Linear Microwave Power Sensor PS112

Contents

General Description

PS112 (Fig. 1) is a general-purpose linear coaxial microwave power sensor based on temperature-compensated Zero-bias Schottky diode detector. With its minimal integration time of 5 ms and maximal throughput of approximately 200 measurement/s, the detector delivers DC voltage or current proportional to the mean input power for various input signal waveforms.

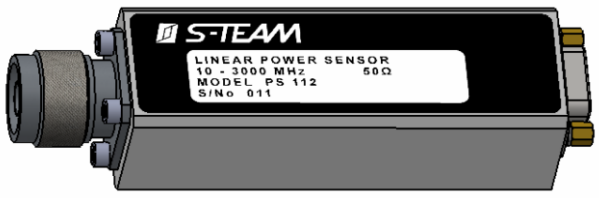

Fig. 1. Power sensor PS112.

Although optimized for 915 and 2450 MHz industrial applications, the sensor can be used in the range from 10 MHz to 3 GHz.

Each power sensor is calibrated individually at 2450 MHz. For other frequencies, user-settable correction factor can be defined. Calibration at a different frequency can be specified in the purchase order.

The power sensor generates one analog and one digital output simultaneously.

The analog output can be, alternatively:

- Voltage output 0 – 10 V
- Current output 4 – 20 mA

The analog outputs are linear functions of the input power in the range 0 – 10 mW.

The digital output can be, alternatively:

- RS232
- CAN Bus
- USB

The desired analog and digital output types must be specified in the purchase order.

RS232 port can be simply controlled and monitored by a COM port terminal, e.g. Tera Term application.

The device is supplied including a 3 m long connectorized output cable.

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Specifications

Frequency range	10 MHz – 3 GHz
Peak input working power	10 mW
Input power damage limit	500 mW
Input impedance	50 Ω
VSWR max	1.6
VSWR typ	1.2
Linearity	±0.5 dB deviation from the best fit straight line
Integration time	5 ms – 5 s (Note 1)
Max measurement cadence	200 points/s (Note 2)
Output voltage polarity	Positive
Output voltage offset	±4 mV max
Max current output load impedance	200 Ω
Supply voltage	24 V ± 10% or powering from USB
Current consumption	max 100 mA (24 V) or 500 mA (USB)
Operating temperature	-10 °C to +50 °C
RF connector	N-male
DC connectors	D-sub 9-pin male; Mini USB
Mass	200 g
Dimensions (L x W x H)	131 x 32 x 30 mm

Notes:

1. Integration time or sampling duration is the sampling time for obtaining one measurement data point. Details about sampling see in section Sampling.
2. Max measurement cadence can be reached with high sampling rates and short sampling durations.

Pin Assignment

Pin	Signal	Description
1		Not connected
2	RX/H	RX (RS232); CAN H (CAN Bus)
3	TX/L	TX (RS232); CAN L (CAN Bus)
4	IOUT	Analog current output
5	GND	Negative DC power supply input (0 V)
6	VOUT	Analog voltage output
7		Not connected
8	SHLD	Shielding, Mass
9	VDC	Positive DC power supply input (+24 V)

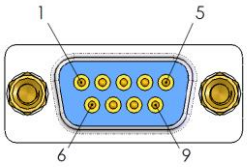

Fig. 2. PS112 D9 connector pin numbering.

Notes:

- GND = signal ground.
- Signal ground GND (pin 5) is isolated from SHLD (pin 8).
- All outputs are referred to GND.
- Although the pins for the analog voltage output and the analog current output are separate, only one output type can be active. The desired analog as well as digital output types must be specified in the purchase order.

