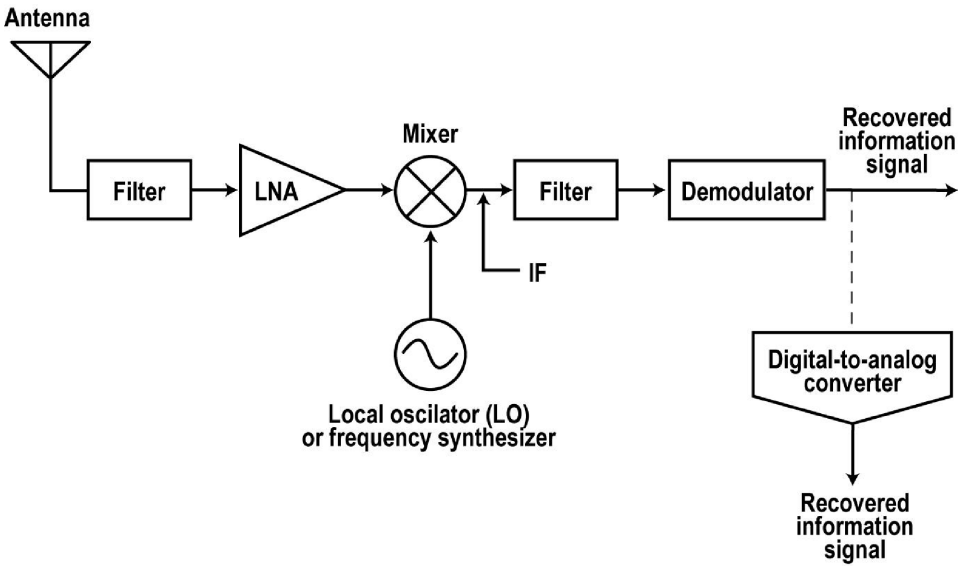
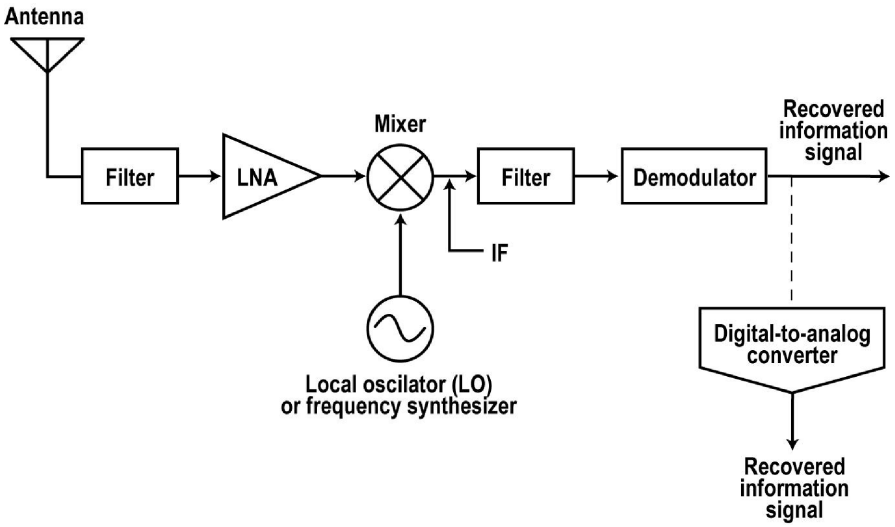
The Electronics of Wireless

Receiver



In a typical receiver, the antenna picks up the signal from space and sends it down a transmission line such as coax cable. The signal is picked up by a filter that selects the signal to be received. The filter feeds the RF amplifier. The RF amplifier is usually called a low noise amplifier (LNA) because it amplifies the very small signal but adds very little noise to the already noisy signal.

