Power Sensor Electrical Overstress (EOS) Failure Verification Guideline

848xA/B/H, 848xD, E930xA/B/H, E441xA, E932xA, N848xA/B/H, U200xA/B/H, U848xA, N192xA, U202xXA, U204xXA, L/U205xXA, L/U206xXA, L2065XT Power Sensor

Introduction

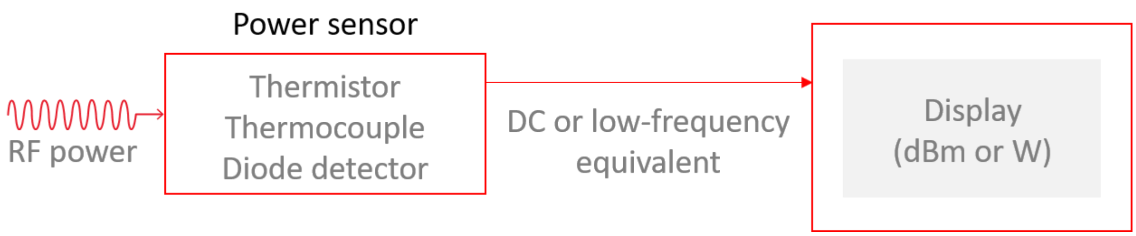
Electrical Overstress (EOS) of a Power Sensor consists of:

1. Overpowering
2. Overvoltage
3. ESD damage

Subjecting a power sensor to EOS is considered a misuse or self-abuse, and is excluded from Keysight Technologies' standard warranty coverage.

Overpowering

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.

Overvoltage

Power sensor's bulkhead can be damaged if the voltage of measured signal exceeds power sensor's maximum handling voltage. A typical DC-blocked power sensor can handle up to 20 VDC. DC-coupled sensors (for example, U2004A and E9304A) have much lower handling voltages — usually 5 V.

ESD Damage

Static electricity can easily damage sensitive internal circuit elements when discharged above product complied regulatory standard's limit. Even static discharges too small to be felt can cause permanent damage. An electrostatic discharge to the center pin of the connector will render the power sensor inoperative.

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. 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 Electrical Overstress (EOS)

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

   Perform sensor zeroing and calibration to determine whether the sensor has any EOS 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, N1920, U2020, U2040, L/U2050, L/U2060 series & L2065XT 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
N-type	10 MHz	18 GHz	1800
3.5 mm	10 MHz	33 GHz	3300
2.92mm	10 MHz	40 GHz	4000
2.4 mm	10 MHz	50 GHz	5000
1.85 mm	10 MHz	70 GHz	7000

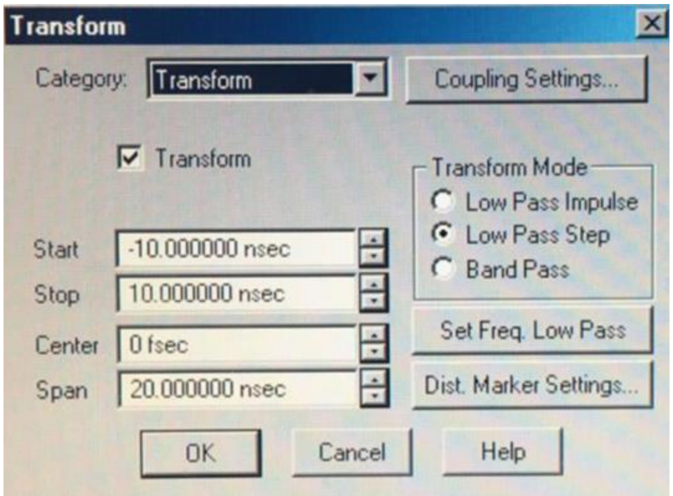
3. **S11 measurement**

   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 not within specification, 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.

