811 Hansen Way
Palo Alto, CA 94303
Phone: (650) 846-3700
Fax: (650) 424-1744

Technical Description

VSTAR®30 Broadband Millimeter Wave TWT Amplifiers

Models VZK-6901J1 and VZA-6902J1 Series

INTRODUCTION

This document provides a detailed description of the CPI VSTAR®30 mmwave J-Series TWTA (PAs). These are state of the art Traveling Wave Tube Amplifiers (TWTAs). Two models are offered, the VZK-6901J1 covering K-band (18.0 to 26.5 GHz), and the VZA-6902J1 covering Ka-band (26.5 to 40 GHz). Both models have TWTs that provide more than 40 watts of output power instantaneously over their full bandwidth. These TWTAs use a modern split mount design where the RF module can be mounted directly to an antenna, thereby minimizing microwave losses in the system and maximizing the available microwave power. The Power Supply Module is a convenient rack mountable design, 5 1/4 inches high, and provides all user controls and monitors for the TWTA. The Power Supply is provided with a 2.5 meter (standard) or an optional 12 meter, rugged interconnect cable set. The VSTAR®30 mmwave J-Series TWTA are a compact and lightweight design capable of continuous efficient operation. An integral microprocessor controls the TWTA and provides all of the TWTA monitor and control functions in a very flexible user interface. The VSTAR®30 mmwave

J-Series TWTA incorporate integral power factor correction (0.95 minimum) and a universal input voltage range which allows the units to meet the total harmonic distortion requirements of EN -60555-2. These units also are certified to meet EN-61010 safety requirements and Electromagnetic Compatibility 89/336/EEC.

The VZK-6901J1 and VZA-6902J1 VSTAR®30 mmwave J-Series TWTA are designed for a wide range of test and measurement applications. They may be used with complimentary CPI Compact Medium Power Amplifier (CMPA) J-Series models providing 250 W in 1.0 to 2.5 GHz, 2.5 to 8.0 GHz and 8.0 to 18.0 GHz frequency bands, to provide extended coverage from 1.0 to 40 GHz.

The VSTAR®30 mmwave J-Series TWTA are members of a comprehensive line of broadband and communications products including TWTAs and KPAs covering 1.0 to 40.0 GHz and providing microwave power levels up to 3.3 kW.

CPI (formerly Varian Electron Device Group) has been a recognized world leader in the field of microwave tube technology for over 50 years and has been active in the design and manufacture of a broad range of microwave power amplifiers and related products for more than 30 years. CPI Satcom Division (formerly Varian MEP) was organized in the mid-1970s to bring together, under a single business center, the strengths of the existing CPI divisions involved with commercial Satcom and Industrial power amplifiers.

Today, CPI Satcom Division has provided thousands of broadband and narrowband fully integrated power amplifiers in the L, S, C, X, M, Ku, DBS and Ka-band frequency ranges to worldwide users and has become the leading supplier of this class of products.

EQUIPMENT DESCRIPTION

General

The VSTAR®30 mmwave J-Series TWTA (Figure 1) is packaged in two separate modules (a PS unit and a RF unit) and is interconnected by two 2.5 meter or optional 12 meter ruggedized cables. The PS unit is a convenient 19 inch rack mount unit, which is 5.25 inches high and 24 inches deep. The PS unit contains the primary operator controls and indicators for the VSTAR®30 mmwave J-Series TWTA. The RF unit is designed for indoor or outdoor mounting on the transmit antenna structure. Separate low voltage and high voltage rugged cables connect the PS unit to the RF unit.

The RF unit includes the TWT, optional input/output isolation circuits, RF detectors and power monitor circuits and a solid state intermediate power amplifier (IPA). The power supply unit includes the power factor correction, power processor and high voltage regulation circuitry. It also contains the microprocessor based monitor and control system necessary to permit safe, efficient and reliable operation of the VSTAR®30 millimeter TWTA.

