

A ferrite circulator (Figure 1) is a passive non-reciprocal three-port (common) or 4-port (uncommon) device, in which a microwave or RF (radio frequency) signal entering any port is transmitted to the next port in a clockwise or counterclockwise rotation only.

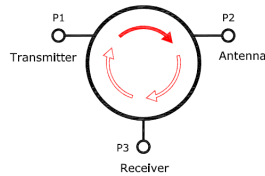


FIGURE 1
3 PORT CIRCULATOR

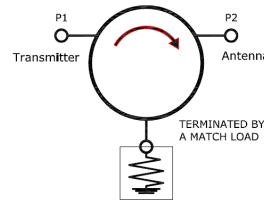


FIGURE 2
2 PORT ISOLATOR

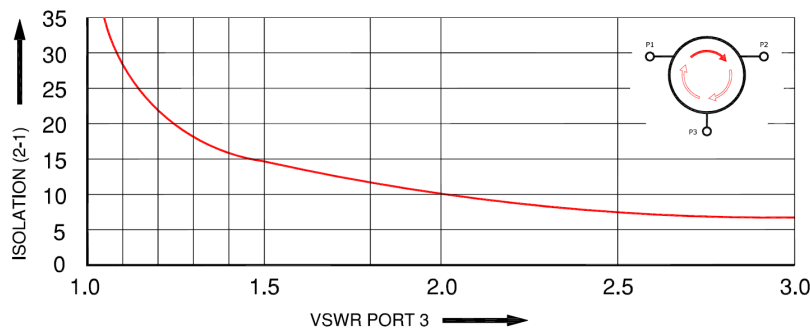
When one of the ports is connected to a matched 50 ohm termination, a circulator becomes an isolator (Figure 2).

Ferrite circulators and isolators are widely used in high frequency applications such as communication systems (radar, cellular base station, etc.) and test equipment. This application note illustrates a few applications of the ferrite circulators and isolators.

The primary functions of three port circulator are twofold:

- To provide a good match at the output of moderate power microwave sources in spite of high system mismatches.
- To act as a duplexer for transmit and receive signals. The first function is depicted in Figure 1

Output power from the transmitter is injected at Port 1 of the circulator. Because of the low loss of the circulator, the power exits at Port 2 essentially unchanged and is radiated out of the antenna. However, signals reflected off the antenna do not return to Port 1 of the circulator, but are dissipated in the Port 3 termination due to the non-reciprocal nature of the junction circulator. Even with a short circuit at Port 2 of the circulator. The Port 1 match presented to the source is typically less than 1.25:1. The Port 2 to Port 1 isolation is better than 20dB; however, the Port 2 to Port 1 isolation is function of the Port 3 VSWR should Port 3 be terminated with a less than well-matched load. The Port 2 to Port 1 isolation will be degraded. The relationship between the Port 3 VSWR and the Port 2 to Port 1 isolation is shown in graphically below:



Systems that share a common antenna for both the transmitter and the receiver use 4 Port circulator as duplexers. (See Figure 3). The transmit signal path is Port 1 to Port 2. The received signal path is Port 2 to Port 3. Mismatched signals that occur at Port 3 are routed to the termination at Port 4 thus protecting the transmitter.

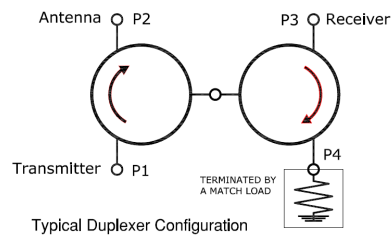


FIGURE 3
4 PORT CIRCULATOR

DECOUPLING OF AMPLIFIER STAGES

Isolators are commonly used for decoupling of cascaded amplifier stages (Figure 4).

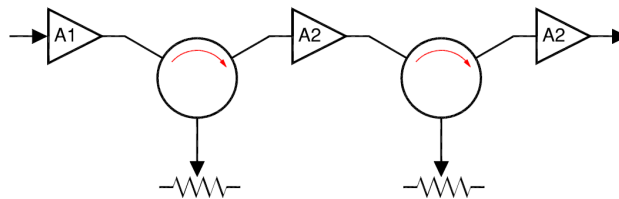


FIGURE 4 - DECOUPLING OF AMPLIFIER STAGES

The isolator between each amplifier stage provides:

- Interstage matching network between amplifiers;
- Protection (from reverse power) for amplifier if any one stage fails.

DECOUPLING OF GENERATORS AND LOAD

To minimize the effect of load, an isolator is connected to the generator (Figure 5). The isolator will attenuate the reflected signal by the same amount as its isolation and will minimize frequency shift and improve the stability of the generator.

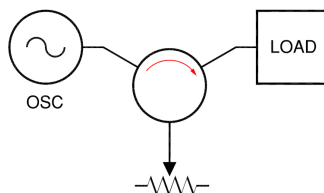


FIGURE 5 - LOAD ISOLATION FOR OSCILLATOR

DUPLEXING

Another common application of ferrite circulators and isolators is duplexing (Figure 6).

