silicon



InGaAs and Ge



InAs



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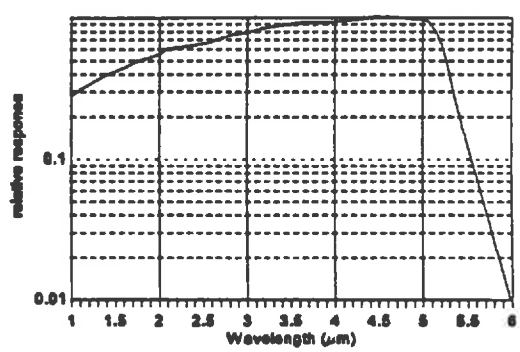
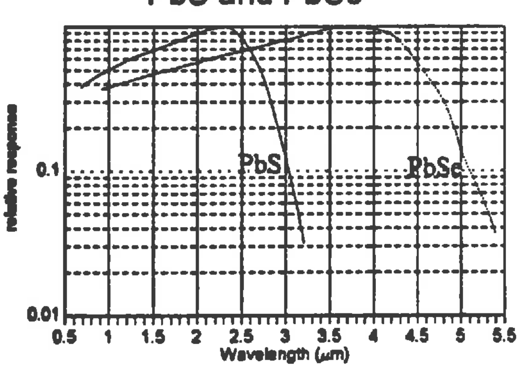
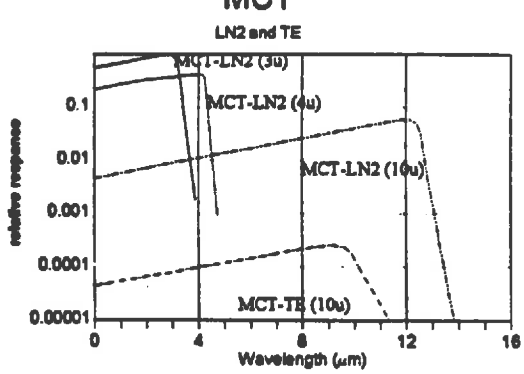
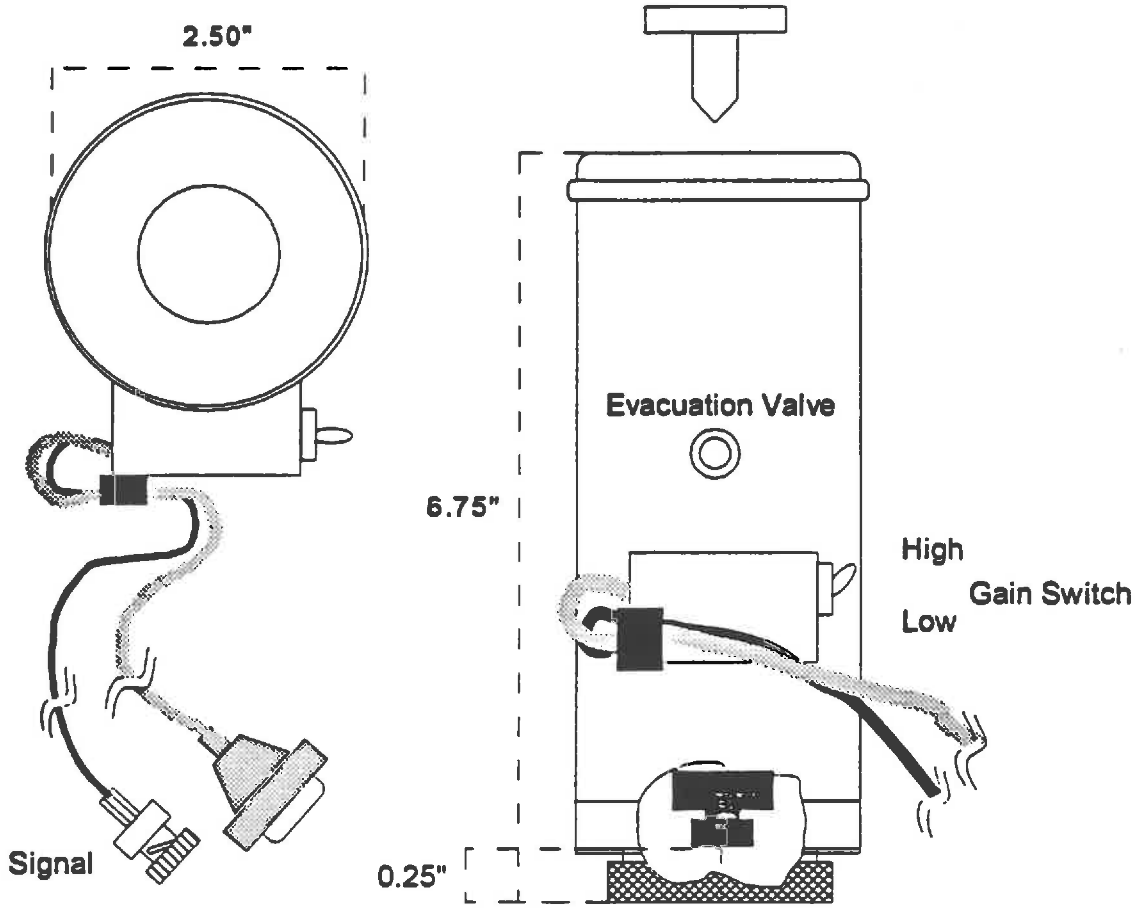


PbS and PbSe



MCT





18" Female Power Cable Connects to the DSS-15VP Only
8 Ft. Male Power Cable Connects to the DataScan AUX Only

