7 Best Practices to Prevent Damaging Power Meters and Power Sensors

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Agenda

- Why these practices are important?
- Best practices to prevent power meter/sensor damage
  - Practice 1: Avoid overpower
  - Practice 2: Avoid overvoltage
  - Practice 3: Adhere to warnings and specifications
  - Practice 4: Protect RF connectors and adaptors
  - Practice 5: Ensure proper grounding
  - Practice 6: Take ESD precautions
  - Practice 7: Check for temperature and humidity
- Summary
- References
- Q&A

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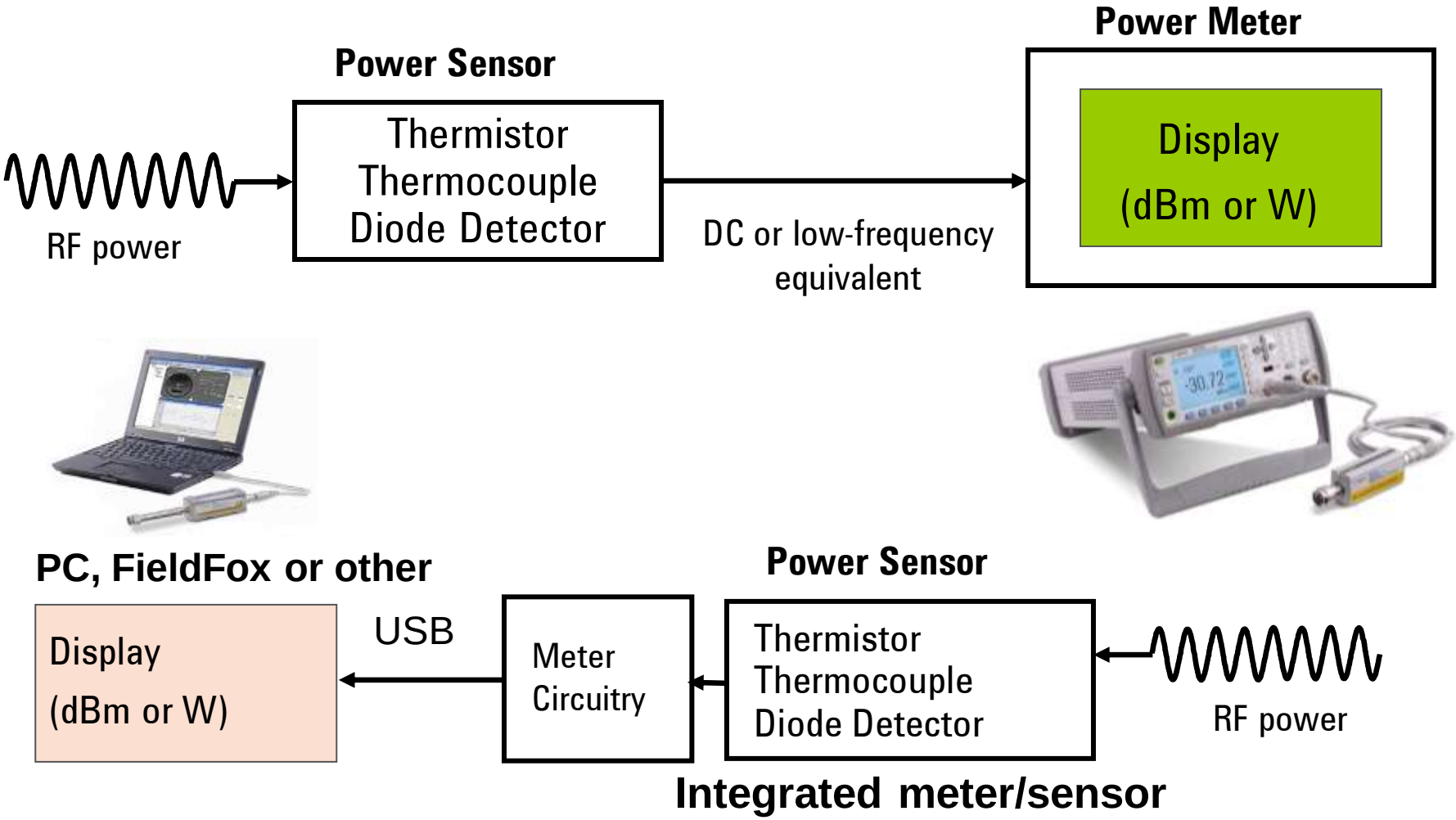
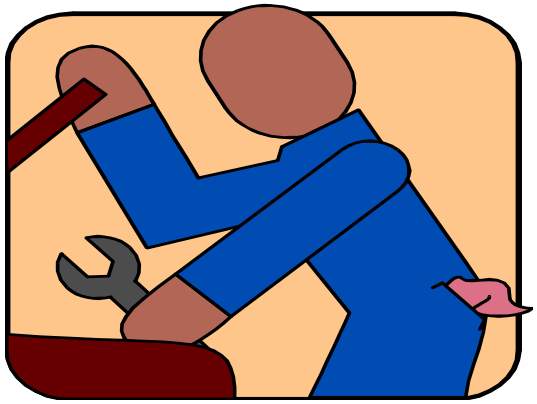
The Power Meter and Sensor Method



