LadyBug Technologies: Custom System Power Sensing Solutions

Introduction:

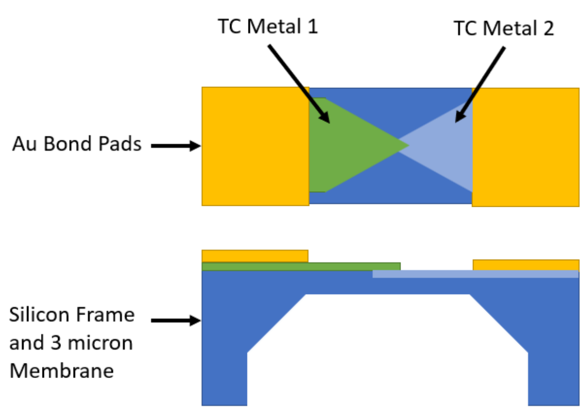
An RF power sensor is a device that is used to measure the power of an RF application. These applications range from: Avionics test systems, semiconductor test systems, telecom infrastructure, medical systems, Satellite communication systems, radar and 5G. It is typical for a system to measure power from a variety of complex waveform adaptive modulation techniques, such as OFDM, CDMA, QAM, etc. Too often, a system will incorporate an internal reference sensor that is used to establish an absolute power level as a means of verifying proper system operation. Understanding of RF power level at various points within a system will ensure safe and proper functionality of a test system. To enable customers with lightweight system requirements, LadyBug Technologies is able to build custom thermocouple-based RF sensors with better than 1% linearity less than .2% per readout movement per degree C.

Technology Overview:

Modern RF sensor transducers are typically either diode or thermally based. Diodes sensors rectify a DC voltage from an RF signal, and thermal sensors convert RF energy to thermal energy to be measured via a secondary transducer. Thermal sensors are desirable because of their true RMS nature as they perform high accuracy waveform agnostic power measurements. Based on industry need, Ladybug has developed a process for generating semi-low volume custom thermocouple based thermal power sensors.

Thermocouple-based sensors leverage the Seebeck effect. This well- characterized process occurs when the two ends of a thermocouple are at differing temperatures, resulting in electricity flowing from the hot metal to the cold metal. In the Ladybug sensor, the RF load has an integrated thermocouple that generates a voltage proportional to RF power put into the device.

Due to the inherently small signals being measured, the thermal mass being heated must also be minimal. For this reason, a 3-micron silicon membrane device was selected to be the transducer substrate in order to minimize the thermal mass the RF energy has to heat. On top of this a 50 ohm termination resistor is built. This device serves 2 purposes: (1) The RF termination and must have match characteristics to meet the intended system requirements. (2) This device itself is a thermocouple and must be built from metals selected to meet voltage output requirements for the targeted system.



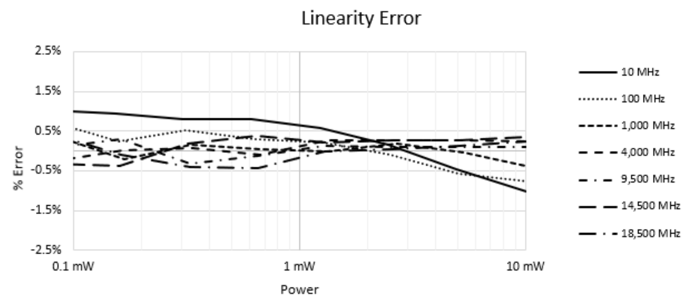
The thermocouple device is manufactured with standard MEMS processes followed by flip-chip bonding to a low loss substrate.

