Dual Channel RF Generator Interface

Instruction Manual

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Table of Contents

1. DESCRIPTION

1.1. Overview

The Dual Channel RF Generator Interface, alternately referred to as Model 841 or "RF Pulser", is designed to connect one or two RF generators to a process sequencer or to a Personal Computer with serial communications capability.

The interface receives commands and queries from the process sequencer via a serial port and generates the appropriate digital and analog I/O signals required by the specific RF Generators. Conversely, the RF Pulser monitors the analog and digital status signals from the generators and transfers the information to the process sequencer when queried.

Since the RF Pulser connects to the control device using a serial protocol, it can provide galvanic isolation between the generators and the process sequencer.

1.2. Features

- *Powered by an external 24 VDC Power Supply from the process sequencer or from either of the RF Generators.*
- *Supports various serial connections such as EIA-232 or EIA-422, isolated or non-isolated with plug-in communications adapters.*
- *Uses a 2-channel, 12-Bit D/A converter to generate the 0 to 10 volt analog setpoint signals.*
- *Uses a 4-channel, 10 Bit A/D converter (internal to the microprocessor) to monitor the RF Generator's Forward Power and Reflected Power analog status signals.*
- *Includes (2) solid-state relay outputs to provide the RF Generator's "Enable" commands.*
- *Includes (2) opto-isolators to monitor the RF Generator's "Plasma OK" status outputs.*

2. INSTALLATION

2.1. RF Generator Connectors, J101 & J201

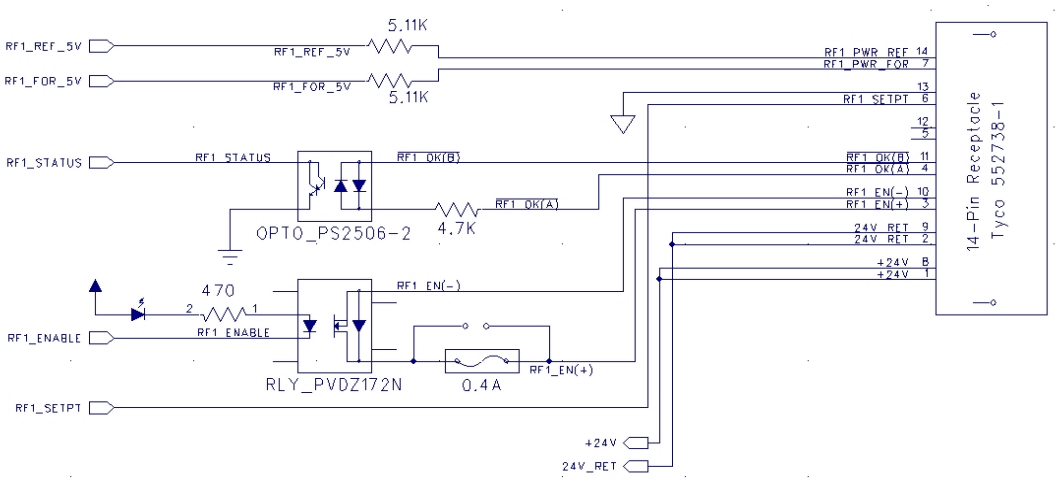
The RF Pulser includes two identical 14-pin interface connectors for use with the RF Generators. The female, board-mounted connectors are manufactured by Tyco as part number 552738-1. Most Tyco or Amphenol male 14-Pin Communications Connectors may be used as mating connectors.

Either, but not both, of the RF Generator connectors may be used to connect to an external 24-volt power. The external supply may range from +18 Volts DC to +36 Volts DC.

