APPLICATION NOTE

ACHIEVING THE HIGHEST SYSTEM PERFORMANCE USING QSPYROELECTRIC DETECTORS

INTRODUCTION

The Gentec-EO QS-IL series of Pyroelectric detectors and UM-I-BNC series of Power Detectors with integrated Analog (BNC) Module are low noise, high sensitivity devices. Using the QS-IL series requires that they be mated to a measurement system to provide power to the amplifier as well as a connection to the measuring instrument. The UM-I-BNC has an internal power supply and a BNC output. Gentec-EO Inc. sells the QS-I-TEST Test evaluation box to provide an easy to use power supply and signal routing system. An QS-IL detector coupled with an QS-I-TEST tests evaluation box forms the basis of a versatile, inexpensive radiometer, but with either detector the user must still choose the instrument to measure the voltage signal.

The purpose of this application note is to guide the user in selecting that instrument. Since the signal output is AC, and set by the chopper frequency, DC measurement devices such as a DVM are not appropriate. The measurement instrument must be able to measure a signal voltage at an arbitrary frequency. The best choices for this are an Oscilloscope or a Lock-In Amplifier.

USING AN OSCILLOSCOPE

There are literally hundreds of instruments to choose from when it comes to scopes. This makes it difficult to provide an absolute guideline for using a scope. Some are simply better than others when it comes to low level voltage measurements. As a rule of thumb, most scopes can reliably provide a 10 mV per div scale with a 1X probe setting. This setting will allow measurements in the µW range. Figure 1 shows the output of an UM5I-BL-BNC in response to a 4.36 µW signal. The voltage output was measured with a Tektronix TDS1002 Scope with the 20 MHz bandwidth limit on.

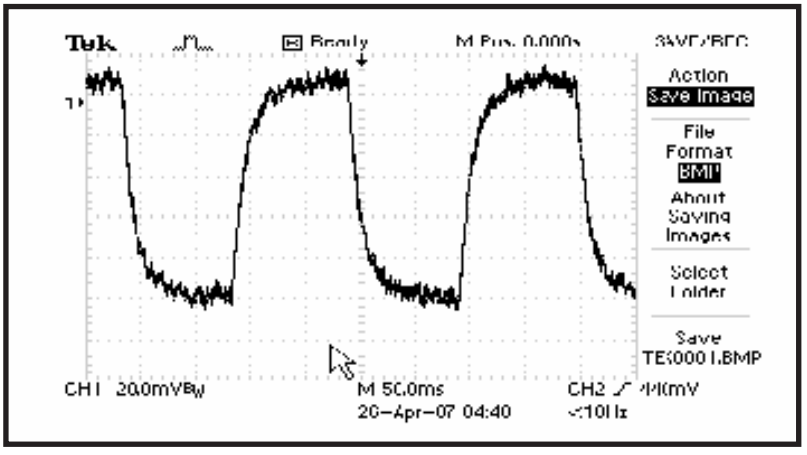

Figure 1: 4.36 µW Measured with QS5-IL and QS-I-TEST Test Box

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An external low noise amplifier coupled with the scope will extend the range down to sub µW levels, but care must be taken to limit the bandwidth of the amplifier to control noise. A good combination is the Tektronix ADA400A preamp mated to a Tektronix TDS400 series scope. These scopes feature a high resolution mode that expands the vertical resolution to as many as 13 bits.
Using a scope to make low level voltage measurements requires that the measurement environment is electrically and acoustically quiet as even small levels of interference will mask the signal. When the signal can no longer be measured due to noise and uncorrelated signal interference, the instrument of choice is the Lock-In Amplifier.

Using a Lock-In Amplifier

An experiment was performed using an QS5-IL detector hybrid mated to an QS-I-TEST Test evaluation box, an UM5I-BL-BNC Analog Radiometer, an SRS 510 Lock-In Amplifier, and a calibrated Silicon photodiode detector as reference. The light source was a 633 nm HeNe Laser. The initial power was measured at 71.2 µW. Power was reduced by inserting a series of ND filters until the reading on the Lock-In Amplifier became too noisy to be useful. The results are shown in Table 1, along with the Lock-In settings. The base settings were:

- Band-Pass Filter IN
- Line Filter OUT
- Line x2 Filter OUT
- Offset OFF
- Expand OFF
- Dynamic Reserve LOW
- Display X
- Phase Adjusted for maximum reading

ND Filter	SRS 510 Range	Pre-Filter Time Constant	Post-Filter Time Constant	QS5-IL Voltage Output	UM5I-BL-BNC Voltage Output	Photo Det. Meas. Power
None	500 mV	1	0.1	526 mV	617 mV	71.2 µW
0.3	500 mV	1	0.1	268 mV	321 mV	36.9 µW
0.5	500 mV	1	0.1	158 mV	190 mV	21.33 µW
1.0	200 mV	1	0.1	51.8 mV	60.3 mV	6.98 µW
1.3	100 mV	1	0.1	25.9 mV	31.8 mV	3.46 µW
1.5	20 mV	1	0.1	15.8 mV	18.4 mV	2.131 µW
2.0	10 mV	10	0.1	5.3 mV	6.31 mV	720 nW
2.3	10 mV	10	0.1	2.69 mV	3.15 mV	379 nW
2.5	2 mV	10	1	1.61 mV	1.91 mV	216 nW
3.0	1 mV	30	1	630 µV	750 µV	81 nW
3.3	500 µV	30	1	310 µV	365 µV	40 nW
3.5	500 µV	30	1	234 µV	298 µV	22 nW
3.6	500 µV	100	1	175 µV	261 µV	17 nW
3.7	500 µV	100	1	130 µV	197 µV	12.3 nW
3.8	500 µV	100	1	100 µV	162 µV	9.4 nW
3.9	500 µV	100	1	78 µV	125 µV	7.9 nW

Table 1: SRS 510 Lock-In Measurement Test

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The normalized data is plotted versus input power in figure 2.