Figure 1: DSS-XXXL Liquid Nitrogen Cooled Detector Head

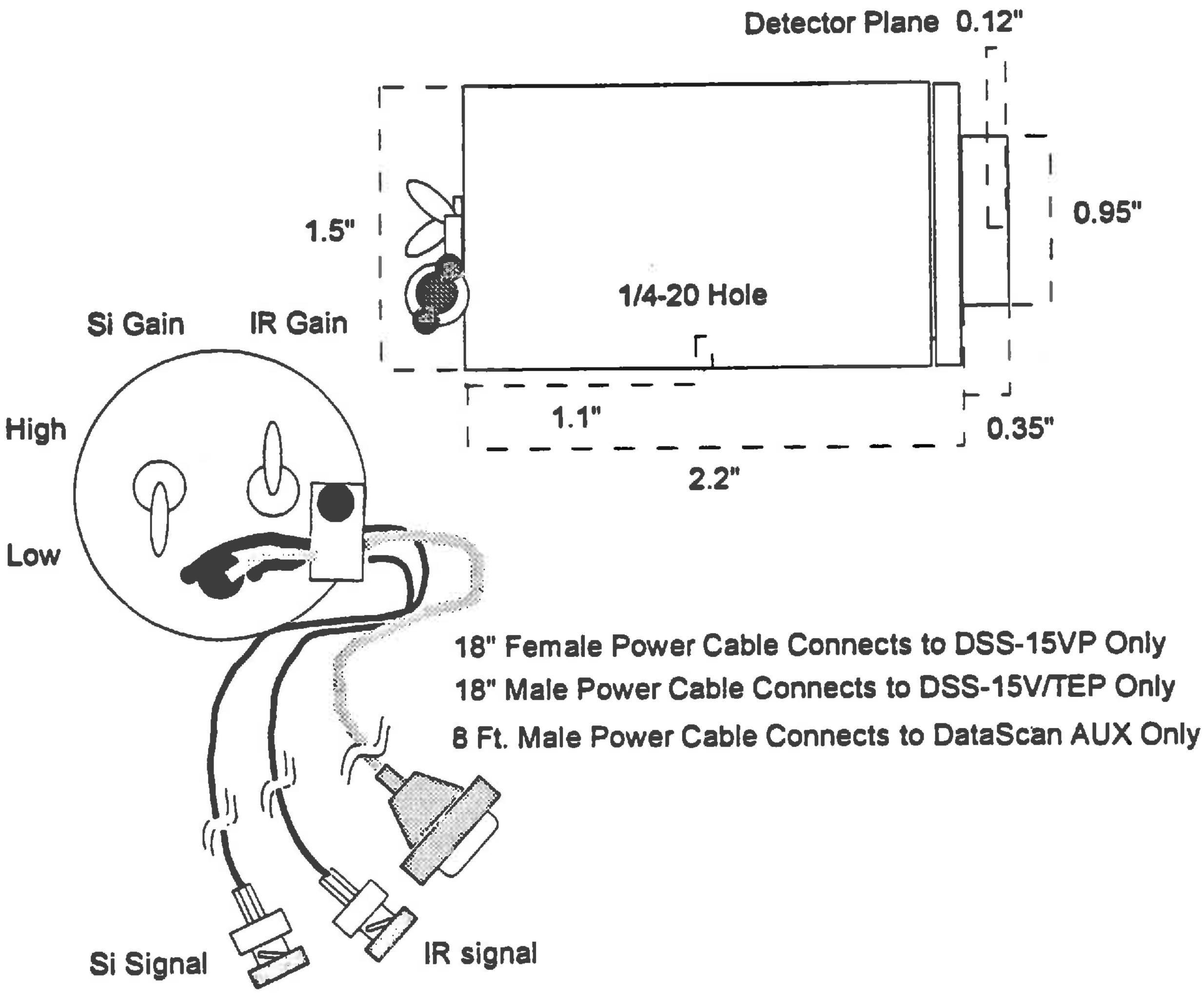


Figure 2: DSS-XXXT Series Thermoelectrically Cooled and DSS-XXXA Ambient Temperature Two Color Detector Head

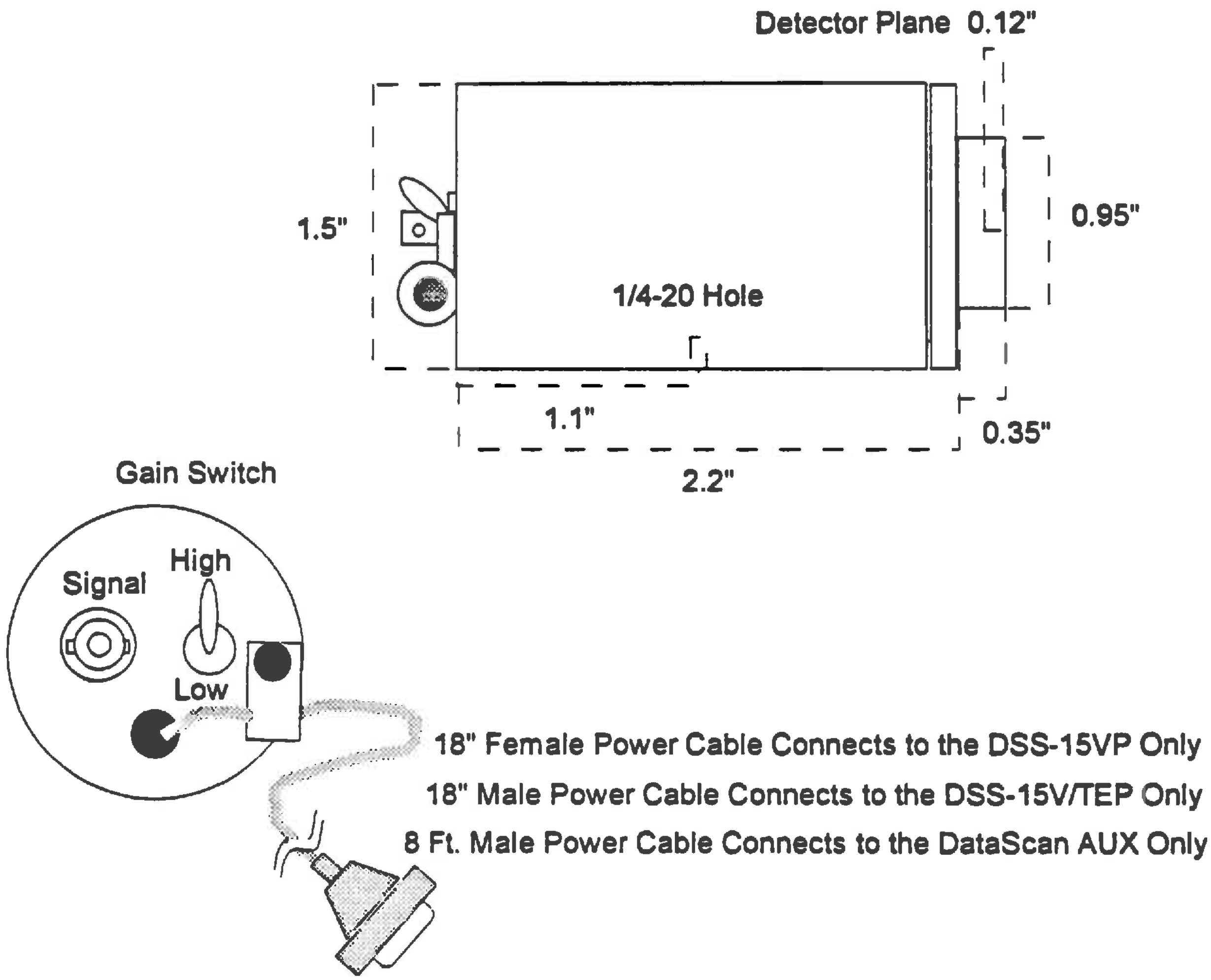


Figure 3: DSS-XXXT Series Thermoelectrically Cooled and DSS-XXXA Ambient Temperature Single Element Detector Head

DSS-15V/TEP Power Supply

Applications	DSS-XXXT
Output Voltage	± 15 V
Current	± 100 mA
Regulation	0.02 % line & load
Ripple	0.5 mV RMS max output
Connector	9- pin D Male Connector
Input Power	120 VAC/0.5 A or 240 VAC/0.5 A

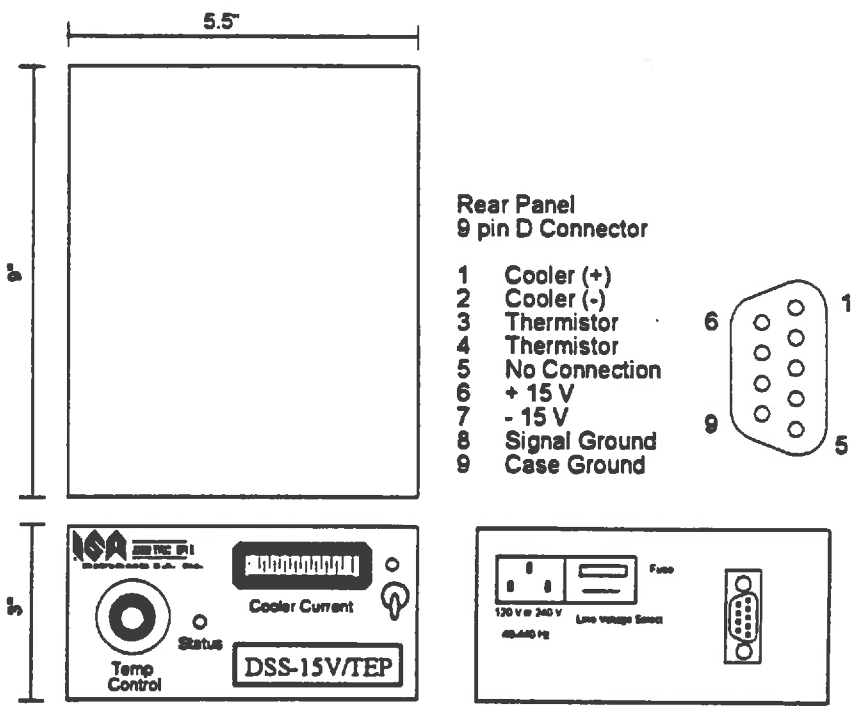


Figure 4: DSS-15V/TEP Power Supply

DSS-15VP Power Supply

Applications	DSS-XXXL, DSS-XXXA
Output Voltage	± 15 V
Current	± 100 mA
Regulation	0.02 % line & load
Ripple	0.5 mV RMS max output
Connector	9- pin D Male Connector
Input Power	120 VAC/0.5 A & 240 VAC/0.5 A