Why these practices are important?

Measurement Quality Degradation

Repair Cost



System Downtime

Schedule Delay

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Practice 1: Avoid Overpower

Typical sensor max power: -20dBm, 20dBm, 30dBm, 35dBm, 44dBm

- Have an idea of the signal level to be measured
- Make sure expected measured power is within the dynamic range of the sensor
- Use a RF limiter to protect sensing element

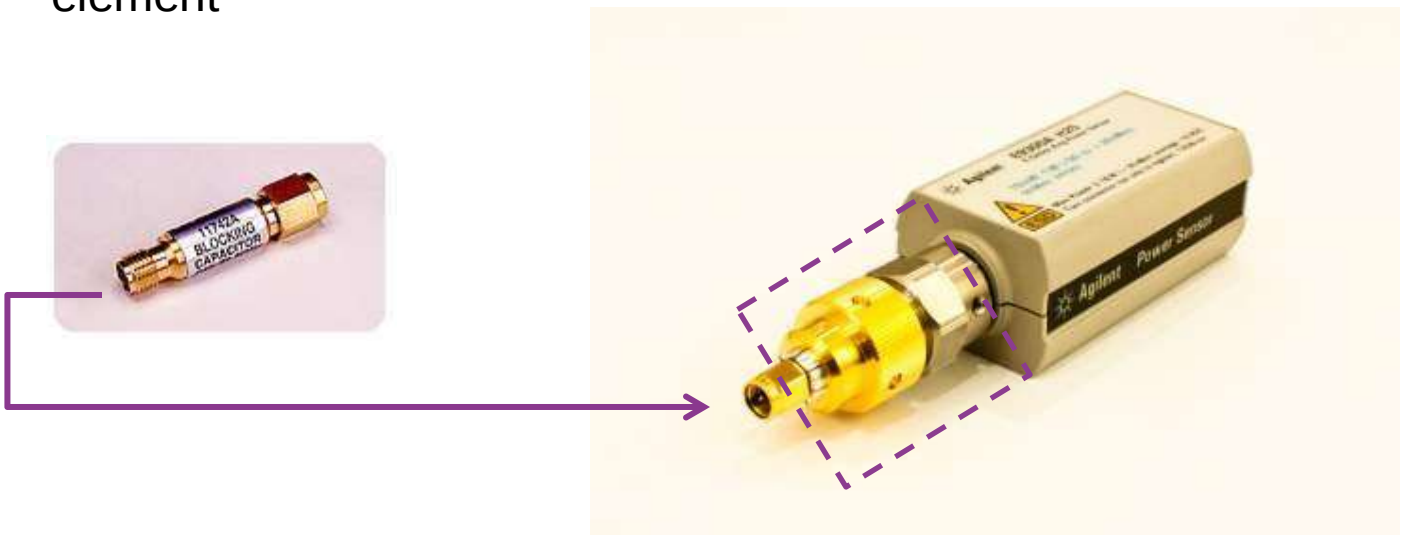
Bulkhead housing the sensing element

Practice 2: Avoid Overvoltage

Typical DC-blocked sensor max handling voltage: 10Vdc, 20Vdc

Typical DC-coupled sensor max handling voltage: 5Vdc

- Be particularly careful with sensors without DC block: U2004A, U8480 series w/ option 200, E9304A
- Use a blocking capacitor to protect power sensor sensing element