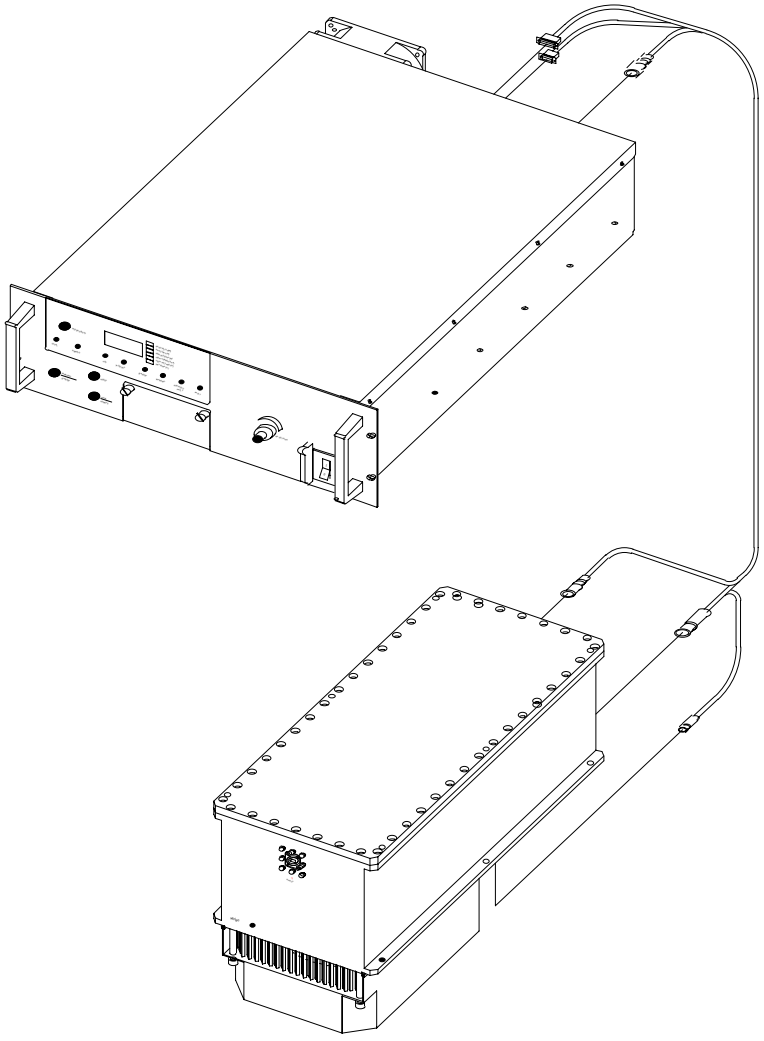

Figure 1. The Power Amplifier

The VSTAR®30 mmwave J-Series TWTA is protected from operational damage caused by abnormal AC, DC, RF faults or insufficient cooling. The amplifier will automatically recycle itself after a prime power interruption or transient fault condition.

Personnel safety is of utmost importance and is safeguarded by proper grounding and by access interlocks and shields, which prevent physical entry into the high voltage sections.

The front panel of the Power Supply unit serves as the primary user interface, housing the monitor and control system.The front panel of the unit includes control switches, indicator LEDs and a vacuum fluorescent alphanumeric display. All unit functions can be controlled and monitored via the front panel.

Principal functions are also brought to the user interface connectors located on the power supply unit rear panel for remote monitor and control. Control, fault and monitoring functions are available via: the standard RS-422/485 interface, or optional RS-232 interface or IEEE-488 parallel interface, designed to interface directly with a computer.

To expedite field maintenance procedures, the VSTAR®30 mmwave J-Series TWTA utilizes a modular design approach consisting of Line Replaceable Units (LRUs) which permit trained service personnel to maintain the VSTAR®30 mmwave J-Series TWTA in the field without need of returning the entire unit to the depot or factory. Comprehensive fault reporting and diagnostic procedures allow field personnel to localize the fault to the individual LRU, make the necessary replacement and return the amplifier to service with a minimum of operational downtime.

