Principles of Signal Generators

A signal generator is an electronic instrument that generates repeating voltage waveforms. An ideal signal generator can simply be modeled as a voltage source as shown in Fig 2.1.1 (a)

(a)   (b)
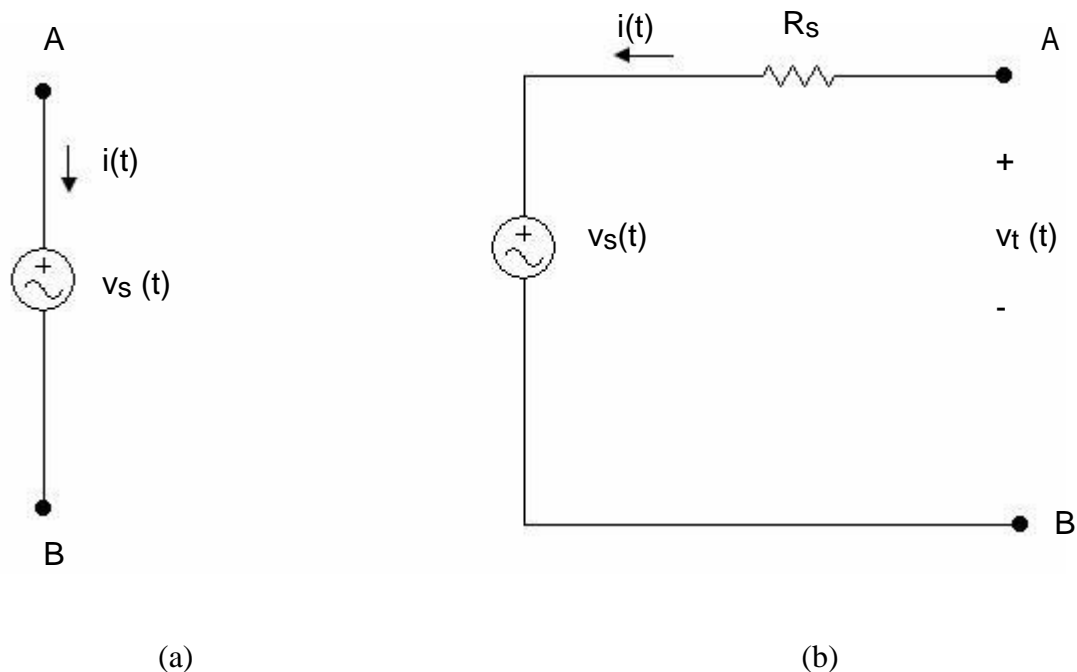
Fig 2.1.1

where $V_S(t)$ is a specified function of time. A practical signal generator is modeled as an ideal signal generator connected to a series source resistance (output resistance) R_S as shown in Fig 2.1.1 (b). The terminal voltage, $v(t)$, is the output of the signal generator and depends on the terminal current, $i(t)$, and R_S. $V_S(t)$ can be, in general, a sine wave, a square wave, a triangular wave or a pulse train. The first three are characterized by three parameters: frequency (or period), amplitude, and DC (Offset) value. The pulse train is associated with frequency, amplitude and pulse duration.

These parameters can be set to any value in the operation range of the signal generator, using the external controls. In general, amplitude ranges of signal generators vary from 10 mV to 20 V, and frequency ranges vary from 1µHz to 40 MHz. This means signals for which the amplitude and frequency can be set to any value in these ranges can be generated using these signal generators.

Signal generators usually produce more than one type of signals. Different signal types can be obtained by proper connection and/or switching.

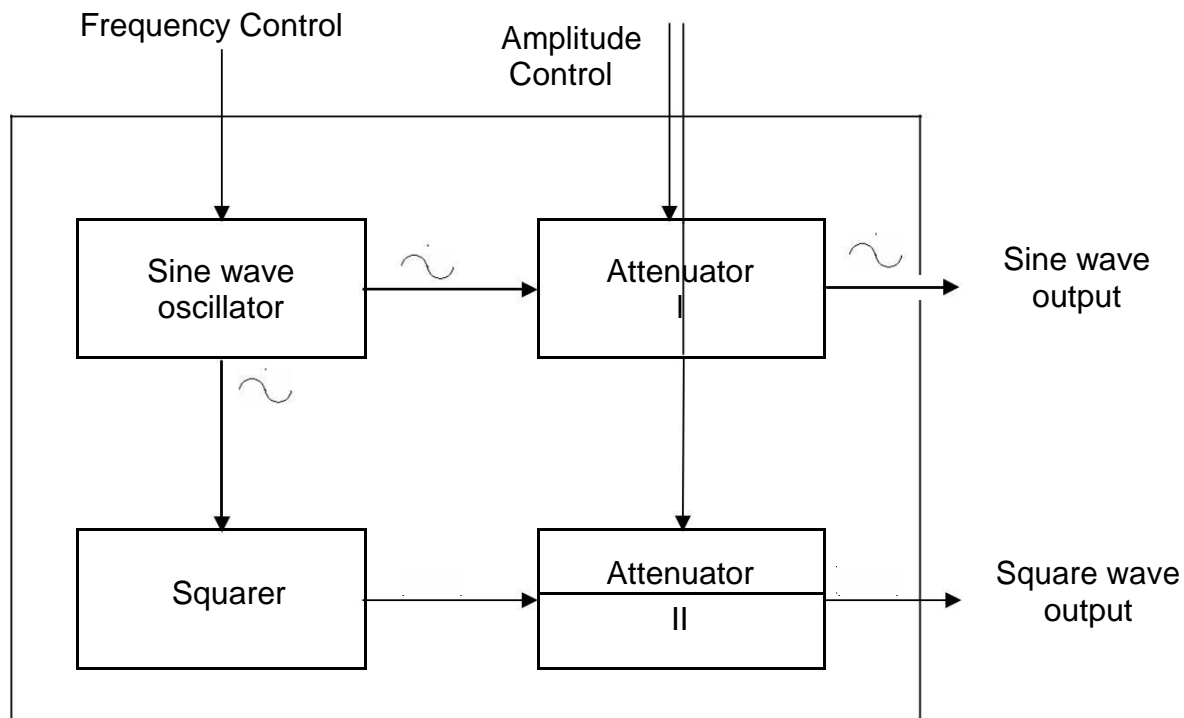A simplified block diagram of a sine and square wave generator is given in Fig.2.1.2.

