CPI Satcom Division
45 River Drive
Georgetown, Ontario
Canada L7G 2J4
Tel: (905) 877-0161

Power Amplifier Phase (Power) Combining

General: When two signals of identical phase and amplitude are fed to a 180 – degree hybrid or "Magic T" combiner, the two signals are summed in one of the O/P ports and cancelled in the other output port. Phase matching is more critical than amplitude (gain) matching. Initial differences at a given frequency, mid-band for example can be balanced out by inserting an adjustable phase shifter in series with one of the power amplifiers, and by adjusting the input attenuator of the respective amplifiers. The basic combining circuit is shown in the figure below. The RF input signal is fed to a 180 – degree divider (or splitter) to form two incoherent equal in amplitude signals. The two signals are amplified by the respective amplifiers and then re - combined in another 180 – degree phase combiner such as a hybrid or magic "T" or a variable ratio combiner. The phase shifter in series with the input to one of the power amplifiers is used in conjunction with the input attenuator of the power amplifier to balance the phase and amplitude of the two power amplifier output signals. The two signals are summed at the RF output port and any small unbalance in power is absorbed by the load termination. This unbalance is observed as a null reading on the power meter, which monitors the power to the dummy termination. A common variable attenuator is included in the input line for adjustment of the combined RF output level.

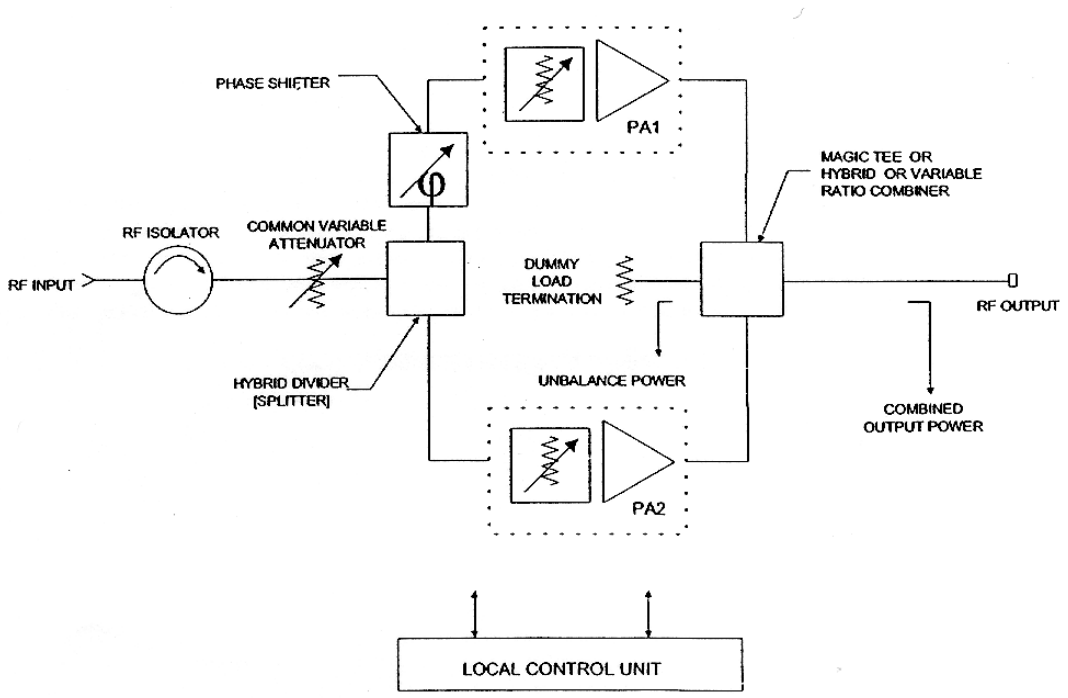

Figure 1. Block Diagram, Basic Power Combiner Circuit

Description: The CPI series of power/phase combiners cover the frequency ranges representative of the TWT amplifiers used in the combining network. The power/phase combiner and the respective amplifiers that are used in the combining system are as follows: VZL2778C1 (using 2-VZL2780C2 TWTA's), VZS/C2778C1 (using 2-VZS/C2780C2 TWTA's), and VZM2778C1 (using 2-VZM2780C2 TWTA's).