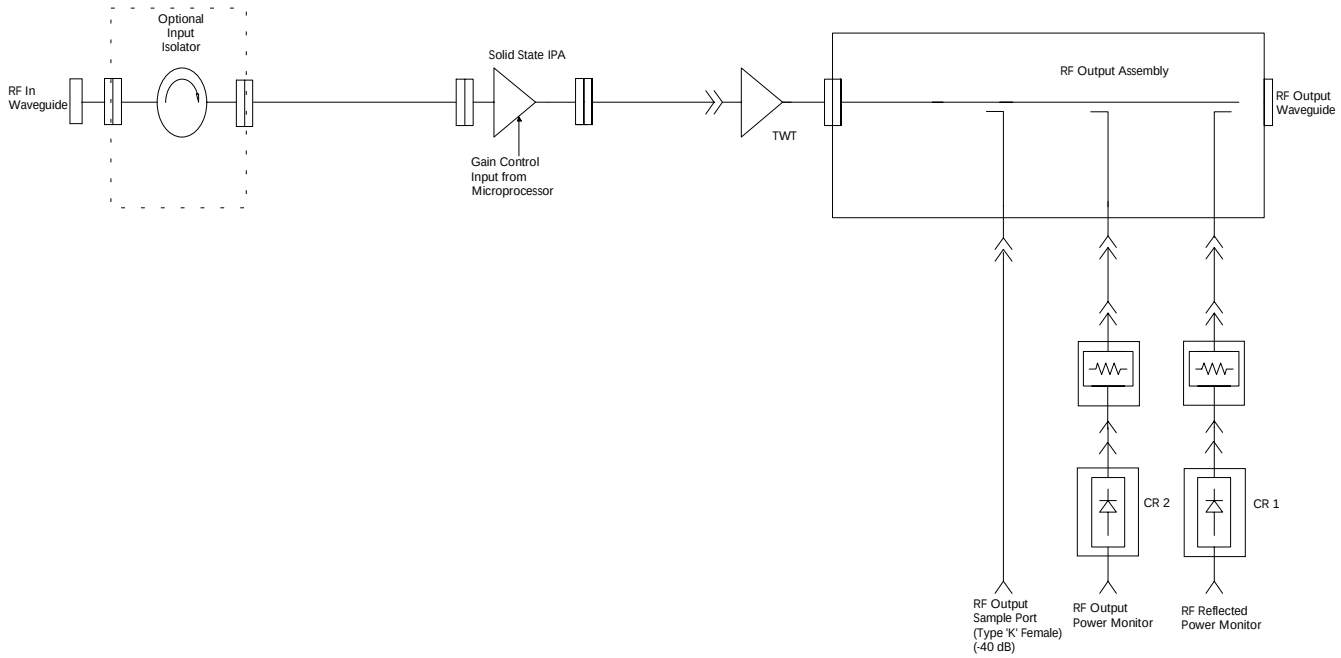

Figure 2. VSTAR®30 RF Diagram

RF Module

A conservative field-proven approach is utilized in the VSTAR®30 mmwave J-Series TWTA RF module. The RF block diagram (Figure 2) identifies all major circuit elements for this technical description.

A low level RF input signal is applied to the VSTAR®30 RF unit via a WR-28 waveguide interface located at the rear of the enclosure. Typical input VSWR is 1.7:1. The optional isolator limits the input VSWR to a level of 1.4:1 or less back to the source. The RF input is then routed to the SSIPA, which provides additional gain and a gain control module. The SSIPA is designed to be transparent to final amplifier RF parameters and is temperature compensated to minimize drift. As a result, the overall VSTAR®30 mmwave J-Series TWTA stability specifications are easily met both with and without the SSIPA installed. The output of the SSIPA is then fed to the input of the TWT. The SSIPA and TWT provide a combined subsystem gain of a least 46 dB at rated power.

The VZK-6901J1 series uses the CPI VTK-6193D4X TWT and the VZA-6902J1 series uses the CPI VTA-6193A4X TWT. Both TWTs feature a forced air cooled and depressed collector for efficient operation, and Periodic Permanent Magnet (PPM) focused helix design. They are designed for compact, light weight applications involving test and measurement applications.

The VTK-6193D4X and VTA-6193D4X series TWTs are unique in that they contain a Personality Identification Module (PIM), integral to each TWT. The PIM contains four programming resistors which connect to the heater, anode, focus element and helix power supply regulator circuits. The PIM provides automatic adjustment of the TWT voltages to the optimum value for the TWT. This allows a field replacement of the TWT with no power supply adjustments needed. This significantly reduces the complexity of servicing the VSTAR®30 mmwave J-Series TWTA.

The output waveguide assembly interfaces to the TWT and protects the TWT from abnormal or transient conditions which could permanently damage the TWT. This assembly consists of a three-port directional coupler.

The three port directional coupler provides one reflected power port coupled via a detector to the RF power monitor assembly for reverse power monitoring and soft-fail protection; and, two forward power ports, one for the user to monitor forward RF power via a type ‘K’ connector on the front panel and one for use by the front panel forward power metering circuit which uses a similar detector to process the RF signal. The RF sample port, calibrated in coupling ratio versus frequency, permits independent monitoring of VSTAR®30 mmwave J-Series TWTA output power levels through the use of an external spectrum analyzer or portable power meter. High reflected RF protection is standard and reflected power information is sent to the front panel for display. User settable low and high RF power alarms via the front panel are controlled via remote panel or CIF port.

A unique soft-fail design is employed, which allows the TWTA to continue operation even after the high reflected power limit is reached, by reducing the RF output power so as to limit the reflected power.