DC-blocked V.S. DC-coupled

DC-blocked power sensor

- A capacitor is placed serially in front of sensing element
- Prevents DC leakage from entering sensing element
- Good for measuring RF signals with DC offset

DC-coupled power sensor

- Have slightly better VSWR performance
- Good for operations at low frequencies down to DC

Further reading:

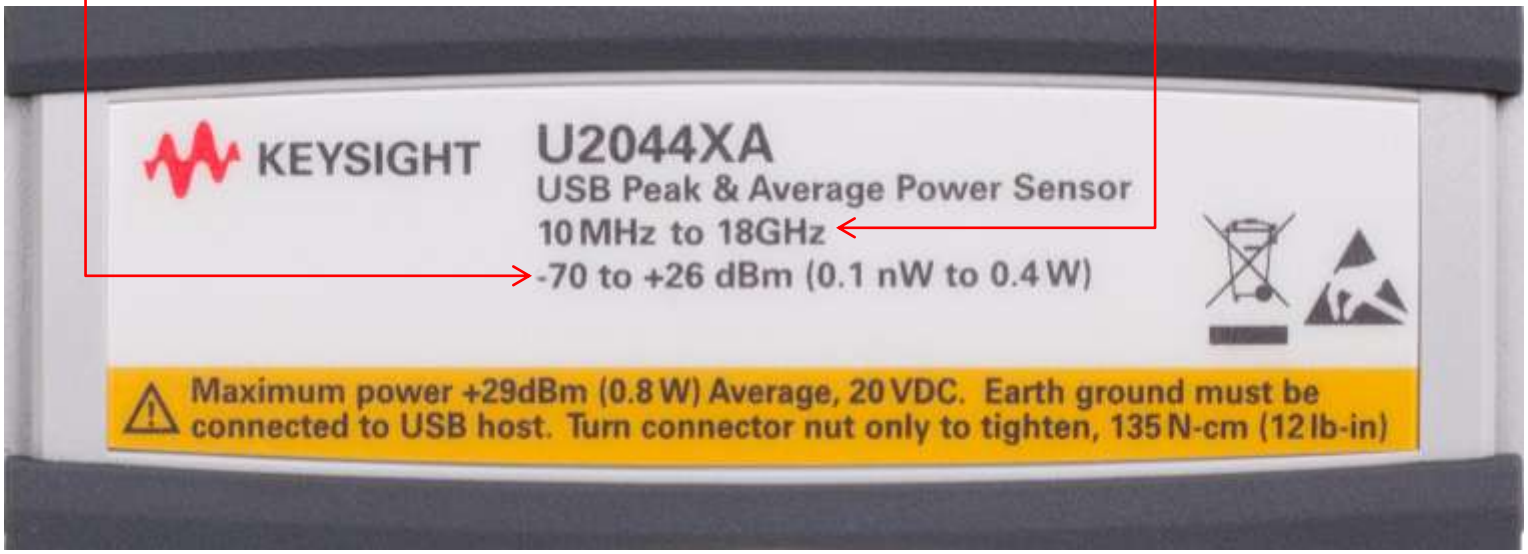
Keysight Technologies
Understanding DC-coupled and DC-blocked Power Sensors

