dB Control

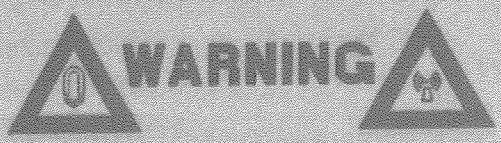
Model dB-3710C 9.4 – 9.8 GHz Traveling Wave Tube Amplifier (TWTA) Operations and Maintenance Manual

dB Control

WARNING

HIGH VOLTAGE

DO NOT ATTEMPT TO REPAIR OR TROUBLESHOOT THIS UNIT UNLESS YOU ARE THOROUGHLY FAMILIAR WITH ITS OPERATION AND ARE EXPERIENCED IN SERVICING HIGH VOLTAGE EQUIPMENT. LETHAL VOLTAGES ARE PRESENT WHEN POWER IS APPLIED TO THE SYSTEM. BE EXTREMELY CAREFUL WHEN WORKING INSIDE THE UNIT. USE ONLY ONE HAND TO MAKE ANY MEASUREMENTS OR ADJUSTMENTS. IF POSSIBLE, TURN POWER OFF BEFORE MAKING ADJUSTMENTS.



RADIO FREQUENCY RADIATION HAZARD

MICROWAVE AMPLIFIERS AND TUBES GENERATE HAZARDOUS RADIO FREQUENCY RADIATION WHICH CAN RESULT IN SEVERE BODILY INJURY INCLUDING CATARACTS, PRODUCING BLINDNESS. SOME CARDIAC PACEMAKERS MAY BE AFFECTED BY THE RF ENERGY EMITTED BY MICROWAVE AMPLIFIERS.

NEVER OPERATE A MICROWAVE TUBE WITHOUT A PROPERLY MATCHED RF ENERGY ABSORBING LOAD ATTACHED. ENSURE THAT PERSONNEL ARE NEVER PERMITTED NEAR ENERGIZED OPEN WAVEGUIDES OR ANTENNAS. IT IS PARTICULARILY IMPORTANT TO NEVER LOOK INTO AN OPEN WAVEGUIDE OR ENERGIZED ANTENNA. MONITOR ALL PARTS OF THE RF SYSTEM FOR RF RADIATION LEAKAGE BEFORE AND AFTER ALL SERVICE WORK AND AT REGULAR INTERVALS.

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1.AMPLIFIER SPECIFICATIONS

GENERAL

RF Output Frequency	9.4 to 9.8GHz
RF Output Power, Peak	8000 Watts, CW minimum
Gain at Rated Power	69dB Minimum @ 0dBm input
Duty cycle	5% Maximum
PRF	50kHz Maximum
Pulse Width	0.5 to 25 microseconds
RF Rise and Fall Times	50 Nanoseconds
Input Pulse	Differential
Harmonics	-10dBc, maximum
Spurious	-50dBc
Prime Power	115/200 VAC ± 10% 3 Φ, 50 Hz or +28 Vdc ±4Vdc
Input VSWR	2.0:1 (50 Ohms Impedance)
Load VSWR	2.0:1 Continuous
TWTA Protection	Helix Over-Current Cathode Over-Current/Arc Over/under Voltage TWT/Power Supply Over-Temp PRF, Pulse Width or Duty Limit Connector Interlock Reverse Coupled Output to Power Fault Circuit
Front Panel Controls	Operate On Local/Remote
Front Panel Indicators	Standby, Operate On, Remote/Local, Iw Fault, VSWR Fault, OVR Temp Fault, Summed Fault
Remote Control	RS-232

dB Control

Mechanical

Size	19" (W) X 8.75" (H) X 28" (L)
Weight	140 Pounds Nominal
Cooling (Operational)	Forced Air with Integral Fan
Air Inlet	Front Panel
Air Exhaust	Back Panel

Back Panel Connectors

AC Power — MS3112E14-5P

Pin Designation

Input	Pin
Phase A	A
Phase B	B
Phase C	C
Neutral	D
Ground	E

DC Power — CA3102E22-22-PB

Pin Designation

Input	Pin
(+)	A,C
(-)	B,D

Remote Control RS-232 — DB-9

Pin Designation

Connection	Pin
TX1	2
RX1	3
GND	5

Pulse Input — MS3112E8-3P

Pin Designation

Connection	
(+)	A
(-)	B
GND	C

RF Input — Type N (F)

RF Output — WR-90 W/G Flange

RF Sample	Type N(F)
Inter Stage Power Sample	Type N (F)

Environment

Altitude	0-10,000 Feet
Ambient Temperature Operating	-10 F to +50 C

2.INSTALLATION/OPERATION

RF input and output connections are located on the front panel and must be terminated before operating the TWTA.