Nominal Transfer Curves for Analog Outputs

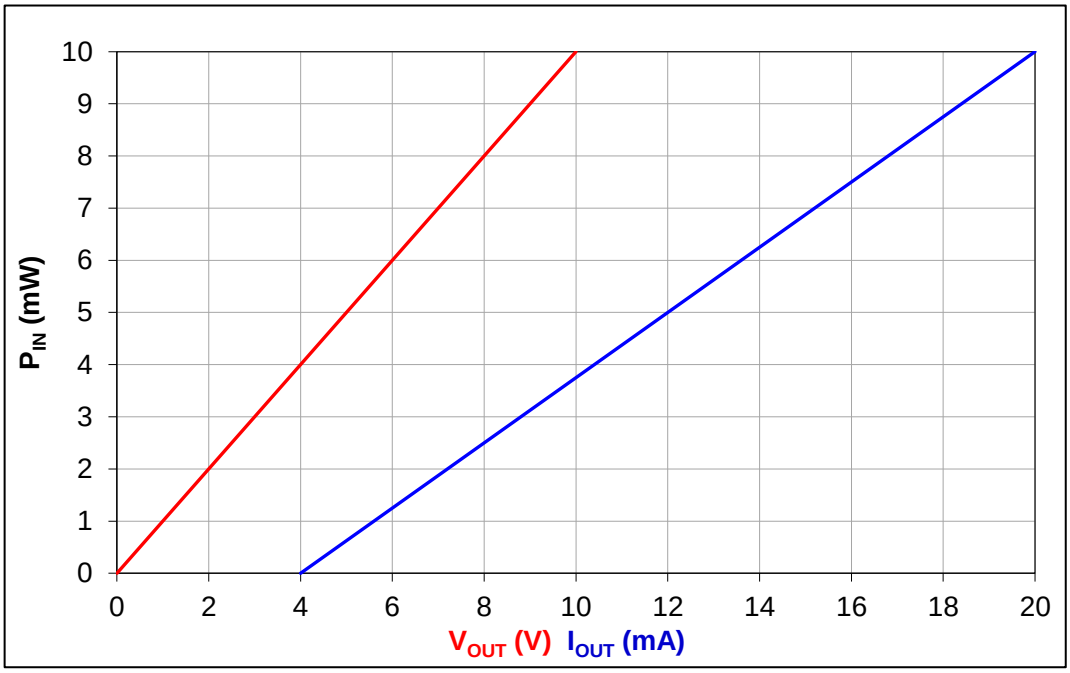

Fig. 3. Nominal PS112 transfer curves for analog outputs 0 – 10 V, 4 – 20 mA.

Typical Input Voltage Standing Wave Ratio

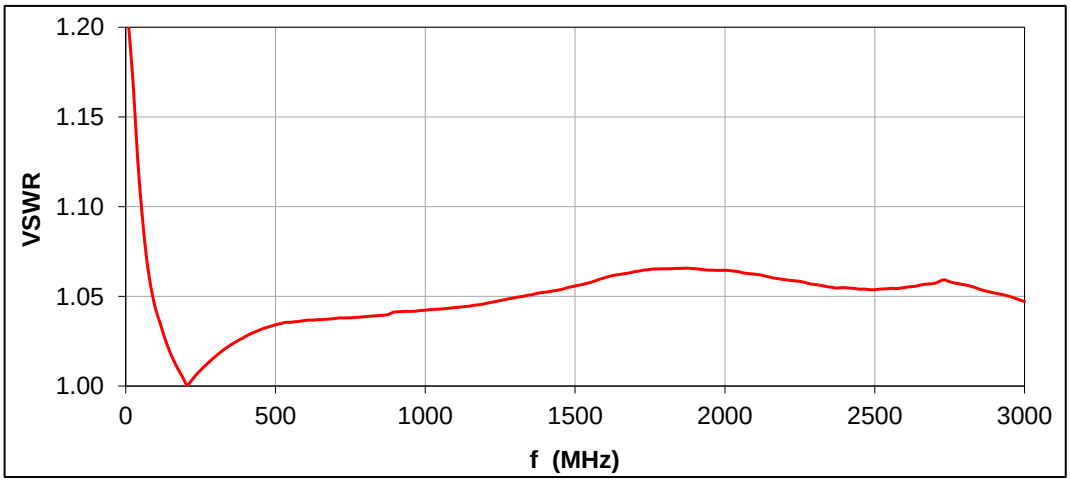

Fig. 4. Typical input VSWR.