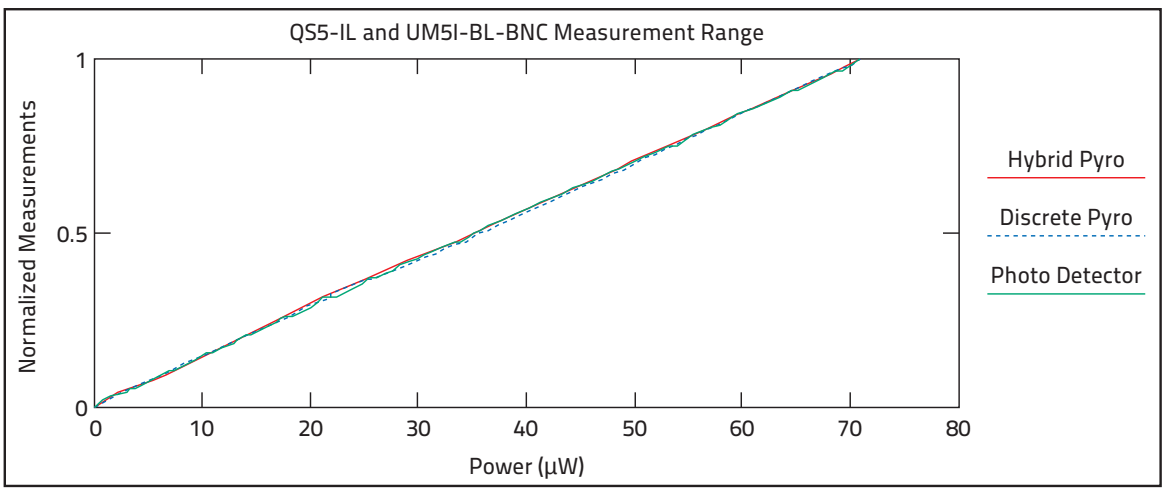

Figure 2: Normalized Measurements vs. Input Power

Figure 3 shows the same data on an expanded scale. It can be seen that around 40 nW, the noise and signal interference start to significantly degrade the measurement accuracy.

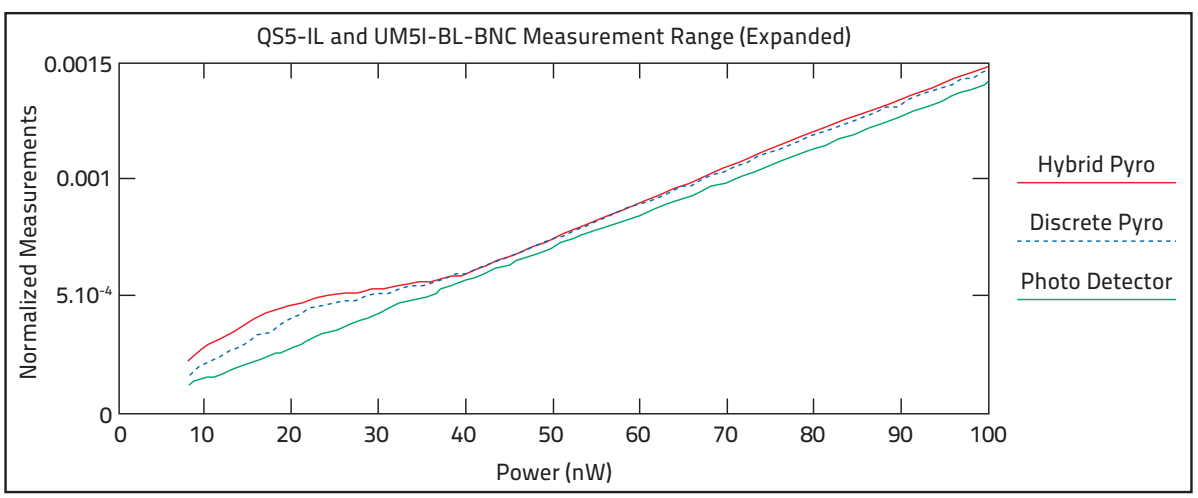

Figure 3: Normalized Measurements vs. Input Power (Expanded)

CONCLUSION

Gentec-EO's QS-IL Hybrid Pyroelectric Detectors and UM-I-BNC Power Detector series with Analog (BNC) Module will accurately measure low level optical power signals as long as the appropriate voltage measurement device is used. For µW and higher power levels, an oscilloscope is a good choice. For lower power levels, an oscilloscope coupled with a sensitive external preamp extends the range to sub µW levels. However, to achieve the highest system performance with our Pyroelectic products, measuring in the nW region, a good Lock-In Amplifier must be used, taking advantage of superior noise and uncorrelated signal rejection.