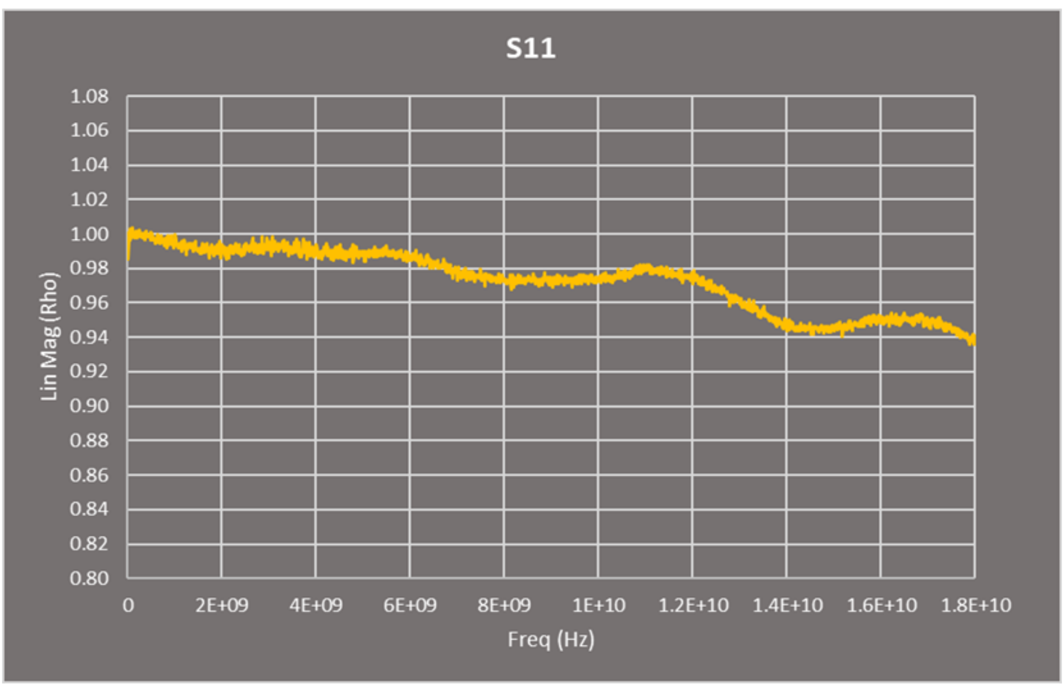
5. Result

Determining electrically overstressed sensor through S11 measurement and TDR measurement.

a. **S11 Measurement**

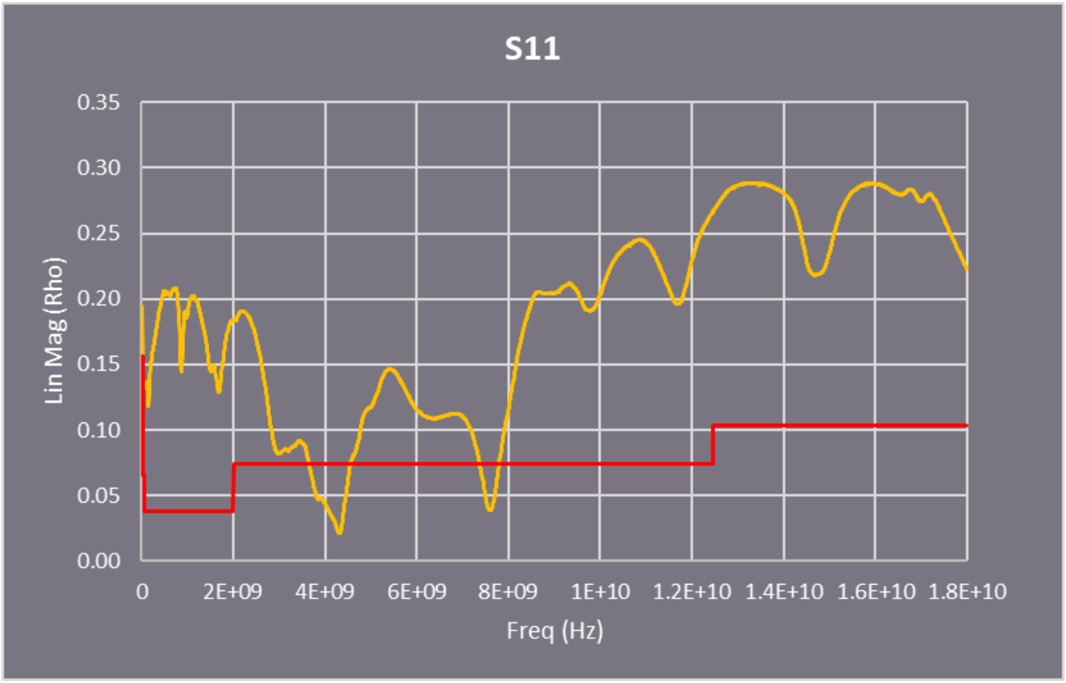
For E930xA/B/H, E441xA, E932xA, U200xA/B/H, N192xA, U202xXA, L/U2050XA, L/U2060XA & L2065XT, S11 at low frequency = 1 while high frequency is close to 1.

