APPLICATION NOTE

Power Sensor Overpower Failure Verification Guideline

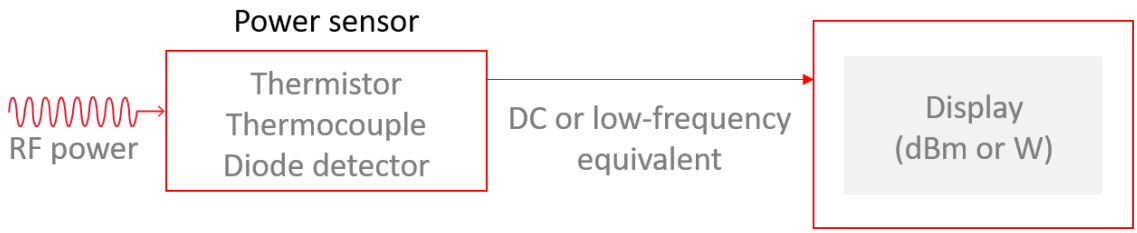
848xA/B/H, 848xD, E930xA/B/H, E441xA, E932xA, N848xA/B/H, U200xA/B/H, U848xA, N192xA Power Sensor

Introduction − Overpowering of a Power Sensor

Power sensor converts RF signal to DC signal for power meter to display as a power value in dBm or watts after processing.

The maximum measurable power of a power sensor varies depending on the sensor model. Incidentally, Keysight Technologies' service centers receive a high number of power sensor that have been damaged due to overpowering of the sensor bulkhead, resulting in the damage of the internal thin film circuit. Subjecting a power sensor module above its maximum allowable power rating is considered a misuse or self-abuse and is excluded from Keysight Technologies' standard warranty coverage.

Limitations to measurable power



History of TDR

The measurement technique of time domain reflectometry (TDR) was introduced in the early 1960's and works on the same principle as radar. A pulse of energy is transmitted down a cable (or another device - not necessarily a good conductor). When that pulse reaches the end of the cable, or a fault along the cable, part or all the pulse energy is reflected to the instrument. TDR measurements are made by launching an impulse or a step into the test device and observing the response in time. Using a step generator and a broadband oscilloscope, a fast edge is launched into the transmission line. The incident and reflected voltage waves are monitored by the broadband oscilloscope at a point on the line. By measuring the ratio of the input voltage to the reflected voltage, the impedance of simple discontinuities can be calculated.

KEYSIGHT TECHNOLOGIES

The position of the discontinuity can also be calculated as a function of time by applying the velocity of propagation along the transmission line. The type of discontinuity can be identified by its response.

Time domain analysis is useful for measuring impedance values along a transmission line and for evaluating a device problem (discontinuity) in time or distance. Time domain display provides a more intuitive and direct look at the device under test (DUT) characteristics. In addition, it gives more meaningful information concerning the broadband response of a transmission system than other measuring techniques by showing the effect of each discontinuity as a function of time or distance.

Time domain reflectometry (TDR): refers to the method of measurement using a fast step generator and a receiver to measure either transmission or reflection. TDR is the common name for an oscilloscope with this capability.

TDR method to verify failure due to overpower

1. **Sensor zeroing and calibration status check**

   Perform sensor zeroing and calibration to determine whether the sensor has any overpower failure symptom. Should the power meter display “Cal Error”, proceed to perform a Return Loss (S11) measurement and TDR using a network analyzer (NA). For the U2000 & U8480 series sensors, if the sensor displays any noise floor regardless of any RF input power, proceed to perform a Return Loss (S11) measurement and TDR using network analyzer (NA).

2. **Network analyzer (NA) calibration for S11 and TDR measurement:**

   a. Preset the NA.

   b. Set power to **-20 dBm** for 8481/5/7D or **-10 dBm** to all other models.

   c. Set the Start & Stop Frequency (Sensor model dependent, refer to below table) on NA.

   d. Set the number of points (Sensor model dependent, refer to below table) on NA.

   e. Set the NA to perform test port (with adaptor, if applicable) calibration.

