Lesson 15

MEASUREMENTS and WAVEFORMS

ACMA Syllabus February 2024 Chapter 8.

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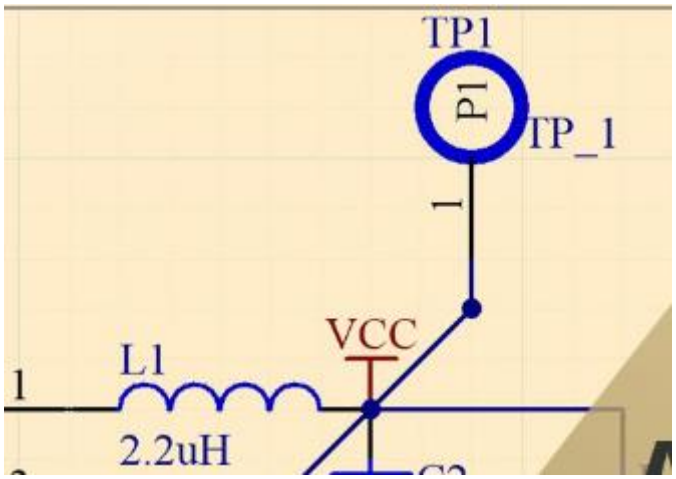
Measurements

Test points.

A test point is a designated point on a circuit that is used to make a measurement or inject test signals. Test points are common in circuits under development but once they go into production, the test points are often removed.

Good drawings include test points and what is to be undertaken at that point. Service manuals for some amateur equipment have test points for servicing and tuning the radio.

Next to the TP, or in a separate table, would be text on what should be expected at that test point. Example: Sine wave at 2 MHz with amplitude of 0.5 V.



Manuals

Whatever instrument or measurement you make, read the manuals and know your tools.

Measuring Voltage, Resistance and Current

A test meter in connected to a circuit is an additional load on the circuit undertest. The meter must have a high input impedance, usually greater than 1 MΩ, to keep the meter load to a minimum. Multimeters have a high input impedance so you can measure low voltages on logic circuits without loading the circuit. Read articles on meters.

Meters Article 1 Article 2

Measuring Voltage watch the video HERE

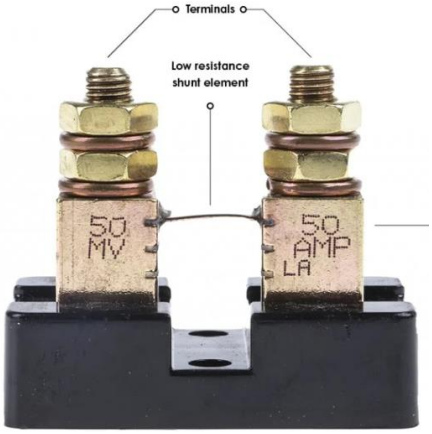
Measuring current watch the video HERE

DC Voltages and Currents

A DC voltage is taken across two terminals and the resulting measurement is the potential difference.

Example: Measuring a car battery should provide a result around 12V.

A DC current needs to be measure in the circuit. This is measuring the amount of current, in Amperes, flowing though the circuit. For high levels of current, a very low Ohm resistor, called a shunt resistor, is wired in the circuit and the voltage drop across this resistor is measured. Knowing the resistor size and voltage drop, the meter can display this as current.



AC Voltages and Currents

An AC voltage is taken across two terminals and the resulting measurement is the RMS value of the potential difference. RMS is 0.707 of the peak value.

Example: Measuring the voltage in a power point should provide a result around 240 V.

Modern meters measure the current via a clamp meter.

Meter Types

Meters basically fall in to two types, digital and analogue.

Multimeters

Digital Analogue

Clamp Ammeters

Clamp ammeters measure the current in the wire by measuring the magnetic field around the wire. This makes measuring current much easier than having to place the meter in the circuit.

Watch a video HERE

VSWR and Power Meter

This is a stable tool for all amateurs.

This instrument can measure forward power, reverse power and provide an SWR reading.

Watch a video HERE

Reflectometer bridge (SWR meter)

Read the article on the Wheatstone Bridge.

Measuring Frequency

Frequency can be measured by a frequency counter, see below, or the waveform can be observed on an oscilloscope.