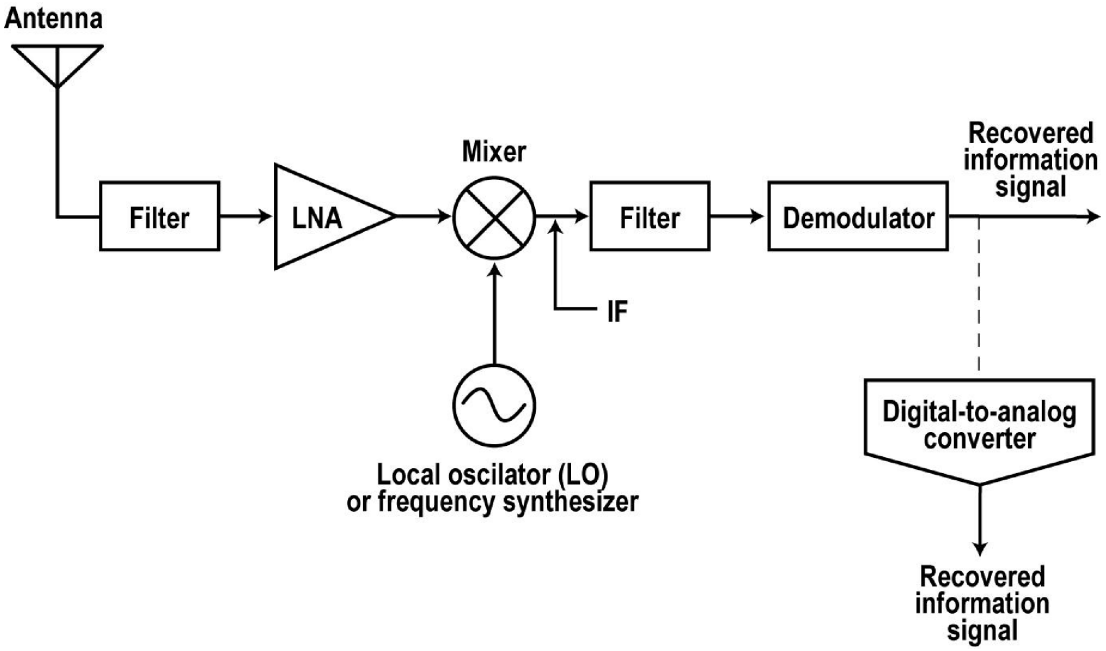
LNA Output



The LNA output goes to a mixer where it is combined with the signal from a tunable oscillator called the local oscillator (LO). The LO allows the desired signal to be selected.

In most cases today, the local oscillator signal comes from a frequency synthesizer. It generates the LO signal but has a provision for changing the operating frequency in increments corresponding to the regulations governing the wireless application.

Mixer



The mixer produces the sum and difference frequencies of the received signal f_s and the local oscillator signal f_o or (f_s+ f_o) and (f_o –f_s). A band pass filter selects the lower difference frequency. This process is known as downconversion. The lower frequency is known as the intermediate frequency (IF).