The pinout of the (2) RF Generator connectors are as follows:

Pin	J101	Pin	J101
1	+24 VDC	8	+24 VDC
2	24 V RET	9	24 V RET
3	RF1 Enable (+)	10	RF1 Enable (-)
4	RF1 OK (A)	11	RF1 OK (B)
5	RF2 PWR FOR	12	RF2 PWR REF
6	RF1 Setpoint	13	Analog Common
7	RF1 PWR FOR	14	RF1 PWR REF

Pin	J201	Pin	J201
1	+24 VDC	8	+24 VDC
2	24 V RET	9	24 V RET
3	RF2 Enable (+)	10	RF2 Enable (-)
4	RF2 OK (A)	11	RF2 OK (B)
5	RF1 PWR FOR	12	RF1 PWR REF
6	RF2 Setpoint	13	Analog Common
7	RF2 PWR FOR	14	RF2 PWR REF


5.11K
RF1_REF_5V
RF1_REF_5V
RF1_FOR_5V
RF1_FOR_5V
5.11K
RF1_STATUS
RF1_STATUS
RF1_OK(B)
RF1_OK(A)
OPTO_PS2506-2
4.7K
470
RF1_ENABLE
RF1_ENABLE
RF1_EN(-)
RLY_PVDZ172N
0.4A
RF1_EN(+)
RF1_SETPT
+24V
24V_RET
RF1_PWR_REF 14
RF1_PWR_FOR 7
RF1_SETPT 6
RF1_OK(B) 11
RF1_OK(A) 4
RF1_EN(-) 10
RF1_EN(+) 3
24V_RET 9
24V_RET 2
+24V 8
+24V 1
14-Pin Receptacle
Tyco 552738-1

2.2. Communications Connector, J1

The RF Pulser includes a 6-pin RJ-12 connector for serial communications. The pinout of the connector depends on what type of Communications Adapter is installed, Adapters are available for isolated and non-isolated versions of EIA-232, 2-wire EIA-485 and 4-wire EIA-422.

2.2.1. EIA-232

If the RF Pulser is to be controlled by a PC, an RJ-12 to 9-Pin Female 'D' adapter is required. Pinout of the adapter follows.

RJ-12 to 9-pin female 'D' adapter			
RJ-12 on RF Pulser	Wire Color (inside adapter)	9-Pin 'D' Connector To PC	Signal
1	Blue	5	SG
2	Yellow	3	TDX from PC to Tymkon
3	Green	2	RDX from Tymkon to PC
4	Red	7	RTS from PC to Tymkon
5	Black	8	CTS from Tymkon to PC
6	White		

2.2.2. EIA-422

If the RF Pulser is to be controlled by a Tymkon Process Sequencer, a special adapter cable is required. Since both the Tymkon and the RF Pulser have the same pinout, the transmit lines and the receive lines must be swapped to avoid signal conflicts.

RJ-12 to 9-pin female 'D' adapter		
RJ-12 on RF Pulser		RJ-12 on Tymkon
1		1
2		3
3		2
4		5
5		4
6		6

3. THEORY OF OPERATION

3.1. General Behavior

Under control of a microprocessor, a dual, 12-bit D/A converter generates an analog setpoint signal for each of two RF control channels. After amplification, the analog setpoints are routed through analog switches before exiting via two 14-pin interface connectors. In the pulsed modes, the analog switches alternatively connect the RF setpoint to analog ground and, then, to the 0 to 10 volt DC setpoint signals. The on and off times of these setpoint pulses, and their amplitudes, can be programmed via an asynchronous serial port. The serial port may be configured for EIA-232 if the unit is being controlled from a PC, or for EIA-422 or EIA-485 if it is being controlled by a process controller.