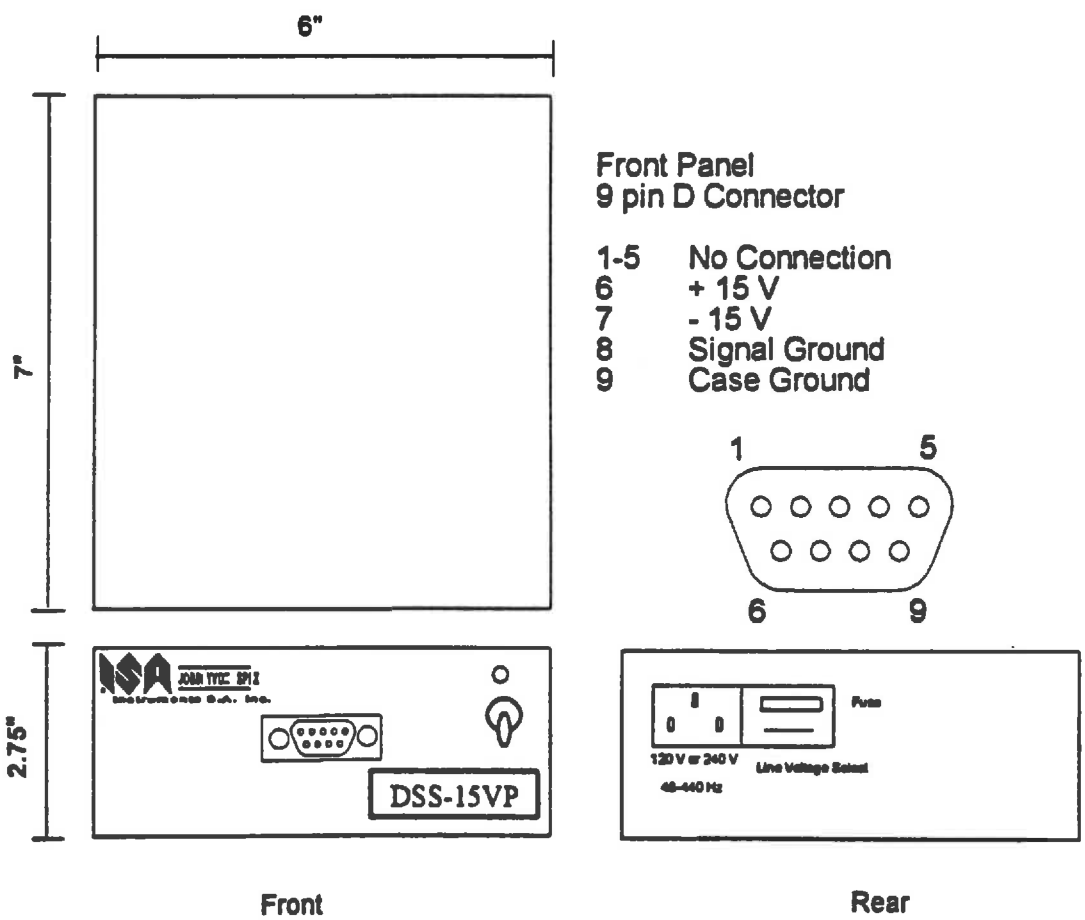


Figure 5: DSS-15VP Power Supply

1427B Detector Interface:

The 1427B consists of an elliptical coupling mirror mounted in a housing that mounts to both the spectrometer exit slit and the detector head.

The light beam exiting the spectrometer slit is diverging from an image point at the slit plane. The elliptical mirror is positioned to efficiently collect the light. The 6:1 demagnification ratio of the ellipse reduces the size of the exit slit image to better fit the typically small active area of a solid state detector.

The elliptical mirror is mounted on an internal bracket that provides X and Y centering adjustments for optimizing the position of the image on the detector.

The detector mount allows vertical translation along the optical axis for positioning the detector at the exit focus of the 1427B

The 1427B fits smaller ambient temperature and thermoelectrically cooled detector heads as well as the larger dewar enclosed LN_2 cooled detectors.

Installation of the 1427B:

Tools required: Hex socket key set in inch sizes, Phillips and flat blade screwdrivers, a visible light source (may be either a white light or a spectral line source), clear plastic centering target (22644 disc, with 22645 rod) packed with the 1427B, and a 3/8" box or open end wrench,.

For the 500-1250M, 1400, and 1700 series spectrometers, attach the 1427B hjousing to the slit using two 1/4"-20 screws. The screws pass through the large holes in the outer lip of the flange. Mount the 1427B housing on the exit slit of the spectrometer such that the housing's exit is direccted upwards.

To mount the 1427B to the slits on 270M, 1680, 1681, and 340 series spectrometers, as well as Fluorolog systems the housing must be partially disassembled to provide access for the two 6-32 mounting screws that pass through the inner lip of the flange. In this case, with a 7/64" hex key, remove the four screws and the front end of the housing (closest to the slit flange). Do not disturb the rear of the housing or the adjusting locknuts.

Additional mechanical support is provided by a universal leg that may be assembled to various lengths to provide support, particularly when mounted on the smaller 1679 or 220/270 slits. Its use with the larger 1451 series slits is optional. If not using the leg, be sure that the threaded hole in the bottom of the housing is plugged with a setscrew.

Assemble the leg rods using the 1/4"-20 set screws provided. Use a combination of rods that will allow support from the table or other surface under the 1427B housing. Using another 1/4"-20 setscrew, attach the completed leg to the underside of the housing. Adjust the leveling foot to the proper height.

If using an ambient or thermoelectrically cooled detector head, Use a 5/64" hex key to snug the three no-mar set screws to fix the holder sleeve inside the holder collar. It is best to insert the sleeve fully until it bottoms in the collar. For 1.5" diameter DSS- series ambient and thermoelectrically cooled heads, use the 38268 holder sleeve. The 1428 series 1' diameter ambient temperature detector heads are accommodated by the 36063 holder sleeve. The detector heads can then be inserted into the sleeve. After alignment (below) it will be tightened in place. If more than one detector is sharing the interface, purchasing ad additional holder sleve of the appropriate diameter is recommended. In this way, the focus adjustment can be done one only once for each detector head, and the heads can be interchanged with their holder sleeves attached to preserve the adjustment.

