Linear Microwave Power Sensor PS112

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General Description

PS112 (Fig. 1) is a general-purpose linear coaxial microwave power sensor based on a temperature-compensated Zero-bias Schottky diode detector. With its minimal integration time of 5 milliseconds and maximal throughput of approximately 200 measurements per second, the detector delivers a 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, this sensor can be used in a wide frequency range spanning 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 simultaneously generates one analog output and one digital output.

The analog output can be, alternatively:

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

The analog output is a linear function of the input power in the range 0 – 10 mW.

The digital output can be, alternatively:

- RS232
- CAN Bus
- USB

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

The RS232 port can be controlled and monitored easily by a COM port terminal, such as the Tera Term application.

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
Max current output load impedance	200 Ω
Power supply voltage	24 V ± 10% or powering from USB
Current consumption	max 100 mA (24 V) or 500 mA (USB)
RF connector	N-male
DC connectors	D-sub 9-pin male; Mini USB
Dimensions (L x W x H)	131 x 32 x 30 mm
Mass	200 g
Operating temperature range	-10 °C to +65 °C
Storage temperature range	-20 °C to +80 °C

Notes:

1. Integration time or sampling duration is the time over which the samples are acquired for obtaining one measurement data point. For more details about sampling, please refer to section Sampling.
2. High measurement cadences can be attained using high sampling rates and short sampling durations.

Pin Assignment

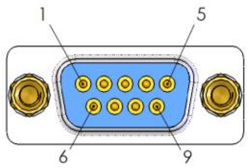

Fig. 2. Pin numbering of D9 connector.

Pin	Signal	Description
1		
2	RX/H	RS232: RX CAN: H
3	TX/L	RS232: TX CAN: L
4	IOUT	Analog current output
5	GND	Signal ground. Negative DC power supply input (0 V)
6	VOUT	Analog voltage output
7		
8	SHLD	Shielding, Mass
9	VPOS	Positive DC power supply input (+24 V)

Notes:

- Unassigned pins are not connected.

- All outputs are referred to GND.
- GND (pin 5) is isolated from SHLD (pin 8).
- Although the pins for the analog voltage output and the analog current output are separate, only one output type at a time can be active.

Nominal Transfer Curves for Analog Outputs

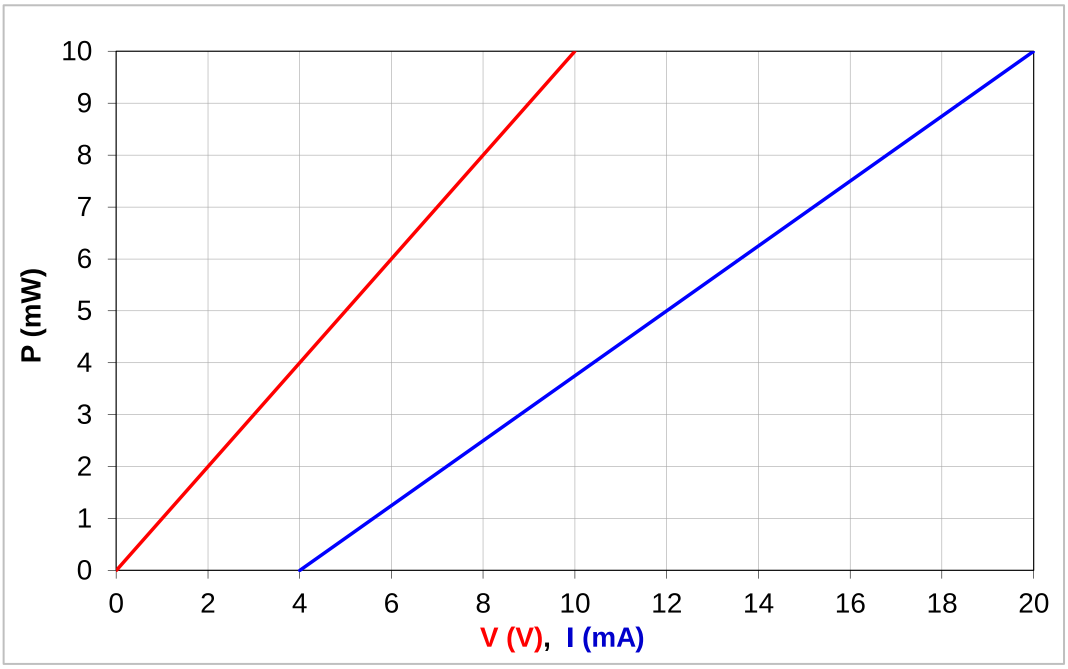

Fig. 3. Nominal PS112 transfer curves for analog outputs 0 – 10 V, 4 – 20 mA.