Do not attempt to operate this unit with the cover removed. There are dangerous high voltages present within the chassis that could be a significant hazard to maintenance personnel not familiar with high voltage

a. INSTALLATION

Input Voltage (115/200 VAC//28 VDC) is applied to the traveling wave tube amplifier (TWTA) through the AC power on connector (MS3112E14-5P) or the DC power on connector (CA3102E22-22-PB) located on the back of the unit. Refer to page 5 for connector pin assignments

b. OPERATION

Local/Remote control, monitoring, protection and status indication functions for the TWT Amplifier are provided by an embedded micro-controller. A high resolution Vacuum Fluorescent Display (VFD) is used for displaying the status of the amplifier and readings of various RF performance parameters being monitored by the control circuits.
Once power is applied to the TWTA, the internal cooling fans are actuated and the power supply is powered on. The TWT warm up time will begin. Local or Remote operation may be selected. The front panel display will read "Warm-up Mode". After three minutes the display should read "Standby Ready" indicating the completion of the TWT warm-up period. Once the Standby Ready message is displayed The TWTA is ready for RF operation. The Operator can then press the Operate On/Off key for local operation or use a command via RS232 for remote operation. This action turns on the high voltage to the TWT and puts the amplifier in the Operate Mode. A RF output can now be achieved, which will be a function of the RF input. RF terminations must be connected to the RF input and output, or damage to the TWT could occur.

c. MONITORS

RF FORWARD POWER is monitored by an Type N female connector on the front panel. The sample is –60dB ± 1db of the actual RF output power

INTER STAGE POWER is monitored by an Type N female connector on back panel. The sample is –10dB±1dB of the actual power.

d. CONTROL

OPERATE ON/OFF applies cathode, collector and control electrode voltages to the TWT and will reset a fault condition.

REMOTE/LOCAL will allow either local front panel control or remote control.

PULSE INPUT allows a TTL level differential pulse pair to be connected at a duty of 5% or less. This pulse is used to enable and disable the TWT output.

e. INDICATORS

All of the status indications for the dB-3710C are provide on the high resolution Vacuum Fluorescent Display located on the front panel.

POWER ON	indication is verified with the activation of the VFD once the power is switched on.
REMOTE	indication will be displayed on the top line of the VFD once the LOCAL/REMOTE button is pressed.
STAND BY	indication will be displayed on the bottom line of the VFD after the three minute TWT heater warm up.
OPERATE	indication will be displayed on the bottom line of the VFD after the OPERATE ON/OFF button is pressed.
TWT OVERTEMP	indication will be displayed on the bottom line of the VFD in conjunction with a SUMMED FAULT indication if the TWT collector operating temperature is exceeded. This fault will also be displayed if the TWTA ambient temperature exceeds operating specifications.
IW O/CURRENT	indication will be displayed on the bottom line of the VFD in conjunction with a SUMMED FAULT indication if a TWT helix over-current condition occurs.

f. CONNECTIONS

RF OUTPUT is WR-90 waveguide

RF INPUT is Type N (F)

FORWARD POWER SAMPLE is Type N (F)

INTERSTAGE POWER SAMPLE is Type N (F)

PULSE INPUT is a 3 pin circular connector MS3112E8-3P

REMOTE CONTROL is a 9 pin connector DB-9

AC POWER is a 5 pin circular connector MS3112E14-5

DC POWER is a 4 pin circular connector CA3102E22-22-PB

g. MODES/FAULTS

POWER ON

When the power is switched on. AC prime power is applied to the internal power supply DC bus voltages, the cooling fans, and all the control and TWTA power circuitry. The front panel display will then light. The heater voltage is applied to the TWT, and a three-minute heater warm up delay is initiated. The TWTA status will be displayed on the front panel (VFD). The RS_232 interface is powered up and can monitor the status of the TWTA at all times. However, RS-232 operate/off reset mode is a function of the local/remote switch.

REMOTE/LOCAL MODE

The TWTA can be operated in the local, front panel control, or the remote, RS-232 control modes. The TWTA will power up in the LOCAL MODE. In the Local mode the TWTA can only be operated by the front panel keypad. The only remote command that the unit will respond to is the Status Query command. To place the Unit in the remote mode of operation the LOCAL/REMOTE keypad must be pressed or a remote instruction command must be sent via a remote terminal. The TWTA is then ready for RS-232 operation. When the TWTA is in the remote mode. The front panel display will read REMOTE MODE, and all the keypad operations except the LOCAL/REMOTE will be inactive. RF transmission is now a function of the RS-232 external interface.