3.2. Glossary

- **Peak Power** – The amplitude of the analog setpoint signal regardless of whether the setpoint is constant or pulsed. This value varies from 0.0% to 100.0% (10 volts) and can be set in 0.1% increments (0.01 volt resolution).
- **Average Power** – In some modes of operation, this value determines the duty cycle of the analog setpoint pulse.
- **Forward Power** – These values originate at the RF Generators and are digitized by a 10-bit A/D converter in the microprocessor. The signals range from 0 to 10 volts DC and, depending on the RF Generator, may represent Total Power or just the power delivered to the load.
- **Reflected Power** – These values originate at the RF Generators and are digitized by a 10-bit A/D converter in the microprocessor. The signals range from 0 to 10 volts DC and represent the wasted power.
- **RF Enable** – The RF Generator Interface generates a digital enable command for each generator. This signal generally energizes a relay in the generator.
- **Plasma OK** – Most RF Generators output a digital status signal that confirms that plasma has formed.
- **ON Time** – In some modes of operation, this value indicates the time interval for the ON portion of the control waveform. This value is programmed in tens of microseconds and may range from 10 to 99990 microseconds (99.99 milliseconds).
- **OFF Time** – This value indicates the time interval for the OFF portion of the control waveform. This value, typically calculated by the microprocessor, is set in microseconds and may range from 0 to 99999 microseconds (99.999 milliseconds).
- **Pulse Width** – This value indicates the total time interval for both the ON and the OFF portion of the waveform and ranges from 10 to 99990 microseconds (99.99 milliseconds).

3.3. Operating Modes

	Analog Mode		PWS Mode		PWM Mode		Test Mode	
RF Enable (Forward)	X	Avg	X	Avg	X	Avg	X	(Avg)
RF Pulse			X	Peak	X	Peak	X	Peak
RF PWS			X	On Time			X	On Time
RF PWM					X	Total Time	X	Off Time
RF Reflected (Optional)		Upper Limit		Upper Limit		Upper Limit		Upper Limit

3.3.1. Off Mode

Each channel can be deactivated individually via the communications port. In addition, both channels can be deactivated with a toggle switch located on the enclosure. Once the toggle switch has been turned OFF, neither channel will turn ON until the toggle switch is turned back ON and an appropriate command is received over the serial port. While the toggle switch is OFF, the microprocessor will continue to respond to queries from the host.

3.3.2. Analog Mode

Either or both channels may be commanded to control in an Analog Mode. In Analog Mode, the value commanded for the Peak Power (0 to 10 volts) is output as an analog setpoint and the analog switch is turned on at 100% duty cycle.

3.3.3. PWS Mode

Either or both channels may be commanded to pulse in a **Frequency Modulation** mode with a fixed (but programmable) **ON Time**, a programmable **Peak Power** and a programmable **Average Power**. In this mode, the microprocessor calculates the **OFF Time** and, consequently, the **Pulse Width** based on the other parameters.

3.3.4. PWM Mode

Either or both channels may be commanded to pulse in a **Pulse Width Modulation Mode** with a fixed (but programmable) **Frequency**, a programmable **Peak Power** and a programmable **Average Power**. In this mode, the microprocessor calculates the **ON Time** and the **OFF Time** based on the other parameters.

3.3.5. Test Mode

Either or both channels may be commanded to pulse in a **Test Mode** that is similar to the **Pulse Width Modulation Mode.** In this mode, the **Peak Power**, the **ON Time** and the **OFF Time** are programmable.

3.3.6. Timing Constraints

All pulse-time parameters are specified in microseconds, but the RF Interface has minimum and maximum constraints on all timing parameters. Generally, the minimum ON time or OFF time in any pulse mode is 75 microseconds. The maximum ON time or OFF time in any pulse mode is 12,000 microseconds (12 milliseconds).

3.4. Front Panel Displays

Each channel includes two LEDs on the front panel, one Green and one Yellow. The Green LEDs indicate which channels are active (not if the OFF state). The Yellow LEDs indicate which channels are in the Analog Mode of operation.

3.5. Tymkon Parameters

The following parameters are used in the Tymkon firmware to configure the Tymkon for use with the RF Interface:

RFCOMM

- TRUE/FALSE – Enables communications on Port 1

RFx_ENAB

- Ranges from 0 to 31 (0FFH disables this feature)
- Assigns a Tymkon Output Function to control the RF Enable Digital Output relay
- Assigns a Tymkon Output Function for setting the Average Power in Pulse Modes, in Analog Mode, PWS Mode and PWM Mode.
- Assigns a Tymkon Output Function for reading the Forward Power in all modes.

