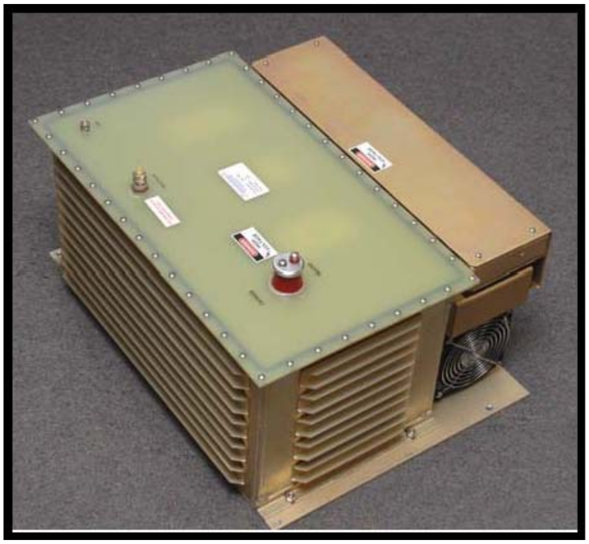
PULSE SYSTEMS TRANSMITTER MANUAL

Technical Manual

Solid State Transmitter S-Band
Pulse Systems Part Number TR-1077



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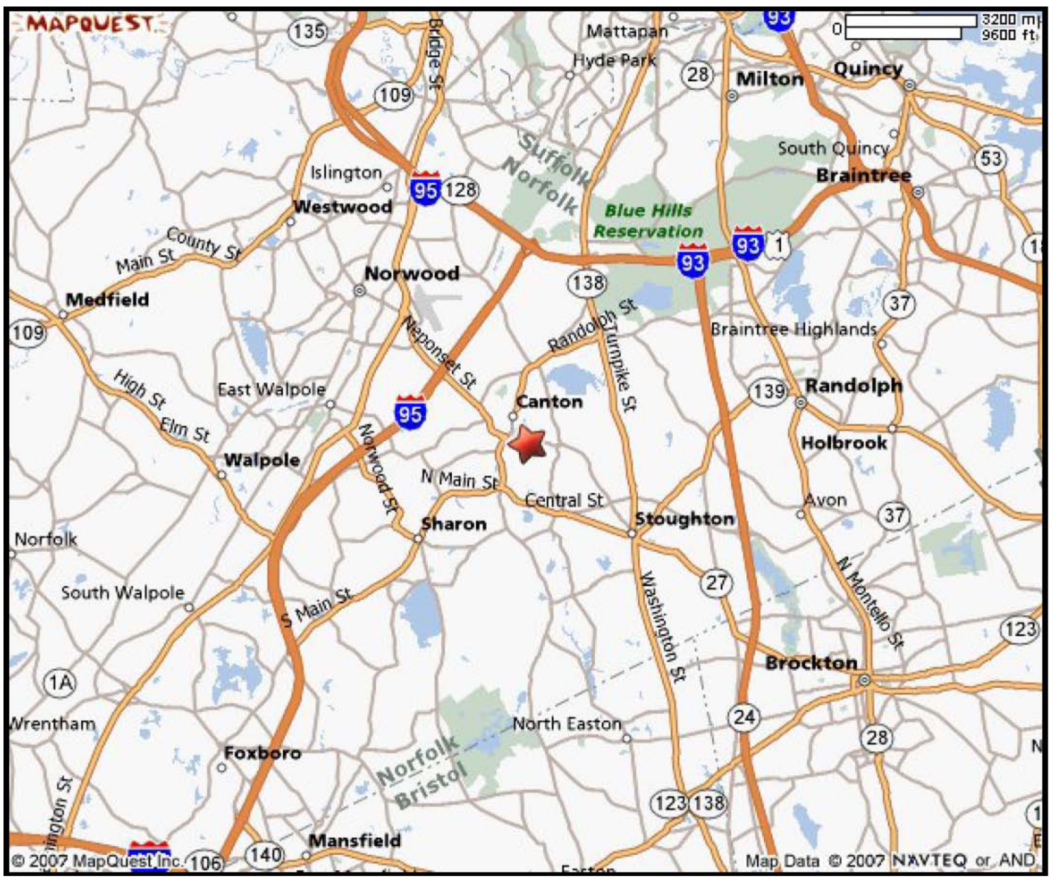

Pulse Systems, Inc.