Typical Linearity Error for Analog Outputs

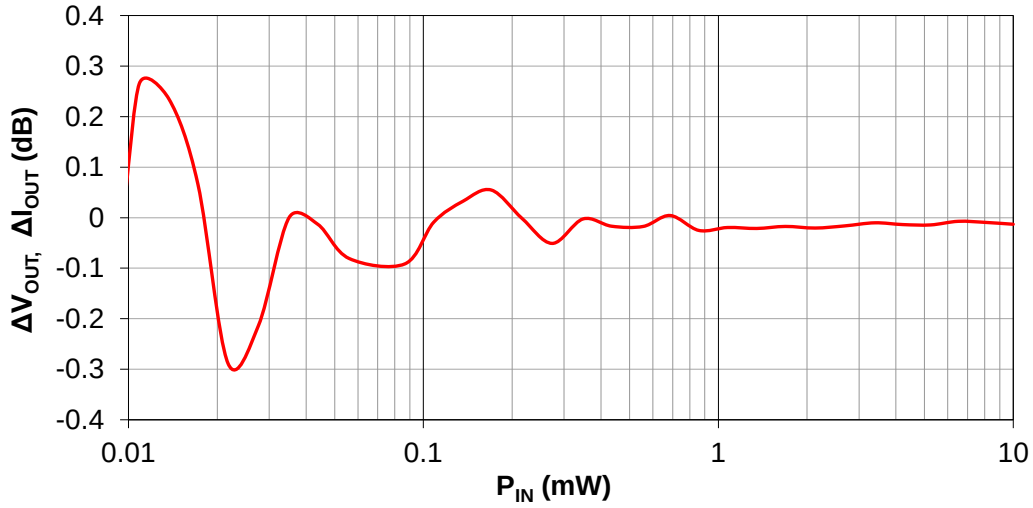

Fig. 5. Typical PS112 linearity error for analog outputs 0 – 10 V, 4 – 20 mA.

Typical Linearity Error for Digital Outputs

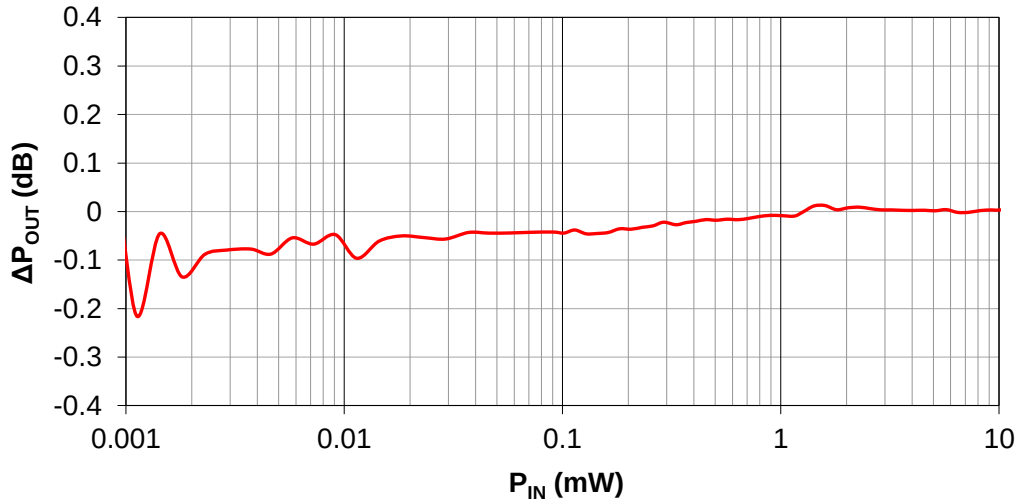

Fig. 6. Typical PS112 linearity error for digital outputs.

Sampling

Both analog and digital outputs are obtained as a result of averaging over a number N_s of signal samples taken with a specific *sampling rate* f_s over a specified time T_s (sampling duration, integration time). The quantities governing the sampling are constrained by the relation

$$T_s = \frac{N_s - 1}{f_s} = \Delta t_s \left(N_s - 1 \right)$$

where $\Delta t_s = 1/f_s$ is *sampling period* (time distance between two consecutive samples). The user can control the sampling by defining Δt_s and N_s via a COM port terminal installed in a PC (see section PS112 User Menu); the resulting sampling duration T_s is then computed using the above formula.