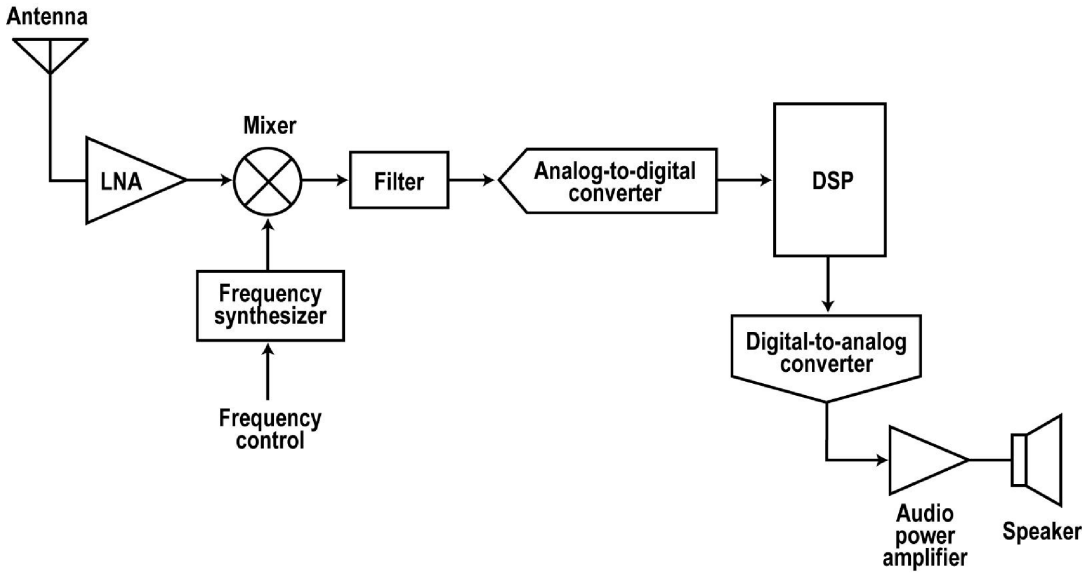
Superheterodyne Receivers

Receivers that convert the incoming signal down to a lower frequency are called superheterodyne receivers. This downconversion is done because it is easier to avoid some types of signal interference and easier to get the selectivity to distinguish one incoming signal from the other.

Assume the incoming signal is 102.7 MHz and the LO signal is 113.4 MHz. The IF is 113.4 – 102.7 = 10.7 MHz. 10.7 MHz is a common IF.

The IF signal contains all of the original modulation such as voice. It is then sent to a demodulator where the original information signal is recovered. The recovered signal is then processed as required by the application. If the recovered signal is digital that represents voice, it is converted to analog by the digital-to-analog converter (DAC) that produces the original analog voice signal. It is then amplified and sent to a speaker or earphone.

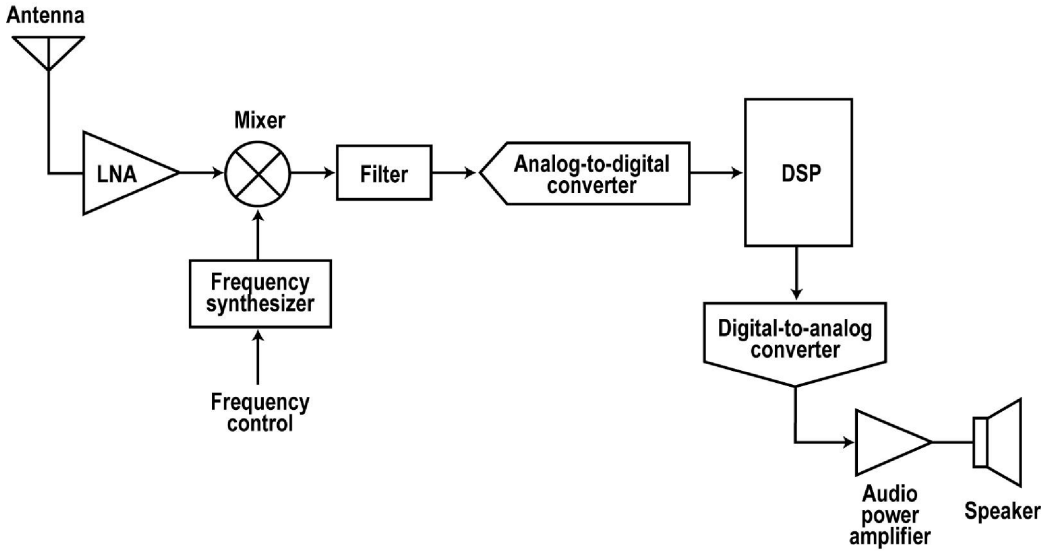
Software Defined Radio Receiver Inputs



A software defined radio (SDR) is one that uses software running on an embedded microcomputer called a digital signal processing (DSP) chip to perform more of the receiver's functions.