WARM UP MODE

Upon initial turn on the TWTA will be in WARM UP mode. The TWTA will be in the warm up mode for three minutes after turn on. In remote mode, a status query will give a warm up indication and when in local the display will read warm up.

STAND BY MODE

After the three-minute heater warm up the front panel display will read STAND BY. The TWTA is now in the stand by mode, and is ready for the operate mode. In remote mode, a status query will give a STAND BY indication.

OPERATE/OFF RESET MODE

In the local mode when the operate on/off button is pressed the TWTA will be set to the operate mode and the front panel display will read OPERATE. In the remote mode operate command is activated via the RS-232 interface and a status query will give an OPERATE indication.. The cathode, collector and bias on voltages are then applied to the TWT, unless a fault condition exists. The TWTA can now transmit as a function of the level of the external RF input.

FAULT CONDITIONS

If a fault occurs the TWTA will stop transmitting and the operate LED will turn off. The summed fault LED will light, or the RS 232 can query the fault condition. Depending on the type of fault, it can be latching or non-latching. A non-latching fault will automatically reset itself when the fault condition clears. A latching fault must be reset. The thermal faults, TWT and power supply, are non-latching all other fault conditions are latching. To reset a fault condition the operate on/off switch must be reset turned off and on, by the front panel switch in local, or the RS 232 in remote. The fault will clear and the TWTA will go back into operate. If the fault cannot be cleared, refer to the troubleshooting guide.

The TWT thermal overload fault circuit is connected to a thermal monitor switch on the TWT collector. If the temperature of the collector exceeds the manufacture specified operating temperature the fault will occur.

The helix over current fault circuit is connected to a helix current monitor. If the helix current exceeds the normal operating level the fault will occur.

The VSWR overload fault circuit is connected to a reverse power monitor on the TWT output. If excessive power is coupled back into the TWT output the fault will occur.
The cathode over-voltage will occur if the cathode voltage exceeds the maximum rating on the TWT
The cathode under-voltage will occur if the cathode voltage drops below the minimum rating on the TWT.
The AC input low, which will occur if the input line voltage falls below a safe operating level or if a phase is missing.
The power supply thermal overload, which will occur if the TWT power supply temperature exceeds 85 C.
If any of these fault conditions occur the VFD display will show a fault and TWTA will not transmit.

h. RS-232 Interface Protocol

The serial communication used by dB Control is a three-wire RS-232 communication system. The data used by the TWTA controller has two formats, one for Data sent to the TWTA controller from the user's terminal program, and one for data returned from the TWTA to the user's terminal program.

Serial Port Configuration:

9600 baud, 8 data bits, no parity, 1 stop bit.

The host computer must wait 350 mS for the respond from the TWTA before sending out another command. If the TWTA fails to respond in 350 mS, the host software should declare a timeout, and alert the operator that the TWTA failed to respond. It should then be free to send commands to other TWTA's.

Command Message:

The data sent to the TWTA controller is a null terminated string consisting of six bytes, formatted as follows:

Byte	Command Message	
1)	Start Frame	"<": Start of Frame
2)	TWTA ADDRESS	"1": TWTA_1 (default address)
3)	Command	"C": Command Message to TWTAs
4)	Operation	"A": Status Query
		"B": Operate "On"
		"C": Operate "Off"
		"D": Local/Remote
5)	End Frame	">": End of Frame
6)	Null ("\0")	End Command Message

The first byte is a "<" which indicates the beginning of a frame, this is to help the controllers know when a new frame is arriving,

The second byte is an ASCII character use to indicate which TWTA is being talked to.

The third byte is a "C", for command, so the other controllers on the network know that it is the master, and not another slave controller on the network talking.

The fourth byte is an ASCII character used to indicate which command the TWTA is supposed to execute. The ASCII characters used are as follows:

"A": Status Query	-Do nothing, but return a Status String
"B": Operate "On"	-Turn the High Voltage On and return a Status String
"C": Operate "Off"	-Turn the High Voltage Off and return a Status String
"D": Local/Remote	-Toggles Local/Remote

The fifth byte is a ">" which indicates an end of frame,

The sixth byte is a /0 (slash zero) which is used because some parsers, such as lab view and C++ especially, like to use the null character (ASCII 0x00, which is what those programs convert /0 into) as an end of line character. This gives the programmer more options for parsing.