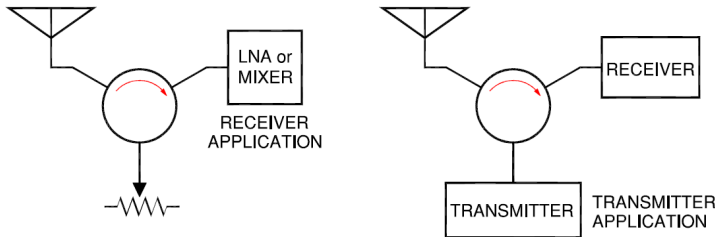


FIGURE 6 - DUPLEXING

By using a circulator or isolator between the antenna and the transmitter/receiver, it avoids interaction between the transmitter and the receiver. Also, the circulator or isolator reduces the effects of impedance changes of the antenna.

MULTIPLEXING

Ferrite circulators and isolators are used to replace 3dB hybrids in multiplexing application (Figure 7) because they have lower insertion loss and higher isolation.

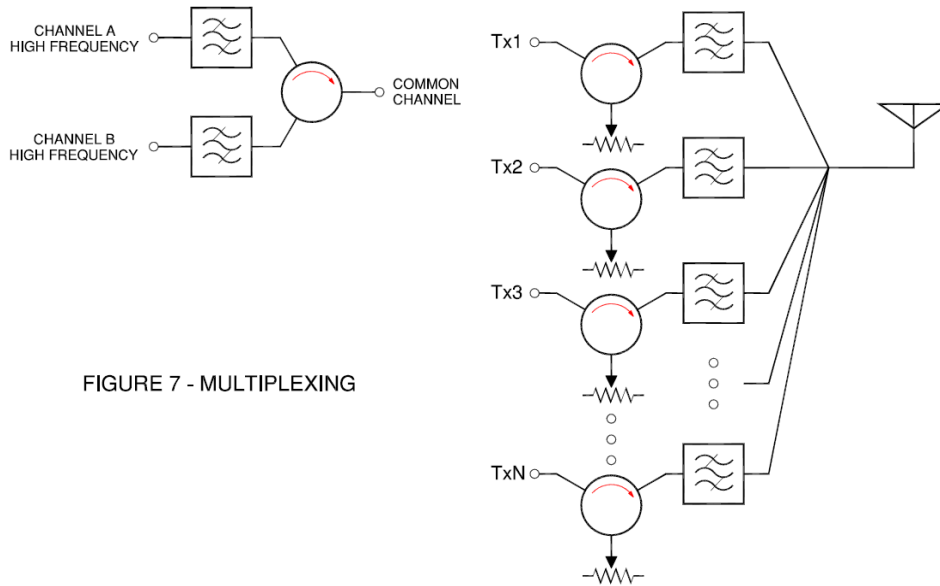
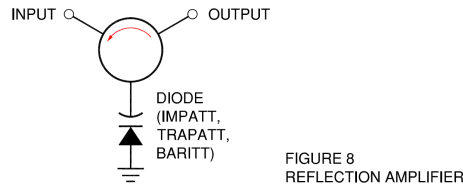


FIGURE 7 - MULTIPLEXING

REFLECTIVE (NEGATIVE RESISTANCE) AMPLIFIER

A reflective (negative resistance) amplifier uses a circulator to separate the input and output ports of the amplifier (Figure 8). Negative resistance diodes such as the IMPATT (IMPact ionization Avalanche Transit Time), TRAPATT (TRApped Plasma Avalanche Triggered Transit), and BARITT (BARrier Injected Transit Time) are used to increase the reflection coefficients at the terminated port and cause higher output power than the input power.



PHASE-ARRAY ANTENNA MODULE

Ferrite circulators and isolators are also popular for phase-array equipments. Figure 9 shows a typical transmit-receive phase-array antenna module.

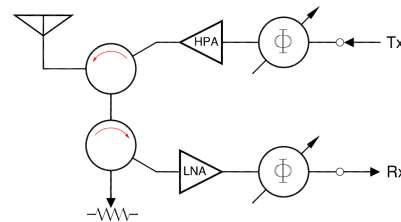


FIGURE 9 - TRANSMIT-RECEIVE MODULE FOR PHASE-ARRAY ANTENNA

INTERMODULATION SUPPRESSION PANELS

A 4-port isolator is used to build an intermodulation suppression panel (Figure 10):

- To suppress intermodulation from the amplifier (transmitter);
- To provide impedance matching between the amplifier and the antenna;
- To protect the amplifier against damage from an open or shorted antenna.

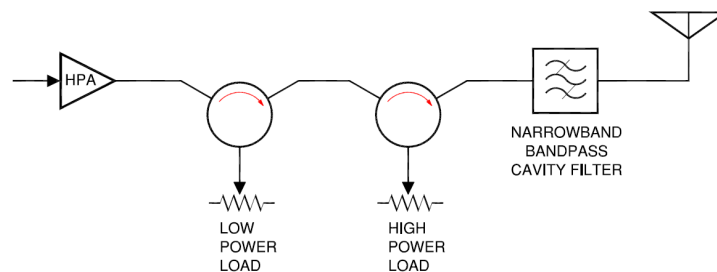


FIGURE 10 - INTERMODULATION SUPPRESSION PANELS

RECOMMENDATION

To assure the optimal performance of RFCI devices in our customers' system, we strongly recommend our customers to discuss their requirements with our application engineer prior to ordering.

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