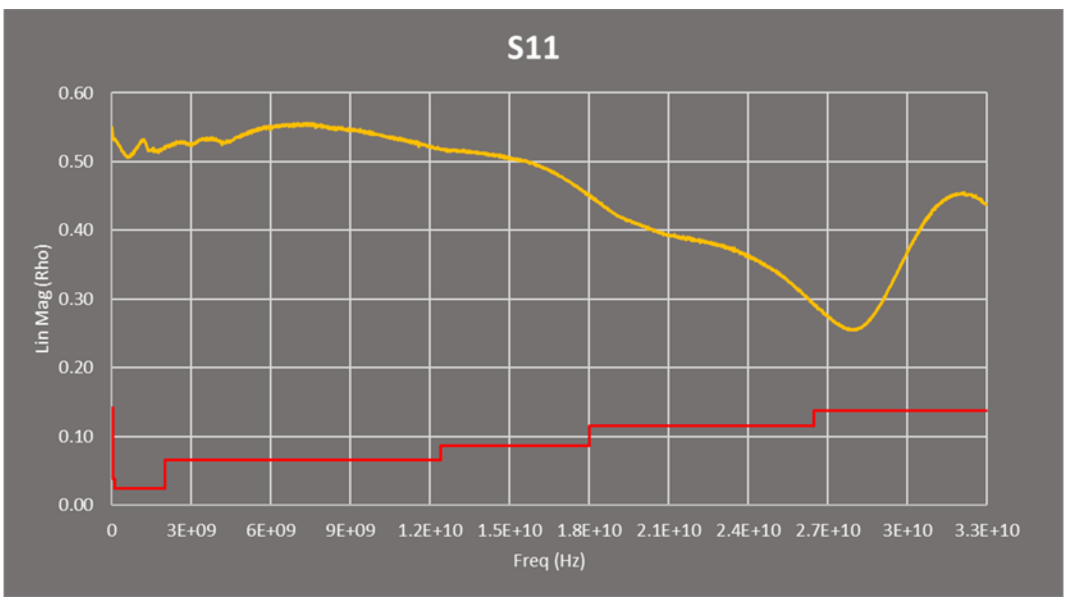
Example:



For 848xA/B/H, 848xD, N848xA/B/H, U848xA, U204xXA, S11 out of respective product specification.

Example:

