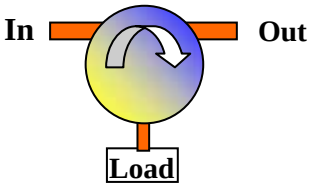
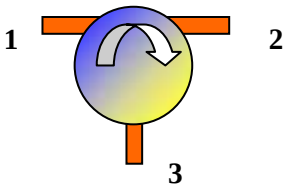
RADITEK INC. Circulator and Isolator Primer

A circulator is a three port device. It is essentially a passive device, but can exhibit some characteristics that make it almost behave as if it were active. An isolator is a two port device having an input and an output, it is simply a circulator whose third port has been terminated.



Isolator

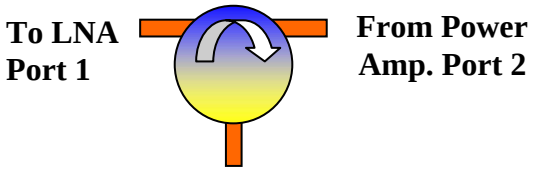


Circulator

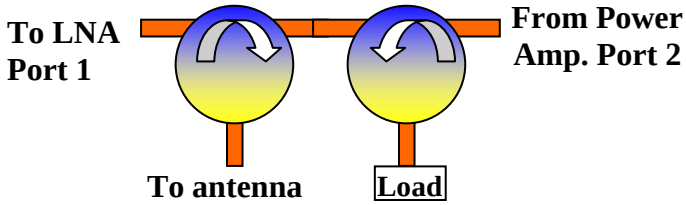
Circulators and Isolators provide unique transmission paths, allowing RF energy to pass in one direction with little (insertion) loss, but with high loss (isolation) in the other direction.

An isolator can exist as Stripline, Coaxial, Microstrip, or Waveguide type, and can be rated for powers from milliwatts to Megawatts. Raditek can provide superb stripline isolators to 18GHz, and Microstrip to over 100 GHz.

A typical use of a circulator would be as a duplexer, connecting a transmitter to Port 1, antenna to port 2 and receiver to port 3. This provides simultaneous transmission and reception of signals.



Simple single junction



Better performance with an iso-circulator as shown.
e.g. see the Microstrip dual junction duplexer for LMDS

A very common use is at the output of a power amplifier. Forward power is passed with a minimal insertion loss. Reverse power resulting from disconnect at the output (removing the connection to antenna), will (with no isolator installed) flow back to the output FET/LDMOS etc. and likely damage or destroy it/them. With the isolator installed, any reflected power will flow into the isolator's load and be safely dissipated as heat (as long as the load is rated to handle the power, and is properly heat sunk, so that the load temperature stays <100°C). **The 100 Watt loads and attenuators, for example, will typically derate to 0 Watts dissipation at 150 °C.**

Typical stripline parameters could be 0.25dB insertion loss, 22dB isolation and VSWR on the ports of 1.2:1 over a 5% percentage bandwidth. Size increases for greater bandwidths.
Optionally available are: High performance models for extended temperature (e.g. **RI-C8)** and very low intermodulation distortion **(-U),**

Optionally, a monitor tab can be provided on the 100W load, where any reverse energy dissipation can be detected and used to shut down the amplifier. A more precise way to quantitatively and reliably detect reflected power at the isolator is to specify a 20 or 30 dB attenuator as the load.

The Raditek isolators and circulators are believed to have the best performance in the marketplace, within constraints and compromises of physical size, power, and RF performance.

Examples of all of these can be found on our web site at www.raditek.com.

IMPORTANT NOTE:
Usually, RADITEK's Stripline carriers are made from Aluminum or Steel. This conducts the heat away from the load (in the case of a mismatch at the output), better than steel.

The high power loads and attenuators are soldered down with a special, high melting point solder (SN96), which contains Silver, and will allow movement (by expansion or contraction) over temperature extremes, so as to avoid any fractures.

Intermodulation

The Standard RADITEK product line has good, **conditional**, intermodulation performance (but it is not tested for or optimized); for example, with two, 30 Watt tones, 10MHz separated, the typical intermodulation level is around –60dBc. With the high magnetic field version (-H option), the intermodulation level is guaranteed lower, typically –65 to –72dBc. The –U Ultra Low IMD unit has better than –80dBc IMD performance

RADITEK has its own high performance Intermodulation measurement test set for 2 x 50 Watts tones at Cellular frequencies and up 2 x 30 Watt tones at PCS and UMTS Frequencies.

To give the lowest intermodulation a Raditek –U isolator has the load is specially specified, together with many other things to ensure the optimum linearity, necessary for the isolator industries best state of the art performance with the lowest intermodulation and best linearity.

More general information you should know when using a circulator:

It is very important you have a good match rated at the proper power on the third port, for the unit to work consistently.

Failure to do this, will invalidate any specified performance of the unit, including Intermodulation characteristics.

Adding phase (i.e. length of cable) between the third port and the load will also affect performance, and change the "s" parameters.

Raditek recommends using an isolator with a correctly matched load rather than a circulator with an external load to ensure optimum isolation

Assuming the device is properly terminated at its third port, the isolation will hold for any mismatch or phase angle at the output. The insertion loss will have an additional mismatch loss associated with the degree of mismatch at the output, but the device connected to the input of the isolator will not see any power greater than the incident power through the isolator, minus the isolation of the isolator.

Example: If 100 Watts is going through the isolator, and the isolator is open circuit at the output, nearly all power will be reflected back into the output of the isolator and be absorbed in the load (assuming a 100W load and the load is kept to below 100 degrees C by a heatsink). At the input, if the isolator isolation is 25 dB, (the 100Watts is 50 dBm) so <25 dBm (50-25dB) (<0.5 Watts) will be seen by the device at the input.