The sampling period Δt_s can be varied in the range 12 µs to 10 ms with 1 µs step.

Sample count N_s is defined indirectly in terms of *averaging exponent* E_s where $N_s = 2\text{^}E_s$. The exponent can assume values E_s = 0, 1, 2, … 11. Consequently, N_s = 1, 2, 4, … 2048.

To prevent the built-in watchdog activation (occurring after 8 seconds of master MCU inactivity), the maximum allowable integration time T_s is 5 seconds. The user is automatically prevented from entering values of Δt_s and N_s that would result in higher T_s.

Sampling Rules. If the signal level is not stable but fluctuates (e.g. due to ripples in magnetron power supply voltage and/or periodically varying load), two rules in choosing Δt_s and N_s should be observed for accurate and stable mean power display:

1. If the slowest oscillations (ripples) observed in the signal have period $T_{r\,max}$, sampling time T_s should be equal to an integral multiple of $T_{r\,max}$, i.e.

   $$T_s = n\, T_{r\,max}, \quad n = 1, 2, \ldots$$

   Alternatively, T_s can be chosen much (at least ten times) longer than $T_{r\,max}$:

   $$T_s \geq 10\, T_{r\,max}$$

2. Sampling rate f_s should be at least ten times higher than the *highest* ripple frequency observed in the signal. The minimal sampling period is 12 µs (the maximal sampling rate 83 kHz), which enables to cover amplitude- or pulse-modulated signals with modulation frequencies up to about 10 kHz.

If the signal level is stable (CW, low-ripple), any sampling settings will theoretically do. To reduce noise and interference, however, N_s and T_s should not be needlessly low. The default settings presented below are a good compromise.

Default Settings. The default sampling period is Δt_s = 100 µs. This corresponds to sampling rate f_s = 1 kHz, ensuring correct sampling of signals with ripple frequencies up to about 100 Hz. The default averaging exponent is E_s = 11, hence N_s = 2048. These default settings result in integration time T_s = 204.8 ms.

Results Refresh Rate. Due to the data processing overhead, maximal cadence of results production is limited to approximately 200 measurements per second even if sampling for the highest rate f_s and lowest sample count N_s.

RS232 Digital Output

After switching on the power supply, PS112 starts automatically transmitting data in form of ASCII strings. The COM port settings are:

- 8 data bits
- 1 stop bit
- No parity
- Baud Rate 115000 bits/s

The transmitted ASCII strings are lines of readable text separated by Line Feed character <LF> (ASCII #10). Each line has normally the form of the following example:

```
P= 10.551mW T=38.0 P= 10.23dBm<LF>
```

Each line consists of items of the form **P=*Value+Unit*** (for powers in mW and dBm) or **T=*Value*** (for internal temperature in Celsius). The individual items are separated by space character (ASCII #32). Spaces *within* an item are irrelevant.

In case of internal ADC overflow, an additional OVERRANGE item occurs, such as

```
P= 15.000mW T=38.0 P= 11.76dBm OVERRANGE<LF>
```

To obtain numerical values for further processing, the recipient should capture these lines and parse them accordingly.

COM Port Terminal

For testing and PS112 configuring purposes using a PC, an RS232 COM Port terminal program should run in the PC. One possibility is using **Tera Term**, which is an open-source free terminal emulator. The program can be downloaded from http://ttssh2.sourceforge.jp/index.html.en (see also http://en.wikipedia.org/wiki/Tera_Term).

An example of RS232 digital outputs is shown in Fig. 7.