http://literature.cdn.keysight.com/litweb/pdf/5990-6745EN.pdf

Practice 3: Adhere to Warnings and Specifications

Dynamic range

Frequency range



Select a Suitable Power Sensor

		POWER METERS												
	Display Sequence	13	12	5	6	3	4	1	2	11	10	7	8	9
	Model Number	432A	N432A	E4416A EPM-P	E4417A EPM-P	E4418B EPM	E4419B EPM	N1913A EPM	N1914A EPM	E1416A VXI	N8262A P-Series	N1911A P-Series	N1912A P-Series	8990B PPA
N8480 / 8480 series thermocouple & diode sensors	N8481A	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	×
	N8482A	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	×
	N8485A	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	×
	N8487A	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	×
	N8488A	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	×
	N8481B	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	×
	N8482B	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	×
	N8481H	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	×
	N8482H	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	×
E9300 series average sensors	E9300A	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	×
	E9301A	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	×
	E9304A	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	×
	E9300B	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	×
	E9301B	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	×
	E9300H	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	×
	E9301H	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	×
E9320 series peak & average sensors	E9321A	×	×	✓	✓	×	×	×	×	×	✓	✓	✓	×
	E9322A	×	×	✓	✓	×	×	×	×	×	✓	✓	✓	×
	E9323A	×	×	✓	✓	×	×	×	×	×	✓	✓	✓	×
	E9325A	×	×	✓	✓	×	×	×	×	×	✓	✓	✓	×
	E9326A	×	×	✓	✓	×	×	×	×	×	✓	✓	✓	×
	E9327A	×	×	✓	✓	×	×	×	×	×	✓	✓	✓	×
CW power sensor	E4412A	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	×
	E4413A	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	×

Select a Suitable Power Meter

Applications

U2000 Series USB power sensor		V3500A USB power sensor	

- ✓ General purpose average power measurement
- ✓ Calibrate other Agilent instruments for better accuracy (U2000)
- ✓ Portable for installation and maintenance purposes
- ✓ Couple with power full software application* for R&D, manufacturing (U2000)
- ✓ Satellite communication test
- ✓ Self powered solution (V3500A) for field, lab or manufacturing use.

EPM Series		U2040XA Series USB Wide BW Sensor NEW	

- ✓ General purpose average power measurement
- ✓ For ATE users who need a standard rack size equipment
- ✓ For Aerospace/Defense and military applications
- ✓ For customers who need multi channel power measurements up to 4 channels

EPM-P Series		U2049XA Series LAN Wide BW Sensor NEW	

- ✓ Mid performance peak and average power meter
- ✓ For Wireless Communications with its <5MHz Video BW
- ✓ E.g. GSM, EDGE, cdma2000, W-CDMA, pulse Tr>200ns

U2020XA Series USB Peak Power Sensor		Peak, Avg, CCDF, pulse analysis, <30MHz VBW> U2021/ 22XA

- ✓ For Aerospace/Defense for fast radar pulses test
- ✓ Wireless communications and networking (WiMAX, WLAN, MIMO, MCPA)
- ✓ Research and development, and manufacturing

P-Series		Peak, Avg, CCDF, pulse analysis, <30MHz VBW> N1911/12A

- ✓ For Aerospace/Defense for fast radar pulses test
- ✓ Wireless communications and networking (WiMAX, WLAN, MIMO, MCPA)
- ✓ Research and development, and manufacturing

Peak Power Analyzer		Peak, Avg, CCDF, pulse analysis, <150 VBW> 8990B

- ✓ For Aerospace/Defense for fast radar pulses test
- ✓ Wireless communications and networking (WiMAX, WLAN, MIMO, MCPA)
- ✓ Research and development, and manufacturing

Practice 4: Protect RF Connectors and Adaptors

All RF connectors have a limited lifespan

Proper care and handling can maximize the lifespan of your connectors

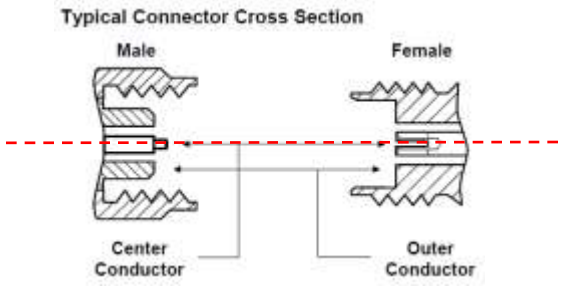
A damaged or out-of-specification device can destroy another good connector

Effects of a bad connector:

- Mismatch
- Measurement error
- Repeatability problems

Practice 4: Protect RF Connectors and Adaptors

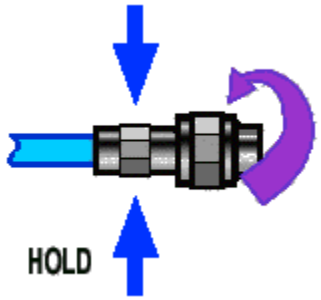
Making a Connection



- Carefully align center axis of both devices.