The RF output interface to connect the VSTAR®30 mmwave J-Series TWTA to the external waveguide run is a WR-42 (K band) or WR-28 (Ka band) flange. The VSTAR®30 mmwave J-Series TWTA has the two (grooved) flanges with tapped mounting holes, mounted on the rear of the RF module. Waveguide gaskets are also provided.

Power Monitor Assembly

Located in the RF module, the RF power monitor assembly receives signals from the forward and reflected power RF detectors for use in fault/alarm sensing and forward and reverse power metering. The reflected RF circuit also protects the TWT against excessive reflected power due to abnormal

waveguide or antenna conditions. Additionally, the forward power meter circuit output may be displayed in either watts or dBm format. Also included in the metering are forward low and High RF alarm circuits which compares the output power with user-settable low RF set points and triggers an alarm, should output power rise or fall outside these set points.

The output and reflected power level readouts are also available for remote monitoring via the computer interface (CIF) port located on the rear panel.

Power Supply Module

Overview

The power supply unit portion of the VSTAR®30 mmwave J-Series TWTA provides all of the internal voltages necessary to operate the TWT, Solid State IPA, and auxiliary circuits for control, monitoring and protection of the VSTAR®30 mmwave J-Series TWTA. Only the AC input power is required for operation. The traveling wave tube derives its operation from five DC power supplies: a filament heater low voltage supply, a focus element supply, an anode high voltage supply, a helix high voltage supply, and a collector high voltage supply. The power supply design utilized is of the switch mode power conditioner (SMPC) type which has an excellent reputation for reliability and stability. An added advantage of the SMPC approach over outdated linear power supplies is its intrinsic high efficiency and safe operation. By limiting the amount of the instantaneous stored energy in the power supply, the risk of permanent damage to the VSTAR®30 mmwave J-Series TWTA due to abnormal or transient conditions is minimal. The momentary level of stored energy (measured in joules) is well below the maximum limit of energy that the tube can safely dissipate during normal operation. A simplified block diagram of the power supply is shown in Figure 3 below. The principal circuit modules are discussed in the following paragraphs.

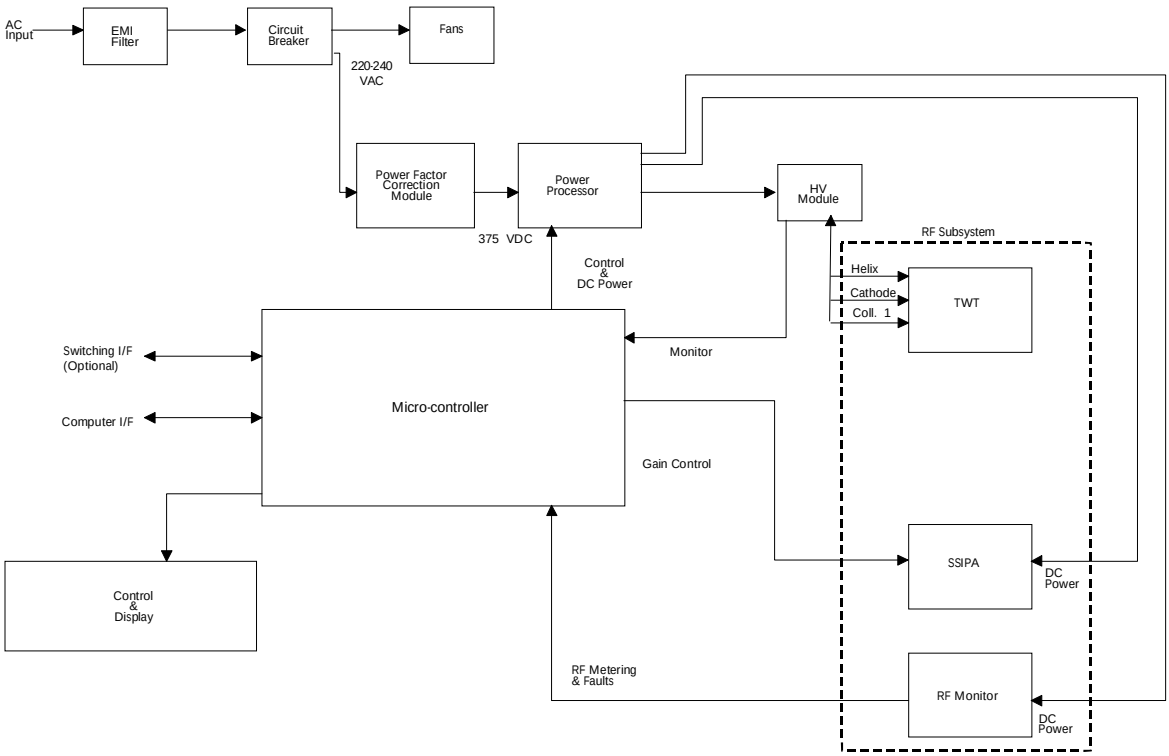

Figure 3 - Power Supply Block Diagram

Power Factor Correction Module

Input primary power (single phase, 100-264 VAC, 47/63 Hz) flows via a EMI filter and the main circuit breaker to the Power Factor Correction Module. This module provides a regulated 375 VDC to the Power Processor and allows the VSTAR®30 to meet the requirements of IEC-555 regarding total harmonic distortion. In the event of a failure of this module, a DC bus fault flag is sent to the microcontroller for proper fault handling and display.