RF Signal

The signal is best observed on an oscilloscope.

Resonant frequency

Grid dip oscillator is used to measure the resonant frequency of a tuned circuit.

Alternatively, a signal can be injected into the circuit and the output monitored on an oscilloscope.

Watch video on Grid Dip Oscillator HERE.

Measuring Devices

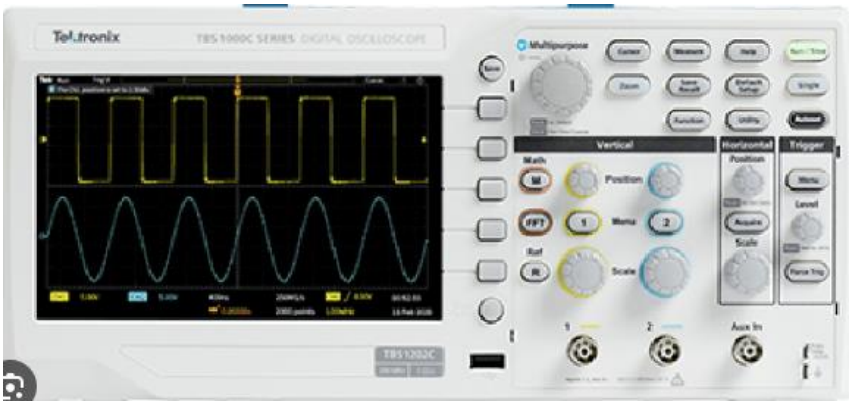
Waveform generator

A waveform generator can output a wave form of the desired shape, frequency and amplitude. These are used to inject test signals into circuits and measure the output results.

Watch a video HERE

Oscilloscope

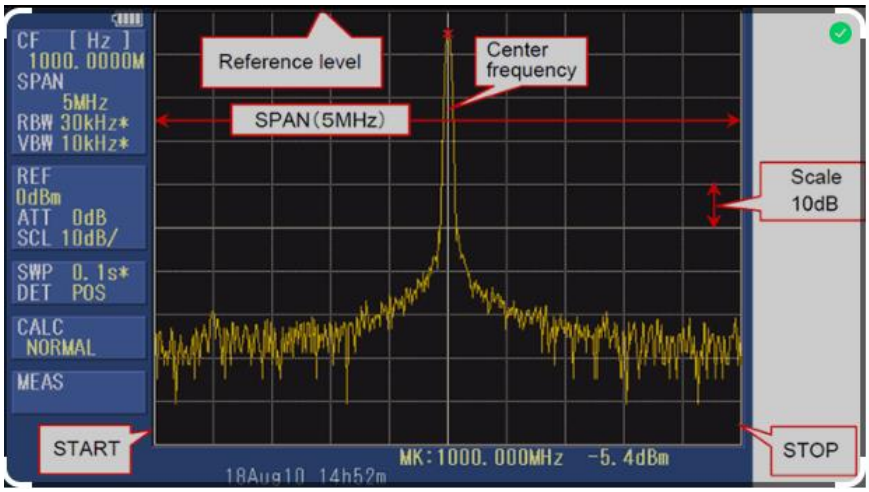
An oscilloscope is a device that displays the waveform of electronic signals. The image is displayed in amplitude and the time domain.



Watch a video HERE

Spectrum Analyzer

A spectrum analyzer is a device that measures and displays signal amplitude (strength) as it varies by frequency within its frequency range (spectrum).

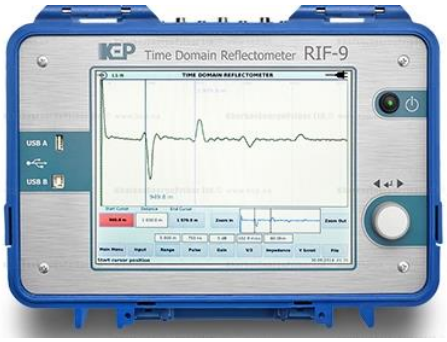


Watch a video HERE

Time Domain Reflectometer

A time-domain reflectometer (TDR) is a measurement tool used to measure the impedance profile of a component (device) under test (DUT). The concept is straightforward. Using a step generator and an oscilloscope, a fast pulse edge is launched into the DUT and the results are viewed.