RFx_PULS

- Ranges from 0 to 31 (0FFH disables this feature)
- Assigns a Tymkon Output Function to enable any of the Pulse Modes.
- Assigns a Tymkon Output Function for setting the Peak Power in any of the Pulse Modes.
- No Read-back Parameter

RFx_PWS

- Ranges from 0 to 31 (0FFH disables this feature)
- Assigns a Tymkon Output Function to enable the PWS Mode (when RFx_PULS is also on).
- Assigns a Tymkon Output Function for setting the ON Time in the PWS Mode and in the Test Mode.
- No Read-back Parameter

RFx_PWM

- Ranges from 0 to 31 (0FFH disables this feature)
- Assigns a Tymkon Output Function to enable the PWM Mode (when RFx_PULS is also on).
- Assigns a Tymkon Output Function for setting the Total Time in the PWM Mode and the OFF Time in the Test Mode.
- No Read-back Parameter

RFx_REFL

- Ranges from 0 to 31 (0FFH disables this feature)
- Assigns a Tymkon Output Function for reading the Reflected Power in all modes.

Time Setpoints (RF1_PWS & RF1_PWM functions)

- 00 = Defaults to 1 millisecond
- 01 to 10 = 0 to 10 milliseconds
- 11 = 110 microseconds
- 20 = 200 microseconds
- 99 = 990 microseconds (0.99 milliseconds)

3.6. Serial Communications

3.6.1. Communications Port

The RF Interface may be supplied with an EIA-232, EIA-485 or EIA 422 communications adapter. When the RF Interface is to be controlled from a PC, EIA-232 is used. When the RF Interface is to be controlled from a Tymkon Process Sequencer, EIA-422 is used.

3.6.2. Communications Parameters

- Baud Rate = 57,600
- Parity = N
- Stop Bits = 1
- Data Bits = 8
- No Flow Control

3.6.3. Communications Protocol

Command	Mode	Avg Pwr %	Peak Pwr %	ON Time µSec	OFF Time µSec	Total Pulse Width µSec
K|k	Off					
A|a	Analog	XXX.X				
F	PWS	XXX.X	PPP.P	NNNNN		
P	PWM	XXX.X	PPP.P			TTTTT
T	Test Mode		PPP.P	NNNNN	FFFFF	

Any command or query to the RF Interface must begin with the ASCII character <@>. Messages to the RF Interface may be terminated with a Carriage Return <CR>, a Linefeed <LF> or both.

The first character of any such message from the RF Interface is the ASCII character <#>. Messages from the RF Interface are terminated with a Carriage Return <CR> followed by a Linefeed <LF>.

While some of the parameters in the table above have decimal points in their values, no decimal points are included in any of the messages. Since the exact format of all messages is predetermined, there is no need to slow the communications with unneeded characters.

There are currently no timing requirements in this protocol. As long as the character bit timing matches the specified baud rate, inter-character delays, though undesirable, will not cause a message to be aborted.

In all messages, the four characters following the start character identify the particular device being addressed. The first two characters must range from “00” to “99” and identity the product category. In particular, the RF Interface products are identified as Product ID = “07”. The next two characters after the Product ID are the Device ID. In most applications, there will be only one RF Pulser on the communications link and it will be identified as Device “01”.

The sixth character of any message to or from the RF Interface indicates the type of command, query or response. See the “Command and Query Summary” below for a list of available commands.

Some messages must include a Channel Identifier following the Command character,. Since the RF Interface supports two independent RF Generators, this character determines which of the channels will react to the command. A Channel Identifier of “1” commands Channel A whereas a Channel Identifier of “2” commands Channel B. Any other character, including “0”, commands both channels.

Following the header information detailed above, most messages contain one, two or three numeric parameters. See the “Command and Query Summary” below for further details.