Typical Input Voltage Standing Wave Ratio

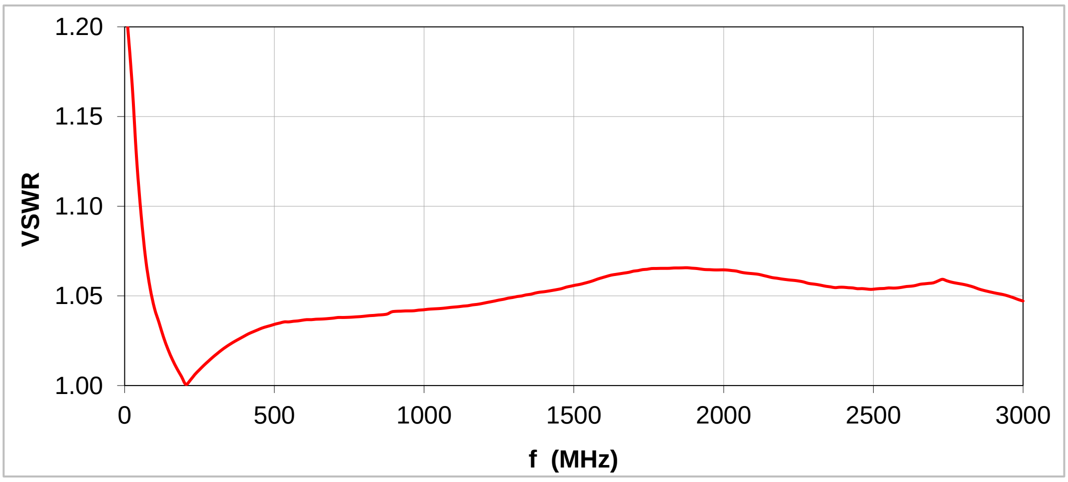

Fig. 4. Typical input VSWR.

Typical Linearity Error for Analog Outputs

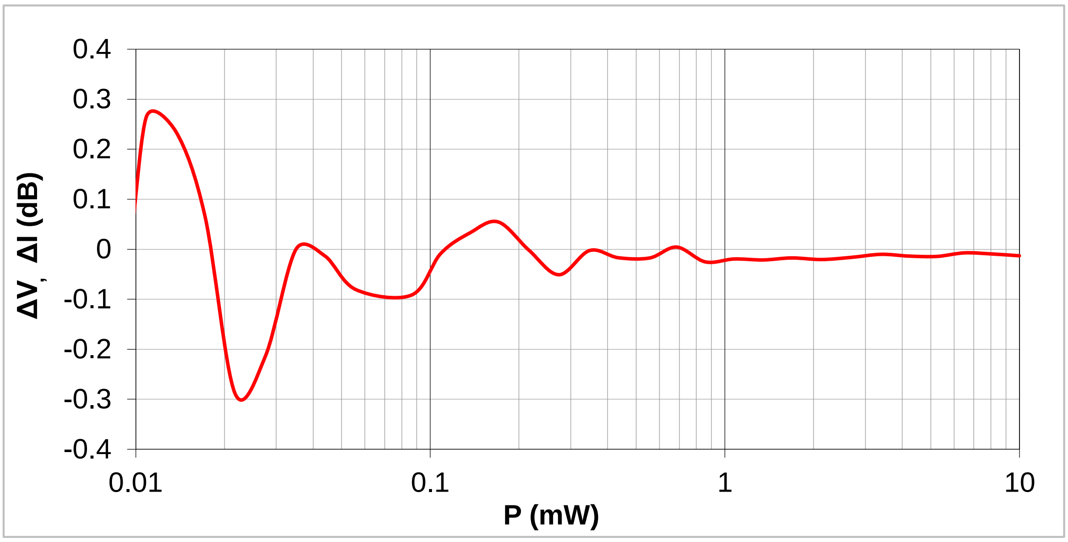

Fig. 5. Typical linearity error for analog outputs 0 – 10 V, 4 – 20 mA.