TDR are handy to find a broken cable. If a coax, many meters long, has a break, the TDR signal can calculate the distance the break is from the device.

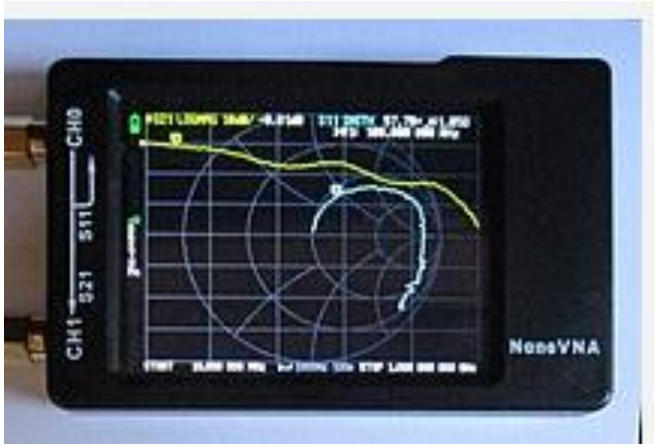


Watch a video HERE

Vector Network Analyser (VNA)

These are relatively new to amateur radio users as previously the cost of these devices was very high.

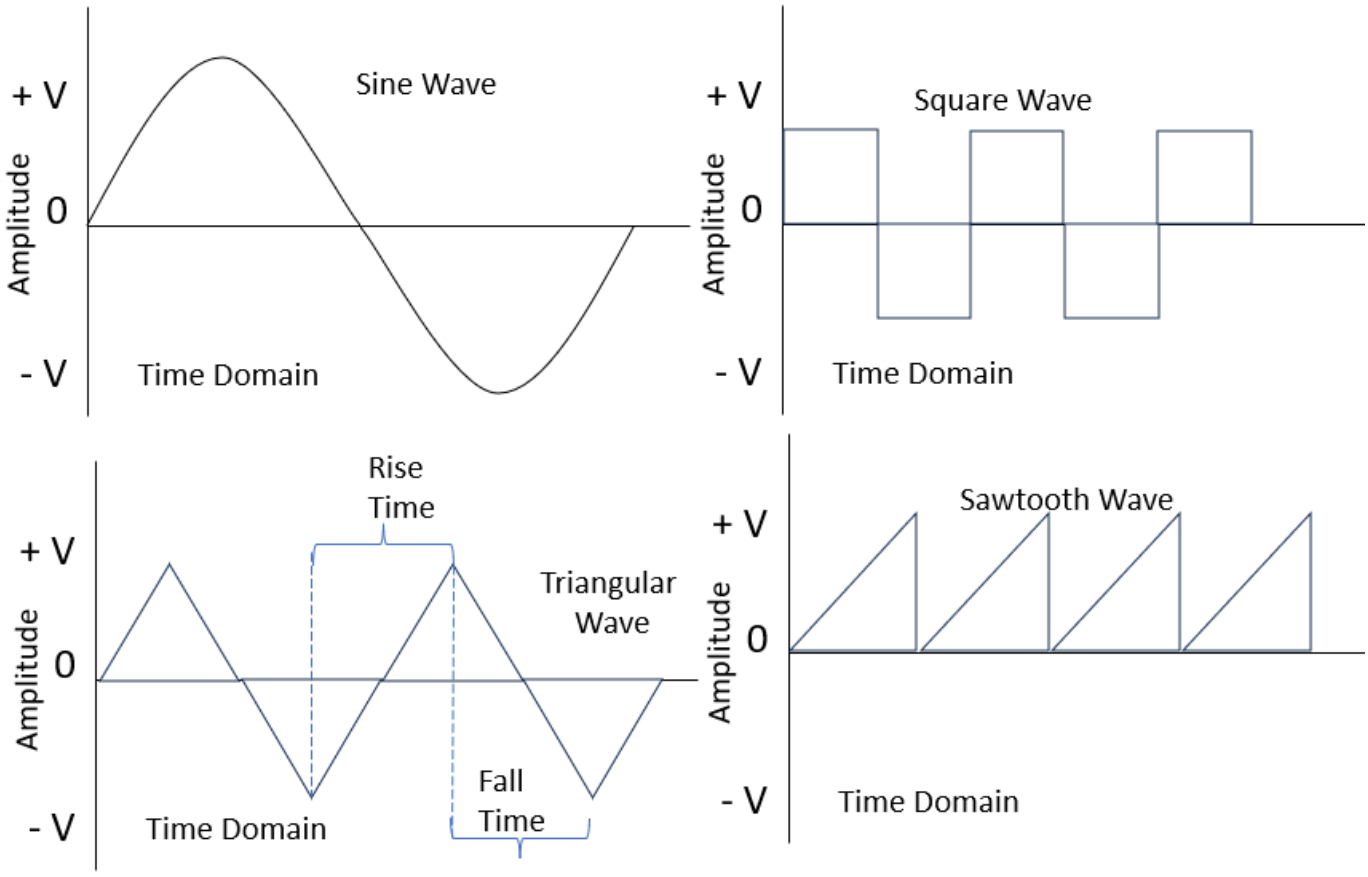
VNAs are used in a wide range of RF and high frequency applications. A VNA injects a known RF signal to the device under test and measures the voltage across its terminals. The VNA can calculate the (complex) impedance. The measurement circuit compares both the amplitude and the phase of the measured signal to that of the source. For gain or loss measurement the VNA connects the same source signal to one port and measures the output signal at the other port of the device under test.