In the simplified form of SDR shown here, the incoming signal is amplified in the LNA and sent to a mixer. The other input to the mixer is the LO signal from the frequency synthesizer. The mixer output is the IF which is filtered.

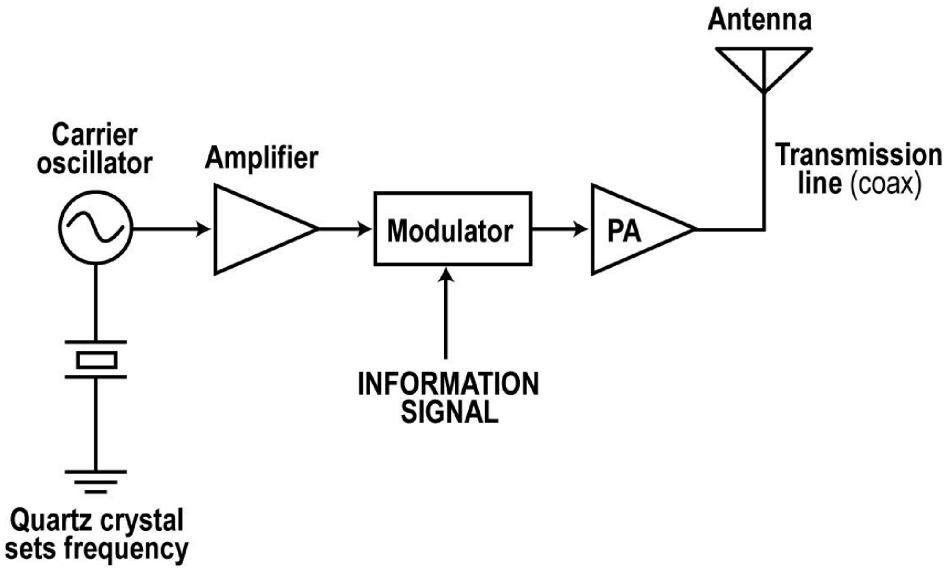
Software Defined Radio Receiver Outputs



The IF signal is sent to an analog-to-digital converter (ADC) where a digital bit stream is developed and sent to the DSP. The DSP performs all additional operations digitally including additional mixing, demodulation, filtering, decoding, and others.

If the output is voice, the digitized voice is sent to a DAC for conversion to analog and amplification before being sent to the speaker.

