App-Note: 006 - Pulse Amplifier Definitions and Terminology

Definitions of Pulse Amplifier Terms

DUTY CYCLE

The typical maximum duty cycle specification for pulse amplifiers used in EMC applications is 6%. The desired PRF rate is setup externally on the test equipment but can be viewed on the Exodus front panel display. This feature is useful for ease of setup with respect to customer applications. The Exodus Amplifiers indicate the Duty Cycle/Pulse Rep Rate and the Pulse Width. Most Exodus Solid-State Pulse Amplifiers can operate up to or @ 10% Duty Cycle, 20% for some models where the majority of TWTs are limited to 6%.

PULSE RATE

The Pulse Repetition Rate (or PRF) known as the "PRF specification" is typically 100 kHz maximum for EMC applications. Some other applications require higher PRF rates as dictated by the requirement. The PRF rate is the pulse train applied as a TTL level that is applied to the pulse input connector for modulating/switching the RF on and off at the rate applied. Most Exodus Solid-State Pulse Amplifiers can operate to a PRF rate of 400kHz.

RISE/FALL TIME

The Rise/Fall time is the time defined for the leading or trailing edge of a pulse measured from the 10% to 90% points of the pulse. Most standard Exodus Solid-State Pulse Amplifiers provide Rise/Fall times in the 15-25nsec range.

PULSE WIDTH

The maximum pulse width specification can be based on the specific Solid-State technology incorporated within the amplifier and its capability. Typically, most Exodus Pulse Amplifiers for instrumentation/EMC testing applications are specified at 100usec for a maximum pulse width. However, some requirements can be for wider pulse widths if the technology can support the specific application.

PULSE ON/OFF RATIO

The RF Pulse On/Off ratio is typically specified at 80dB. This is because when the Solid-State High-Speed Switching circuits are engaged the RF is no longer enabled to be amplified and transmitted through the RF-line.

RF DELAY

The RF Pulse delay is the difference in time from when the TTL Pulse trigger is applied to the Pulse input connector to when the RF pulse is present. This is the time for the propagation through the system to enable the RF Amplification through the RF-lineup.

PULSE to PULSE JITTER

The deviation/variation from the leading edge of each repeating pulse.

PULSE WIDTH JITTER

The deviation/variation in the Pulse Width for each repeating Pulse.

PULSE to PULSE STABILITY

The amplitude deviation/variation from Pulse to Pulse.

DUTY CYCLE CORRECTION FACTOR

Knowing the Duty Factor or Duty Cycle allows simple multiplication or division to arrive at a peak power level given an average level or vice versa. For example, a pulse signal with a duty cycle of 10% and an average power indication of 100 watts would be multiplied by 10 to arrive at a 1KW peak power. The same 10% duty pulse train is 1/10th or the total time period so the average power level would be 10 times less than the peak or -10 dB. The same process would hold true for a 1% duty cycle signal, but the average power would be multiplied or divided by a factor of 100 or 20 dB.

Table 1 shows a list of duty percentages and multipliers at 1KW.

Duty Cycle Percentage	Correction factor in dB to correlate average power to peak power	Examples			
		Avg Power in dBm/watts	+ correction factor in dB	Peak Power (dBm)	Peak Power (watts)
1%	20	40dBm/10 W	20	60dBm	1000 watts
2%	17	43dBm/20 W	17	60dBm	1000 watts
4%	14	46dBm/40 W	14	60dBm	1000 watts
6%	12.2	47.8dBm/60 W	12.2	60dBm	1000 watts
10%	10	50dBm/100 W	10	60dBm	1000 watts

Table 2 shows a list of duty percentages and multipliers at 4KW.

Duty Cycle Percentage	Correction factor in dB to correlate average power to peak power	Examples			
		Avg Power in dBm/watts	+ correction factor in dB	Peak Power (dBm)	Peak Power (watts)
1%	20	46dBm/40 W	20	66dBm	4000 watts
2%	17	49dBm/80 W	17	66dBm	4000 watts
4%	14	52dBm/160 W	14	66dBm	4000 watts
6%	12.2	53.8dBm/240 W	12.2	66dBm	4000 watts
10%	10	56dBm/400 W	10	66dBm	4000 watts

FORWARD AND REFLECTED PEAK POWER

Exodus Solid-State Pulse Amplifiers with the Option DMC, include a power indication function that shows both forward and reflected peak power on the front panel display. Additionally, they include a real-time VSWR measurement within each customer's specific application. Not all labs are outfitted with peak power analyzers so power verification can be done in an average mode converting average power to peak power with the standard formula.