- Push the connectors straight together so the male center conductor pin slips concentrically into the contact finger of the female connector.

- Rotate only the connector nut - **NOT THE DEVICE OR CONNECTOR BODY** - until finger-tight, being careful not to cross the threads.



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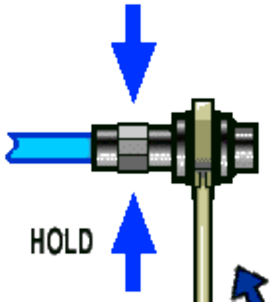
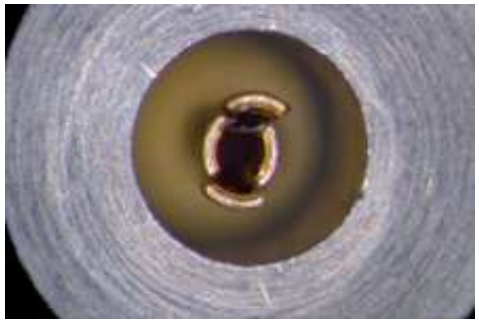
Practice 4: Protect RF Connectors and Adaptors

Separating a Connection



- Support the devices
- Use an open-end wrench to loosen the connector nut.
- Complete the disconnection by hand, turning only the connector nut.
- Pull the connectors straight apart.



Damaged female centre conductor fingers on a 1.85 mm connector (photo courtesy of Jürg Rüfenacht, METAS, Switzerland).

A bent 3.5 mm female centre conductor finger. The centre conductor has been removed here for replacement (photo courtesy of Jürg Rüfenacht, METAS, Switzerland).

A bent female centre conductor finger on an N-type connector (photo courtesy of Tuomas Haitto, Finnish Defence Forces)

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Practice 4: Protect RF Connectors and Adaptors

Use Torque Wrench

Recommended Torque Values for Connectors

Connector Type	Torque lb-in (N-cm)
Precision 7 mm	12 (136)
Precision 3.5 mm	8 (90)
SMA	5 (56) Use the SMA torque value to connect male SMA connectors to female precision 3.5 mm connectors. Use the 3.5 mm torque value to connect male 3.5 mm connectors to the female SMA (8 lb-in)
Precision 2.4 mm	8 (90)
Precision 1.85 mm	8 (90)
Type-N	Type-N connectors may be connected finger tight.If a torque wrench is used, 12 lb-in (136 N-cm) is recommended

Example of a Type-N torque wrench

Torque wrench remains straight when in use

Stop when the handle begins to yield

Practice 4: Protect RF connectors and adaptors

Use Adapters as Connector Savers

- Protect power sensor RF input by using an adapter
- Do not use during metrology calibration
- Do not use damaged adapters

Practice 4: Protect RF connectors and adaptors

Visual Inspection

- Use magnifying glass or microscope to look for:
  - Badly worn plating, deep scratches, dents
  - Deformed threads
  - Bent or misaligned center conductor
  - Debris on the threads or mating surfaces

Clean connectors

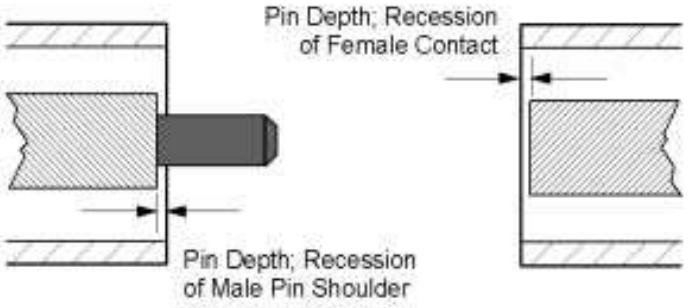
- Clean with compressed air
- If required, use lint free swab with minimal alcohol
  - Avoid plastic parts
  - Avoid snagging swab on female contact fingers
  - Let dry and inspect again for residue

Practice 4: Protect RF Connectors and Adaptors

Use a Gauge

– Pin depth is positive if the center conductor protrudes from the reference plane.