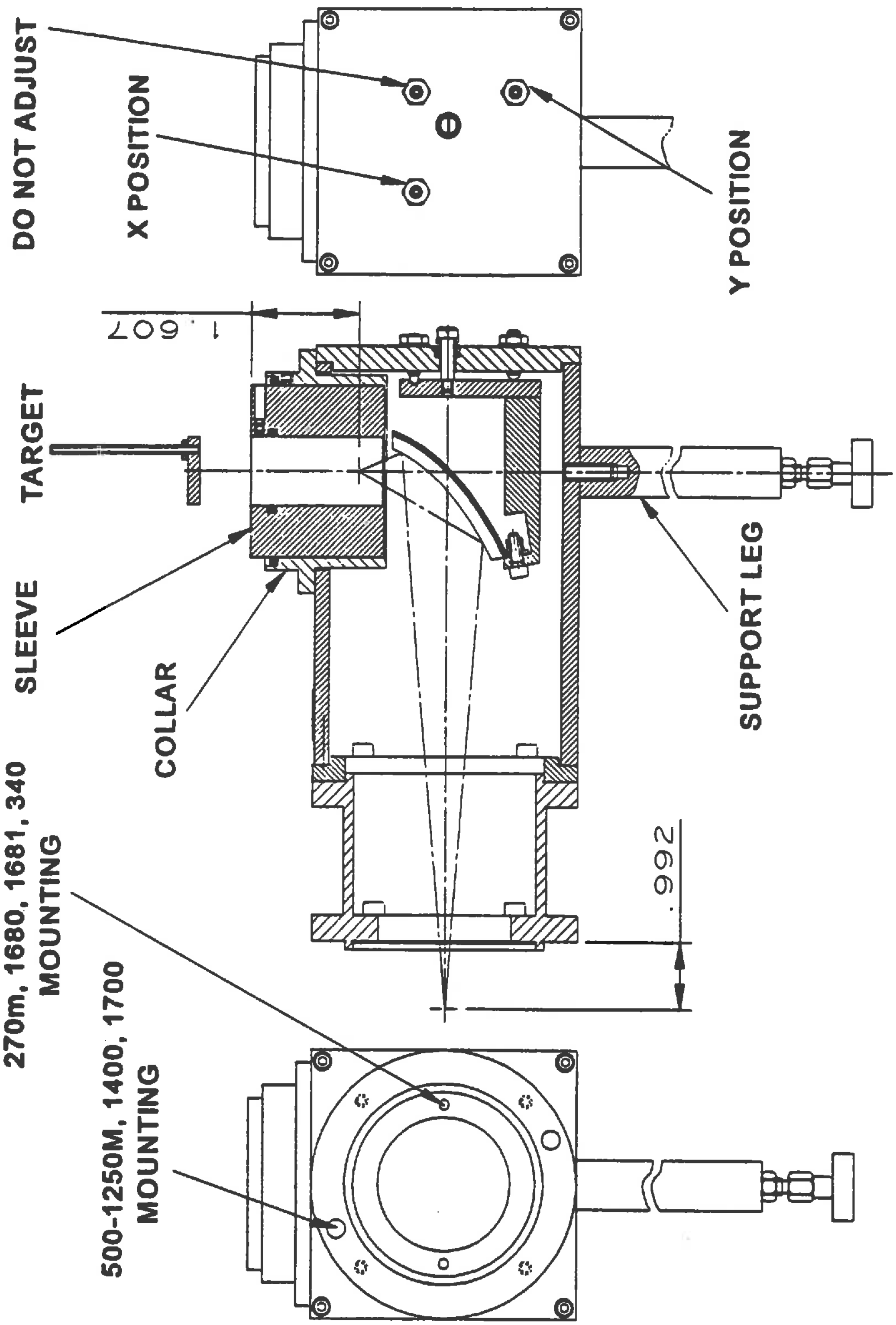


Figure 6: 1427B Detector Interface

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For the liquid nitrogen cooled heads, the holder sleeve is not required. The DSS-XXXL dewar and earlier 1428 series liquid nitrogen cooled heads will simply fit into the 36064 standard 2 9/16" I.D. collar directly. A 2 5/8" bore collar, part number 36788, is available for oversize detector housings (e.g. certain Northcoast dewars)

X-Y Alignment:

Direct the light source into the spectrometer entrance and set the wavelength position such that vsible wavelengths are present at the exit slit. For gratings blazed in the infrared choose a higher order close to the blaze of the grating. For example: a mercury vapor lamp that emits a 546.1 nm line can be used in the fourth order at 2.1844 μm. For a 2 μm blaze grating, This will give a brighter image than tuning to 546.1 nm.

Set the entrance and exit slits to at least 50 μm width, or larger so hat the image is easily visible, but relatively small. Place the clear plastic alignment target into the 38268 holder sleeve. If the O-ring light seal interferes, tilt the target as it passes the O ring.
Then the target may be lowered to the bottom.

Align the image with the center of the target by adjusting the X and Y position screws at the back of the housing. Do not disturb the corner pivot or the slotted spring retainer screw. The 3/8 " locknuts on the X and Y positioning screws must be loosened to allow adjustment. Use a 3/32" hex key to adjust. When finished, snug the locknuts while holding the setscrews with the hex key to prevent the adjustment from changing..

Move the target up and down to observe the approximate location of the sharpest focus. Close the slits and remove the target and store it for future use. If mounting a DSS-XXXXL liquid nitrogen detector head, remove the holder sleeve. If mounting a DSS-XXXXA or T head, leave the 38268 sleeve in place. Place the detector Into the 1427B. If it is sensitive to visible light, continue with focusing, below. If the detector is not sensitive to visible light, replace the source with one that emits in the usable wavelength range of the detector, and tune the spectrometer to a suitable wavelength.

Focusing:

Open the slits carefully while observing the signal intensity. Avoid saturating the detector during this procedure. As the detector is moved, the slit widths may have to be reduced, or neutral density filters may be required to reduce the intensity entering the spectrometer. Move the detector head vertically while monitoring the signal strength. When satisfied that the detector is positioned for highest intensity, tighten the setscrews to secure it. Small adjustments to the X and Y positioning may be made to further optimize the optical coupling to the detector. Recheck the focus and finish by tightening all mounting setscrews.
Take care that the detector is not saturated by

After positioning the detector at the focus, tighten the no mar detector screw in the adapter sleeve using a 1/8" hex key.

DSS-H1020 Detector Adapter:

The DSS-H1020 is a simple mechanical adapter to connect the DSS-XXXXA & T series ambient and thermoelectrically cooled heads to H10, H20, and DH10 monochromators. To install the DSS-H1020, unscrew the four countersunk screws and remove the end plate and height limiter from the monochromator. Replace them with the DSS-H1020 adapter. Insert the nose of the detector head fully into the adapter and tighten the set screws.

Connecting the Detectors:

Warning: Do not connect or disconnect system cables while any components are powered on. The resulting electrostatic discharge may damage the electronics. Depending on the system configuration, this may include: the detector power supply, spectrometer, controller, lock-in and computer.

DSS-XXXA Series Ambient Temperature Detectors:

If the DSS-XXXA is to be used with a DataScan 2 controller, the head is provided with an 8 ft power cable which is wired specifically for the DataScan 2. Connect the cable from the head to either the 9 pin AUX 1 or AUX 2 connector on the rear panel of the DataScan. For single element detectors, connect the 30646 BNC signal cable provided from the detector head to the V1 or V2 input connector of the DataScan. For consistency, use AUX1 with V1 or AUX2 with V2. If a two color detector is used, connect the two BNC cables attached to the head to the V1 and V2 inputs and the power cable to AUX1.

When not using the DSS-XXXA with a DataScan, the DSS-15VP low noise power supply is required. In this case, the DSS-XXXA is supplied with a short 18 inch power cable wired specifically for the DSS-15VP power supply. Connect the signal cables to the lock-in amplifier or other signal processor according to the instructions provided with it.

> *CAUTION:* Make sure the beam power incident on the detector is below the saturation limit. Neutral density filters should be used to attenuate high optical power levels. Extremely high beam power can result in detector damage.

DSS-XXXT Series Thermoelectrically Cooled Detectors:

The power input module is located on the rear panel of the DSS-15V/TEP
Verify that the voltage selection card is properly oriented for the line voltage (120 V or 240 V).

The front panel of the DSS-15V/TEP contains the TE cooler control potentiometer, the temperature status LED, the ammeter, and a power switch with power on indicator LED.

The rear panel contains the nine pin D type connector jack for connection to the DSS-XXXT series detectors. .

> ***Caution for DSS-XXXT detectors only::***
> Connect the 9 pin male D-shell connector from the DSS-XXXT detector to the DSS-15V/TEP rear panel connector ONLY.

Before switching on power, rotate the temperature control fully counter-clockwise (OFF).

Switch on power (detector preamplifier is immediately activated) and observe that the current drops to near zero and the green status LED turns on.

Turning the control pot clockwise lowers the temperature set point. Initially this should be done on a gradual basis, until the control current is in the proper range (typically 0.5 to 1.0 A).

Do not leave the set point in a position where the status control indicator LED does not turn on.