Note: The wide range of 100-264 VAC input is accomplished without reconnecting or switching, making the VSTAR®30 mmwave J-Series TWTA a truly universal product.

Power Processor Module

The power processor circuits provide the necessary line and load regulation of the input 375 volt DC bus, which is converted via a switch regulator and bridge circuit to a nominal 200 volt, 25 kHz to drive the high voltage module. A sample of the helix high voltage output is returned to the switch regulator for error feedback correction and sends a pulsewidth modulated signal through an optical isolator to the switching transistors. This approach allows careful regulation of the TWT helix and collector voltages and protects both supplies from over voltage/under voltage or short circuit conditions. Low voltage outputs are also produced by this assembly (+16V, $\pm$15V) which are used to operate various internal circuit functions as well as provide power for the RF monitor circuit, microcontroller assembly, front panel display and IPA. Internal sensors provide the necessary over-current protection functions for these supplies.

5 VDC Power Supply

This module is a DC to DC converter. It accepts a +16 VDC input from the Power Processor and converts this to provide +5 VDC with grounded common and +5 VDC isolated inputs to the microprocessor control circuits.

High Voltage Module

The high voltage module provides the following key power supply functions: regulated TWT heater supply, regulated focus element voltage, regulated anode voltage, regulated TWT high voltage helix and collector supplies, helix supply current/voltage monitoring and fault protection. The high voltage module contains the transformers, rectifiers, filters and voltage/current sense resistors for all critical TWT voltages. The incoming 200 volt, 25 kHz signal is applied to the primary of a multi-section high voltage transformer which provides all of the high voltage levels necessary to operate the traveling wave tube. Since the helix and collector share the same transformer and regulator, the high voltage circuit design establishes the collector voltage at 45% of the helix voltage. This relationship permits optimum efficiency and substantial energy savings while extending the useful life of the TWT. A separate step-down transformer with rectifier and filter network is employed to provide the heater voltage.

Control and Display Modules

The microprocessor based monitor and control system is designed to assure proper operation of the power amplifier and easy maintainability with minimal operator training and activity. The microprocessor based monitor and control system includes three parts: a main controller board, an interface board and keyboard/vacuum fluorescent display. The system provides required operational sequencing and monitoring of critical parameters. If a fault should occur, the unit either recycles back to its state prior to the fault or latches into the FAULT state. In either case, the front panel display will provide fault information. Also, the user can consult the Fault Log for time/date stamped fault information.

Figure 4 and the Product Specifications below present a complete list of controls, displays and LED indicators on the PS unit front panel.

When control power is turned on, the microprocessor self-tests all internal functions and starts HTD (Heater Time Delay). Once the HTD is completed, the STANDBY indicator illuminates to tell the operator that the high voltage may be applied. Depressing, the TRANSMIT/STANDBY key initiates the BONS (Beam On Sequence). At the successful conclusion of BONS, the unit is in the TRANSMIT state (high voltage is on).

Alternatively, the operator may depress the TRANSMIT/STANDBY key during HTD causing TX SELECT to be displayed on the front panel. In this case, the BONS is initiated automatically at the completion of HTD. In the interest of promoting long life of the TWT, the heater voltage is reduced by 5% whenever the VSTAR®30 mmwave J-Series TWTA is in any beam off state (either STANDBY or FAULT states) for more than one minute.

In the event of AC prime power interruptions, the power supply will automatically recycle when the AC power is reapplied. If the loss of power is less than a few seconds, the amplifier will return immediately to its previous state. If the outage is of longer duration, a proportional HTD is performed before returning to the previous state. The longest HTD is seven minutes.

If a fault occurs during any normal operating state (the following text will use TRANSMIT as an example), the FAULT LED will light and the unit will switch from TRANSMIT to FAULT. Two scenarios are possible.