Typical Linearity Error for Digital Outputs

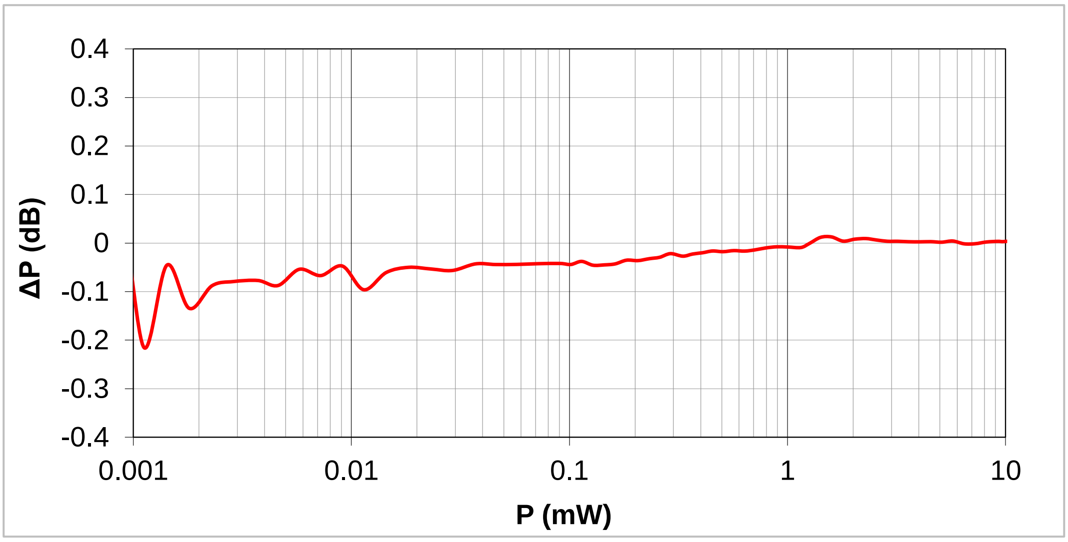

Fig. 6. Typical linearity error for digital outputs.

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 *sampling time* T_s (sampling duration, integration time). These sampling-governing quantities 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 the *sampling repetition 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 repetition period Δt_s can be varied in the range 12 μs to 10 ms with 1 μs step.

The sample count N_s is defined indirectly in terms of the *averaging exponent* E_s where N_s = 2^E_s. The exponent can assume values E_s = 0, 1, 2, … 11. Consequently, N_s = 1, 2, 4, … 2048.

To prevent activation of the built-in watchdog (which occurs 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 a higher T_s.

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

1. If the slowest oscillations (ripples) observed in the signal have period $T_{r\,\max}$, the sampling duration 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 longer (at least ten times longer) than $T_{r\,\max}$:

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

2. The 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 nearly constant (CW, low-ripple) then, theoretically, any sampling settings will do. However, in order to reduce noise and interference, N_s and T_s should not be needlessly low. The default settings presented below are a good compromise.

Default Settings. The default sampling repetition period is Δt_s = 100 μs. This corresponds to the sampling rate f_s = 1 kHz, which ensures 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 the integration time T_s = 204.7 ms.

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

RS232 Digital Output

After switching on the power supply, PS112 starts automatically transmitting data in the 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 a Line Feed character <LF> (ASCII #10). Normally, each line has the following form:

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

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

In the case of internal ADC overflow, an additional OVERRANGE item occurs, for example,

`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

In order to test and configure PS112 using a PC, one should run on the PC a RS232 COM Port terminal program. One possibility is using the open-source free terminal emulator **Tera Term**. This program can be downloaded from http://ttssh2.sourceforge.jp/index.html.en (see also http://en.wikipedia.org/wiki/Tera_Term).

An example of the RS232 digital output is shown in Fig. 7.