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All of the components described herein making up the combiner network (excluding the TWTA's) are packaged in a 19 – inch rack mountable enclosure thus allowing for installation in a standard rack/cabinet. As a standard feature the TWTA's come equipped with chassis slides necessary for installation into the same 19-inch rack (see Figure 2).

Figure 2 – Recommended installation

Along with the TWTA RF source specified herein, the series of power/phase combiners consist of a coaxial input divider network, phase shifter, and a front panel module. The front panel combiner module comes equipped with the following features:

- Voltage controlled step attenuator.
- Front panel phase adjustment
- Excessive RF load power alarm.
- RF sample ports for O/P power and load.
- LCD display giving constant power monitor of O/P power and load.
- O/P power in dBw and in Watts.
- Local and remote control.
- Complete set of installation and operating manuals including list of replaceable parts.

Please see Figure 3 below for a diagram of a typical power combiner module front panel.

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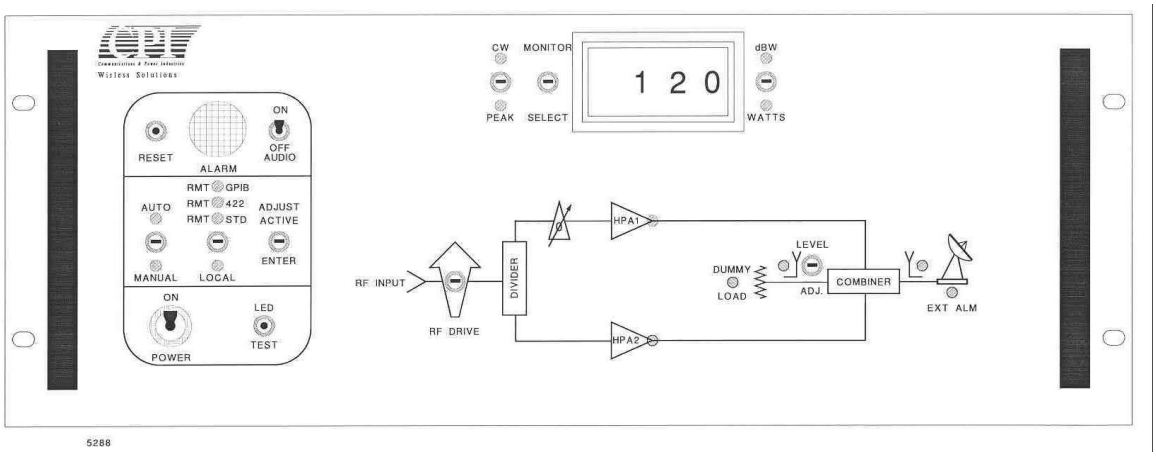

Figure 3: Power Combiner Module Front Panel

It is understood that due to the inherent properties of the phase combiner, **t**he power/phase combining network will ensure that the performance in most instances will exceed that of the individual TWTA. However since measurements of some of the parameters have not been taken, the performance of the "SYSTEM" requires testing over the frequency ranges specified and thus only typical performance specifications are identified below.

1000-Watt Power/Phase "Combined System" Electrical Specification

• Frequency	VZL2778C1	1.0 – 2.5 GHz
	VZS/C2778C1	2.0 – 8.0 GHz
	VZM2778C1	8.0 – 18.0 GHz
• Output power	TWT Flange	500 Watts minimum
	"RF Combining System"	1000 Watts typical (see Figure 4)
• Instantaneous Bandwidth	VZL2778C1	1.5 GHz
	VZS/C2778C1	6.0 GHz
	VZM2778C1	10.0 GHz
• Gain		50 dB typical at rated power
• RF attenuator adjust range		0 to 20 dB
• Gain stability		Typically ±0.2dB max.
• Small signal gain variation		Typically 12 dB peak – to – peak
• Input VSWR		2.5:1 max, 1.5max with optional input isolator
• Output VSWR		2.5:1 typical
• Load VSWR	Full spec. Compliance	1.5 max.
	Operation w/o damage	Any value
	Continuous operation	2.0:1 max. For full O/P power
• Harmonic output		-10dBc typical at lower band edge, decreasing to – 15dBc typical at upper band edge.
• Primary power		220 – 240 ±10%, single phase 47 – 63 Hz
• Power factor		0.95 min. (meets requirements of EN60555-2, total harmonic distortion)
• Power consumption	VZM2778C1	13.5 kVA typical 16.5 kVA max.
	VZS/C2778C1	13.5 kVA typical 16.5 kVA max.
	VZM2778C1	13.5 kVA typical 16.5 kVA max.