During the first few days of operating continue to observe the cooler current periodically. A gradual increase indicates heating of the cooler assembly (hot plate) in the detector head. In this case, additional heat sinking should be provided to the detector housing. In a normal laboratory environment the 1427B detector interface provides ample heat sinking.

> ***CAUTION:*** Make sure the beam power incident on the detector is below the saturation limit. Neutral density filters should be used to attenuate high optical power levels. Extremely high beam power can result in detector damage.

DSS-XXXL Liquid Nitrogen Cooled Detectors :

> ***Warning:*** **Do not turn on the power to the DataScan or DSS-15VP until the DSS-XXXL detector reaches operating temperature (77°K). The preamplifier gain in the cryogenic detector heads is very high to take advantage of the reduced thermal noise. If the detector is powered at higher temperature, the preamplifier will saturate due to high dark current from the detector. In this condition, the preamplifier will overheat. After a few minutes damage may occur.**

Liquid Nitrogen Precautions:

Warning:
Liquid Nitrogen requires special handling. Read this section carefully before filling the dewar.

Ventilation:
In confined spaces lacking adequate ventilation, nitrogen gas can displace air to the extent that it can cause asphyxiation. Always use and store liquid nitrogen in well-ventilated spaces.

Extreme Cold:
The boiling point of liquid nitrogen at atmospheric pressure is 77.3 K (about -156°C). This extreme cold can cause tissue damage similar to a severe burn. Therefore, exposure of the skin or eyes to the liquid, cold gas, or liquid-cooled surfaces must be avoided.

The liquid should be handled so that it will not splash or spill. Gloves impervious to liquid nitrogen and goggles should be worn when handling the liquid. Feet can be protected by wearing rubber boots, with trousers (without cuffs) on the outside.

Storage and Transfer:
Liquid nitrogen should always be stored in vacuum-insulated containers, which should be loosely covered but not sealed. Covering prevents moisture condensing out of the air to form ice which may cause blockage. Sealing results in pressure buildup. DO NOT ATTEMPT TO SEAL THE MOUTH OF THE DEWAR!

The gas-to-liquid volume ratio is about 680:1. All containment vessels must therefore be fitted with exhaust vents to allow evaporating gas to escape safely. If these vents are sealed, pressure will build up rapidly and may result in the fracture of the containment vessel.

LN_2 Filling Instructions:

Caution: The electronics must not be turned on until 5 minutes after the liquid nitrogen is added to the dewar.

> ***CAUTION:*** Carefully fill the metal dewar with liquid nitrogen using the enclosed funnel. Fill a little at a time to allow time for the boil- off vapor to escape. Filling too quickly at first will cause the LN_2 fluid to spurt out forming a geyser. The dewar should be slowly filled over a five minute interval to reduce the geyser effect.

Take care not to overfill. If the liquid nitrogen is spilled on apparatus around or below the detector, the resulting thermal shock may have a detrimental effect.

To fill the detector head dewar with LN2, use the funnel provided and a transfer dewar. Insure that the funnel fits loosely into the fill hole to provide a gap to vent the boiled off vapor as the liquid nitrogen is added. Set the funnel into the mouth of the dewar.

Pour the liquid nitrogen into the funnel slowly. When filling the dewar, an initial period of nitrogen boiling occurs until the internal components of the dewar have cooled to liquid nitrogen temperatures. Allow a few minutes for the liquid to stop boiling before topping up the dewar. After this initial boil-off period, refill the dewar as needed to extend the cold temperature hold time. Replace the cap each time the dewar is fulled.

The cap is insulated to help extend the interval between fills. It also minimizes moisture condensation into the dewar. The loose fit of the cap prevents pressure buildup in the dewar by allowing evaporating nitrogen to escape.

If the DSS-XXXL is to be used with a DataScan 2 controller, the head is provided with an 8 ft power cable which is wired specifically for the DataScan 2. Connect the cable from the head to either the 9 pin AUX 1 or AUX 2 connector on the rear panel of the DataScan. Connect the BNC cable attached to the head to the V1 or V2 input connector of the DataScan. For consistency, use AUX1 with V1 or AUX2 with V2.

When not using the DSS-XXXL with a DataScan, the DSS-15VP low noise power supply is required. In this case, the DSS-XXXL is supplied with a short power cable DSS-15VP power supply.

The high preamplifier gain range set for 10 times more gain than the low gain setting. Start with low gain and consider using neutral density filters for strong signals when conducting initial tests. If the signal level is less than a tenth of the saturation level, it is better to switch to high gain for best performance. Boosting gain at the detector head reduces the effect of noise pickup as compared with using a higher input gain on the DataScan, lock-in amplifier, or other signal processing electronics. Liquid nitrogen cooled detectors have very high preamplifier gain. For these LN_2 heads, ambient light can easily saturate the preamplifier. The detector must be mounted on the spectrometer or the detector window shielded to prevent preamplifier damage.

> ***CAUTION:*** Make sure the beam power incident on the detector is below the saturation limit. Neutral density filters should be used to attenuate high optical power levels. Extremely high beam power can result in detector damage.

Lock-in Amplifier Installation:

To prepare the system to acquire signal with a lock-in amplifier requires special software setup and cable interconnections.

The software configuration is covered in the documentation provided with the software. Refer to the SpectraMax manual and any supplemental instructions relating to the lock-in.

The connections between the detector, lock-in amplifier, and computer are diagrammed below.

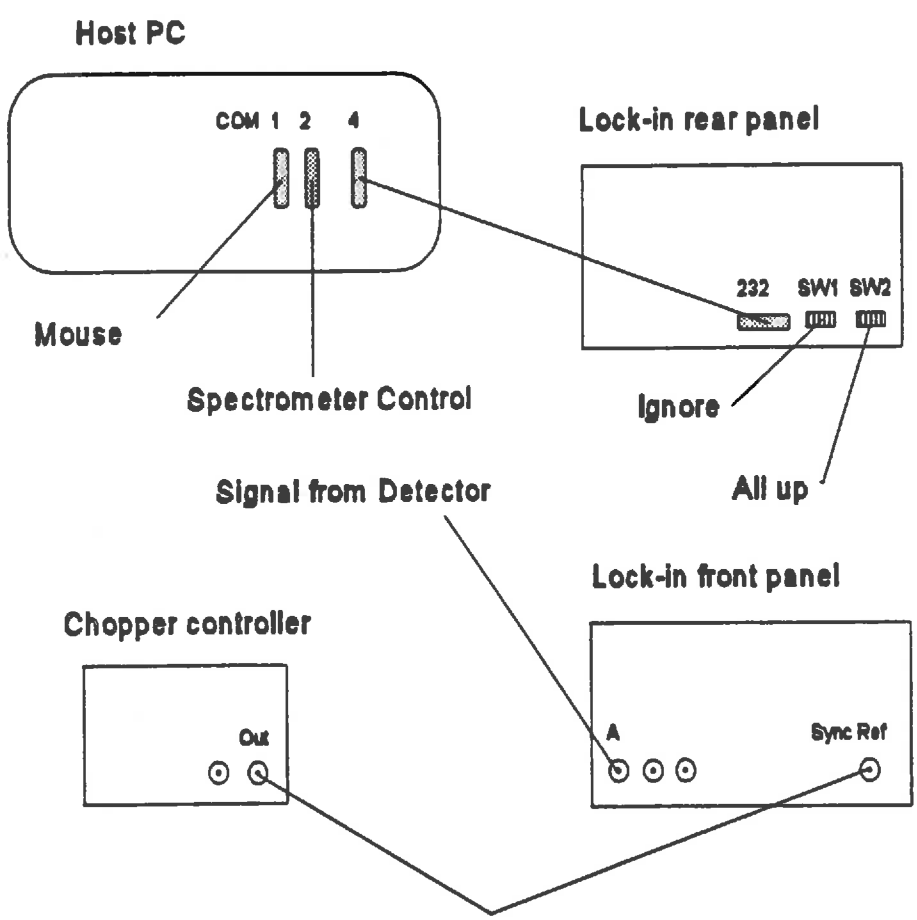


Figure 7: Lock-in Cabling for SR510 and SR540 or Equivalent

Optimization:

The signal to noise ratio of the detected signal is dependent on optical coupling, detector temperature, the timing aspects of signal collection technique, and the electronic treatment of the signal once it leaves the detector.

