PRELIMINARY

RFuW Engineering Ltd.

RFD2T28125-700

SP2T PIN Switch Driver – Positive Voltage Driver

Features:

- Supports High Output Drive Voltage and Current
- Supports MSW2T Series of High Power Switches
- Operates from +5V and +28 V to +125 V
- High Output Current (200 mA) for Low Loss and High Isolation
- Controllable with One or Two TTL Signals, Two Driver Outputs
- RoHS Compliant

Description:

The RFD2T28125-700 surface mount PIN Switch Driver assist the user in translating TTL level control signals into high biasing voltages and high biasing currents required to properly bias PIN diode based SP2T PIN diode switches. The fundamental building block consists of a PIN Diode and it is the intrinsic layer which gives this device its unique characteristics. When charge is injected into the intrinsic layer it becomes highly conductive and then presents a very low insertion of a few tenths of a dB. When charge is depleted from the intrinsic layer it becomes highly nonconductive and in this state presents a high isolation state. As the operating power increases or the frequency of interest drops into the HF & VHF realms, the necessary biasing voltages climb into the hundreds of voltage which exceeds the capabilities of all MMIC style Switch Drivers.

This device has been designed to support the MSW2T family of SP2T high power switches. The RFD2T28125-700 operates with two positive bias voltages: +5V and a +28V to +125V.

The RFD2T28125-700 driver can source up to 200mA to enable the PIN diodes to operate in both the on state, at optimum low insertion loss or off state, high isolation state. The RFD2T28125-700 can be configured to operate with either one or two TTL input control signals to toggle between the two states. There are two complimentary outputs to support the typical series-shunt PIN diode switch topology.

The RFD2T28125-700 is packaged in a 33mm x 33mm x8.4mm surface mount package. The device is compatible with surface mount, solder reflow processes typically employed in high volume production.

The RFD3T28125-701 Driver is capable of meeting the environmental requirements of MIL-STD-202 and MIL-STD-750.

ESD and Moisture Sensitivity Rating

The ESD rating for this device is Class 1A, HBM. The moisture sensitivity level rating is MSL1.

Absolute Maximum Ratings

T_A= +25°C as measured on the base ground surface of the device.

Parameter	Conditions	Absolute Maximum Value
Input Voltage, $+V_{CC1}$		-0.5 to +6.0 V
Input Voltage, $+V_{CC2}$		-0.5 to +130 V
Control Port Input Voltage		-0.5 to 5.5 V
Output Sink Current	V_{OUT} ~ 0 V	+200 mA
$+V_{CC}$ Output Source Current	V_{OUT} ~ $+V_{CC2}$ V	+25 mA
Operating Temperature		-40°C to +85°C
Storage Temperature		-65°C to +150°C
Assembly Temperature	T < 10 sec	+260°C
Total Dissipated Power	T_{CASE} = 85oC	2.0 W

Note 1: T_{CASE} is defined as the temperature of the bottom ground surface of the device.

RFD2T28125-700 Electrical Specifications

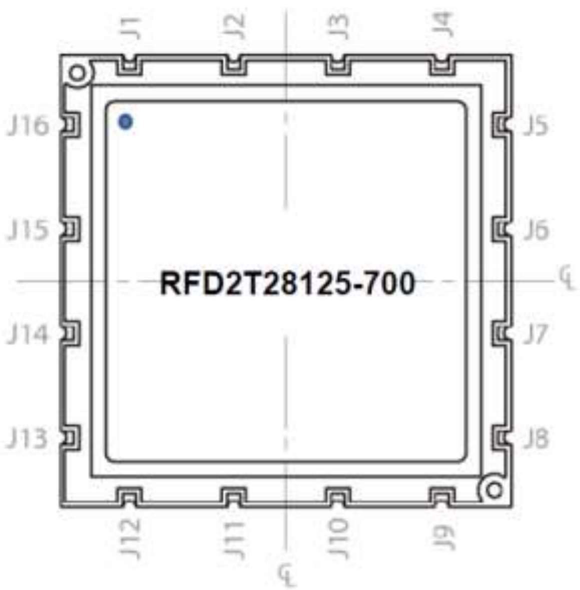
@ Z_o=50Ω, TA= +25°C as measured on the base ground surface of the device.