4. COMMAND AND QUERY SUMMARY

Message Format		Type	Message to Pulser	Reply from Slave
@ggddXc[<CR>|<LF>]	6	Command	Go to Off Mode	#ggddQ:111:222:333:444:AaBb<CR>
@ggddAc:PPPP[<CR>|<LF>]	11	Command	Go to Analog Mode	#ggddQ:111:222:333:444:AaBb<CR>
@ggddFc:PPPP:VVVV:NNNNN[<CR>|<LF>]	22	Command	Go to PWS Mode	#ggddQ:111:222:333:444:AaBb<CR>
@ggddPc:PPPP:VVVV:TTTTT[<CR>|<LF>]	22	Command	Go to PWM Mode	#ggddQ:111:222:333:444:AaBb<CR>
@ggddTc:PPPP:NNNNN:FFFFF[<CR>|<LF>]	23	Command	Go to Test Mode	#ggddQ:111:222:333:444:AaBb<CR>
			Error Reply	#ggdd_:ERROR:_<CR>
@ggddQ[<CR>|<LF>]	5	Query	Data Request	#ggddQ:111:222:333:444:AaBb<CR>
@ggddV[<CR>|<LF>]	5	Query	Version Request	#ggddV:?????????<CR>

```
 Off     @ggddXc<LF> or @ggddxc<LF>
 ANALOG  @ggddAc:PPPP<LF>
 FM      @ggddFc:PPPP:VVVV:NNNNN<LF>
 PWM     @ggddPc:PPPP:VVVV:TTTTT<LF>
 TEST    @ggddTc:PPPP:NNNNN:FFFFF<LF>
 QUERY   @ggddQ<LF>

 REPLY   #ggddQ:111:222:333:444:XY<CR>
    111 = Ch 1 Forward   00.0 to 99.9%, AAA=100%, ^^^=Overrange
    222 = Ch 1 Reflected 00.0 to 99.9%, AAA=100%, ^^^=Overrange
    333 = Ch 2 Forward   00.0 to 99.9%, AAA=100%, ^^^=Overrange
    444 = Ch 2 Reflected 00.0 to 99.9%, AAA=100%, ^^^=Overrange
      A = Ch 1 Mode
      a = Ch 1 Flags
      B = Ch 2 Mode
      b = Ch 2 Flags
  Flags = 010xmspe, x = unused, m = mode override, s = enabled, d = Plasma OK, e = error

The terminator character on incoming messages is either <CR> or <LF> or both.
The terminator on outgoing replies is <CR>.
```

4.1. Special Commands for Dual Frequency Generators

```
@ggddG:X:::::::::::::::X:::::::::::::::[<CR>|<LF>]
@ggddG:Apppp::::::::::::Apppp::::::::::::[<CR>|<LF>]
@ggddG:Fpppp:VVVV:NNNNN::Fpppp:VVVV:NNNNN:[<CR>|<LF>]
@ggddG:Ppppp:VVVV:NNNNN::Ppppp:VVVV:NNNNN:[<CR>|<LF>]
@ggddG:Tpppp:NNNNN:FFFFF:Tpppp:NNNNN:FFFFF[<CR>|<LF>]
```