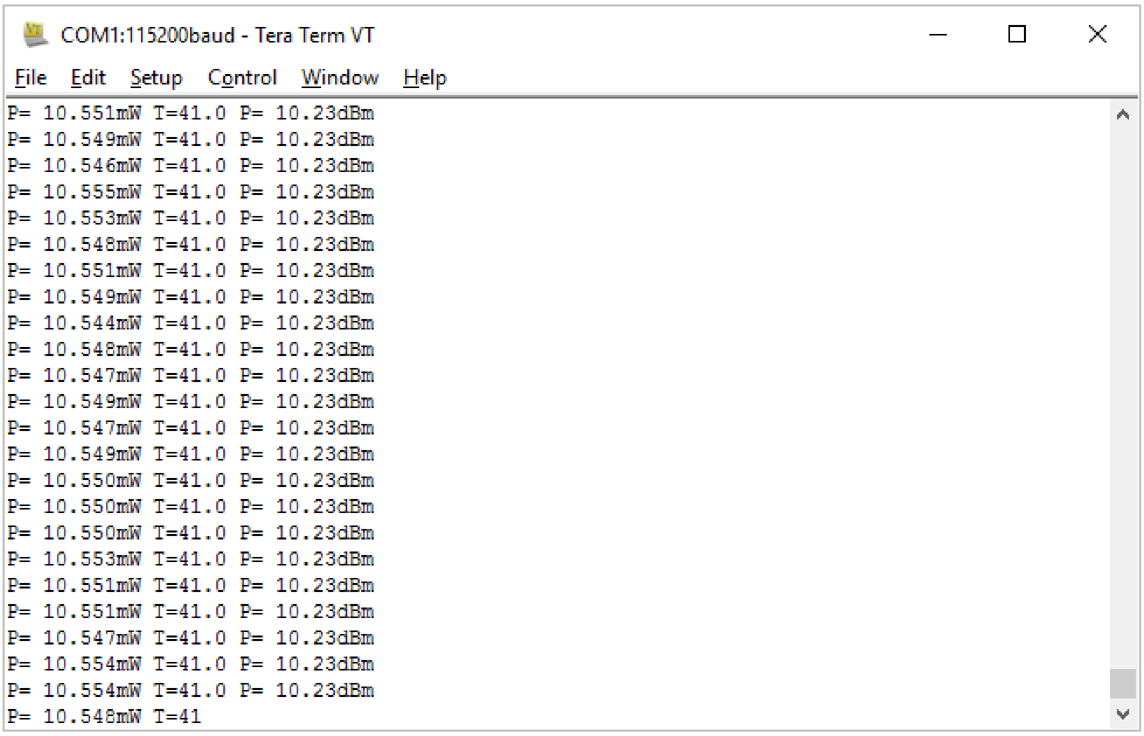

Fig. 7. Example of RS232 digital output.

PS112 User Menu

The PS112 User Menu can be used for configuring the signal sampling and introducing power offset to the measured data (e.g. to correct for frequency response). If a COM port terminal is running on your PC, the menu is invoked by transmitting either the ASCII character “x” or “X” (ASCII #120 or #88) from the terminal by pressing the **x** or **X** key on the PC keyboard . An example of the PS112 User Menu is shown in Fig. 8.

