INSTRUCTION SHEET

EXTENDED FREQUENCY TERMINATING POWER SENSOR MODEL 5011-EF

Instruction Book Part Number 920-5011-EF Rev. A

Description

The Bird 5011-EF Terminating Power Sensor (TPS) is a diode-based power sensor that measures true average power from 40 MHz to 12 GHz and from –20 dBm to +10 dBm. It can be used with the Bird 5000 Digital Power Meter and the Bird Site Analyzer.

☞ NOTE: DPM firmware version 2.45 or SA firmware version 07JUN02, or later, is required. For the latest firmware upgrade, contact Bird Customer Service at (440) 248-1200 or visit our website at *http://www.bird-electronic.com*

For best results, wait 5 minutes after applying power to the sensor before taking readings.

CAUTION Do not exceed 2 W average or 125 W peak power for 5 µs. Doing so will render the sensor inoperative.

Correction Factors

The Bird TPS-EF-18 uses frequency-dependent correction factors to improve its accuracy. To use the correction factors:

1. Look at the Correction Factor Table on the side of the TPS and find the correction factor corresponding to the frequency under test.
2. Add the correction factor to all other necessary offsets (for example, the coupling factor of a directional coupler).
3. Enter the total offset into the power meter.

☞ NOTE: Correction factors are only required above 4 GHz. Below 4 GHz, the TPS-EF-18 can be used as a normal TPS. Refer to the 5011 manual for specifications.

Accuracy

The TPS is highly accurate. The accuracy under normal conditions is ± (5% of reading + 1.0 µW). For a 10 mW signal the uncertainty is ± 0.501 mW. For a 1 mW signal the measurement uncertainty is ± 0.051 mW. While this value is a good estimate, the sensor is actually more accurate. To determine the true measurement uncertainty use the process below.

Sensor Uncertainty

Accuracy depends on temperature, and the power and frequency of the source; Figure 1 lists the uncertainty factors. If an uncertainty is given as a power, divide this value by the measured RF power and convert to a percentage. For example, an uncertainty of ± 0.25 μW with a RF power of 10 μW is a 2.5% uncertainty.

Figure 1 TPS-EF Uncertainty Contributions

Error Source	**Conditions**	**Uncertainty**
Calibration Uncertainty		± 1.7%
Frequency Response	After Correction	± 0.5%
Temperature Linearity	+10 to +40 °C –10 to +50 °C	± 3.8% ± 5.5%
Connection Repeatability		± 0.5%
Other		± 0.5%
Resolution	± ½ smallest displayed digit (e.g. for a mW scale, three decimal places are displayed. ½ the smallest is 0.5 μW)	
Zero Set*		± 0.125 μW
Noise*	above 1.05 mW	± 0.7 μW
	105 μW to 1.05 mW	± 0.4 μW
	below 105 μW	± 0.2 μW

* After a 5 minute warmup, measured over a 5 minute interval and 2 standard deviations

Figure 2 lists external factors, such as using attenuators or using a cable to connect the TPS to the transmitter, which could affect the measurement accuracy.

Figure 2 External Uncertainty Contributions

Error Source	**Conditions**
Attenuator Uncertainty	Frequency dependent
Cable Uncertainty	Frequency and length dependent (± 5% at 1 GHz for a 'reasonable' 1.5 m cable)

The root sum square (RSS) uncertainty is the industry standard method for combining independent uncertainties. To determine the TPS's RSS uncertainty:

1. Square each uncertainty factor.
2. Add these values together.
3. Take the square root of this sum.

Figure 3 has two examples of uncertainty calculations. The first is a 10 mW signal at room temperature. The second is a 10 µW signal at 50°C. Since this measurement is at high temperature, the uncertainty will be increased. Note that the RSS uncertainties are smaller than the values from the rough estimate. This will always be the case.