A Simple Transmitter

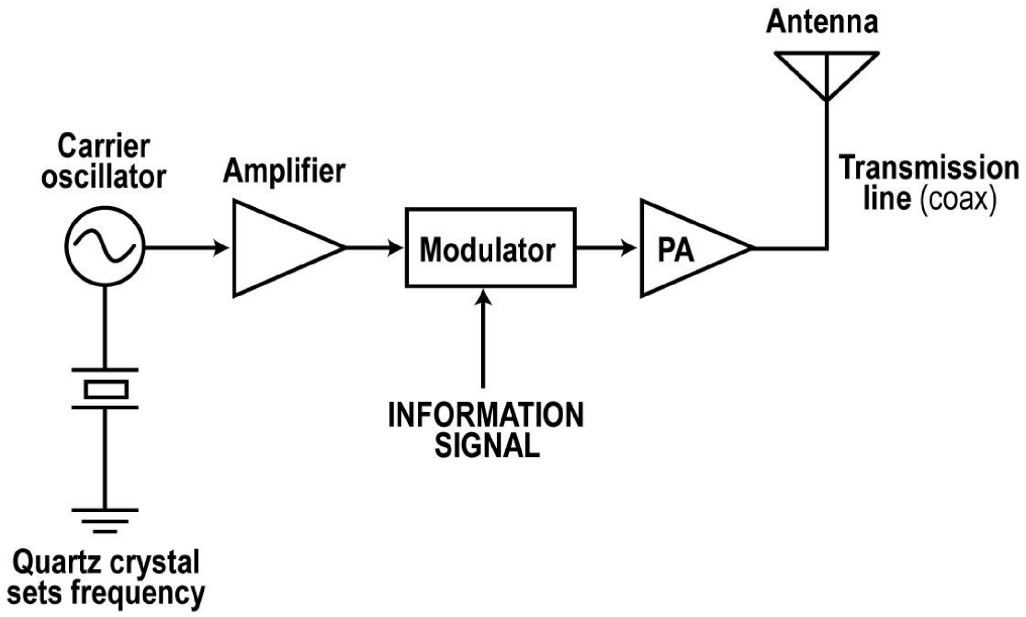


A generic block diagram representative of the simplest form of wireless transmitters is shown here.

The wireless signal to be transmitted begins by developing the carrier signal. This is done with a crystal oscillator. The oscillator circuit generates the signal whose frequency is set by the quartz crystal.

This low level signal is then amplified to give it greater power.

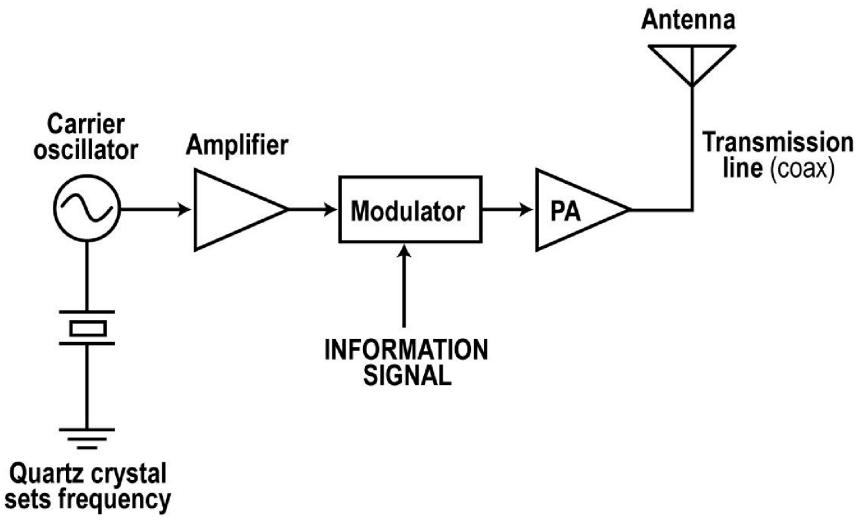
Modulation and Amplification



Next the signal is sent to the modulator where the information modifies the carrier. The information is usually voice, but can also be video or digital data.

The modulated signal is then amplified in a power amplifier (PA). The maximum amount of output power to be radiated is set by the FCC but is important because it determines how far a signal will travel.

