23.8: Carrier Recovery

Carrier recovery refers to establishing a local carrier reference signal which accurately reproduces the frequency and, with some modulation methods, the phase of the carrier of the modulated signal. All digital modulation methods require carrier recovery to establish a reference to determine the state of the carrier at the clock ticks. In addition digital modulation methods require that the timing of the clock ticks be established. Since radios using digital modulation all send packets of data, i.e. sequences of symbols, having a known sequence at the beginning of packet transmission enables the timing to be determined.

With FSK modulation the frequency at the clock ticks must be determined. This is relatively simple because the frequency at the clock ticks can be accurately measured as a local clock can be established within a few hertz because of the availability of accurate crystal references. The frequency of the received signal can still be shifted by the Doppler effect of the transmitter or receiver is moving but this is quite small compared to the frequency differences between the received states. With FSK it is not necessary to determine the phase of the carrier.

All digital modulation other than FSK modulates a carrier by shifting the carrier's phase and/or amplitude to a number of discrete states. Recovering the state of this modulated carrier requires that the phase of the carrier be recovered from the receive signal and to do this there must be a constant phase local version of the carrier. The circuits that implement the local version of the carrier are called carrier recovery circuits. These circuits modify a very stable internal oscillator in the receiver that after an initial setting of an approximate frequency, has a frequency and phase that can only change slowly. However, there must be a received signal at all times, because if the received signal falls below the noise level the carrier recovery circuit will try to track the noise. This requirement has led to a number of different modulation schemes that avoid the amplitude of the modulated signal from ever being small during a transition. This is important in 2G and 3G cellular radio but 4G and 5G cellular systems use pilot tones to achieve carrier recovery.

In early digital radios carrier recovery was implemented in analog circuitry and more modern radios implement carrier recovery by splitting the function between an analog oscillator signal that can be assigned to a large number of discrete states (providing course carrier recovery) and DSP of the (coarsely recovered) baseband signal to precisely recover the carrier signal. Thus in modern digital radios the carrier recovery circuit is implemented partially as an analog circuit and partially as a digital circuit.