Optical Considerations:

The coupling of the optical signal from the exit slit of a monochromator to the active area of the detector greatly affects the system's performance. Small detector areas are often desirable because they have better D* and NEP figures. The small active area detectors require coupling optics to direct the diverging energy exiting the spectrometer's slit to be concentrated on the detector. The 1427B Solid State Detector Interface uses a 6:1 elliptical mirror to achromatically collect the diverging beam and focus the light onto the detector. A user designed lens interface may also perform this function, but the wavelength range may be limited depending on the lens material. Chromatic aberration from the lens can shift the focus causing uneven coupling as a function of wavelength as well.

Thermal Considerations:

The thermally generated blackbody signal of the detector itself is a source of noise, but this can be reduced by orders of magnitude by choosing a cooled detector. By reducing the induced background noise contributions of the detector, the minimum detectable signal level can be lowered.

Two modes of cooling are offered by Instruments S.A.: Thermoelectric (TE) cooling and liquid nitrogen (LN_2) cooling, operating nominally at -20°C and -190°C respectively..

The TE cooled detectors are mounted to a two stage Peltier cooling device with an integral heat sink. A separate power supply / temperature controller is provided to power and thermostatically control the cooler.

The LN_2 cooled devices are mounted in a dewar capable of better than six hours liquid nitrogen hold time.

Note that cooling temperature affects the upper wavelength response. For photodiode detectors, long wavelength response is reduced. Photoconductors, however, exhibit enhanced response at longer wavelengths

The uncooled detectors, operating at nominally 20°C, are mounted in housings similar to the TE units for ease of interchange.

Timing Considerations:

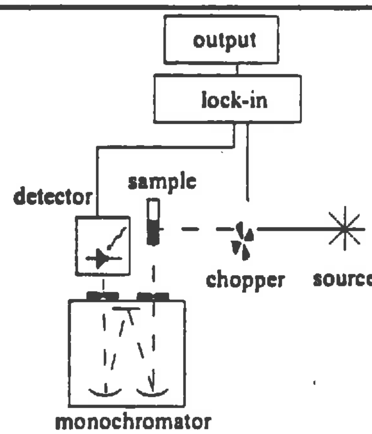
The acquisition speed for the detector is based on the response time of the detector as well as the speed of the amplifier package. Photodiodes are generally very fast detectors, able to respond to chopping speeds in the megahertz range. However, the amplifier speed at the set gain is slower, limiting the frequency response to just over 1000 Hz and a minimum datapoint time of 1 ms. Conversely, photoconductors tend to be slower detectors. The lead sulfide detector is the slowest detector, with a recommended operating frequency of 100 Hz corresponding to a minimum datapoint time of 10 ms. The lead selenide is faster, returning optimized performance at 1000 Hz. The MCT detectors can be run at chopper speeds in the range of 1000 Hz to approximately 10,000 Hz to minimize its 1/f noise component.

Electronic Considerations:

The output of a photodiode detector can be collected in DC mode by connection to the I1 or I2 input on a DataScan or to a DM303 module used with a DM3000 or SpectrAcq controller analog input. This minimal hardware configuration is suitable when the signal is much larger than the noise sources, as when measuring diode responses, performing lamp characterizations, and performing routine transmission / absorption characterizations.

The total DC signal includes the signal of interest along with some background noise due to the environment, dark signal from the detector and DC amplifier offset. As the signal levels decrease or accuracy needs to be increased, additional signal conditioning is required. DC signal collection is not suitable for photoconductors.

Background noise, detector noise, and offset of the DC signal can be suppressed by operating in AC mode (also called synchronous or lock-in mode). AC operation is mandatory for photoconductors, and recommended for photodiodes when the DC signals are noisy. AC operation is commonly performed by using an optical chopper in the experiment light path and connecting the detector to a lock-in amplifier. The chopper is a shutter which blocks and unblocks the optical path at a fixed frequency; it is generally configured as a series of equally sized blades and holes mounted on a motor shaft rotating at a controlled rate. The chopper is placed closest to the experiment source, modulating the signal at the chopper frequency. The signal is then modulated while the noise and stray signals that may be introduced later in the optical system are not modulated. The lock-in amplifier acts as a very narrow frequency bandpass filter to extract the modulated signal from the total signal. By using a lock-in system, it is possible to acquire the experiment signal at a desirable S/N from a much larger background noise signal.



Typical Lock-in and chopper configuration

Photoconductors are susceptible to noise related to the inverse of the chopper frequency (1/f noise) which climbs geometrically as the DC mode is approached; therefore, they are always operated in the AC mode. Typical chopping frequencies for photoconductors range from 10 - 1,000 Hz, while the photodiode detectors range from DC to many kilohertz. The maximum chopping frequency is dependent on the response time of the particular detector type and limits the fastest data acquisition speed.

User Servicing:

The DSS Series Detectors are designed to perform for years with minimal maintenance. The ambient and thermoelectric cooled heads typically require no further attention once put in service.

The LN_2 detector heads are evacuated, and eventually will need re-pumping. In as much as the level of vacuum required is beyond the capabilities of mechanical vacuum pumps, user re-pumping is not recommended. The user's responsibility in this regard is simply to monitor the operating temperature on a periodic basis. Monthly checking of the dark signal level will indicate loss of vacuum as the vacuum insulation performance degrades and the dark current increases due to increased operating temperature. When the cooling can no longer maintain a stable dark current, contact the factory for assistance. Frost formation on the outside of the dewar and rapid consumption of LN_2 indicate extreme vacuum loss.

If the signal is too noisy:

- Try to increase signal strength at the detector.
- Do what you can to eliminate or reduce the non-signal light that is allowed to enter the spectrograph entrance slit, whether on the optical axis or not.
- Check for light leaks as suggested under "Background signal too high" in this section.
- If noise is reduced by turning off or disconnecting the power to the spectrometer motor, rearrange power connections to be sure the spectrometer, source, and detector are tied to the same ground and, if possible, the same power circuit.
- Adding redundant ground wires to various points in the total system often helps to reduce the effect of electromagnetic noise sources. Please understand that ground loops and electromagnetic interference can sometimes be challenging problems. Connecting the detector head to a central ground may help. For DSS-XXXX heads, remove one of the case screws near the cable end of the detector, scratch away the black anodize coating in the countersink under the screw head, and tighten the screw on the wire. Connect the other end of the wire to the central ground point. The central ground may be a rear panel chassis ground on the controller or lock-in amplifier. In extreme cases, some prefer to create a "star" ground, that is a central point on a metal baseplate or optical table that has straps or wires radiating to the various system components. In extreme cases, the best approach is to patiently experiment by trying various combinations of grounding connections. As a general rule, try to keep ground wires short, make tight connections, avoid painted, coated, and anodized surfaces when possible. Leave no loose ends.
- In extreme cases, such as working with or around high powered pulsed lasers or other high energy apparatus, it may be helpful to construct RFI / EMI shields or cages to contain the noise at its source, or to isolate the detection system from the noise. In these cases, colleagues who are working with similar apparatuses may be your best resource for noise control suggestions.

Background signal too high, background reduced when room lights are turned off:

- Be sure all covers are in place
- Make sure that the area between the source or sample and the entrance slit is enclosed, and light tight. Block the entrance slit as a test.
- Check detector mounting and/ or housing for light leaks.
- Starting from the detector, close exit and entrance slits and shutters in turn to determine where stray light may be entering the system. Note that to prevent damage to the knife edges, the slits do not close completely, and will therefore not block all of the light, however, with the signal blocked, reducing the slit width will reduce any stray light that is passing through it.
- Be sure all openings and screw holes are plugged.
- Check that the cover, side, and baseplate should fit tightly, foam or rubber light seals should be partly compressed, not flattened.
- If leaks persist, use a small flashlight in a dark room to isolate where the leaks are by shining at any suspicious part or joint in the system. and observing detected signal levels.