– Pin depth is negative if the center conductor is recessed below the reference plane



When to gauge connectors :

- Prior to first use
- When visual inspection or electrical performance suggest connector interface may be out of typical range
- After every 100 connections and as often as experience suggest thereafter

Gauging Connectors: http://na.support.keysight.com/pna/connectorcare/Connector_Care.htm

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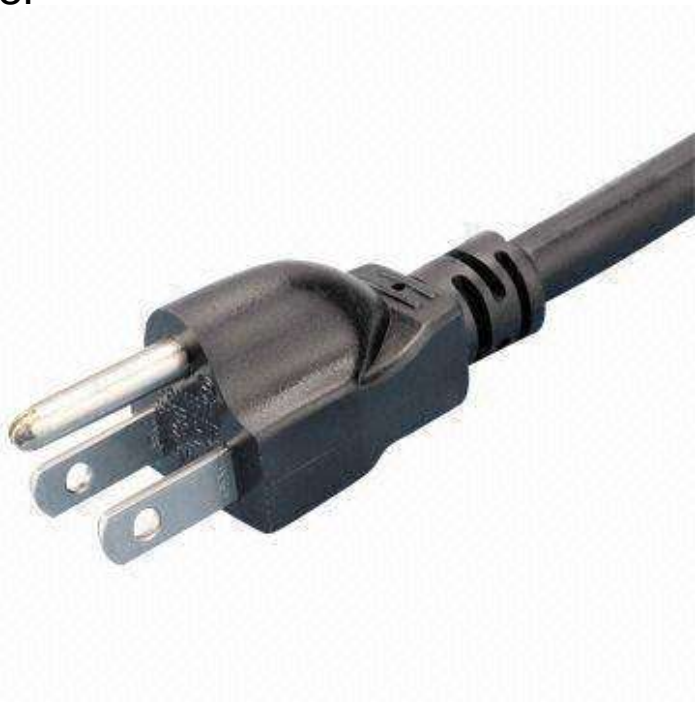
Practice 4: Protect RF connectors and adaptors

Handling and Storage

- Use plastic end caps during storage
- Store in a clean and dry environment at room temperature
- Never store connectors loose in a box
- Do not touch mating plane surfaces
- Do not set connectors contact end down

Practice 5: Ensure Proper Grounding for Power Meter

- Always use the three-prong AC power cord supplied with the power meter
- Proper grounding of the instrument will prevent harm to the instrument and operator



Practice 6: Take ESD Precautions

– ESD (Electro-Static Discharge)

– Electrostatic discharge to the *center pin* will render the sensor inoperative
  - Put connector cap on unused power sensor
  - Conduct testing at static-safe workstation
  - Clean RF input connector only at a static-safe workstation
  - Avoid bringing sources of static electricity within 1meter of a static-safe workstation