Sensor’s Connector Type	Start Frequency	Stop Frequency	Number of Points	Start Frequency
N-type	10 MHz	18 GHz	1800	N-type
3.5 mm	10 MHz	33 GHz	3300	3.5 mm
2.4 mm	10 MHz	50 GHz	5000	2.4 mm
1.85 mm	10 MHz	70 GHz	7000	1.85 mm

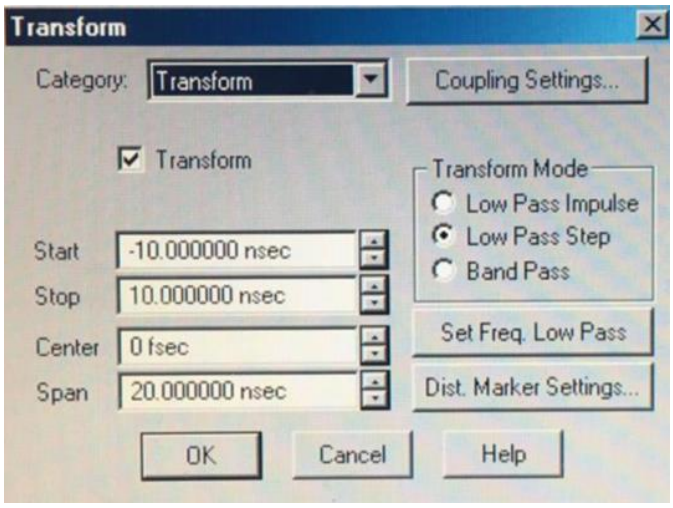
3. **S11 measurement**

   The full S11 trace will be displayed on the screen of the NA and set “Format” to “Lin Mag”. Save the S11 trace as.s1p file if you wish to keep a copy of the result. Should S11 for any of the frequency point = 1, proceed with the TDR measurement.

4. TDR measurement

a. Set trace “Format” to “Real”.

b. Without connecting the power sensor, click on “Trace” tab, select “Transform”. Click on “More” pushbutton on the Transform tab, in the Transform Mode section, select Low Pass Step. Click OK.



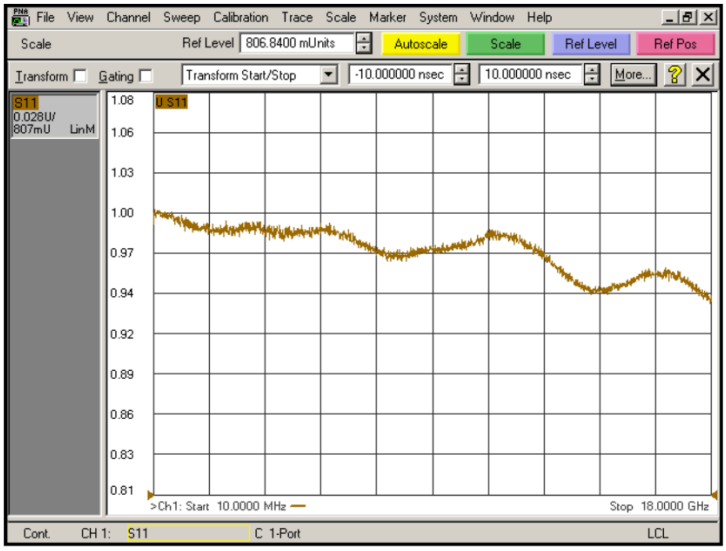
c. Connect the damaged power sensor to the NA. the graph shown on the NA screen represents the step response of the connected sensor.

d. Select “Print to file” to save a copy of TDR display if necessary.

