



APPLICATION NOTE # 35 PULSE TWTAS

AR RF/Microwave Instrumentation's pulse traveling wave tube amplifiers (TWTAs) offer a cost-effective source of high RF power for applications in which only a low to moderate RF duty cycle is required, i.e., where the RF power is on for only a small percentage of the time. A typical application is electromagnetic compatibility (EMC) RF pulse susceptibility testing. This Application Note discusses the unique specifications and characteristics applicable to pulse TWTAs.

Pulse-rated TWTAs use a traveling wave tube (TWT) incorporating a control grid that can be used to turn on and off the TWT's beam current. The TWT acts as an RF amplifier only when the beam is turned on. Turning the beam off when no RF output is needed results in a significant reduction in power consumption, and hence reduces the amount of heat to be dissipated.

When compared to a continuous wave (CW)-rated amplifier with similar power specifications, a low to moderate duty cycle PULSE TWTAs typically: uses less AC input power, produces less heat, is smaller and lighter, costs less, has lower noise power output during the pulse off time, and allows use of peripheral components (connectors, cables or waveguide, directional couplers, loads, and so forth) with lower CW power ratings. AR's pulse TWTAs are designed specifically for pulsed applications. They cannot be used to produce CW output. AR's TP series of pulse TWTAs do incorporate many of the excellent features of AR's T series of CW TWTAs such as: foldback protection, bright 4 line by 20 character alphanumeric display and extensive remote status and control via a GPIB (IEEE-488) interface. For CW applications, contact AR RF/Microwave Instrumentation for information on its extensive line of CW-rated amplifiers.

UNIQUE SPECIFICATION FOR PULSE TWTAS

Some unique specification characteristics (those not commonly specified for CW rated amplifiers) of AR RF/Microwave Instrumentation's pulse TWTAs are listed below, along with a set of typical parameter values. An explanation of their significance follows.

PULSE CAPABILITY

Pulse Width.....	0.07-30 microseconds
Pulse Rate (PRF).....	100 kHz maximum
Duty Cycle	4% maximum
RF Rise and Fall	30ns maximum (10% to 90%)
Delay	300ns maximum from pulse input to RF 90%
Pulse Width Distortion	±30ns max (50% point of output pulse width compared to 50% points of input pulse width)
Pulse Off Isolation	80 dB minimum, 90 dB typical
NOISE POWER DENSITY	(Pulse on) xxx
.....	(Pulse off) Minus 140dBm/Hz (typical)

CONNECTORS

Pulse Input..... Type BNC female on rear panel

DELAY, RF RISE AND FALL TIME AND THE PULSE INPUT

The beam is turned on and off in response to a TTL-level input (typically from an external Pulse Generator) applied to the Pulse Input Connector. A positive level (logical 1) turns on the beam. If RF had been applied to the TWTA input prior to the positive (logical 1) TTL input, the RF output would reach 90% of its final value within 300ns (Delay) with an observed RF Rise time of up to 30ns (10% to 90%). (See Figure 1.)

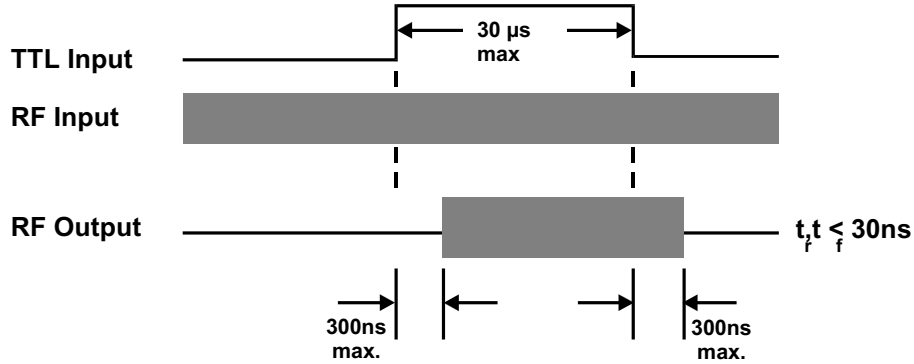


FIGURE 1. CW RF INPUT

After this initial delay in enabling the RF output, the RF output level will respond to the level of the RF input. As with a CW amplifier, the subsequent RF rise and fall times are inversely related to the RF bandwidth of the specific TWTA, with typical rise and fall times in the low- or sub-nanosecond range.

If the RF input remains and the TTL level goes low (logical 0), then the RF output would reach 10% of its prior "on" value within 300ns (Delay). The observed RF Fall time would be less than 30ns (10 to 90%). (See Figure 1.) Using the TTL input to modulate the RF output may result in some small distortion of the output pulse width (usually shrinkage), as compared to the TTL-level input pulse width, and therefore is not recommended for producing pulses lasting less than 0.2 microseconds, or for applications where the pulse width must be accurately preserved. Alternately, the RF input can be turned off prior to the end of the TTL pulse to obtain a fast and well-defined RF fall time.