Fig 2.1.2

A sine wave oscillator is the heart of the signal generator. It generates a sine wave of fixed amplitude and adjustable frequency, which is set by the external frequency control. This signal is fed to both attenuator I and squarer. The signal amplitude is set to the desired value determined by external controls, by attenuator I. The output of attenuator I is a sine wave with desired amplitude and frequency.

The squarer generates a square wave of fixed amplitude and at the same frequency with the sine wave. The output of the squarer is fed to attenuator II which acts similar to attenuator I. The output is the square wave with amplitude and frequency which are determined externally.

Effect of Output resistance

As explained above, terminal voltage depends on source voltage ($V_S(t)$) and terminal current ($i(t)$). For example given $V_S(t)=20\sin(wt)$ Volts, and $R_S=50$ Ohm, terminal voltage for a 10 KOhm load is 19.9 $\sin(wt)$ Volts, but if a load of 50 Ohm is connected, terminal voltage drops to $10\sin(wt)$ Volts. The terminal voltage will be closer to the $V_S(t)$ if the resistance of the load is higher. The value of the output resistance is mostly written on the front panel of the signal generator, and its effects should be considered when dealing with low circuits with low resistance.

In most of the digital signal generators the user can specify the resistance of the circuit to be connected to the signal generator (default value for Agilent 33220A is 50 Ohm).
However,changing this value does not affect the output resistance of the signal generator, but rather informs the signal generator, about the circuit in order to modify its output so that the user selected waveform properties (amplitude) can be seen between the output terminals.

Also when dealing with circuits with high resistance, the existence of the output resistance of the signal generator as a very small effect on the value of the terminal voltage as seen in the previous example. In such cases the signal generator can be used in High-Z mode. In this case, if the connected circuit is specified to have a large resistance value, source voltage is directly set to the desired terminal voltage.

For example if a terminal voltage of 5sin(wt) Volts is desired when connecting the signal generator (output resistance of the signal generator is 50 ohm) to a 25 Ohm circuit. When the resistance value of the circuit is specified, the signal generator adjusts its source voltage, $V_S(t)$ to 15sin(wt) Volts, in order to output the desired voltage between the terminals. Using the same settings, if the signal generator is connected to a 10 KOhm circuit the voltage between the output terminals will be approximately 15sin(wt) Volts. If the signal generator is set to its High-Z mode the voltage between the output terminals will be approximately 5sin(wt) Volts.

Grounded Output – Floating Output

The signal generators can be separated into two categories depending on their output characteristics: Floating output signal generators and grounded output signal generators.

Grounded Output Signal Generators: One of the output terminals is ground, and should be connected to the ground of the circuit (or ground probes of other instruments in the circuit). The value of the other output terminal is the desired output voltage with respect to the ground.

Floating Output Signal Generators: There is no necessity to connect one of the output terminals to ground. Actually floating output signal generators can be connected in series to other signal generators or power supplies. The voltage in one output terminal is the desired voltage with respect to the other terminal, whatever the value of the other terminal is.
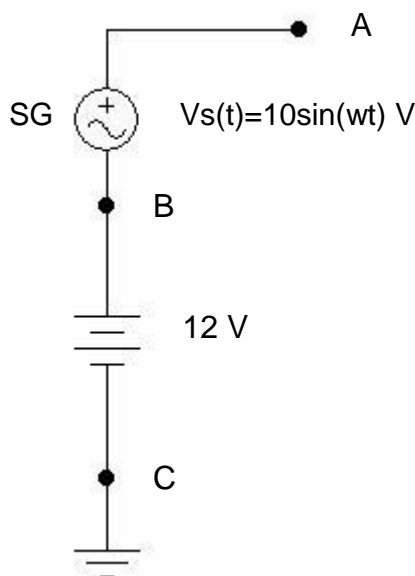
Consider the circuit shown in Fig 2.1.3. A signal generator (SG) is connected in series to a 12 Volt power supply. If the signal generator is a grounded output signal generator, one of the output terminals should be ground terminal. If the ground terminal is connected to B then $V_{BC}=0$ as both B and C are grounded (0 V). And $V_{AC}=$ 10sin(wt) Volts, the power supply has no function.

But if a floating output signal generator is used V_{AC} would be 12+10sin(wt) Volts.

Fig 2.1.3