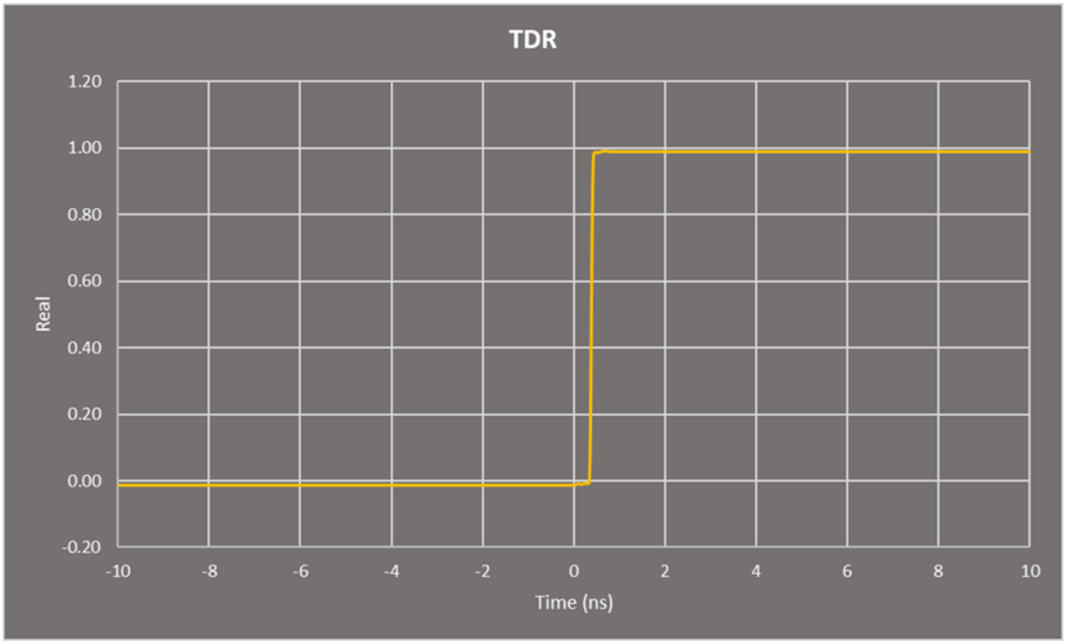




b. **TDR Measurement**

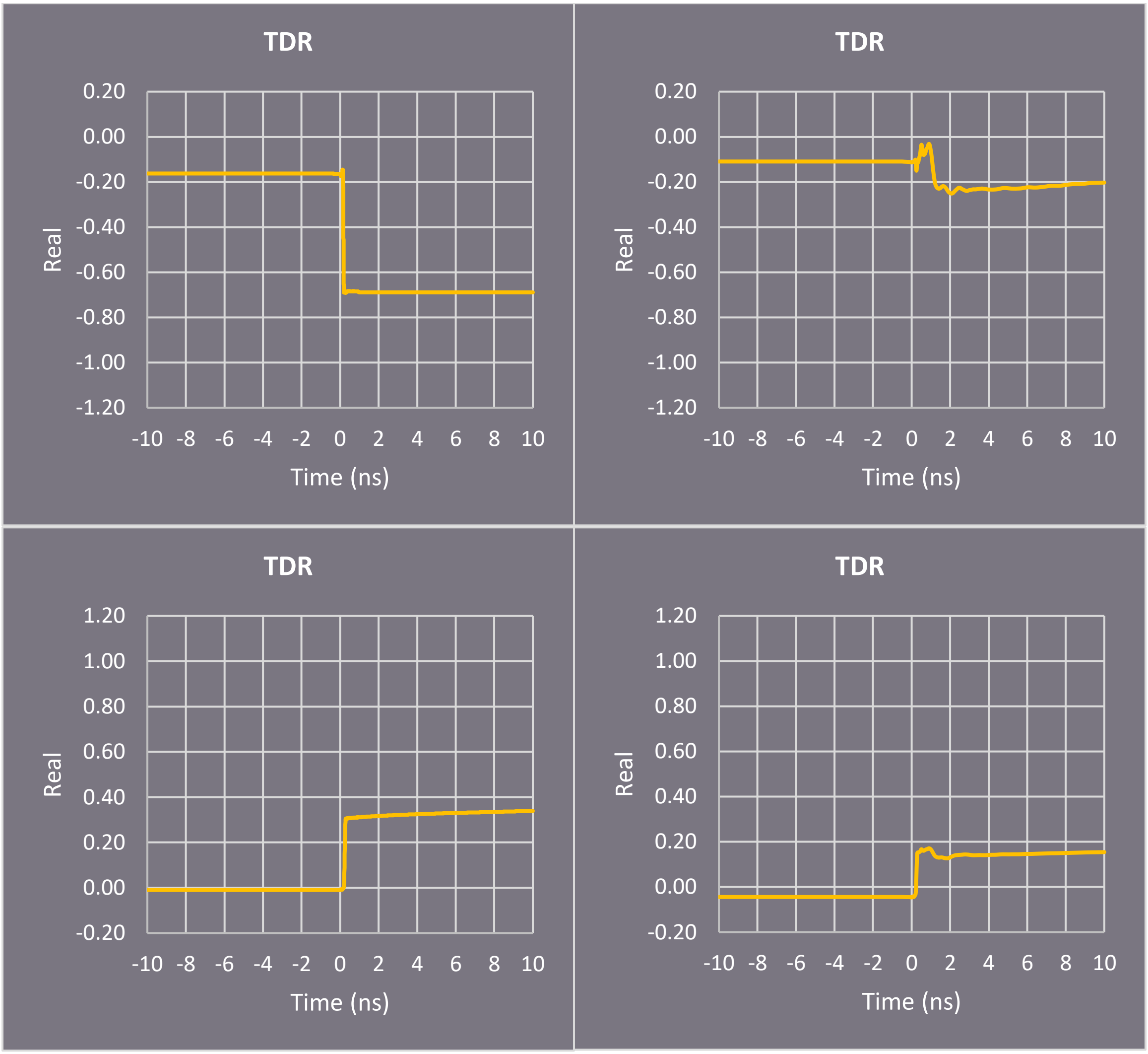
For E930xA/B/H, E441xA, E932xA, U200xA/B/H, N192xA, U202xXA, L/U2050XA, L/U2060XA and L2065XT, TDR shows step up response from 0 to 1.

