Mixer Application Guide

The unique characteristics of the double balanced ring modulator utilizing Schottky-Barrier diodes with their high speed switching, square law characteristic, and low noise, provide a near ideal component for a variety of applications in modern communications and navigation systems. TELE-TECH employs a variety of proprietary, very wide band ferrite hybrid techniques, which assure exceptional performance in all possible applications.

**TERMS and DEFINITIONS:** The ring quad double balanced mixer is the most versatile configuration and the most popularly used mixer. All TELE-TECH mixers use the ring quad configuration with the exception of the single balanced units and some high level models.

![Fig. 1 - Double Balanced Mixer](image)

Figure 1 is a schematic representation of a typical double balanced mixer. By unfortunate convention, the three ports of the mixer have come to be known as the Local Oscillator (LO) port, the Radio Frequency (RF) port, and the Intermediate Frequency (IF) port. The LO port is the transformer coupled port whose transformer secondary is signal grounded. The RF port is the transformer coupled port whose transformer secondary center tap is used as the IF port. These labels are for port identification only and should not be confused with the actual signals applied to the ports in its application. For purposes of application clarity, the high level switching signal will be referred to as the CARRIER signal, the lower level linear signal will be called the INPUT signal, and the result will be the OUTPUT.

**MIXER or FREQUENCY TRANSLATOR:** When the mixer is applied as an upper or lower sideband, up or down converter, the ports to which the CARRIER and INPUT should be applied is dictated by the particular design requirement. In signal generator, synthesizer, or transmitter applications where CARRIER and INPUT signal suppression are paramount, it might be advisable to apply the CARRIER signal to the RF port and the INPUT to the IF port. This will result in the maximum isolation of these two signals from the OUTPUT at the LO port. In applications where maximum isolation of the CARRIER from the INPUT signal is required, such as receiver front ends where local oscillator radiation is of concern, the CARRIER should be applied to the LO, the INPUT to the RF, and the OUTPUT taken from the IF port. The double balanced mixer will operator in any combination of signals and ports but the IF port is the only one which will go to DC.

**DSB or AM MODULATOR:** Double Side Band (DSB) and Amplitude Modulation (AM) applications dictate the CARRIER be applied to the LO port and the baseband or audio INPUT be
applied to the IF port. A DSB suppressed carrier OUTPUT will appear at the RF port. For AM applications, the desired amount of CARRIER may be reinserted by adding a controlled DC current to the IF port. In Single Side Band (SSB) systems where the modulator is followed by a high selectivity filter for selecting one of the sidebands, it is advisable to isolate the mixer OUTPUT from the out-of-band impedance gyrations seen by the undesired sideband to minimize Intermodulation Distortion (IMD) products.

**PULSE or BIPHASE MODULATOR:** If the CARRIER signal is applied to the LO port, it will be suppressed at the RF port by at least the specified LO-RF isolation. For pulse modulation applications, a current pulse of 20mA of either polarity applied to the IF port will pass the CARRIER through at very little insertion loss for the duration of the pulse. For biphase modulation applications, reversal of the 20mA IF port current will shift the CARRIER phase by 180 degrees. In most mixers the IF port will switch in less than one nanosecond and will support a pulse of any duration.

![Graph](image)

**Fig. 2 - IF-DC Output vs. LO-RF Phase Difference**

**PRODUCT or PHASE DETECTOR:** In SSB product detector applications the local CARRIER should be applied to the LO port and the INPUT SSB signal to be demodulated should be applied to the RF port. The baseband OUTPUT with all of its components down to DC will appear at the IF port. In phase comparator or phase detection applications, the reference local CARRIER should be applied to the LO port and the INPUT signal to be compared or demodulated should be applied to the RF port. A DC voltage proportional to the phase difference between the reference and INPUT signal will appear at the IF port. Unless otherwise specified, this voltage will be negative for in phase signals if the mixer is connected as recommended. For best performance, the IF port should be bypassed at the signal frequencies and loaded with 1000 ohms. The load resistance can be varied to optimize the linearity of the voltage versus phase characteristic.
ATTENUATOR or SWITCH: The LO-RF port isolation is almost inversely proportional to the DC current flowing in the IF port. Therefore, the double balanced mixer may be applied as a wide range current controlled attenuator or high-speed switch. The control current polarity is irrelevant.

PCB MIXERS: When applying through hole PCB mixers, best performance will be obtained with a large top-side ground plane common to all the mixer ground pins and their associated CARRIER and INPUT signals. The width of the circuit side conductors carrying the signal to and from the mixer should be calculated to form 50 ohm striplines with the top side ground plane (typically 0.17 inch wide for 1/16 inch glass epoxy). All of the unused and ground pins should be connected together on the circuit side and plated through to the top side ground plane to form a ground plane barrier between the signal ports. Glass epoxy (G-10) PCB will generally prove adequate for frequencies up to 500 MHz but for higher frequencies, glass Teflon or equivalent is recommended.

Fig. 3 - LO-RF Attenuation vs. Current