5. SPECIFICATIONS

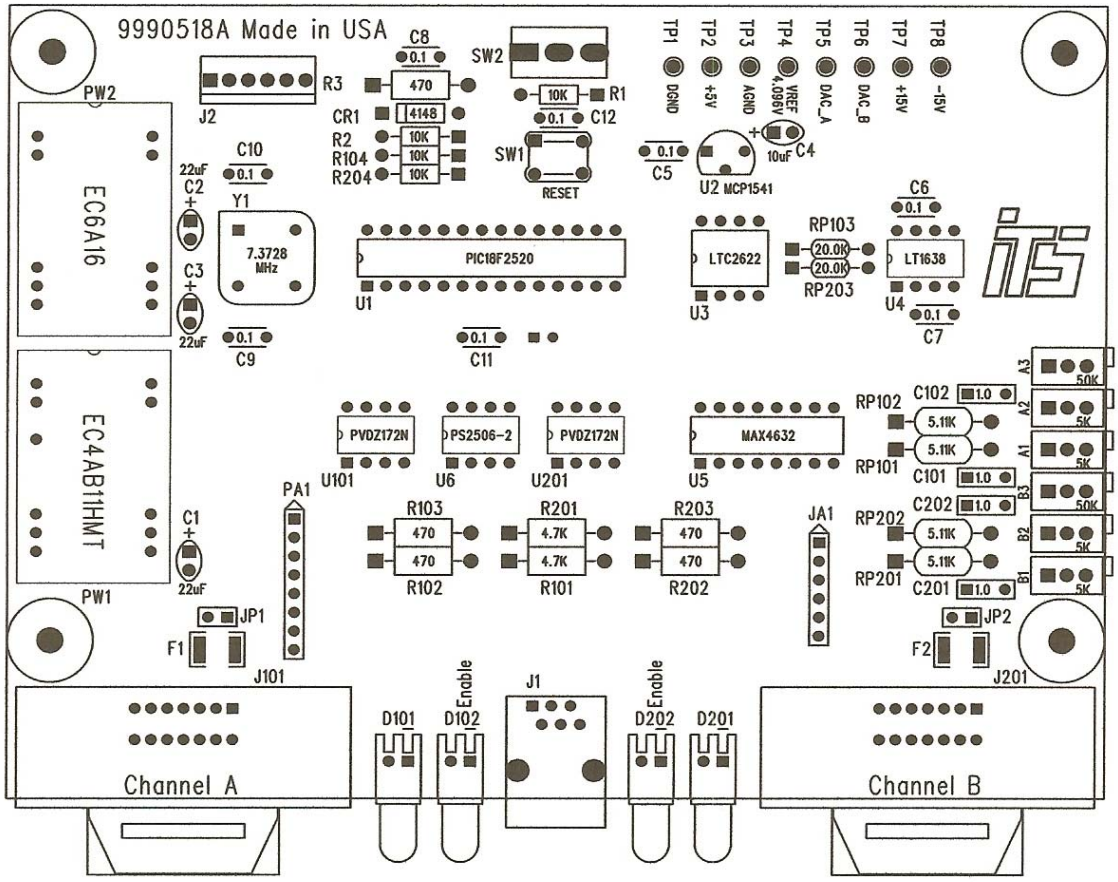
5.1. Physical

Dimensions:	6 in. wide x 5.75 in. deep x 2.25 in. high
Weight:	1 lb. maximum
Finish:	Cardinal, high bake, water-based paint, medium texture.

5.2. Electrical

Supply Voltage:	18 to 36 VDC
Current:	0.5 Amp maximum, 0.1 Amp typical
Timing Resolution:	1 microsecond

6. APPENDIX - PC BOARD LAYOUT



7. APPENDIX – TYMKON APPLICATION NOTES

THE FOLLOWING SECTION DESCRIBES THE OPERATION OF THE RF PULSER WHEN USED WITH TYMKON PROCESS SEQUENCERS.

RF Enable – This function enables the RF Interface and the RF Generator. When this function is turned ON with no other RF functions, the generator is operated in the conventional analog mode with no pulsing. The set-point entered for this function has a set-point resolution of 1% and ranges from 0 to 99%. This value determines the average power requested from the generator and represents a percentage of the total wattage that the generator is capable of producing. The analog input reported for this function is the value returned from the generator as "Forward Power".

RF Pulse – This function enables the RF Pulse Modes. This function has no effect unless the RF Enable function is also on. The set-point entered for this function has a set-point resolution of 1% and ranges from 0 to 99%. This value determines the peak power requested from the generator and represents a percentage of the total wattage that the generator is capable of producing. For example, a setting of 35% sends to pulses of 3.5 Volts amplitude to the generator. There is no analog input assigned to this function.