When the TWTAs are in the Local mode they will only respond with a Status Query Message. They will not perform any of the following commands: Operate "On" and Operate "Off".

Example Command Message: <3CA>/0
Translates to "TWTA_3 Do nothing, but return a Status String"

Status Query Message:

The data returned by the TWTA controller is a null terminated string consisting of fourteen characters. The format is the same as the command string coming from the user terminal. The response string is mapped as follows.

Byte	Status Query Message			
1)	Start Frame		"<": Start of Frame	
2)	TWTA		"1": TWTA_1 (default address)	
3)	Reply		"R" TWTA is replying to user terminal	
4)	Reserved		"0" thru "9"	
5)	Reserved		"0" thru "9"	
6)	Local /Remote Select	(TWTA)	"0" Local	"1" Remote
7)	Standby Ready	(TWTA)	"0" Warm up	"1" Standby
8)	Operate "On"	(TWTA)	"0" Operate off	"1" Operate on
9)	Summed Fault	(TWTA)	"0" No Fault	"1" Fault
10)	(VSWR)	(TWTA)	"0" No Fault	"1" Fault
11)	Thermal	(TWT & HVPS)	"0" No Fault	"1" Fault
12)	Helix Over Current	(TWTA)	"0" No Fault	"1" Fault
13)	End Frame		">": End of Frame	
14)	New Line ("\n")		End Command Message	

Transmitted from the Amplifier

Byte 1 Byte 2 Byte 3.....Byte 14

Example Status Query Message: <3R000001100>/0

Translates to "TWTA_3 replying; local mode, Warm up mode, Operate off, Summed Fault (P.S. #1), and VSWR Fault.

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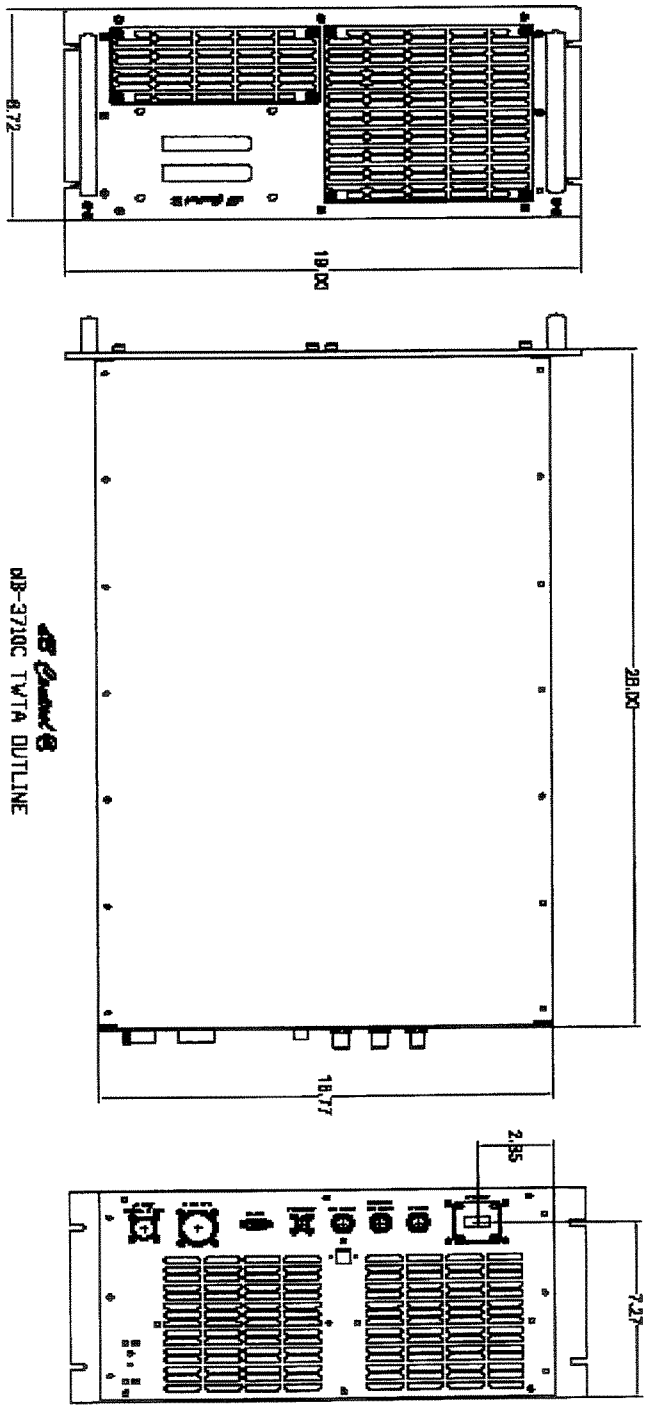
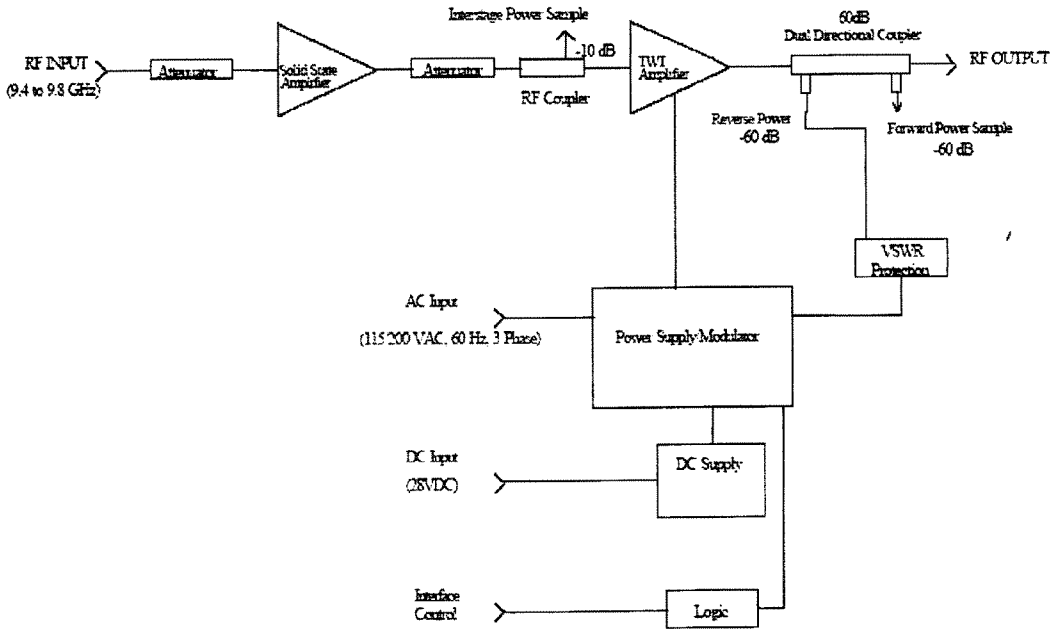
3. OUTLINE DRAWING