Example:



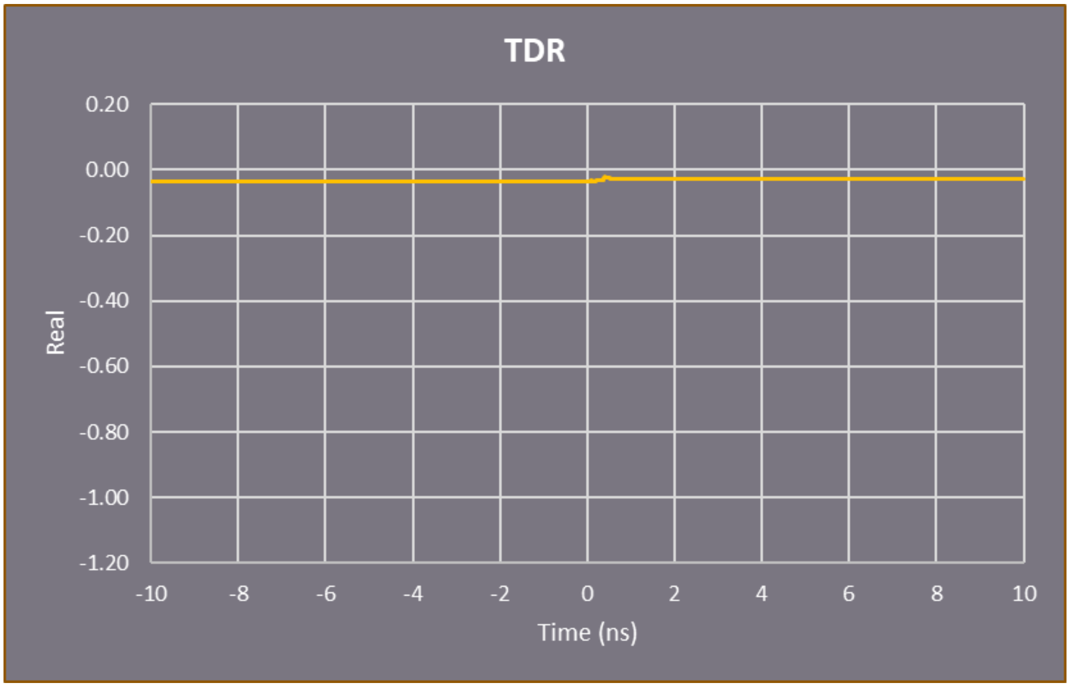
For 848xA/B/H, 848xD, N848xA/B/H, U848xA, U204xXA, TDR shows step up/down response with magnitude changed > 0.1.

Example:



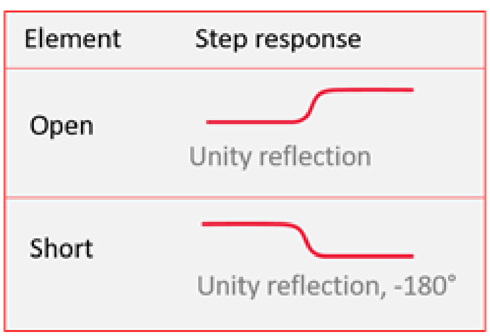
If the Time-domain reflectometer (TDR) is showing reflection step as specified above, the sensor is considered to have been Electrically Overstressed