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Pulse Systems represents and warrants all Products manufactured by Pulse Systems to be free from defects in workmanship and material for a period of one year from the date of shipment, when owned by the original purchaser. The original purchaser must obtain a return authorization number (RMA) from Pulse Systems prior to returning product to Pulse. The freight is to be prepaid by the original purchaser to and from our facility for all returns. During the warranty period, Pulse Systems will at its option repair or replace parts that prove to be defective.

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- Misuse or other unsuitable or unauthorized use of the Product or negligence or error in storing, maintaining or in handling the Product or any equipment thereof;
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Pulse Systems, Inc.

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General Description

Introduction

The system described in this manual is designed to power a CPI S-Band magnetron, 850-1000 kW, operating in a normal environment.

The system is a hard modulator system driven by a series resonance solid state power supply. The input line voltage is 220VAC 50/60 Hz and the maximum input line current is 20 amperes.

The system described in this manual consists of three main parts.

- The Main High Voltage Power Supply
- The Modulator System
- Control Panel

Our design objective is to incorporate the latest technology in both the power supply and the modulator to meet the magnetron requirements and to satisfy our customer's needs.

The customer requires a system that is flexible on both pulse width and PRF with emphasis being placed on reliability, size and cost.

The first objective was to design the system with a variable pulse width and variable PRF. In contrast with a line type modulator system where the pulse width is set by the pulse forming network and it becomes difficult to fine tune, the pulse width of this system can be set from 0.5 μsec to 2.0 μsec. The pulse selection is done through the modulator control system with four pre-selectable pulse widths: 0.5 μsec, 0.8 μsec, 1.0 μsec and 2.0 μsec.

The power supply section is self-contained in an enclosure as shown in Figure 1.0 (See Appendix). Our design is based on series resonance topology driving a full bridge IGBT circuit.

The modulator is a hard-tube type, utilizing IGBT technology, and is under an oil environment. The mechanical enclosure for the modulator is shown in Figure 2.0 (See Appendix).

System Specifications

The specifications for the system are outlined in the appendix along with the magnetron specifications.

General Technical Discussion

As previously mentioned, the whole system consists of the high-voltage power supply and the solid-state hard tube modulator.

The solid-state power supply contains the following sections:

A. Off-Line Power Factor, Filters, and Controls
B. Series Resonance Full Bridge Inverter
C. Series Resonance Frequency Modulation Controller
D. High Voltage Output Section
E. Low Voltage Power Supplies
F. Hard Tube Modulator Control
G. Filament Power Supply (control section)

The Modulator section contains the following sections:

A. IGBT Driver Card Array
B. PRF Driver
C. High Power Switch Section with Despike Network
D. Corner Cutter Section
E. Despike Network
F. Magnetron Peak Current Detector
G. Magnetron Filament Power Supply Section (Power Section)

Figure 4.0 shows the full system including the control panel and the magnetron connections. The following discussion is in reference to this figure.

The input voltage for the system is 220 VAC single phase and it enters the system via the rear panel of the high voltage power supply via terminals E2 and E3 of terminal strip.

The input line voltage enters the Power Factor Correction Module, which performs the rectification, inrush current limiting and pre-regulation of the input line voltage.

The power factor module provides a pre-regulate voltage level of 360 VDC. The above 360 VDC is applied to the input of the series resonance converter which, in turn, provides a final adjustable level of 0-900 VDC available at the modulator section.

The above DC output is sent to the modulator section via a connector leaving the back of the power supply section from terminal strip, terminals E7, E8, and E9 and terminating at J3 of the modulator. The above connector is a four wire connector including the system ground.

The input PRF, which is TTL level, enters the rear panel of the power supply marked J1, "PRF IN". It enters the Modulator Control Circuit, which transforms this input signal to a selectable pulse width level proper for triggering the modulator section of the system. The modulator control circuit performs additional functions and this will be discussed later under the power supply section.

Figure 3.0 shows the complete power supply section of the system. The left lower section of the above diagram shows the connectors for the external control panel. The power supply also provides the low voltage bias levels required by the modulator. The modulator section receives the trigger input from the modulator control circuit located in the power supply. The input pulse is TTL level and the output pulse from the modulator control to the modulator section is CMOS level.