The first scenario occurs when fewer than three faults occur within twenty seconds. In this case, the unit will recycle back to TRANSMIT. Each fault will generate a recycle. Each recycle from FAULT to TRANSMIT will be delayed by one second. This LED will remain lit until the RESET button is pressed or power is cycled.

The second scenario occurs when at least three faults occur within twenty seconds. In this case the unit will be latched into FAULT and the FAULT LED will flash. To reset the unit for normal operation, clear the source of the fault. Then, press CANCEL. If the fault was successfully cleared, the FAULT LED will extinguish and the unit will be in STANDBY. Press TRANSMIT to resume transmitting.

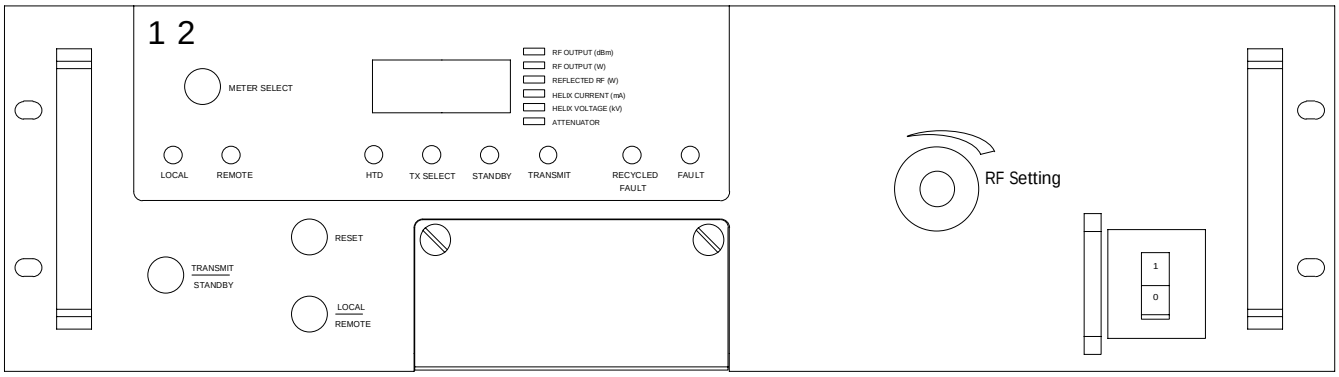

Figure 4 - VSTAR®30 PS Unit Front Panel

In either case, the time/date stamped Fault Log will capture each fault event. If multiple faults were detected during one event, they will be listed together. This allows the user or technician to identify individual faults to a specific module or subassembly.

Mechanical Design

The power supply is packaged in a standard rack mounted drawer measuring 19" wide by 5.25" high and 24" deep (plus connectors and fan). The unit is cooled via a forced air cooling system consisting of one AC blower, an air filter and an internal exhaust duct. Since the heat dissipation of the power supply module is very low, external ducting of the heat is generally not required.

LRU Philosophy

The VSTAR®30 mmwave J-Series TWTA utilizes a modular design approach incorporating LRUs for ease of maintainability in the field. The maintenance concept employed is to localize a malfunction or circuit failure down to the level of an LRU, extract the LRU and replace with an equivalent part provided in the spares kit. This procedure can be completed in the field without resorting to the costly practice of returning the entire VSTAR®30 mmwave J-Series TWTA to the depot for servicing. The philosophy is to configure the VSTAR®30 mmwave J-Series TWTA LRUs as building blocks with a specific function that can be monitored by sensors and fault indicators on a real-time basis.

PRODUCT SPECIFICATIONS

Electrical

Frequency	
•VZK-6901J1	18.0 to 26.5 GHz
•VZA-6902J1	26.5 to 40 GHz
Output Power	
•TWT	(40 Watts min.)
•Flange	(39 Watts min.)
Bandwidth	
•VZK-6901J1	8.5 GHz
•VZA-6902J1	13.5 GHz
Gain	
•at rated power	46 dB min.
•small signal	55 dB (K band), 65 dB (Ka band) typical
Gain Stability	
•at constant drive & temperature	±0.25 dB/24 hr max. (after 60 min. warm-up)
•over temperature, const. dr.(any frequency)	0.07dB/°C typical
Gain Variation over full bandwidth	±5 dB typical at 6 dB backoff
Input VSWR	
•K & Ka band	2.4:1 max. (1.7:1 typical)
•K band	1.4:1 max., 1.30:1 (typical) with optional input isolators
•Ka band	1.5:1 max., 1.35:1 (typical) with optional input isolators
Output VSWR	2.7:1 max, 2.0.1 typical
Load VSWR	
•operation without damage	any value
•operation without degradation	2.0:1 max.
Phase Noise	
•0 to 1 MHz	-6 dB below IESS-308 profile (-21 dB typical)
•1 MHz to 350 MHz	-120 dBc/Hz max.
AM/PM Conversion	3.5°/dB typical for a single carrier at 6 dB below rated power. 5.0°/dB typical at rated power
Spurious	-50 dBc max.
Noise Power Output	+23 dB max.
Intermodulation	Typically -24 dBc or better with two equal carriers at total output power level 7 dB below rated single carrier output.