Duty Cycle Correction + Average Power = Peak Power
Example:
Duty Cycle 1%=Correction factor = 20dB
Average Power measured = 40dBm Peak
Power= 60dBm
20dB (Duty cycle correction) + 40dB (Average power) = 60dBm (Peak Power)

Common features included within Exodus Solid-State Pulse Amplifiers.

Exodus Pulse Solid-State Amplifiers

Protection
Safety Requirements of IEC-348
VSWR Reflected Power Protection (reverse power monitor)
Over/Under voltage Protection
Overcurrent Protection
Module/System Overtemperature
Duty Cycle Protection

High Stability For:
Very Low Phase Ripple
Very Low Amplitude Ripple
Very Low Pulse/Phase Droop
Very Low Pulse Overshoot and Pulse Ringing

Additional Standard Features with Exodus Option DMC

Front Panel Controls and Indicators
Power On/Off
Standby/RF-ON
Local/Remote Fault
Air-cooled (Integrated Forced Air – self-contained)
LAN, USB, RS422/485 Remote (Optional IEEE GPIB 488)
Self-Diagnostic Circuitry
GUI Provided

Large Front Panel Color-Touchscreen Display

Forward RF Power	Reflected RF Power	VSWR Indication
Module Voltages	Duty Cycle/PW and PRF Rate	Module Currents
Remote Information	Front Panel Settable	Operating Hours

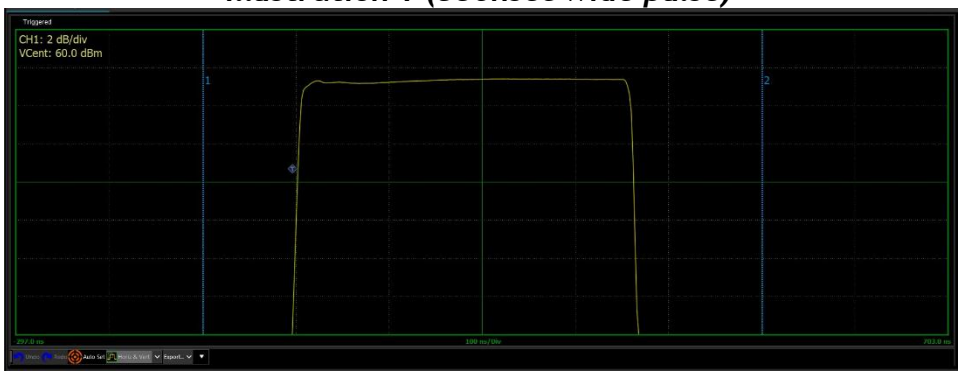
The Exodus SSPA monitors and transfers the operating voltages and currents to the Large Color Touchscreen Display. This aids the user in troubleshooting in the event of a failure. The amplifier indicates on the display where the fault has occurred.

Solid-State Amplifier Operation Description Turn ON/OFF

Pulse Amplifiers amplify RF signals applied to the RF input. Amplifiers have a Pulse input connection that accepts a TTL pulse level from an external pulse generator or signal source for modulation of the RF-Line. The RF is modulated from the pulse input connector via internal switching circuitry. This method of pulse modulation enables very fast Rise/Fall times for most all customer applications. The fast switching provides the >80dB ON/OFF ratio with typically 15-20nsec Rise/Fall times for Exodus Pulse amps. RF pulse bursts can be applied to the RF input while the pulse input has the RF-line Enabled. Various combinations can be applied to fulfill whatever your test requirements specify. Although six percent (6%) is a typical duty cycle for most EMC applications, higher duty cycles are often available. Pulse amplifiers are used for EMC susceptibility testing as well as many other applications such as Radar.

Illustration 1 shows the Pulse response for a High-Power Solid-State Amplifier.
Pulse overshoot- as illustrated is less than a Pulse TWT, typically <0.1dB.
Rise Time- as illustrated is typically equal or better than a Pulse TWT
Fall Time- as illustrated is typically equal or better than a Pulse TWT

Illustration 1 (350nsec wide pulse)



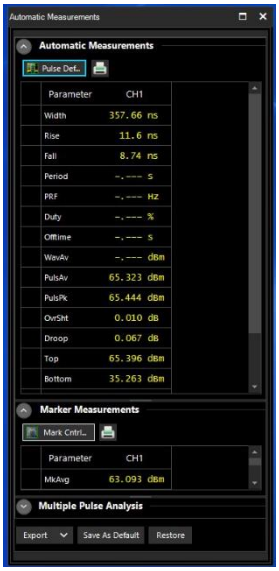


Illustration 2 shows the Pulse response for a High-Power Pulse TWT Amplifier.
Pulse overshoot- as illustrated is typically 1dB.
Rise Time- as illustrated is not significantly different from the SSPA.
Fall Time- as illustrated is not significantly different from the SSPA.

Illustration 2 (350nsec wide pulse)