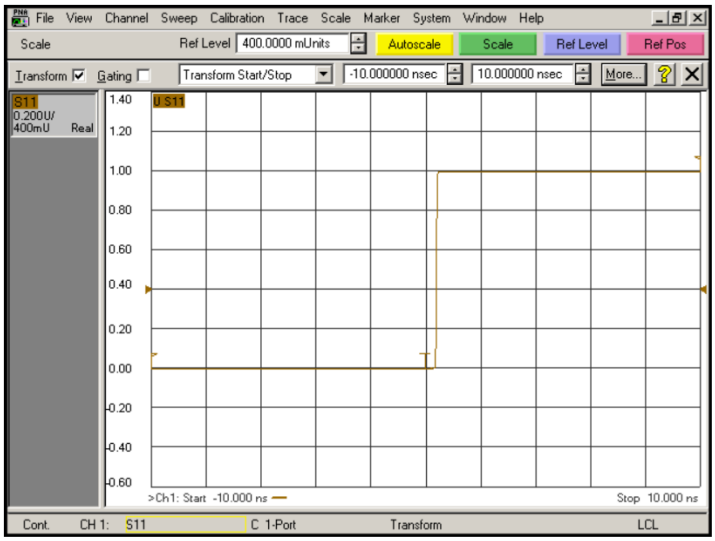
5. Result

Determining overpowered sensor through S11 and TDR

S11 at low frequency = 1 while high frequency is close to 1

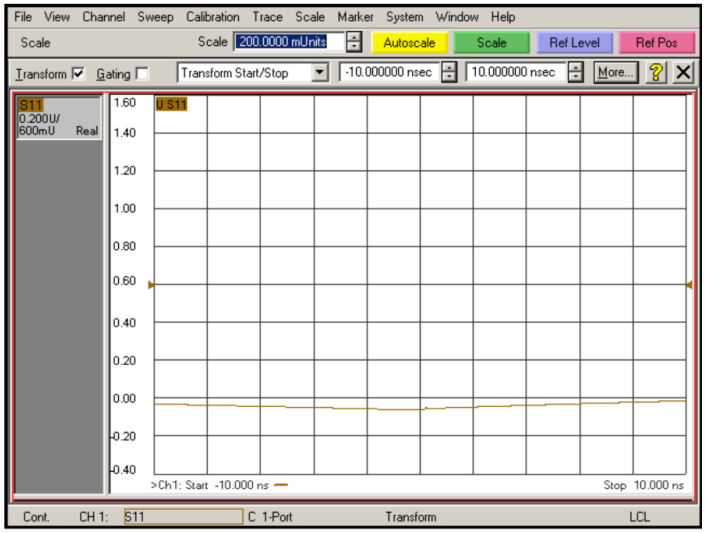


TDR shows step up response from 0 to 1



If the time-domain reflectometer (TDR) is showing a unity reflection step as specified above, the sensor is considered to have been overloaded with too much power.

TDR for good non-overpowered sensor (no step, full sweep close to 0)