4.THEORY OF OPERATION

Brief Description of the TWT Amplifier

Traveling Wave Tube (TWT) Amplifier Model No. dB-3710C from dBControl is a rack mounted amplifier operating in the frequency range of 9.4 to 9.8 GHz providing a minimum of 8000Watts pulse power at a duty of 5% or less. A wide band, periodic permanent magnet (PPM) focused, conduction cooled TWT is used for power amplification. The power supply section uses modular architecture and low noise power supply topology utilizing high efficiency, solid-state power conversion circuits. An internal logic and front panel VFD Controllers provide the interface, control and protection functions as well as extensive fault diagnostics and status indication for the TWT amplifier. A solid-state driver amplifier at the front end for increasing the overall RF gain and protection against "high reflected power" at the output of the TWT are standard features in this product. Remote protocol is RS-232 via a remote cable.



RF DIAGRAM

Power Supply

The prime power input for this TWT Amplifier is 115/200 Volts three phase +/- 10%, 60 Hz AC or 28 VDC ±4V. For the operation of RF devices such as the SSA, the TWT and associated logic circuits, many different voltages from 5 volts to few thousand volts are necessary. All these voltages at appropriate current and regulation levels are generated in the Power Supply Assembly as per the following explanation:

The AC input is passed through the EMI filter and rectified by the diode bridge circuit that is part of the EMI section. The rectified DC bus output is filtered and applied to the power processor assembly. Power conversion is based on a switch mode regulation technique. A high frequency inverter circuit in the power processor section chops the DC bus voltage into an AC waveform. This is stepped up by a high voltage transformer. This transformer also provides isolation between the low voltage circuits referenced to the amplifier chassis or ground and the high circuits referenced to the TWT cathode. A sample of the high voltage is fed back to the power processor, via a post regulator, for regulating the high voltage. The cathode voltage is well regulated before being feed to the TWT. This improves the spectral purity and spurious rejection of the RF output.

The DC input drives 5 DC-DC power modules producing a 240VDC output capable of delivering over 2KW of DC power. This DC voltage is filtered and applied to the power processor assembly.