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

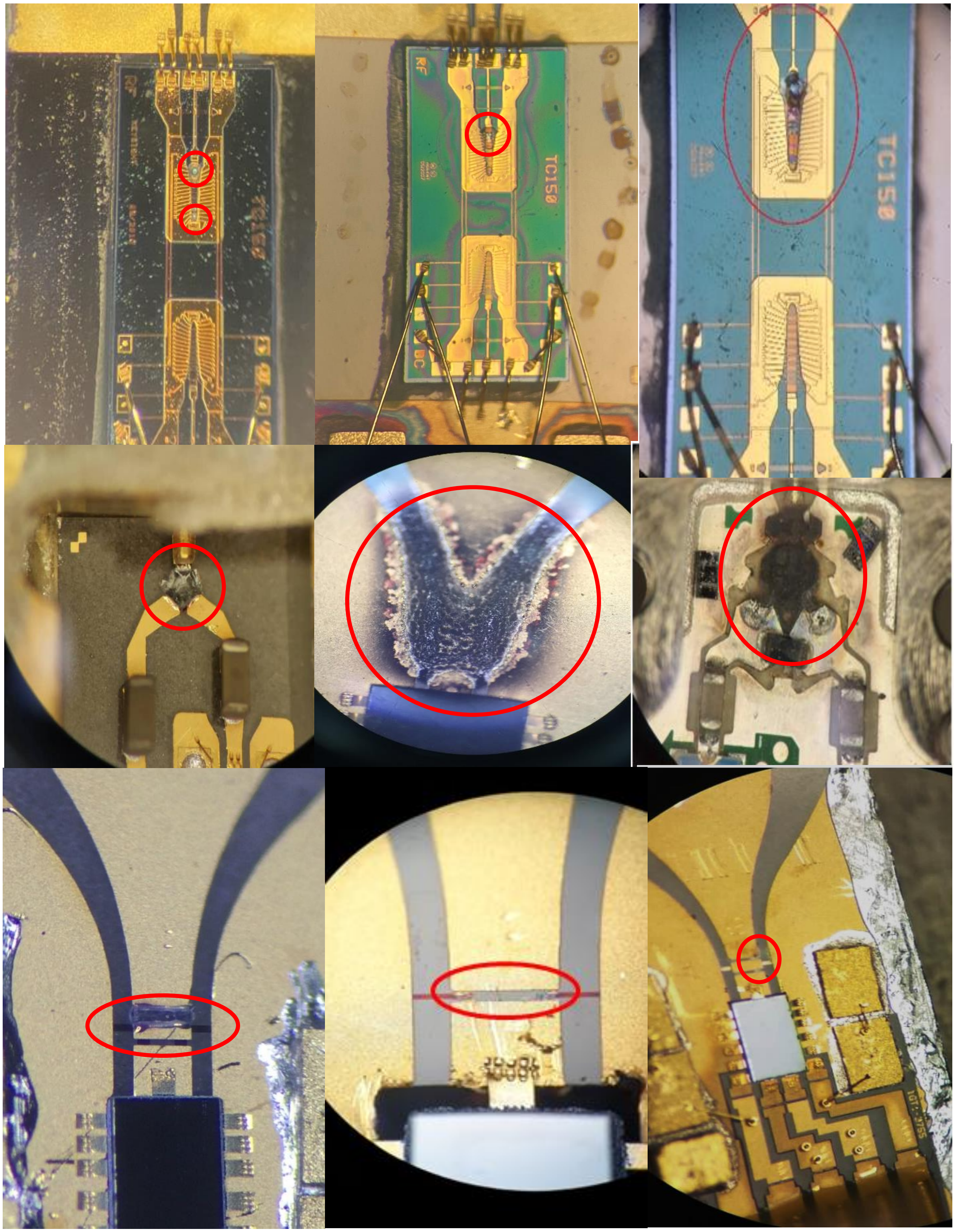


Notes:

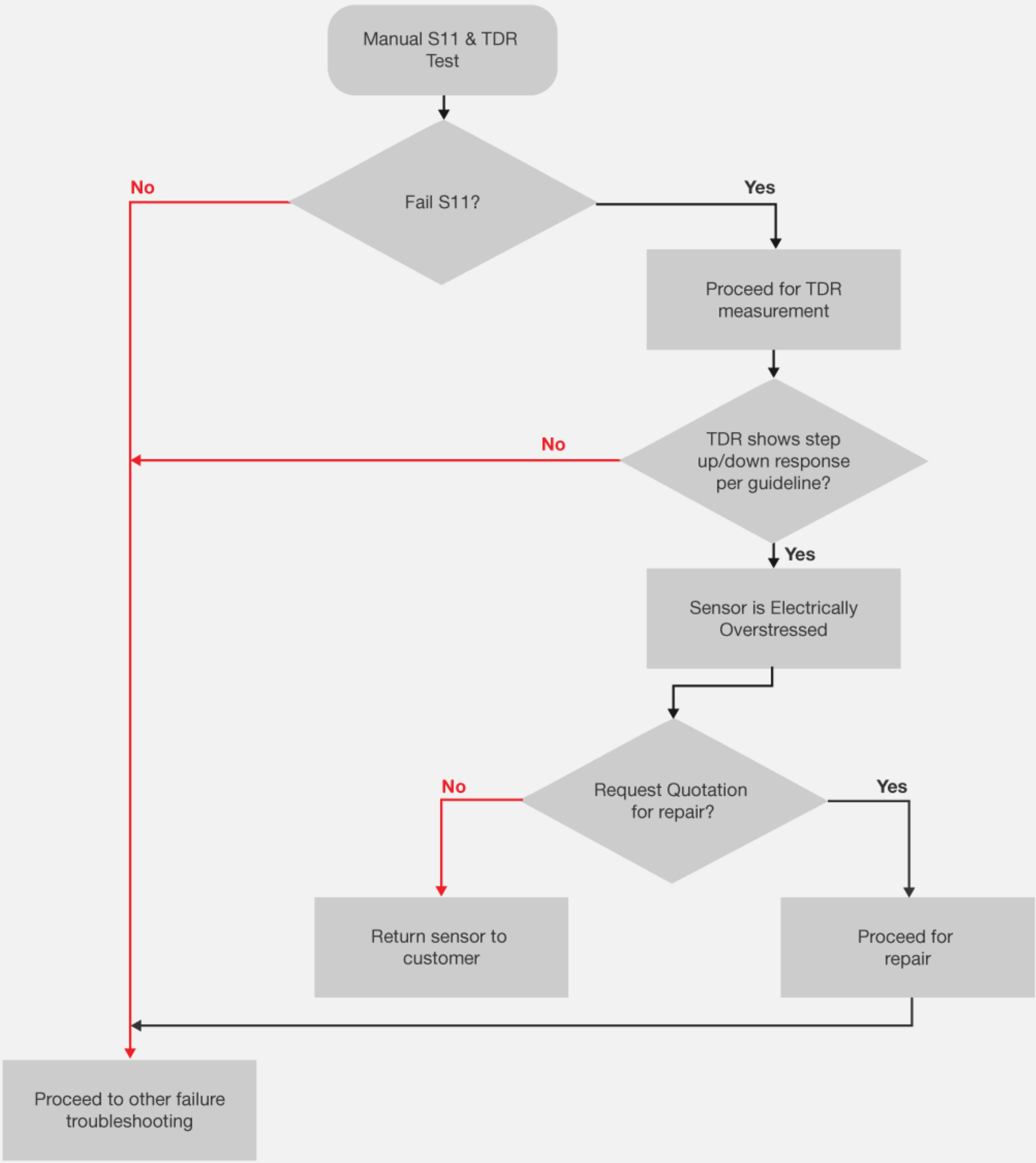
1. The steps above are applicable for all the Keysight's network analyzers that has Time-domain analysis capability.
2. The Start and Stop frequency is dependent on the capability/specification of network analyzers being used for S11 and TDR measurement.
3. The image below illustrates the step response of specific elements ("OPEN" & "SHORT") in TDR mode.



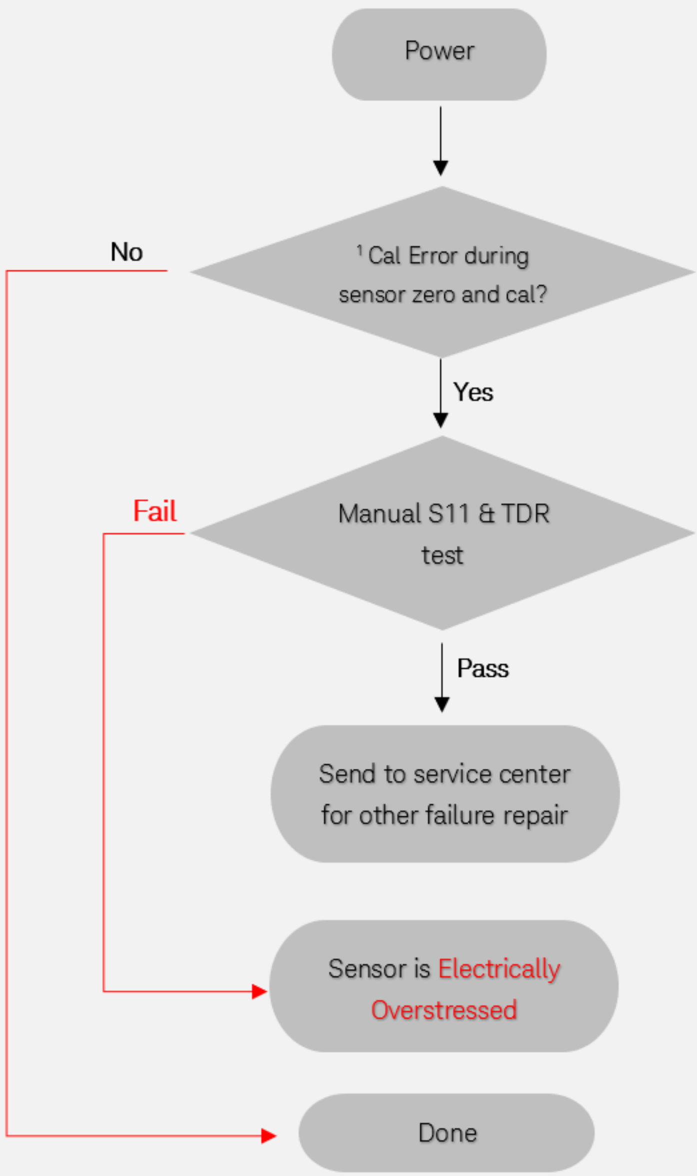
Photos of Internal Circuit Condition after Sensor Experienced EOS



