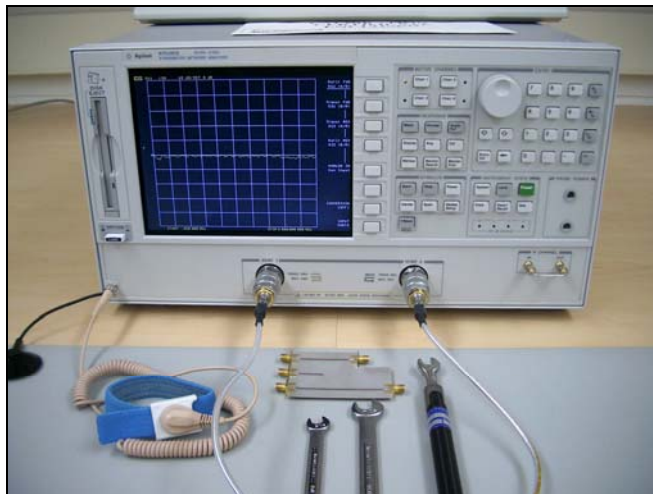


## Lecture 19: Proper Microwave Laboratory Practices.

Microwave circuit measurements are very different than electrical measurements at lower frequencies. Here are five key differences:

1. We often use a **network analyzer** to make  $S$  parameter measurements rather than traditional instruments for voltage or current measurements.
2. **Systematic errors** are removed using measurement calibration before making measurements.
3. **Precision connections** are necessary for accurate and repeatable measurements.
4. **Special tools** are used to tighten coaxial connectors.
5. **Electrostatic protection** is absolutely necessary.

You will be using an **Agilent 8753ES** Vector Network Analyzer (VNA) to make all of your measurements this semester. This VNA operates from 30 MHz to 6 GHz.



A VNA measures **both the magnitude and phase** of  $S$  parameters. Note that a VNA is intrinsically making frequency domain measurements, i.e., sinusoidal steady state.

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## Types of Coaxial Connectors

There are nine types of coaxial connectors that you may encounter in most RF and microwave engineering laboratories:

- |           |            |
|-----------|------------|
| 1. BNC    | 5. APC-7   |
| 2. Type F | 6. APC-3.5 |
| 3. Type N | 7. 2.92 mm |
| 4. SMA    | 8. 2.4 mm  |
|           | 9. 1.85 mm |

The right-hand column lists metrology-grade connectors.

The photograph on p. 134 of your text shows Type N, TNC, SMA, APC-7, and 2.4 mm connectors:



In this course, you will primarily be using the SMA connector.

## Proper Microwave Coaxial Connections

We will use only **SMA connectors** in the EE 481 laboratory. Do **NOT** finger tighten these, or any other, precision microwave connectors. Instead, use a **black-handled** torque wrench, which provides the proper 5 in-lbs of torque required for SMA.



If you over-tighten a connection, it is possible you will damage the VNA connector, the cable, or your microwave circuit. There may be different types of torque wrenches lying about the lab. Be certain you are using the **BLACK**-handled torque wrench.

**Standard operating procedures** for making microwave coax connections include:

1) When **initially** making coaxial connections:

- Make sure you are electrostatically grounded.
- Be certain there are no metal filings or other debris inside the connectors. If there are, use canned air to lightly blow into the connector at an angle (not end on). Use a special

cleaning “Q tip” to clean out the connector. Repeat if necessary.

- Carefully line up the connectors before threading. You will likely discover it is common for the internal connections to be unaligned as you start threading.
- Do not bend or twist the flexible coaxial cables more than necessary.
- Hand tighten the connectors to the point where you first feel resistance.

NOTE: If you feel resistance prematurely, it is likely the connectors are not properly aligned. Simply undo the connection and try again. Forcing the connection may lead to damage.

2) To **tighten** a microwave coaxial connection:

- Use two tools to tighten the connectors. One is a precision torque wrench for tightening and the other is an open-ended wrench for resistance. Place the torque wrench on the connector you wish to tighten with the “knee” pointing away from the direction you wish to tighten. Use the open-end wrench on the other connector to hold the connection as you tighten.
- Hold the torque wrench near the groove at the end of the handle. Slowly tighten the connection with the torque wrench to the point where the wrench **begins** to bend. Do

not let the torque wrench bend more than approximately  $45^\circ$ . Notice after a certain threshold the wrench will move quickly with a snapping action.

- Always fully tighten the connection with the torque wrench.

3) To **loosen** a microwave coaxial connection:

- Make sure that you are loosening the connection and not tightening it further. In fact, you should use the torque wrench as a check that you are turning in the correct direction.
  - Use the same care in loosening as when tightening.
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## Laboratory Policies

You will be performing measurements for this course in the *Laboratory for Applied Electromagnetics and Communications* (LAEC) located in 230 EEP.

1. This is a research laboratory and your conscientious treatment of the facility, its equipment, and experiments is requested.
2. You must be electrostatically grounded if you touch the VNA, cables and connectors attached to the VNA, or your microwave circuit if it is connected to the VNA. There are no exceptions to this rule.
3. Please do not touch any equipment or experiments in the laboratory other than your own.
4. Please do not bring food or drink to the lab. Under no circumstances should food or drink be placed on the lab benches.
5. Please do not bring guests with you into the laboratory.