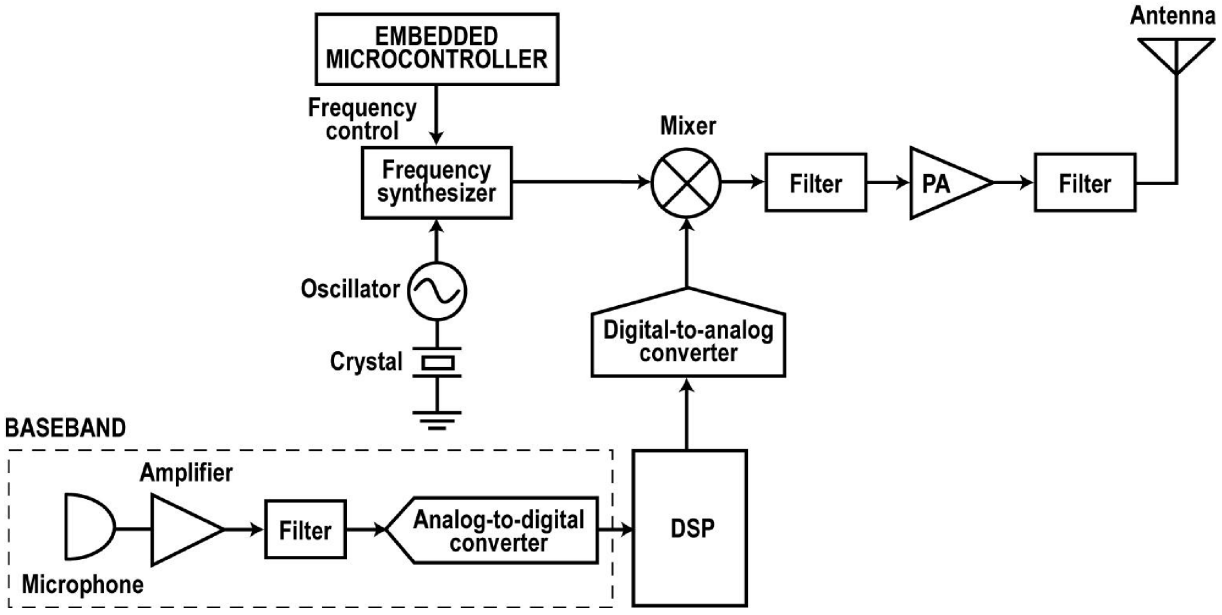
Antenna



The amplified signal is then applied to a transmission line, usually a length of coax cable. The transmission line carries the signal to the antenna.

The antenna may be just a short loop of copper on a printed circuit board or a complex array of conductors on a 200 foot tower.

A More Sophisticated Transmitter

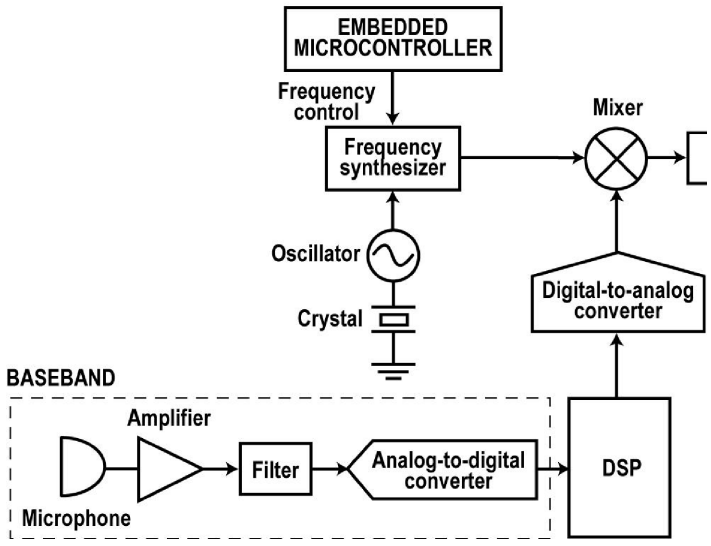


A more complex but more typically more representative transmitter is shown here.

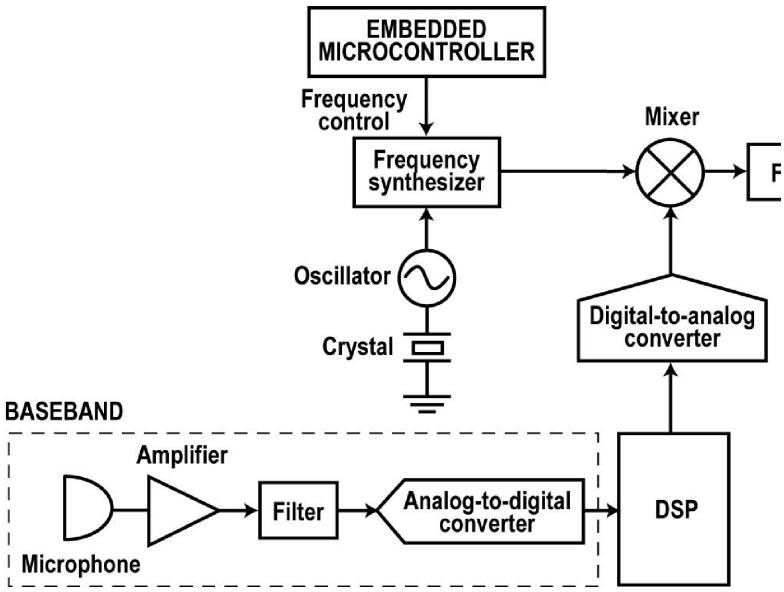
In wireless radios that must operate on multiple channels, the signal begins with a frequency synthesizer that generates the carrier frequency.