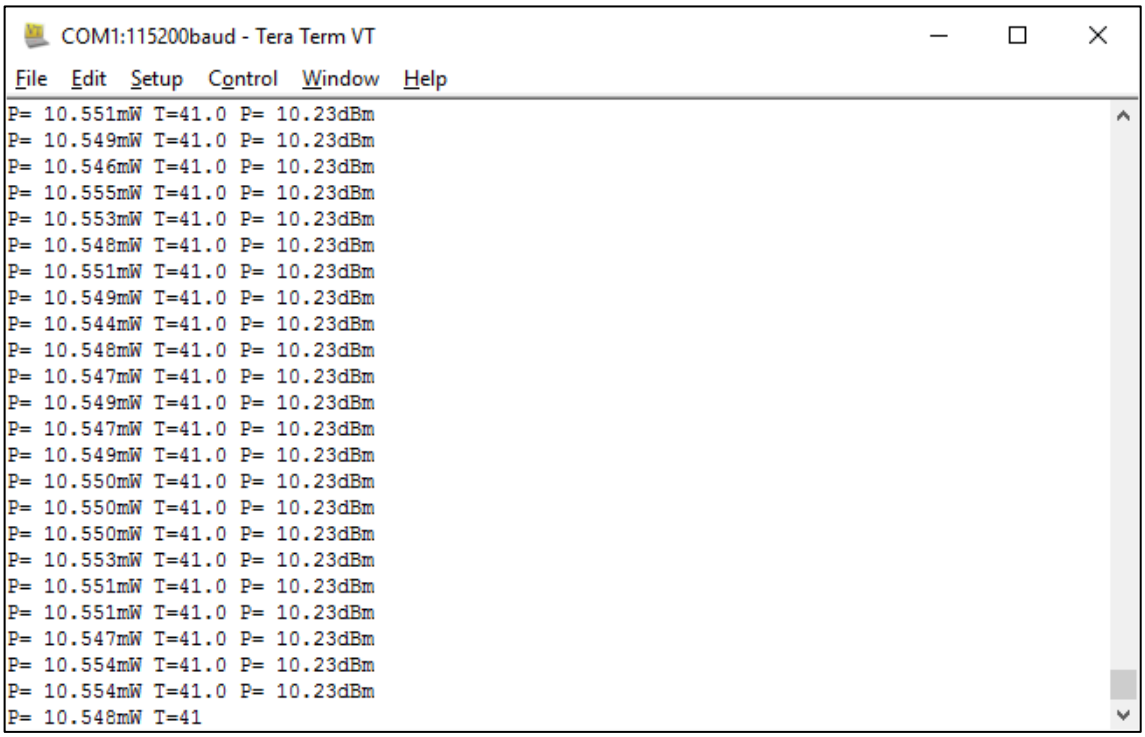

Fig. 7. Example of RS232 digital output.

PS112 User Menu

The PS112 User Menu serves for configuring the signal sampling and introducing power offset to measured data (e.g. to correct for frequency response). If a COM port terminal is running in your PC, the menu is invoked by transmitting "X" ASCII character (hitting the X key on the PC keyboard). An example of PS112 User Menu is shown in Fig. 8.