Figure 3 Uncertainty Examples

	Example 1 (10 mW, 8 GHz, Room Temp)		**Example 2 (10 µW, 8 GHz, 50°C)**	
Error Source	**Percent Uncert.**	**RSS Term**	**Percent Uncert.**	**RSS Term**
Cal. Uncert.	1.7 %	2.89	1.7 %	2.89
Freq. Resp.	0.5 %	0.25	0.5 %	0.25
Temp. Lin.	3.8 %	14.44	5.5 %	30.25
Conn. Rep.	0.5 %	0.25	0.5 %	0.25
Other	0.5 %	0.25	0.5 %	0.25
Res.	0.005 %	0.00	0.5 %	0.25
Zero Set	0.00125 %	0.00	1.25 %	1.56
Noise	0.007 %	0.00	2 %	4.00
Sum Uncert.		18.08		39.70
RSS Uncert.		4.26 %		6.30 %
Quick Uncert.		5.01 %		16 %

Mismatch Uncertainty

Another factor of measurement accuracy is mismatch uncertainty. When a source and a load have different impedances, some signal will be reflected back to the source. This uncertainty depends not on both the VSWR of the TPS and the VSWR of the rest of the system. For a system VSWR of 1.0, the mismatch uncertainty would be 0. For a VSWR of 5.0, the mismatch uncertainty would be 15.4%. Given the VSWR of the TPS and the source, the mismatch uncertainty can be calculated as follows.

Mismatch uncertainty (MU) is related to the reflection coefficient (ρ) by the formula:

$$MU\ (\%) = [(1 + \rho_s \rho_l)^2 - 1] \times 100$$

where ρ_s = reflection coefficient of the source,
and ρ_l = reflection coefficient of the load (the TPS)

The reflection coefficients can be calculated from the VSWR by the formula:

$$\rho = (VSWR - 1) / (VSWR + 1)$$

For example, if you were to use a source with a 1.50:1 VSWR with the Bird TPS-EF, which has a max VSWR of 1.25:1, the mismatch uncertainty would be calculated as follows:

$$\rho_s = (1.50 - 1) / (1.50 + 1) = 0.200$$
$$\rho_l = (1.25 - 1) / (1.25 + 1) = 0.111$$
$$MU = [(1 + 0.200 \times 0.111)^2 - 1] \times 100 = \pm 4.49\ \%$$

If you were to use a source with a 1.30:1 VSWR instead, the mismatch uncertainty would be:

$$\rho_s = (1.30 - 1) / (1.30 + 1) = 0.130$$
$$\rho_l = (1.25 - 1) / (1.25 + 1) = 0.111$$
$$MU = [(1 + 0.130 \times 0.111)^2 - 1] \times 100 = \pm 2.92\ \%$$

Using a lower VSWR source can drastically reduce the mismatch uncertainty. Keep in mind that that the typical VSWR of the Model 5011 is 1.05:1, which gives a much lower mismatch uncertainty. For example, with the 1.50:1 source, the mismatch uncertainty would be:

$$\rho_s = (1.50 - 1) / (1.50 + 1) = 0.200$$
$$\rho_l = (1.05 - 1) / (1.05 + 1) = 0.024$$
$$MU = [(1 + 0.200 \times 0.024)^2 - 1] \times 100 = \pm 0.96\ \%$$

To determine the total uncertainty of your measurement, combine the RSS uncertainty with the mismatch uncertainty using the RSS method. Square the RSS uncertainty, add it to the square of the mismatch uncertainty, and take the square root.

Using Example 1 in Figure 3 with a source VSWR of 1.50 and a TPS VSWR of 1.25, the total uncertainty would be:

$$\sqrt{4.26^2 + 4.49^2} = 6.19\ \%$$

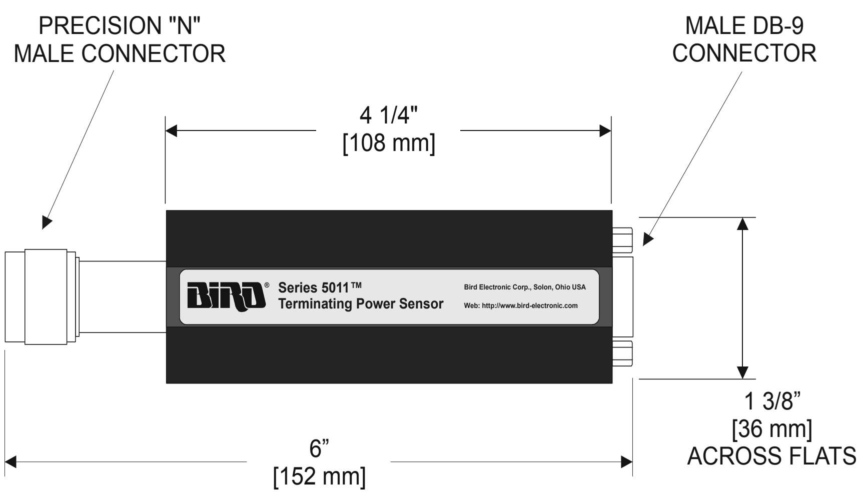
For example 2, the total uncertainty would be 7.74 %.

Display Resolution and Filter Length

The TPS has three power “ranges” that set the display resolution and the noise level, as shown in Figure 4. As the power decreases, the noise decreases but the time before the display updates also increases.

Figure 4 TPS Display Resolution

Input Power	Display Resolution (# digits)	Update Time (s)	2σ Noise (µW)
+10 to 0 dBm	4	1	0.7
0 to –10 dBm	3	2	0.4
–10 to –20 dBm	3	3	0.2



Specifications

Power Measurement Characteristics

General	Terminated average power
Frequency Range	40 MHz to 12 GHz
Power Measurement Range	–20.0 to +10.0 dBm (10 µW to 10 mW)
Maximum Power	2 W avg., 125 W peak for 5 µs
Peak/Average Ratio	12 dB maximum
Accuracy After Correction	±(5% of reading* + 1.0 µW) (excluding mismatch uncertainty)
Input Impedance	50 Ohms (nominal)
Input VSWR:	
Typical	1.05 (32.0 dB return loss)
Maximum	1.25 (19.1 dB return loss)
Input Connector	Precision N Male
Output Connector	Male DB-9 to host instrument
Power Supply	From host instrument via cable connection

* Above 40 °C or below 10 °C add 2%.

Physical and Environmental Specifications

Operating Temp.	–10 to +50 °C (+14 to +122 °F)
Storage Temp.	–40 to +80 °C (–40 to +176 °F)
Mechanical Shock	IAW MIL-PRF-28800F class 3
Vibration	IAW MIL-PRF-28800F class 3
Humidity	95% maximum (non-condensing)
Altitude	15,000 ft. operating
Dimensions	6” long max (including connectors); 1.5” diameter nominal
Weight	3/4 lb. max.
Recommended Calibration Interval	12 months

DECLARATION OF CONFORMITY

Manufacturer: Bird Electronic Corporation
30303 Aurora Road
Cleveland, Ohio 44139-2794

Product: Terminating Power Sensor
Models: 5011-EF

The undersigned hereby declares, on behalf of Bird Electronic Corporation of Cleveland, Ohio, that the above-referenced product, to which this declaration relates, is in conformity with the provisions of the following standards;

- European Standard EN 61326-1:1997 – Electronic Equipment for Measurement, Control, and Laboratory Use - EMC Requirements
- European Standard EN 55011:1998 – Radiated Emissions
- European Standard EN 61000-4-2:1995 – ESD Immunity
- European Standard EN 61000-4-3:1995 – Radiated RF / EMF Immunity
- European Standard EN 61000-4-4:1995 – Fast Transient / Burst Immunity
- European Standard EN 61000-4-6:1995 – Conducted Immunity

These standards are in accordance with EMC Directive (89/336/EEC).

- European Standard EN 61010-1:1993 – Part 1: General Requirements Including Amendment 2:1995

This standard is in accordance with Low Voltage Directive (73/23/EEC), 1973

The technical documentation supporting compliance with these directives is maintained at Bird Electronic Corporation, 30303 Aurora Road, Cleveland, Ohio 44139.

Robert Gardiner

Bob Gardiner
Director of Quality
Bird Electronic Corporation