Frequency Synthesizer

The synthesizer frequency is changed usually by a digital input signal or code sent to it by an embedded microcontroller or external computer. The frequency may be selected by the user with a keyboard or other manual means or it may be chosen automatically by the wireless system in accordance with some plan or the operating conditions. The synthesizer output is then sent to a mixer circuit.

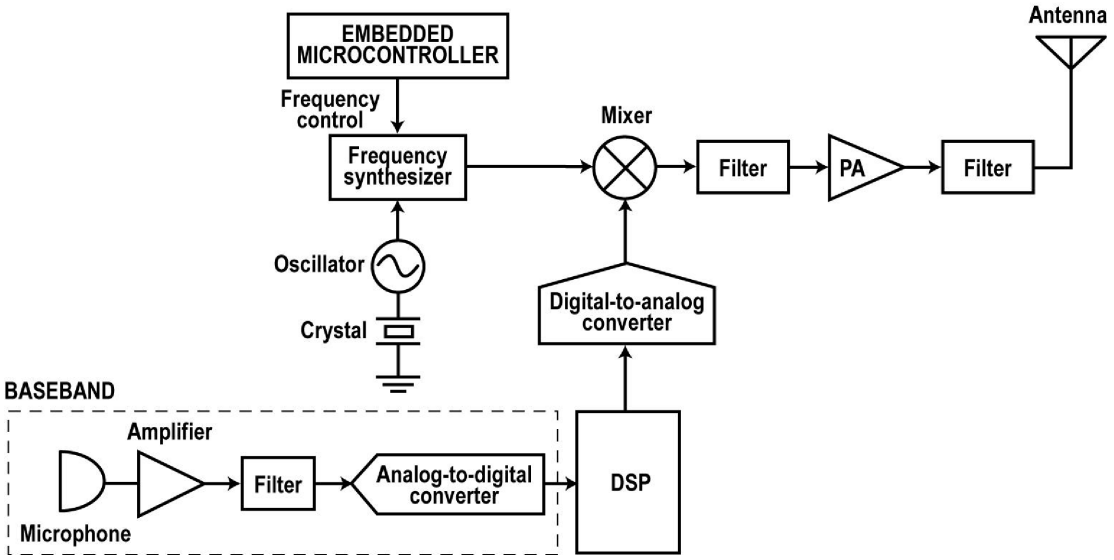


Mixer



The information to be transmitted usually comes from a section of the radio called the baseband section. This section processes the original signal and prepares it for modulation. For example, in a cell phone, the voice from the microphone is amplified, filtered, and converted into a serial binary signal by the ADC.

DSP



This signal is then further processed in the DSP with special coding. The DSP also performs modulation. The resulting baseband signal is then converted to analog by the DAC.

The DAC output is then sent to the mixer that generates the modulated signal at the carrier frequency.

The signal is then sent to a final power amplifier and the antenna.

Transceiver

Today, most radios contain both a transmitter and a receiver and the combination called a transceiver or radio modem.

Transceivers are usually implemented in integrated circuit form where most of the circuitry is contained in one or two chips. One chip includes the RF circuitry while the other contains the baseband processing circuits. In some cases, both RF and baseband sections are contained in the same chip.

The radio may still contain some discrete components external to the IC. These include those items that cannot be implemented in IC form such as the quartz crystal, some larger inductors, capacitors, or transformers. Many power amplifiers are also in a separate IC because of the amount of heat they produce.

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The Electronics of Wireless

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