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- Inrush current 200% maximum.

Figure 4: Typical Measured O/P Power versus Frequency for the VZL2778C1, VZS/C2778C1, and VZM2778C1 series of TWT amplifiers.

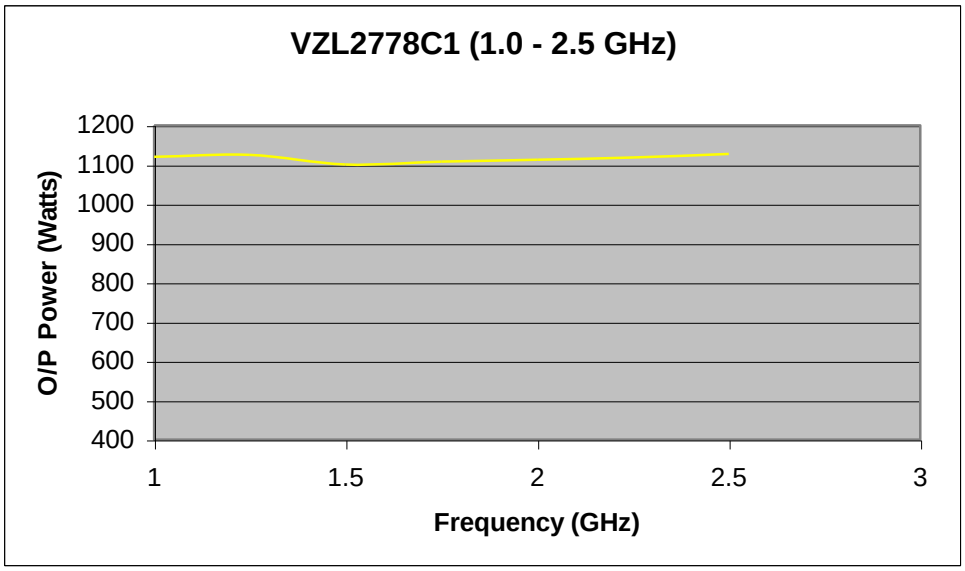

Figure 4(a): VZL2778C1 (1.0-2.5GHz, 1000-Watts) O/P Power versus Frequency

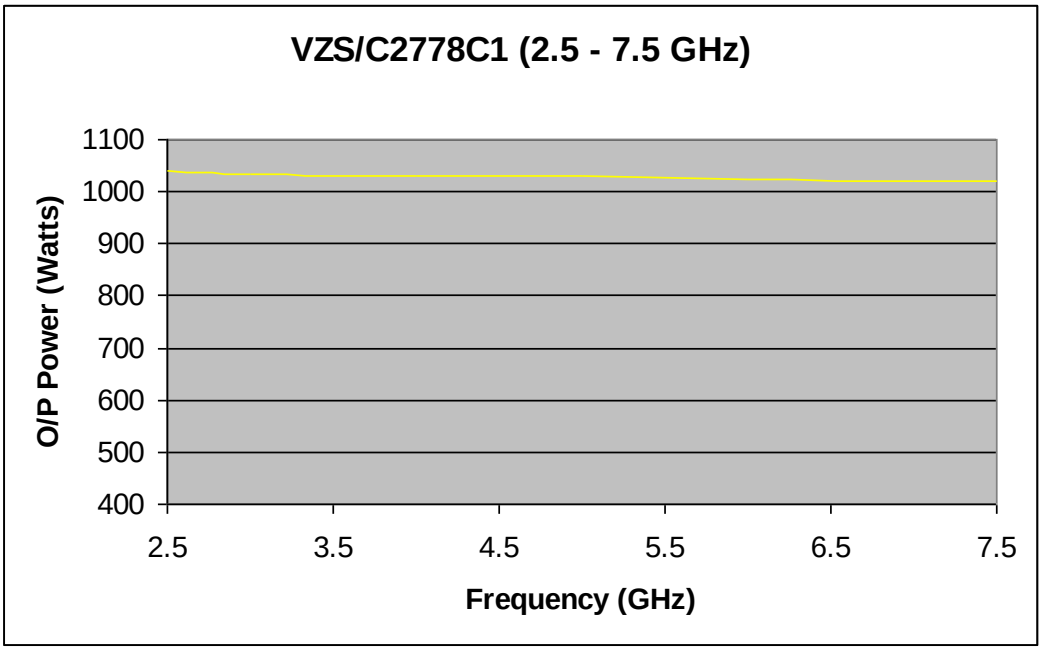

Figure 4(b): VZS/C6963J2 (2.5-7.5GHz, 1000-Watts) O/P Power versus Frequency

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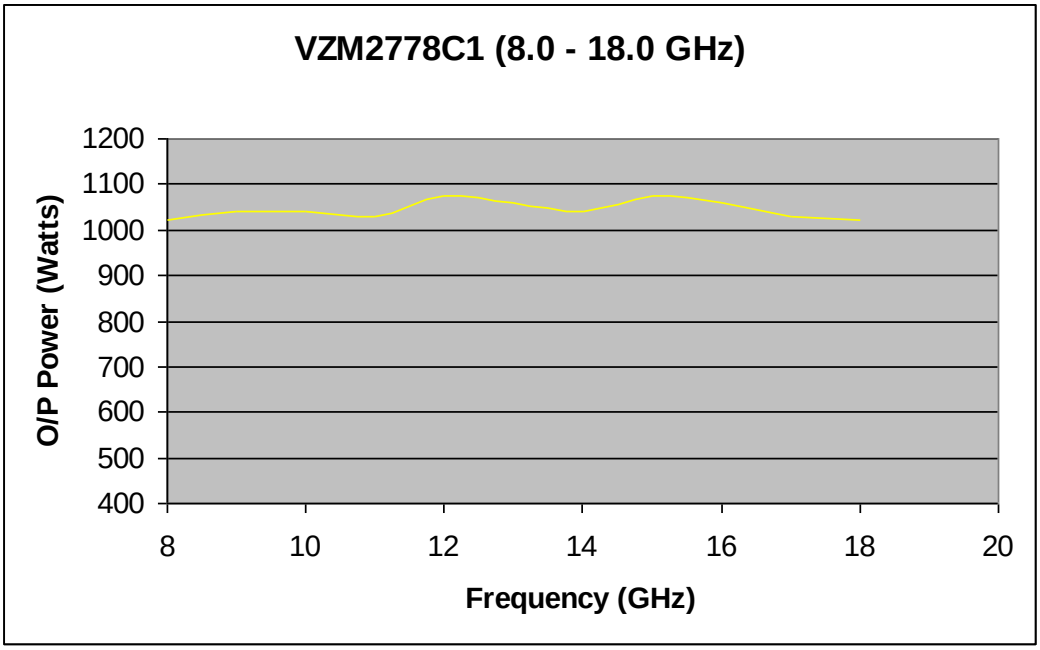

Figure 4(c): VZM2778C1 (8.0-18.0GHZ, 1000-Watts) O/P Power versus Frequency

NOTES:

1. The RF and electrical performance of the system is understood to be the performance of four CPI TWT amplifiers power/phase combined with a VZL2778C1, VZS/C2778C1 or VZM2778C1 power/phase combiner.

2. In the event of a fault in one of the power amplifiers, the hybrid or "Magic Tee" combiner will divide the output of the surviving power amplifier equally between the termination port and the RF output port. The resulting output power is about 6 dB below the initial combined output.

*** Customer specified RF connections will be used whenever mechanically/electrically possible.**