Watch a video HERE

Measuring Waveforms

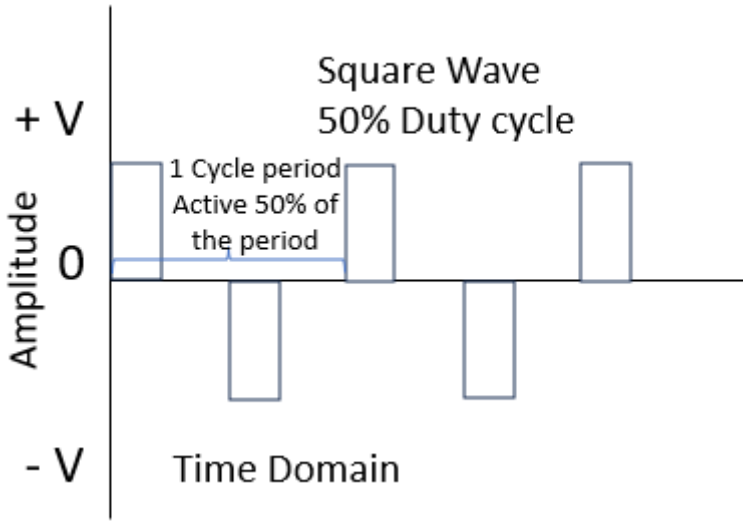
A signal carries information and a waveform does not. A waveform is a representation of voltage or a current over time. The best device for viewing and measuring waveforms is the oscilloscope. Sample wave forms are shown below.



There are additional considerations when measuring wave forms compared to a simple sine wave.

- **Frequency.** - If a signal is continually repeated, the frequency can be calculated.
- **Period** - The time that it takes for a repeating signal to complete one cycle.
- **Voltage** – Peak or Peak-to-peak voltage can be measured.
- **Amplitude** – Highest voltage at one point.
- **Phase** - Variations in time/position between two comparable signals.

- **Rise/Fall Time** - The rise and fall time of a signal describes the transition of the signal from a low to a high level (or vice versa).
- **Duty cycle** – The ratio of the time a waveform is present during the period of the wave form.



Measurement Errors

The errors occurring when testing are known as measurement errors, and these are grouped into three broad categories.

- Operator Errors
- System Errors
- Random Errors

Operator Errors

Operator errors can vary from ser to user, depending on the experience of the user.
Some common operator errors can be due to one or all of the following examples.

- Selection of the incorrect instrument. If in doubt, ask but this error will reduce with experience.
- Parallax error. This occurs on needle indicator equipment where the operator views the needle at an angle and not directly above.
- Failure to Calibrate

System Errors

- Instrument Error – The measuring device may not be sensitive enough for the task.
- Environmental Error – Environmental effects such as temperature and temperature may impact results.
- Errors in the frequency of the crystal oscillator for frequency measurement.

Random Errors

These errors are unpredictable and not possible to eliminate or minimize. Being consistent with your measurements is a method to minimize any random errors.