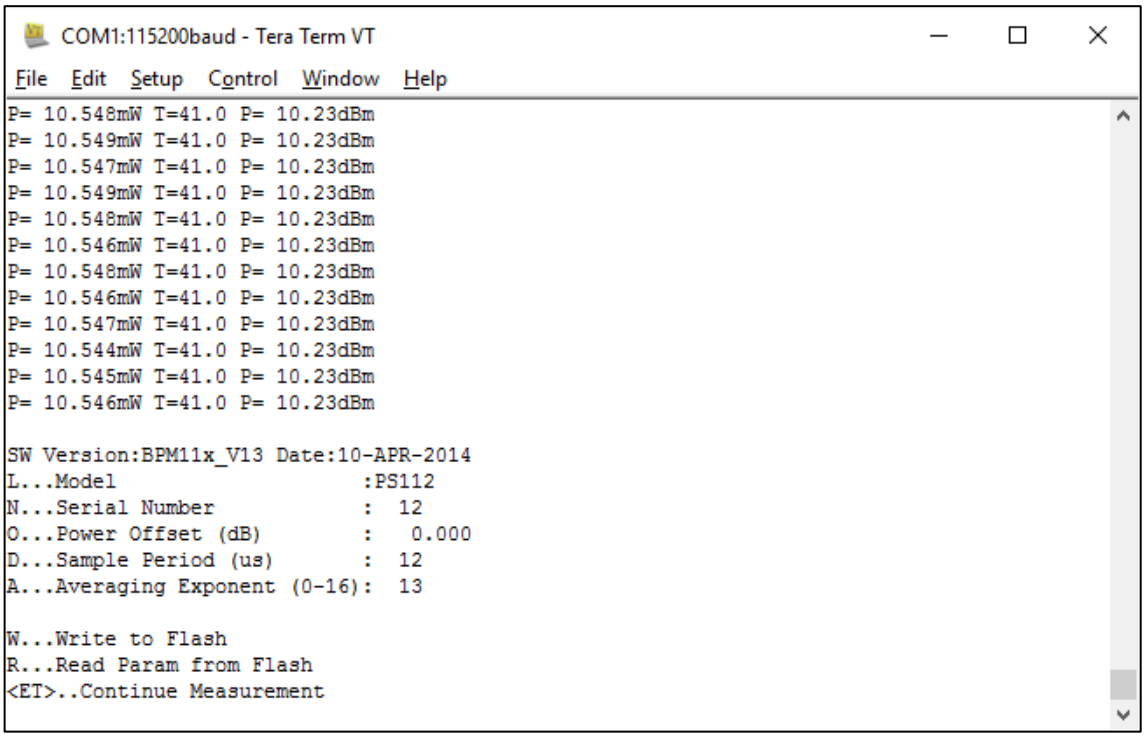

Fig. 8. PS112 user menu. Only the keys O, D, A, W, R, <ET> = <Enter> are enabled to the user.

Dimensional Drawing

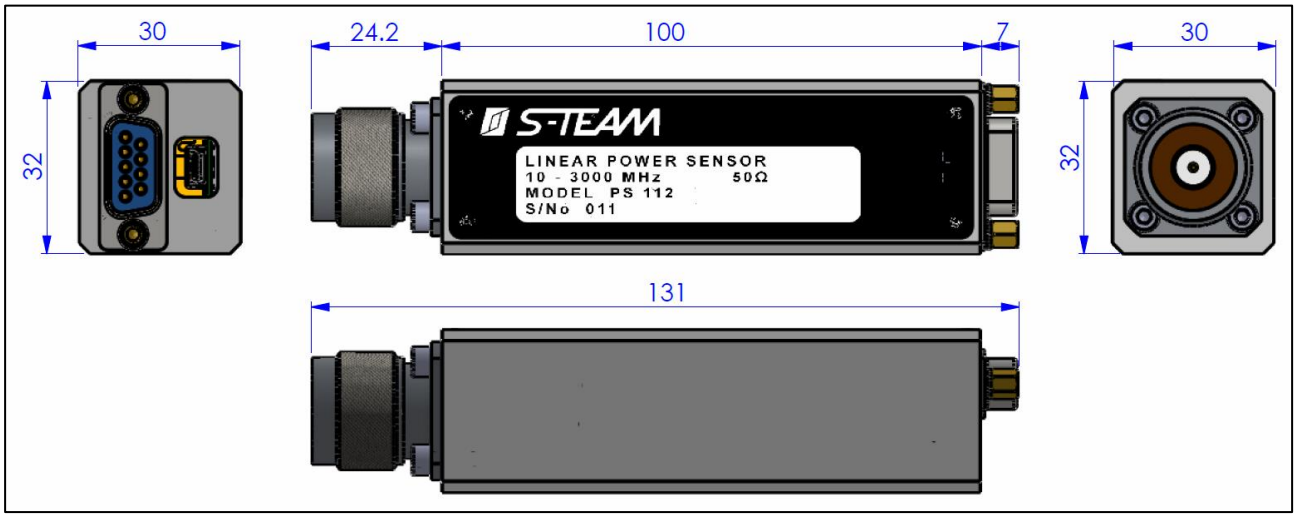

Fig. 9. Basic PS112 dimensions. All dimensions are in millimeters.