Chapter 5

Function Generators and Oscilloscopes

5.1 Function generator (or signal generator)

- used when you want a known time-varying signal to feed into a circuit

5.1.1 Waveform characteristics

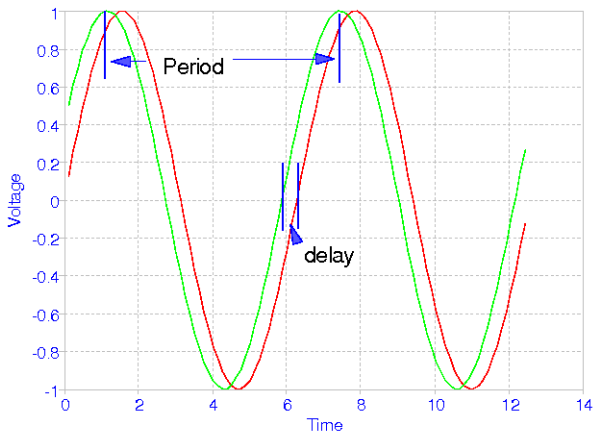

Figure 5.1: Waveform

- Shape
  - Depends on application
  - Usually square, sine, triangle available
  - Other possibilities are ramp and pulse (see below)
- Frequency
  - Measured in Hz
  - Rate of full cycle
  - $Frequency = \frac{1}{period}$
- Amplitude
  - Measured in volts or mV
  - Can be given as peak-to-peak or as amplitude
  - AC component of a signal (see below)
- Phase
  - Measured in degrees
  - Compare the time difference between two signals
- Offset
  - Measured in volts or mV
  - Sometimes you don't want a signal centred around zero volts.
  - DC component of a signal (see above)
  - **Warning: Different signal generators handle switching from zero DC offset to adjustable DC offset differently!**

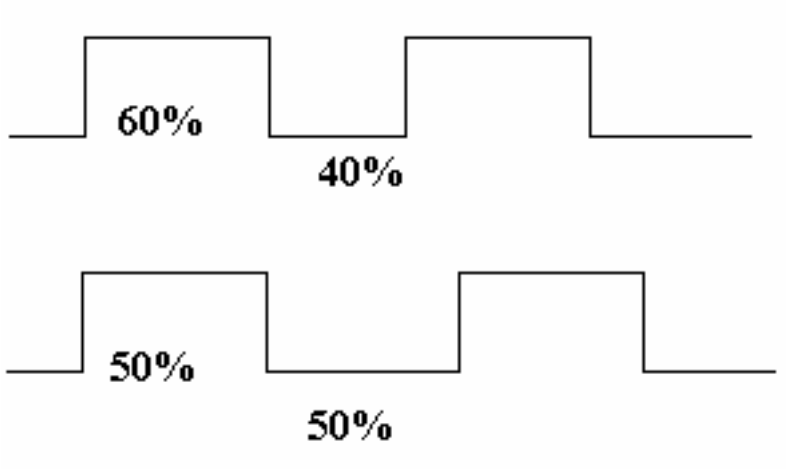

Figure 5.2: Duty cycle

Special characteristics of pulse waveforms

- Duty cycle
  - Measured in percent
  - Sometimes you don't want the high and low parts equal
  - Usually referred to like this: "60-40" which means 60% of the time it will be high; 40% of the time it will be low;
- Rise time/Fall time
  - Measured in ms, ns, etc.
  - Sometimes you don't want the edges of the signal to be vertical; you want the changes to be ramps rather than vertical

5.1.2 Connector characteristics

- Connector types
  - Usually BNC (bayonet Neil-Concelman) or bananna plugs
  - Sometimes there are different ones for signals that can only be square or pulse for use in logic circuits
  - **BNC connectors are polarized for a reason; usually the outside connector is grounded**
  - BNC connectors are *coaxial* to shield them from electrical noise
- Output resistance
  - Think of the output as a voltage followed by a series resistor
  - Output voltage will start to drop if enough current is drawn
  - *If you put a resistor from the output to ground, what value of R would drop the output voltage to half of what it would be otherwise?*
- Inputs
  - Some function generators will have inputs to allow control of the output signals (such as a TTL signal to turn the output ON or OFF)

5.2 Oscilloscope

- a very fancy voltmeter *with one important difference*
- allows you to see how a voltage varies in time

Question: How do you display a signal that changes very quickly, (say 1000 times per second?)

1. slow it down, and don't try to keep up
2. *if it's periodic*, i.e. it repeats at certain intervals, keep "replaying" successive intervals so it looks static (like a stagecoach wheel in a movie, or many stroboscope effects)

An oscilloscope uses the second approach.[1]

In a periodic signal, every time it repeats, every point in the signal will be repeated. Consider a sine wave: Except for the peak and the trough, every value within the waveform will be repeated twice in one cycle; once on the way up, and once on the way down. If we pick a value and a direction, (going up or down), we can specify any point in the cycle uniquely.

If we now start drawing the signal on a screen at that point, we will show some of the wave. If we then look for the same point on the *next* cycle, and redraw it over the original, it should look exactly the same. This is how a scope works.

Most scopes have at least two input channels, so that two signals can be compared.

5.2.1 Triggering

1. channel
2. level
3. polarity

[1] Actually a digital storage scope can use the first one as well.

5.2.2 Leads and inputs

1. single voltage and ground; *not differential voltage!*
2. 1x, 10x probes (must agree with channel setting)
3. external trigger

5.2.3 Channels

1. X, Y ; *Make sure to use ground clips!*
2. 1x, 10x probe (must agree with lead)
3. vertical resolution
4. vertical position
5. AC/DC coupling (like meter)

5.2.4 Other controls and features

1. horizontal position
2. XY mode (instead of timebase mode)
3. signal math; X + Y, X - Y *last one allows differential measurement*