Background signal too high, background not reduced when room lights are turned off:

- For thermoelectric cooled heads, check for green status light on DSS-15V/TEP
- For LN_2 heads, check to be sure the dewar is filled.
- Acquire data with a background subtraction: Take a background scan under the same conditions as the desired signal, but with the signal of interset blocked and subtract the background from future scans of the signal of interest. Update the background data periodically to compensate for long term drift or other changes that affect the system. If an automated shutter is available, use it to block the signal and acquire background data at each point in the scan.
- Use a chopper and lock-in amplifier to modulate and synchronously detect the signal.

Service Policy:

If you need assistance in resolving a problem with your instrument, contact our Customer Service Department directly, or if outside the United States, through our representative or affiliate covering your location.

Often it is possible to correct, reduce, or localize the problem through discussion with our Customer Service Engineers.

All instruments are covered by a warranty. The warranty statement is printed on the inside back cover of this manual. Service for out-of-warranty instruments is also available, for a fee. Contact ISA for details and cost estimates.

If your problem relates to software, please verify your computer's operation by running any diagnostic routines that were provided with it. If there is a support diskette provided, refer to the manual for that diskette, and follow the troubleshooting procedures. Be ready to provide version numbers for the DOS that you are using, as well as the software version and firmware version of any controller or interface options in your system. To determine the firmware version of your DataScan 2, refer to the procedure in the appendix on page 31. The software version can be determined by reading the version from the welcome panel that is displayed when the software is loaded. Or select the software name at the right end of the menu bar and click on "About" to view the same panel. Also knowing the memory type and allocation, and other computer hardware configuration data from the PC's CMOS Setup utility may be useful.

In the United States, customers may contact the Customer Service department directly:

- By phone at (908) 494-8660.
- The Service fax numbers are (908) 549-2571 for Raman, 549-5157 for Fluorescence, or 549-9309 for Systems Group.
- Or you may write to:
  Instruments SA, Inc.
  Customer Service (Specify Raman, Fluorescence, or Systems Group)
  3880 Park Avenue
  Edison, N.J. 08820 U.S.A.

From other locations worldwide, contact the representative or affiliate for your location.

If an instrument or component must be returned, the method described on the following page should be followed to expedite servicing and reduce your down-time.

Return Authorization:

All instruments and components returned to the factory must be accompanied by a Return Authorization Number issued by our Customer Service Department.
To issue a Return Authorization number, we require:

- The model and serial number of the instrument
- A list of items and/or components to be returned
- A description of the problem, including operating settings
- The instrument user's name, mailing address, telephone, and fax numbers
- The shipping address for shipment of the instrument to you after service
- Your Purchase Order number and billing information for non-warranty services
- Our original Sales Order number, if known
- Your Customer Account number, if known
- Any special instructions

Appendix A: Glossary

The discussion of detection with solid state devices requires some familiarity with the terminology used. This section includes definitions specific to the context of this manual for some familiar terms, as well as several unique terms, abbreviations and acronyms.

ADC:

An Analog to Digital Converter (ADC) converts a sample of an analog voltage or current signal to a digital value. The value may then be communicated, stored, and manipulated mathematically. The value of each conversion is generally referred to as a datapoint.

Blackbody Radiation:

An ideal blackbody completely absorbs all radiation that strikes it. Blackbody radiation is the emission from a blackbody when heated. All objects at temperatures above absolute zero emit some radiation. For convenience, this emission is often referred to as blackbody radiation.

Chromatic Aberration:

Lenses do not form perfect images at a single point or plane when a polychromatic source is used. at varying distances depending on the wavelength. This is due to the refraction of different wavelengths at slightly different angles. This same phenomenon is what makes a prism split a collimated beam of white light into diverging colored beams. Sometimes the displacement is significant, such as when imaging into a narrow spectrometer slit and working over a broad range of wavelengths. In such cases, throughput may vary considerably as a function of wavelength. The effect can be visualized as multiple images formed at slightly displaced positions along the optical axis. The distance from the lens to each image is a function of the wavelength of that image and the index of refraction of the lens at that wavelength. Images that are formed in front or behind the slit will not couple as well as the image that is formed at the slit plane.

D*: *(pronounced DEE-star)*

This is an area- weighted figure of merit for detectors. The higher the D* number, the more sensitive the detector. To realize the best performance in a spectroscopic system, coupling optics are often required to collect the diverging signal beam from the exit slit and concentrate it on the small (therefore high D*) detector.

Dark Signal:

Dark signal is generated by thermal agitation. This signal is directly related to exposure time and increases with temperature. The more dark signal, the less dynamic range for experimental signal.

Dynamic Range:

The **Dynamic Range** is the ratio of the maximum and minimum signal measurable. The weakest detectable signal is limited by the **Dark Level** plus the **Sampling Noise.** For single channel detectors, the most intense detectable signal is the lesser of the the **Saturation Level** or the ADC maximum limit. The dynamic range of the detector can be greater than that of the system which is limited by the ADC. A 16 bit ADC limit is 65,535 (2^{16}-1) counts. A 14 bit ADC is limited to 16,383 counts. **Gain Ranges** can be used to shift the ADC range to match the signal levels of a given spectral measurement. In this way, stronger or weaker signals can be accommodated with optimal Dynamic Range.

Linearity:

When photo response is linear, if the light intensity doubles, the detected signal will double in magnitude as well.
Although not a detector specific term, another related type of linearity is the spectral positioning accuracy or tracking error of a spectrometer drive mechanism.

NEP (Noise Equivalent Power):

This is the radiant power level impinging on a detector that results in a signal / noise ratio of 1:1. NEP is specified at a particular modulation frequency, wavelength and effective noise bandwidth. A lower NEP value means more detector sensitivity. The NEP is also improved by detector cooling.

Noise:

Noise is common to all detectors. The total amount of signal that exists is less important than the ratio of signal magnitude to noise magnitude (S/N). With a high signal to noise ratio a signal peak can be discerned even though signal counts per second may be low. The noise components are as follows:

Amplifier Noise: Some noise is introduced in the process of electronically amplifying and conditioning the signal read from the detector before conversion to a digital value. Part of **Sampling Noise.**

Conversion Noise: During the conversion of an analog signal to a digital datapoint some electronic noise is introduced, statistical variations occur in the least significant bit of the converted data. Part of **Sampling Noise.**

Dark Noise: The detector will integrate a thermally generated **Dark Current** at all times, whether light is reaching the detector or not. Most of the dark current signal is a steady state level that can be subtracted, and so will not ultimately contribute to the noise. However, a component of **Dark Current** is **Dark Noise** due to statistical variations in the Dark Current. The Dark Noise component increases as the square root of the Dark Current. Dark Current, and therefore Dark Noise, can be reduced by cooling.

Sampling Noise: The electronic noise impressed on the signal during the amplification and digitization of the signal. For convenience, usually all of the noise associated with biasing, amplifying, and converting the signal are considered as sampling noise.

Shot Noise: This is due to the random statistical variations of light. It includes both experimental and dark signal components. Shot noise is equal to the square root of the number of electrons generated. Its effect can be minimized by increasing signal intensity, signal integration time, or summing a number of samples.

Photodiode detectors:

Photodiode devices generate a voltage or current as a result of photons impinging on the junction. Interfacing to support electronics is straightforward, as they often require only amplification to boost the current or voltage to a level sufficient for accurate digitization.

Photoconductive detectors:

This type of detector decreases resistance in response to increases in photon flux. Photoconductive detectors require a biasing voltage and usually lock-in (synchronous) signal processing to extract the signal from the inherent noise that is characteristic of this class of detectors.