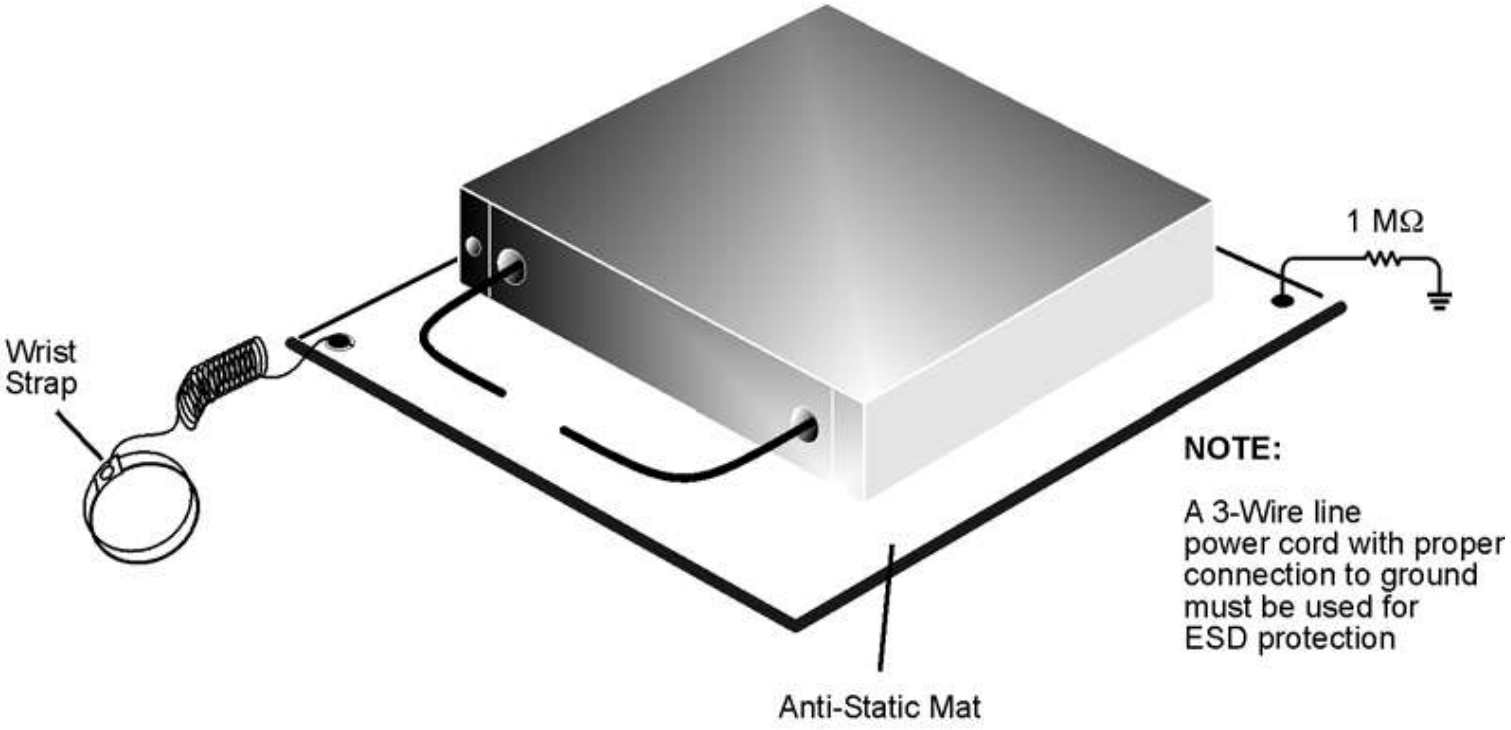
Practice 6: Take ESD Precautions

– Sources of static electricity:
  - People
  - Conveyor belts
  - Other moving machinery

– When removal of the source is not practical, ground the source

Practice 6: Take ESD Precautions

ESD Protection setup



Practice 7: Check for Temperature and Humidity

- Keep power sensor and meter in a clean and dry environment
- Ensure proper ventilation among rack
- Cooling vents and fans should be inspected and cleaned frequently
- Operating environmental conditions
- Storage environmental conditions
- Relative humidity is a significant factor in ESD

Summary

- Practice 1: Use RF limiter to attenuate high power
- Practice 2: Use DC block to remove DC component
- Practice 3: Adhere to warnings and specifications
- Practice 4: Protect RF connectors and adaptors
- Practice 5: Ensure proper grounding
- Practice 6: Take ESD precautions
- Practice 7: Check for temperature and humidity

References

– Tips for Preventing Damage to Power Sensor & Meter

- http://literature.cdn.keysight.com/litweb/pdf/5990-9136EN.pdf

– AN362 Principles of Microwave Connector Care: excellent reference

– http://na.support.keysight.com/pna/connectorcare/Connector_Care.htm

– Fundamentals of RF and Microwave Power Measurements

– http://www.keysight.com/main/editorial.jspx?cc=US&lc=eng&ckey=272209&nid=-35560.0.00&id=272209

– Selection Guide

– http://literature.cdn.keysight.com/litweb/pdf/5989-6240EN.pdf

Q & A