The function of the modulator is to receive the input signal and provide a high power pulse of 36-38 kV at the cathode of the magnetron, thus causing the magnetron to oscillate at C-Band frequency under the selected pulse width set by the modulator control circuit.

The nominal cathode peak current under the above conditions is 50 Amperes peak. The above voltage and current levels result in a peak output power of 850 KW. In the meantime, the filament power supply requires programming according to the magnetron specifications.

For the stand-by condition, the filament voltage is set to 9.0 VDC at 24 Amps. At 001 duty cycle the heater voltage should be reduced to 7.0 VDC.

The cathode voltage is fed to the magnetron via the high voltage bushing located on top of the modulator. The following is an option. At the base of the high-voltage bushing, a wide band current transformer can be provided to monitor the peak cathode current. The calibration of the current transformer is set at 0.1volt per ampere of peak current.

For example, if we are looking at the scope displaying the current monitor output, a 5.5 volt peak pulse level will indicate 55 Amps peak magnetron current. A spark gap is required and supplied with each system, which prevents the magnetron from reaching much higher than normal pulse voltage levels. The voltage of the spark gap is set to 45 kVpk.

The spark gap should be connected between the cathode voltage and ground.

Mechanical

As previously mentioned, the mechanical outline drawings of both the power supply and modulator are shown in figures 1.0 and 2.0. The power supply is of a dry construction and can be mounted in any orientation. The modulator on the other hand is enclosed in an oil-filled container for insulating and cooling reasons. The modulator should be mounted in a horizontal position.

Power Supply Section

Technical Approach

For the power supply of the system, we feel that the series resonance converter topology is the best choice.

First, the efficiency of the system is greatly optimized under this topology and both the RFI and EMI levels are kept at a minimum. In contrast, with PWM systems, the series resonance converter operates smoothly with sine wave currents, rather than square wave excitation. Efficiency levels of 97% are easily attained under the chosen power supply topology with proper design techniques.

Schematic Diagram

Figure 3.0 shows the complete schematic of the power supply. There are several sections shown in the block diagrams; the relay section, the SRI Control, the Modulator Control , the Bridge Inverter, the low voltage power supplies, the filament power supply, the high voltage section and the input and output connections to the rest of the system. This is done to facilitate the technical description for the power supply that follows.

The input power enters the power supply at the command of the 24 VDC control voltage. This voltage is received from the control panel via pin 13 of the control connector J3 located at the rear panel of the power supply. Relays K1and K2, receives the +24 VDC level and allows the main power to enter the power supply. The control transformer T-3 when energized provides low voltage ac power for the gate drive of modulator section.

At the same time, the main voltage of 220 VAC is applied to the two low voltage power supplies in the upper section of the schematic. These two power supplies provide the +24 VDC and the +15 VDC needed by the system.

Next, the input line voltage enters the Power Factor Correction Circuit. The power factor module rectifies the input line voltage, regulates it, and limits the input inrush current to a reasonable level.

The final level of 360 VDC is applied to a capacitive input filter properly sized for the full power of the system and, finally, is applied to the full bridge circuit shown next to the power factor circuit. The full bridge circuit is driven by the SRI Control circuit, which generates, regulates and provides protection for the whole power supply system.

The SRI control circuit sends two drive pulses, noted as Drive A and Drive B. Both pulses are identical in amplitude and pulse-width and they occur in a time sequence dictated by the SRI Controller. These pulses are also frequency modulated, depending on the power demand of the system. This is the way the power supply regulates.

When the load demands more power, the drive pulses occur at a higher frequency and when the load demand diminishes, the frequency slows down to the point that the system meets its regulating requirements.

The two drive pulses are applied to the bridge circuit of the main inverter and they drive the main switches into full conduction during their on state and off during their off state. Turn-on and turn-off occur at zero current conditions. The schematic diagram of the full bridge driver circuit is shown on figure 6.0.

This alternating voltage waveform is impressed across the primary winding of the inverter transformer and with the proper turns ratio the output is rectified and filtered to a maximum level of 850 VDC.

The output voltage of the power supply is controlled by a potentiometer located at the control panel. The top arm of the potentiometer is connected to +10 VDC and the wiper is connected to one terminal of an operational amplifier. The other input terminal of the operational amplifier is connected to the feedback terminal of the output section of the power supply.

The design objective is to keep the two input terminals of the operational amplifier to an equal level. If the arm of the potentiometer is set to a higher