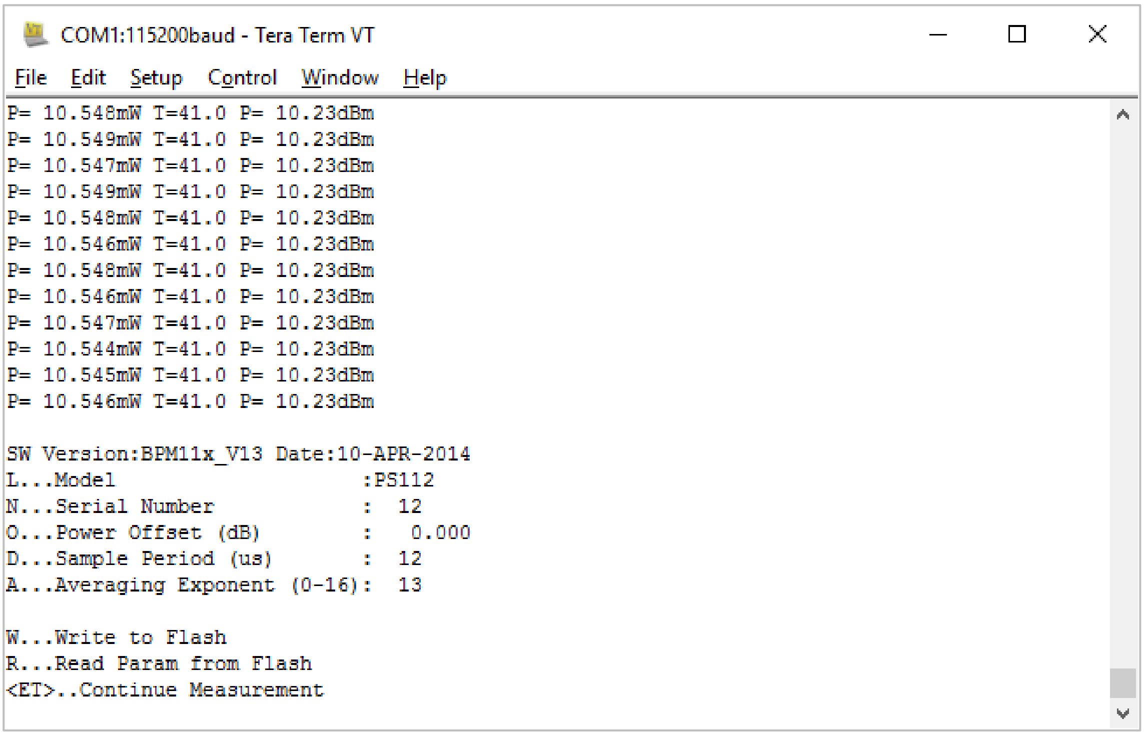

Fig. 8. PS112 user menu. Only the keys O, D, A, W, R, <ET> = <Enter> are enabled to the user.

Dimensional Drawing

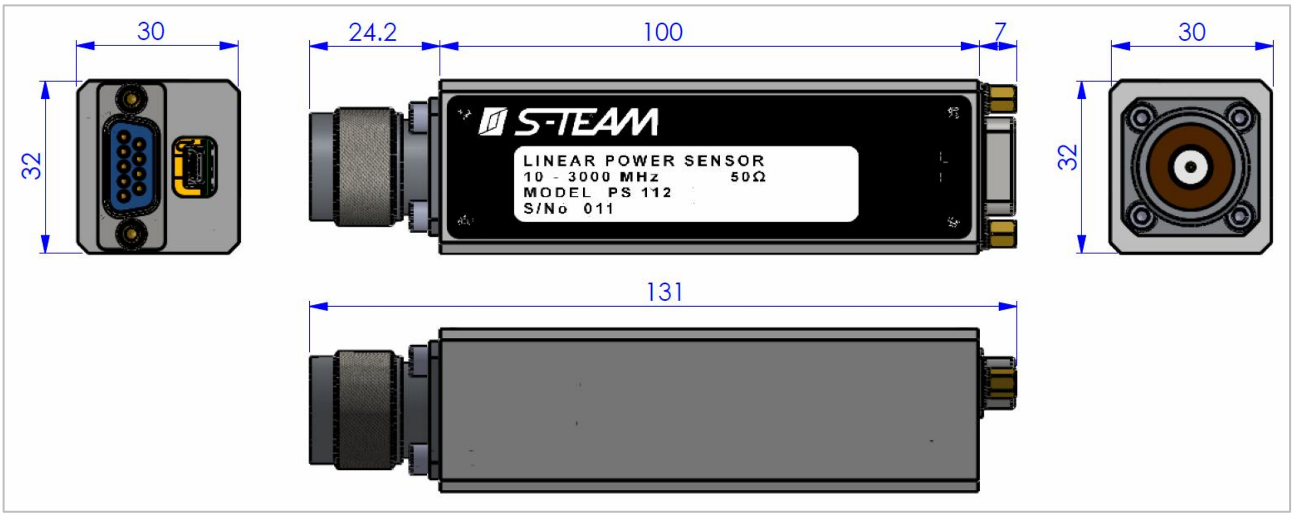

Fig. 9. Basic PS112 dimensions. All dimensions are in millimeters.