Photoelectric Effect:

Some materials respond to illumination from photons by releasing electrons. When light of sufficient energy hits a photosensitive material, an electron is freed from being bound to a specific atom. Such materials include the P-N junctions of photodiodes. The energy of the light must be greater than or equal to the binding energy of the electron to free an electron. The shorter the wavelength, the higher the energy the light has.

Photoelectron

A photoelectron is an electron that is released through the interaction of a photon with the active element of a detector. The photoelectron could be released either from a junction to the conduction band of a solid state detector, or from the photocathode to the vacuum in a PMT. A photoelectron is indistinguishable from other electrons in any electrical circuit.

Quantum Detectors:

Quantum detectors interact with the photons directly in their electronic structure. These are the most sensitive solid state detectors for general spectroscopic use. The two types of quantum detectors are photodiodes and photoconductors.

Quantum Efficiency (QE):

The quantum efficiency is the quantity of photoelectrons produced by a detector expressed as a percentage of the quantity of photons incident on that detector. A QE of 20% means that five photons would produce a single photoelectron. Detectors made of silicon yeild about 45-50% peak QE at 750 nm. The QE of a detector is determined by several factors. These include the material's intrinsic electron binding energy or band gap, the reflectivity of the surface, the thickness of the surface, and energy of the impinging photon (hv). QE varies with the wavelength of incident light.

Responsivity

Responsivity is the ratio of output voltage to corresponding exposure ($\mu J/cm^2$). Technically it is measured at $V_{Sat\ min}/2$ under specified conditions of illumination, sample rate, and temperature.

S/N (Signal to Noise Ratio):

For any given signal, there is some noise present. S/N is the ratio of the desired signal level over the associated noise level. The higher the S/N, the cleaner the signal.

Saturation Level

The maximum signal level that can be accommodated by a device is its saturation level. At this point, further increase in input signal do not result in a corresponding increase in output. This term is often used to describe the upper limit of a detector element, an amplifier, or an ADC.

Spectral Response

Most detectors will respond with higher sensitivity to some wavelengths than to others. The spectral response of a detector is often expressed graphically in a plot of responsivity versus wavelength. The graphs on page 12 show the spectral response of several detectors.

Appendix B: AC Power Selection and Fusing

The DSS-15V/TEP power supply and Thermoelectric cooler controller has a power input module on the back panel. This module combines the line voltage selection, fuse holder and power line cord entry into one compact unit. To change the power fuse, disconnect the line cord and slide the cover open. Pull the lever to remove the fuse. Inside the fuse cavity, there is a small circuit board inserted to select the line voltage. There is a voltage selection board which has 4 possible positions, and is labeled so that the present line voltage setting will show below the fuse. Note that only the 120 and 240 settings are valid, and will work for 100 and 220 line voltages respectively

Line Voltage	Fuse rating (3AG type)
120 VAC	0.5 Amp fast blow
240 VAC	0.5 Amp fast blow

Appendix C: Detector Type Selection

If the need arises for higher sensitivity or to cover wavelengths beyond the capabilities of the detector(s) originally ordered, this section is provided to assist in selecting additional detectors as needed.

The first parameter for selection of a solid state detector is the wavelength range. This will typically narrow the selection down to a few detector types. To choose between a photoconductor and a photodiode, for high signal level on may simplify the electronics by operating in DC mode with a photodiode. AC mode is preferred when the optical S/N is not as good. AC mode is the only choice for photoconductors.

Next, choose the detector with the lowest NEP. Signal / Noise (and therefore NEP) is also improved by detector cooling. While thermoelectric cooling is usually the most convenient, LN_2 cooling yields the highest sensitivity.

Silicon detectors are recommended for studies to 1.1μm; remember that a PMT has gain and will outperform a silicon detector through most of its photocathode response range. The 304.25.520 silicon detector is the simplest and least expensive detector, well suited for lower performance applications. Because the detector area is very large, it does not require coupling optics as long as it is mounted near the slit focal plane. Its large area contributes to a larger noise signal; higher performance can be realized with the DSS-S025A amplified Silicon detector, so long as it is coupled with a 1427B Detector Interface. The DSS-S025A is also convenient for those applications where interchangeability between Silicon and other DSS detectors is required,

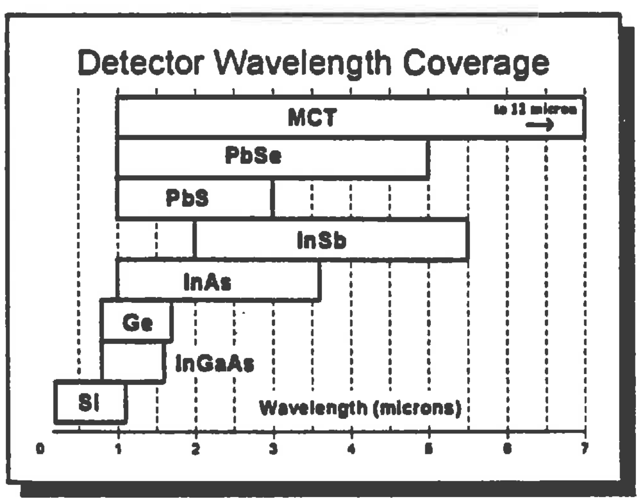
For the wavelength range of 1.1 - 1.7μm, the DSS-IGAXX InGaAs detectors offer the highest sensitivity. They are recommended over the DSS-GXX Germanium detectors when the maximum wavelength is still within range. The DSS-GXX Germanium detectors give an additional 100 nm of spectral range to 1.8 μm.

For longer wavelengths, select the DSS-ISXX Indium Antimonide if cryogenic cooling is suitable. Otherwise, the DSS-PSXX Lead Sulfide and then the DSS-PSEXX Lead Selenide detectors are next best suited. The DSS-IAXX Indium Arsenide offers DC operation at a lower performance level for much of the same range.

The DSS-MCT* offers the longest detection range. The detector is optimized for peak response through the alloy mixture ratios; performance is traded for range. Specify desired peak and maximum wavelength when ordering. This detector requires a chopping frequency of ≥1000 Hz.

Two color detectors extend the range of the IR detectors to the visible range at some efficiency penalty. A wide variety of detectors are available for spectroscopic applications. Selection is based on maximizing signal and reducing noise. The four major issues to consider in the selection are:

- Wavelength range
- Acquisition electronics
- Temperature control
- Detector performance ratings



Wavelength Range

The first criterion used in selecting a detector wavelength coverage. The detector must be operable over the wavelength range required. The chart at the right illustrates the detectors' nominal wavelength coverage, without respect to detector efficiency.

The silicon detectors generally are less sensitive than photomultiplier tube (PMT) detectors when operating in the UV-visible range of approximately 200-700 nm. Factors such as durability, no requirement for HV power supplies, cost, and size often favor the solid state detectors even when operating in the UV-VIS range. As the wavelengths approach one micron, most PMT's become insensitive and the silicon and other solid state detectors are favored.

To some extent the operating temperature of the detector will affect the upper limit of its wavelength range. A photodiode will lose range, but a photoconductor will gain range as the detector operating temperature is lowered.

When it is necessary to cover a wider wavelength range than a single detector can handle, for best sensitivity, use two detectors. An automated exit port selection mirror installed in the spectrometer can be employed to switch between detectors during an acquisition scan. Otherwise the detectors can be interchanged manually as part of a system configuration change between measurement sessions. This latter method may require some alignment of the detector position, depending on the detector interface used.

Without mechanically switching detectors, a "two-color" detector may be employed. These devices take advantage of silicon's transparency beyond 1.1μm by mounting a second detector behind the silicon chip. The silicon detects wavelengths shorter than 1.1μm while passing longer wavelengths to the back detector. The silicon device attenuates approximately 40% of the signal passing to the back detector, but greatly simplifies the optical system. The two detector signals are available at individual BNC connectors for noise isolation and interfacing ease.

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