RF PWS – This function enables an RF Pulse Mode in which the user sets the ON Time of the pulses and the RF Pulser calculates the OFF Time based on the Average Power and the Peak Power requested. This function has no effect unless the RF Enable function and the RF Pulse functions are also on. The set-point entered for this function determines the ON Time of the pulse as determined by the table following this section.

RF PWM – This function enables an RF Pulse Mode in which the user sets the Total Pulse Width of the pulses and the RF Pulser calculates the ON and OFF Times based on the Average Power and the Peak Power requested. This function has no effect unless the RF Enable function and the RF Pulse functions are also on. The set-point entered for this function determines the Total Pulse Time as determined by the table following this section.

RF Reflected – This function has no purpose other than to log and display the "Reflected Power" data returned from the generator. The data will be recorded in the database and displayed on the graph whether the function is ON or OFF. In a future version, this function will also be used to set an upper limit on the Reflected Power so the Tymkon can alarm or abort as required.

Test Mode – Another pulse mode is provided to allow the user to explicitly set both the ON Time and the OFF Time of the pulses. To enable this mode, The RF Enable, RF Pulse, RF PWS and RF PWM functions must all be programmed on. In this mode, the RF PWS function determines the ON Time and the RF PWM determines the OFF Time.

Analog Mode			
	Digital Output	**Setpoint**	**Actual**
RF Enable	RF Enable Relay	Average Power Setpoint	Forward Power
RF Pulse			
RF PWS			
RF PWM			
RF Reflected	* Enable Alarm	* Upper Limit	Reflected Power

PWS Mode			
	Digital Output	**Setpoint**	**Actual**
RF Enable	RF Enable Relay	Average Power Setpoint	Forward Power
RF Pulse	Enables Pulses	Peak Power Setpoint	
RF PWS	Enables PWS Mode	On Time	
RF PWM			
RF Reflected	* Enable Alarm	* Upper Limit	Reflected Power