Design Considerations:

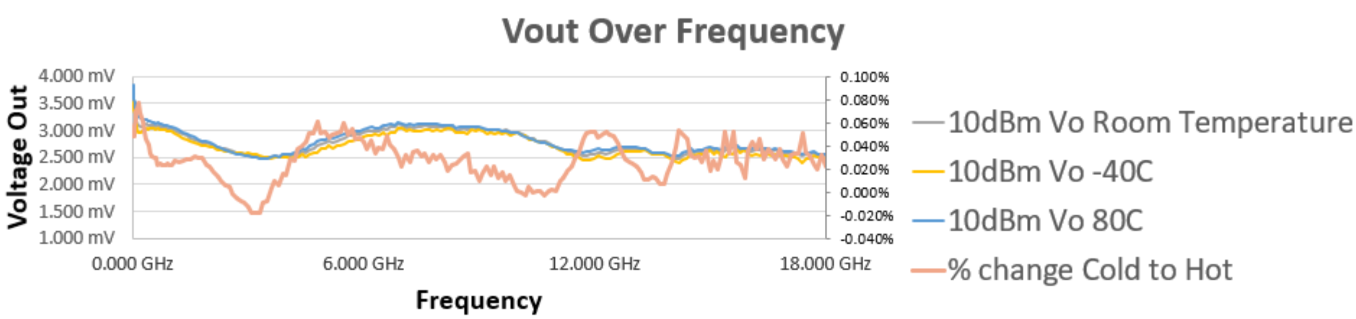
When designing a custom thermal couple-based RF power sensor, it is essential to understand the key requirements of the sensor:

Sensitivity: The sensor must produce an output voltage that gives resolution into the desired RF signal—typical sensor sensitivity is around .1mili-volts per milli-Watt.

Linearity: The output of the sensor should be proportional to the power input over a wide range. Since the underlying technology for the ladybug sensor is a thermocouple, exceptional 1% linearity can be been realized.



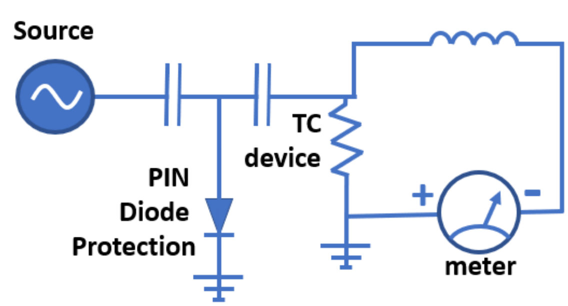
Temperature Stability: The sensor should maintain accuracy over a wide range of temperatures. Since thermocouple sensors give output based on a temperature differential, it is inherently immune to changes in ambient temperature as thermal gradients within the sensor remain intact. Our thermally based sensors have exceptional temperature stability.



Maximum power rating: Fundamentally, thermocouple based power sensors generate a voltage proportional to RF power by the transduction of RF power to thermal heat. For every 3dB of power increase, the thermal gradient across the detector must double in temperature. As a result, the thermal gradient within the sensor has an absolute temperature in excess of hundreds of degrees C. Great care must be taken in balancing dynamic range and sensitivity.

Ladybug thermocouple power sensors can meet these requirements and prove the best outcome when optimized in an embedded system.

Implementation:



The custom thermal couple-based RF power sensor uses a thermocouple to detect changes in temperature, which are then converted into changes in voltage. As signals become large (around 20dBm) un-checked device temperatures would exceed a few hundred degrees centigrade and impact device lifetime. A protection diode was added to mitigate risk and enable use of the full dynamic range; shunting away high-power RF signals Which help to maintain device temperature (protecting the silicon and metal films).

When the device is bonded to the carrier PCB, a highly thermally conductive silver solder compound is utilized. Thermal energy that is dissipated within the TC device.

Once devices are mounted to the RF circuit, they are encased in a water proof package to maximize device durability.

Once a device passes final assembly, each unit is tested to ensure proper functionality accompanied by a full traceability report.

Conclusion:

A custom thermal couple-based RF power sensor can be designed and implemented within customer specifications using our unique development and assembly process. Ladybug utilizes the cutting-edge industry standards for calibration, design and implementation to provide personalized solutions to solve any unique customer requirements.