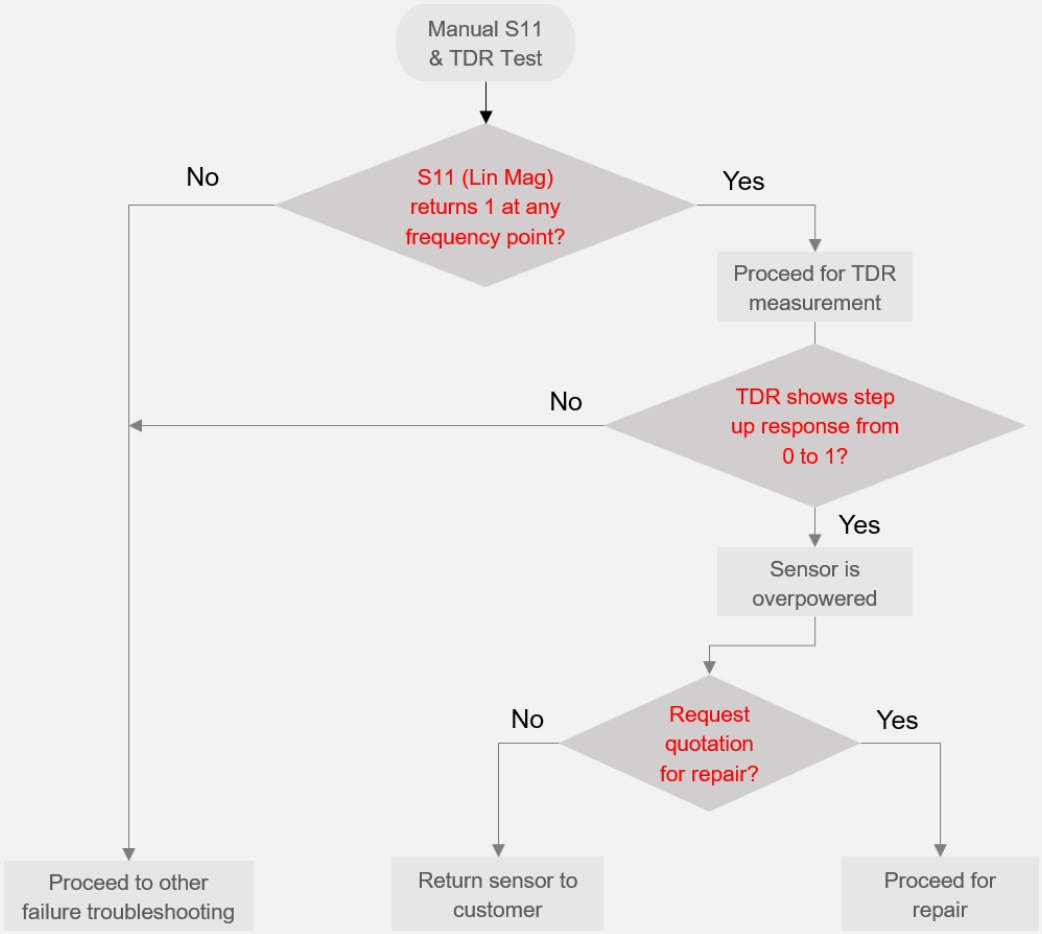


Notes:
1. The steps above are applicable for all the Keysight's network analyzers that has Time-domain analysis capability.
2. The Start and Stop frequency is dependent on the capability/specification of network analyzers being used for S11 and TDR measurement.

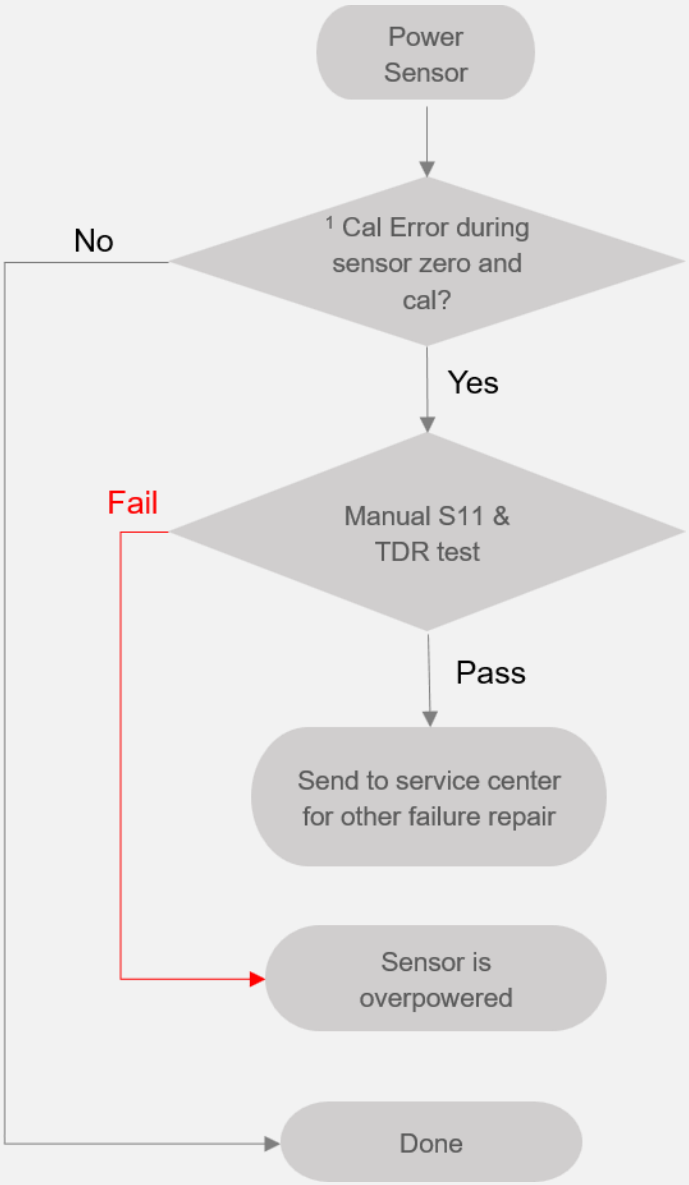
The image below illustrates the step response of specific elements ("OPEN" & "SHORT") in TDR mode.