Electrical (Cont)

Primary Power	Single Phase, 100 to 264 VAC; 47-63 Hz
Power Factor	0.95 min. (meets requirements of EN60555-2 total harmonic distortion)
Power Consumption	700 VA (typical) 1200 VA (max.)
Inrush Current	200% max.

Environmental

Ambient Temperature	
•PS Unit	-10° +50°C
•RF Unit	-10° to +50°C (+65°C with solar loading)
Relative Humidity	
•PS Unit	95% non-condensing
•RF Unit	100% condensing
Altitude	
•operating	10,000 ft., with standard adiabatic derating of 2°C/1,000 ft.
•non-operating	50,000 ft.
Shock and Vibration	Designed for normal transportation environment by commercial carriers

Mechanical

Cooling	Forced air with integral blowers. No ducting is required for either PS or RF units
Interconnecting Cables	2.5 meters (standard); 12 meters (optional)
RF/Input and Output Connections	
•VZK-6901J1	WR-42 WG flange grooved, threaded UNC 2B 4-40
•VZA-6902J1	WR-28 waveguide flange, grooved, threaded UNC2B 4-40
RF Output Monitor	Type 'K' Female, -40 dB nominal
Dimensions (W x H x D)	
•PS Unit	19 x 5.25 x 24 in. (483 x 133 x 610 mm)
•RF Unit	8.5 x 12.83 x 20 in. (216 x 324 x 508 mm)
Weight	
•PS Unit	50 lbs (22.7 kg) max.
•RF Unit	40 lbs (18.2 kg) max.

Heat and Acoustic

Heat Dissipation	
•PS Unit	200 Watts max.
•RF Unit	1000 Watts max.
Acoustic Noise	Meets EN-61010 Requirements

Characteristics and performance limits are based on current data and are subject to change without notice. Please contact CPI Satcom Division before using this information for system design.

Controls and Monitors (Located on Power Supply Front Panel)

Pushbuttons

•*Transmit/Standby*
Toggles beam state between beam selected or beam not selected. When beam is on, as indicated by a solidly lit Transmit LED, the TWTA will provide RF output.

•*Reset*
Resets the unit after Fault conditions. (Extinguishes all captured fault LEDs and the Recycled Fault LED).

•*Local/Remote*
Toggles between the two control points.

•*Meter Select*
Toggles through all valid meter selections.

•*Lamp Test*
(Hidden switch) - Lights all Front Panel indicators (LEDs).
(Located behind the Front Panel access door).

Status LEDs

•*Local*
Lit when valid control point is the Front Panel.

•*Remote*
Lit when valid control is the Remote Port.

•*HTD*
Lit during Heater Time Delay (HTD).

•*TX Select*
Lit when transmit is selected during HTD; TWTA will automatically transition to Transmit at the conclusion of HTD.

•*Standby*
Lit during Standby state.

•*Transmit*
Flashes during beam-on sequence (BONS); lit during Transmit state.

•*Recycled Fault*
Flashes after unit successfully recycles from fault.

•*Fault*
Flashes anytime unit is in Fault condition.

Controls and Monitors (Located on Power Supply Front Panel)

Displaying Meter Readings

Six different meter readings can be selected for viewing on the Digital LED Display located on the Front Panel. To view a meter reading, press the METER SELECT push-button repeatedly until the LED lights next to the desired item to be displayed.

The following metering items can be displayed as indicated by a lit LED:

•RF Output (dBm)

Indicates RF output power in dBm. (LED flashes for either Low or High RF Alarm).

•RF Output (Watts)
Indicates RF output power in Watts, (LED flashes for either Low or High RF Alarm).

•Reflected RF (Watts)
Indicates reflected RF power in Watts.

•Helix I (mA)
Indicates helix current in mA.

•Helix V (kV)
Indicates helix voltage in kV.

•Attenuator
Indicates TWT baseplate temperature in ^{0}C. LED flashes for TWT Overtemp Alarm.
Indicates the appropriate setting in dB (uncalibrated) of the SSIPA RF variable attenuator.