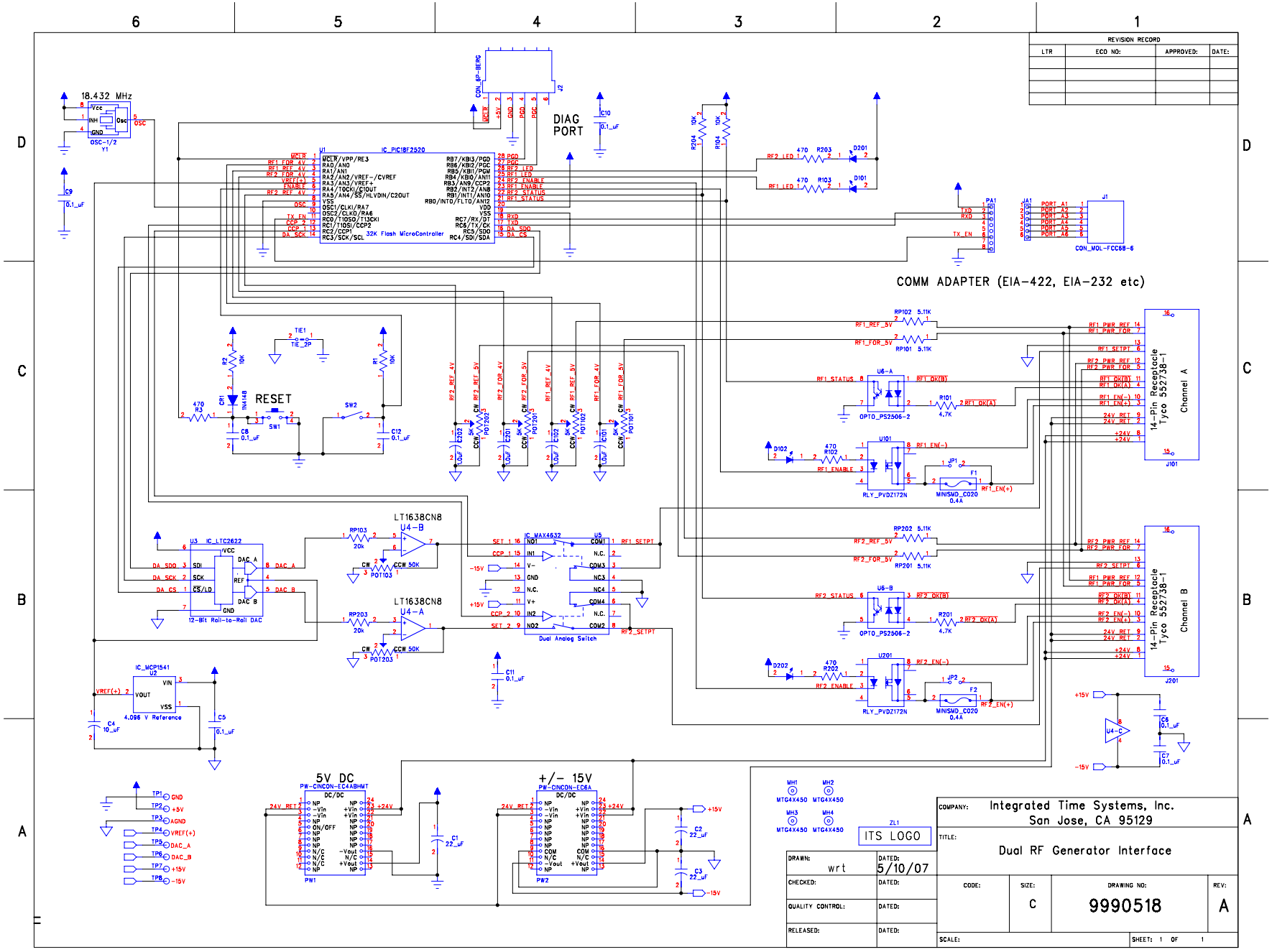
PWM Mode			
	Digital Output	**Setpoint**	**Actual**
RF Enable	RF Enable Relay	Average Power Setpoint	Forward Power
RF Pulse	Enables Pulses	Peak Power Setpoint	
RF PWS			
RF PWM	Enables PWM Mode	Total Time	
RF Reflected	* Enable Alarm	* Upper Limit	Reflected Power

Test Mode

	Digital Output	Setpoint	Actual
RF Enable	RF Enable Relay	Average Power Setpoint	Forward Power
RF Pulse	Enables Pulses	Peak Power Setpoint	
RF PWS	Enables Test Mode	On Time	
RF PWM	Enables Test Mode	Off Time	
RF Reflected	* Enable Alarm	* Upper Limit	Reflected Power

*Future feature

Setting	Interval
0	1 Millisecond
1	1 Millisecond
2	2 Milliseconds
3	3 Milliseconds
4	4 Milliseconds
5	5 Milliseconds
6	6 Milliseconds
7	7 Milliseconds
8	8 Milliseconds
9	9 Milliseconds
10	10 Milliseconds
11	110 Microseconds
20	200 Microseconds
90	900 Microseconds
99	990 Microseconds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APPROVED:
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32K Flash MicroController
COMM ADAPTER (EIA-422, EIA-232 etc)
RESET
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12-Bit Rail-to-Rail DAC
LT1638CN8
U4-B
U4-A
IC_MAX4632
Dual Analog Switch
IC_MCP1541
4.096 V Reference
OPTO_PS2506-2
RLY_PVDZ172N
MINISMD_C020
14-Pin Receptacle
Tyco 552738-1
Channel A
Channel B
5V DC
+/- 15V
PW-CINCON-EC4ABHMT
PW-CINCON-EC6A
ITS LOGO
Integrated Time Systems, Inc.
San Jose, CA 95129
Dual RF Generator Interface
DRAWN: wrt
DATED: 5/10/07
CHECKED:
QUALITY CONTROL:
RELEASED:
CODE:
SIZE: C
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