Element	Step response
Open	 Unity reflection
Short	 Unity reflection, -180°

Process Flow for Manual S11 and Time-domain Reflectometer (TDR) Test



Customer Troubleshooting Process

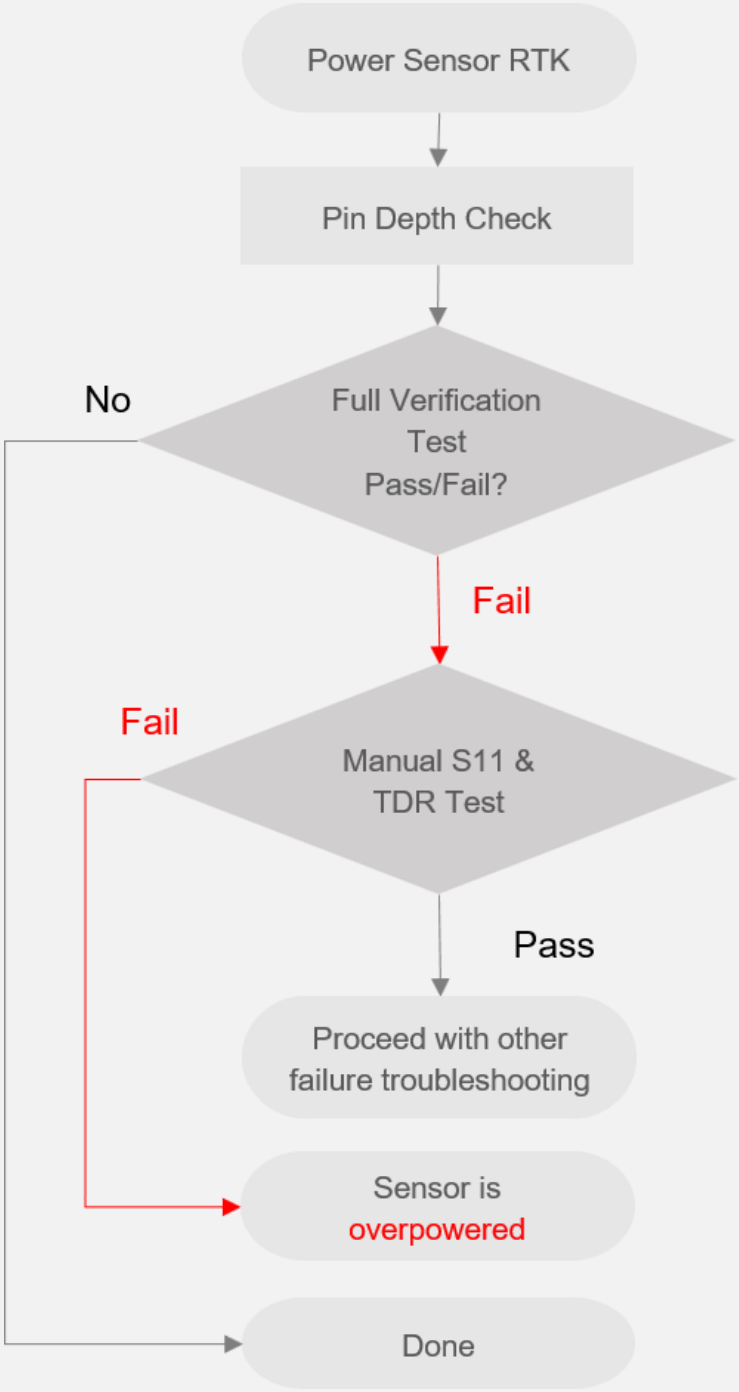


[1] For U2000 and U8480 Series, please follow the steps below to perform sensor calibration:

1. Upon power up, connect the sensor to the Power Meter's POWER REF port and turn on 50 MHz REF power.
2. For U2000 series, send "CAL:ZERO:AUTO ONCE" through Interactive IO.
   For U8480 series, send "CAL:AUTO ONCE" through Interactive IO.
3. Wait for the sensor LED to turn OFF.
4. Send & Read "Fetch?" through Interactive IO.

Troubleshooting process done by Keysight

Keysight Service Center conduct full test checking process.



Related Literature

Publication title	Pub number
7 Practices to Prevent Damaging Power Meters and Sensors	5990-9136EN
Fundamentals of RF and Microwave Power Measurements (Part 1) Application Note 1449-1	5988-9213EN
Fundamentals of RF and Microwave Power Measurements (Part 2) Application Note 1449-2	5988-9214EN
Fundamentals of RF and Microwave Power Measurements (Part 3) Application Note 1449-3	5988-9215EN
Fundamentals of RF and Microwave Measurements (Part 4) Application Note 1449-4	5988-9216EN
Keysight Power Meters and Sensors Selection Guide	5989-7837EN
Time Domain Analysis Using a Network Analyzer	5989-5723EN

Learn more at: www.keysight.com

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at: www.keysight.com/find/contactus

KEYSIGHT TECHNOLOGIES

This information is subject to change without notice. © Keysight Technologies, 2019, Published in USA, June 19, 2018, 5992-4039EN