Controls and Monitors (Located on Power Supply Front Panel)

Switches (located behind PS Front Panel access door)	Helix under and overvoltage fault setting Helix current fault setting High Reflected RF alarm set High Reflected RF fault set High and Low RF alarm and fault settings Reset to defaults Remote interface settings: *Address* *Baud Rate* *Parity* *Protocol* *Check Byte Type* *Accept bad check byte* *Set CR/LF*
Fault/Alarm Display (LEDs located behind PS Front Panel access door)	Low RF Fault and Alarm High RF Fault and Alarm High Reflected Power Interlocks Open (power supply temp. or amplifier cover) Helix Over Current Helix Over Voltage Helix Under Voltage Power Supply Arc DC Buss Fault TWT Over Temperature Fault

Remote Control Interface (Serial)

Control Functions	Transmit/Standby (Beam On/Off) Fault Reset Low RF Fault Setting High RF Fault Setting Low RF Alarm Setting High RF Alarm Setting RF Attenuator Setting (gain control)
Monitoring	RF Output Power (Watts, dBW or dBm) RF Reflected Power (Watts, dBW or dBm) Helix Current (mA) Helix Voltage (kV) Beam Current (mA) Heater Elapsed Time Meter Beam On Elapsed Time Meter Attenuator Setting (dB uncalibrated)
Status Display	Heater Time Delay (HTD) TX (Transmit) Select Standby Transmit (Beam On) Local/Remote
Fault/Alarm Display	Fault Low RF Fault and Alarm High RF Fault and Alarm High Reflected Power Interlocks Open (power supply temp. or amplifier cover) Helix Over Current Helix Over Voltage Helix Under Voltage Power Supply Arc DC Buss Fault TWT Over Temperature Alarm and Fault Blower Fault External Interlocks Fault Helix Voltage present in Standby

Options & Compatibility

Features	•Alpha-numeric Menu-driven 4-line display and front panel •Meets EN-61010 and EN60555-2 Safety/Harmonic standards as well as EEC 89/336 EMC standards •Filament voltage reduction in standby •RS-422/485 (4 wire) computer interface •Auto Fault Recycle (except for Power Supply Arc and External Interlocks) •Internal test points for ease of maintenance •MTTR < 1 hr •Forward power metering •TWT voltages automatically set via PIM interface in TWT •Integral Solid State IPA with gain control module
Options	• IEEE-488 Interface •RS-232 Interface •12 meter interconnect cables • Input Isolator

Support Services

Documentation

CPI Satcom Division provides a commercial documentation package for all products. The content of this package is determined by the nature of the product concerned, and the quantity is governed by contractual requirements. The standard package includes a comprehensive Installation and Operation Manual, outline and interface drawings, Manufacturing Test Performance Sheet and spare parts lists. Outline and interface drawings provide dimensions and the location and size of mounting holes, duct work, and waveguide, so that site preparations can be accomplished prior to receipt of the equipment.

The Installation and Operation Manual provides instruction for unpacking and installation, initial setup, normal operation, preventive maintenance and RF test of the equipment. The manual includes specifications, warranty and support information.

The Test Performance Sheet (TPS) outlines the test performed limits established. Space is provided on the test report for recording and certifying the test results, consolidating all related information in one document. The spare parts documentation consists of a recommended spare parts list to support the equipment for a one-to-two year period of operation. A CSI Acceptance Test can be performed at customer's option which will repeat and verify results of selected performance tests that were already recorded in the standard acceptance test.

Training

CPI Satcom Division is prepared to conduct training courses covering the installation, operation and maintenance of its equipment. The training course on high power amplifiers consists of lectures using training material, such as technical manuals and drawings, plus actual operation and adjustments demonstrated on the equipment.

Small training groups (up to five students) assure the customer that each student has an opportunity to participate fully in demonstration activities. Courses may be conducted at the CPI factory or on-site. Course duration varies from two days to one or two weeks, depending on the scope of work agreed upon and the skill level of the students.

Field Service

The product support activity of CPI includes a staff of experienced, professional service technicians to assist users in maintaining their CPI power amplifiers. A telephone "hot line" permits access to one of these technicians on a 24-hour per day basis. Operational problems often can be diagnosed, corrective action prescribed, and normal operation restored through telephone consultation. When called for, however, the service technicians are prepared to give on-site assistance.

Product Support carries an inventory of spare parts that can be made ready for shipment within 24 hours. Coupled with a dedicated dial-in telephone line, this service is effective in aiding users to restore equipment to operational status with minimum downtime. Technical assistance and factory approved replacement parts are also available at strategically located Regional Service Centers in the U.S.A., Europe and the Pacific Rim.