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



Customer Troubleshooting Process

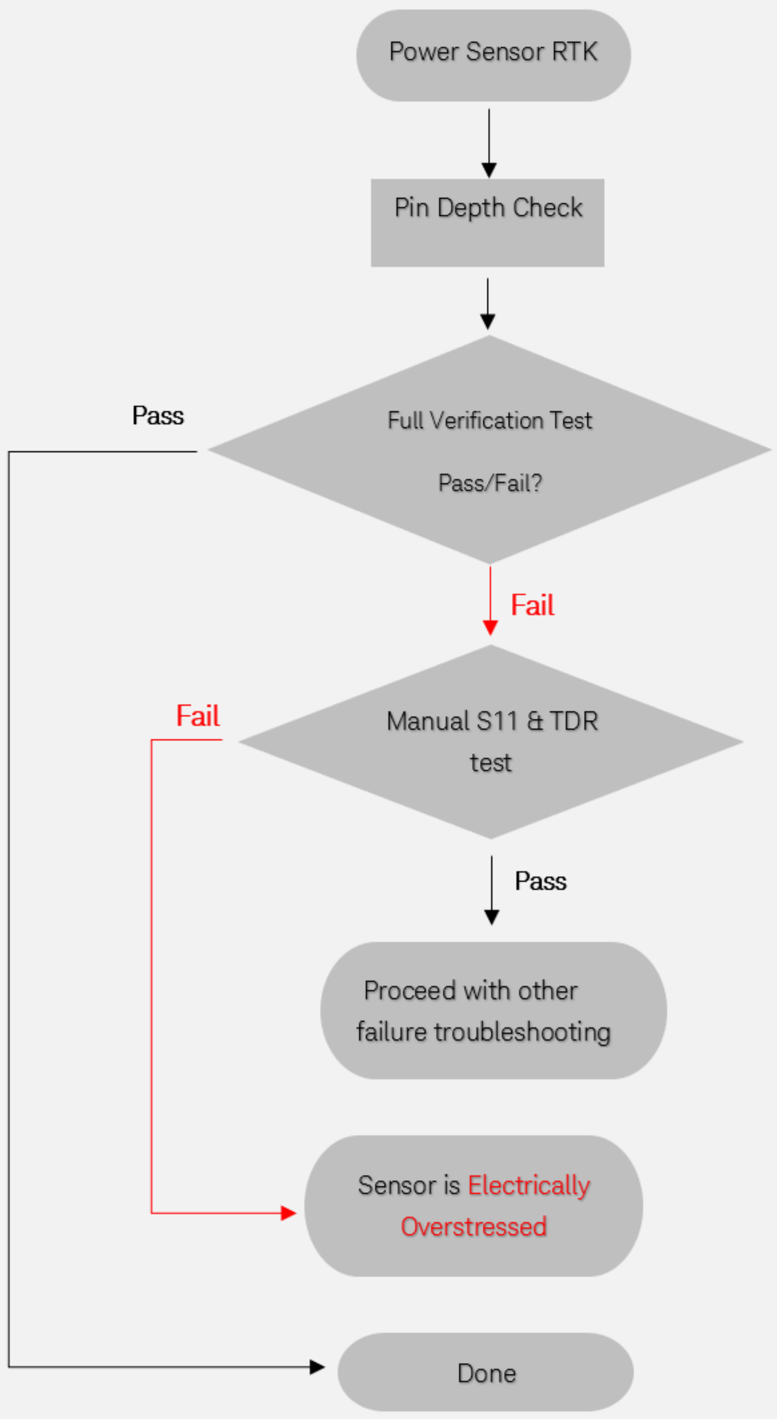


[1] For U2000, U8480, N1920, U2020, U2040, L/U2050, L/U2060 series & L2065XT, please follow the steps below to perform sensor calibration:

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.
3. For other than U2000 series, send "CAL:AUTO ONCE" through Interactive IO.
4. Wait for the sensor LED to turn OFF.
5. Send and Read "Fetch?" through Interactive IO.
6. Proceed to perform Manual S11 & TDR if Interactive IO returns timeout error or returned value is noise floor or **NOT** 0 dBm.

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

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