To obtain well-defined RF timing while minimizing power consumption, the RF and TTL-level inputs should be timed as shown in Figure 2:

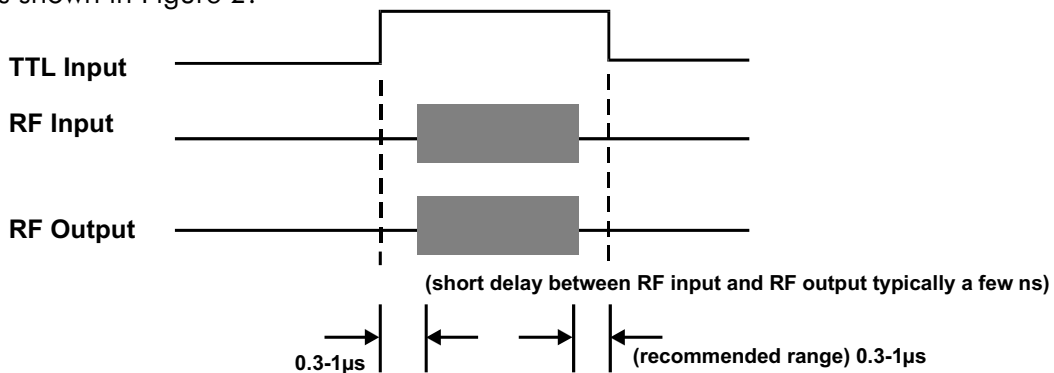


FIGURE 2. PULSE RF INPUT

PULSE WIDTH

The Pulse Width specification (0.07-30 microseconds) defines the range of acceptable pulse widths that must be presented at the TTL input to operate the TWTA. The maximum value (30 microseconds) describes the greatest RF pulse width available from the TWTA. RF output pulse widths less than 0.2 microseconds can best be produced by providing a correspondingly short RF pulse at the RF input, with timing as shown in Figure 2.

The Pulse Width Distortion specification further defines the maximum pulse width distortion at the 50% points of the output pulse width compared to 50% points of the input pulse width when using the pulse input. Lower distortion can be obtained with timing as shown in Figure 2.

PULSE RATE

The Pulse Rate (PRF) specification (100 kHz max.) defines the rate of the maximum continuous pulse stream that may be fed to the TTL-level input. In other words, each succeeding TTL-level input pulse (of a continuous stream of pulses) must begin no sooner than 100 microseconds (1/10,000 sec.) following the beginning of the previous pulse. There is no minimum rate specification. Users should contact AR RF/Microwave Instrumentation regarding any specific requirements they may have for non-continuous pulse-stream applications with higher burst rates.

DUTY CYCLE

The Duty Cycle specification (4% max.) is an additional limitation on the TTL-level input that must be observed by the user. This specification defines the maximum percentage of the time that the TTL-level input can be allowed to remain positive (logical 1). For example, if the chosen PRF is 5 kHz, then the maximum allowable TTL input pulse width is reduced to 8 microseconds (1/5,000 x .04 sec.).

PULSE OFF ISOLATION

Pulse off isolation specifies the reduction of signal level, input to output, when the Pulse Input is not high (i.e. in the pulse-off condition), causing the beam to be off.

NOISE POWER DENSITY

Noise Power Density describes the noise level at the TWTA's output. TWTs typically produce considerable broadband RF noise when they are operating (TTL high). When the TTL-level input is not high, (i.e. in the pulse-off condition) the TWT noise is significantly reduced. A typical Noise Power Density level is thus indicated.

FORWARD AND REFLECTED PEAK POWER

AR RF/Microwave Instrumentation Pulse TWTAs feature a display for peak RF power output to supplement the usual display for average RF power output. This display is developed from a measurement of the peak RF and is especially convenient for setting the peak power level when using a varying duty cycle. This feature operates when the pulse width is greater than 1 microseconds and the RF input is present before the start of the TTL pulse.

Peak power measurements using laboratory power meters are typically accomplished by measuring the average power and then calculating the peak power using the known duty cycle:

$$\text{Peak Power} = \text{Average Power} \div \text{Duty Cycle.}$$

For accurate indirect measurements of peak power, it may be desirable to measure the actual RF output pulse width to determine the duty cycle.

SUMMARY

This Application Note has discussed some features of AR RF/Microwave Instrumentation's Pulse high power TWTAs and their unique specifications, those not commonly specified for CW rated amplifiers. A number of conditions have been defined which must be observed to obtain proper operation of these Pulse TWTAs (though TWTA design prevents damage when these conditions are exceeded). Be sure to refer to the appropriate AR Data Sheet for detailed amplifier specifications.

Users should contact AR RF/Microwave Instrumentation at 215-723-8181 to discuss any specific application requirements for high burst rates, low off-level noise and special off-level timing (such as in NMR spectroscopy applications), Peak Power measurement of narrow pulses or other characteristics.