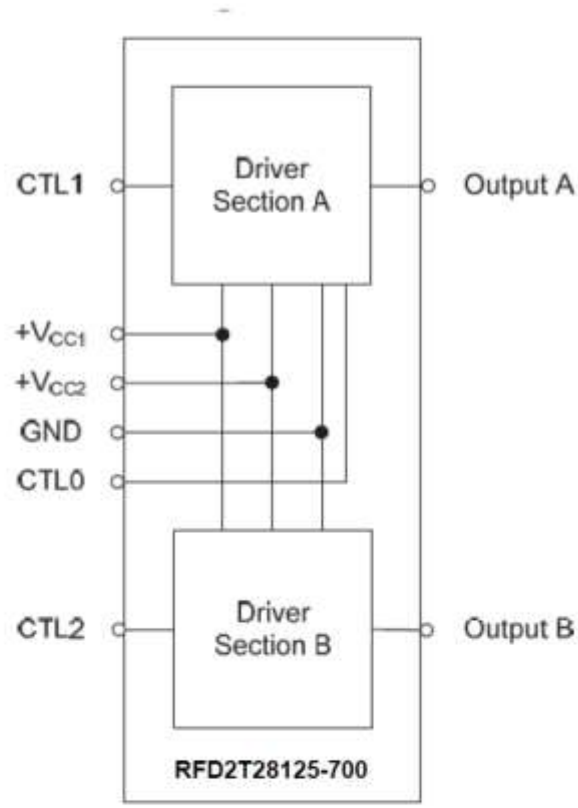
Parameters	Symbol	Test Conditions	Min Value	Typ Value	Max Value	Units
Operating Frequency	PRF	$+V_{CC1}$= 5 V, $+V_{CC2}$= +28 to +125 V	0	100	500	KHz
Supply Voltage	$+V_{CC1}$		4.5	5	5.5	V
Supply Voltage	$+V_{CC2}$		+10	+28	+125	V
Quiescent Current ($+V_{CC1}$)	I_{Q1}	$+V_{CC1}$=5V, $+V_{CC2}$= +28V to +125 V, No load connected to output A & B	5	10	20	mA
Quiescent Current (=V_{EE})	I_{Q2}	$+V_{CC1}$=5V, $+V_{CC2}$= +28V to +125 V, No load connected to output A & B	+30	+40	+50	mA
TTL Input Voltage	V_{LOW} V_{HIGH}	Logic 0: sink current = 20 uA Logic 1: source current = 500 uA	0 2		0.8 5.0	V V
Low Level Output Voltage Output A, B or C	V_{OUTL}	$+V_{CC1}$=5V, $+V_{CC2}$= +28V to +125 V, Sink current = +200 mA	0.05	0.1	0.2	V
Low Level Output Voltage Output A, B or C	V_{OUTH}	$+V_{CC1}$=5V, $+V_{CC2}$= +28V to +125 V, Source current = +20 mA	$+V_{CC2}$ - 1	$+V_{CC2}$ - 0.3	$+V_{CC2}$ - 0.1	V
Switching Time	T_{SW}	$+V_{CC1}$=5V, $+V_{CC2}$= +28V to +125 V, F =10kHz, 50% TTL to 10% or 90% RF output voltage		1.5	2	usec

Notes:

1. Switching Time (T_{SW}) is measured using the MSW2T-2040-193 SP2T, f_{RF} = 500 MHz, $+V_{CC1}$= +5 V and $+V_{CC2}$= +50 V.

RFD2T28125-700 Pin Out





Pin Out Description

Pin	Pin Name	Input/Output	Description
1	CTL1	I	TTL input control (CTL1) to Driver Section A
2	GND		$+V_{CC1}$ & $+V_{CC2}$ ground return
3	CTL2	I	TTL input control (CTL2) to Driver Section B
4	CTL0	O	Complement of CTL1. Maybe be connected to CTL2 for single control port operation via CTL1.
5	GND		$+V_{CC1}$ & $+V_{CC2}$ ground return
6	Output A	O	Bias voltage/current output from driver port A
7	GND		$+V_{CC1}$ & $+V_{CC2}$ ground return
8	Output B	O	Bias voltage/current output from driver port B
9	GND		$+V_{CC1}$ & $+V_{CC2}$ ground return
10	GND		$+V_{CC1}$ & $+V_{CC2}$ ground return
11	GND		$+V_{CC1}$ & $+V_{CC2}$ ground return
12	GND		$+V_{CC1}$ & $+V_{CC2}$ ground return
13	$+V_{CC2}$		Positive high voltage (+28 to +125 V) input
14	GND		$+V_{CC1}$ & $+V_{CC2}$ ground return
15	$+V_{CC1}$		+5V supply voltage input
16	GND		$+V_{CC1}$ & $+V_{CC2}$ ground return

Truth Table

CTL1 (notes 1 & 2)	CTL2 (notes 1 & 2)	Driver Output Section A	Driver Output Section B
V_{HIGH}	V_{LOW}	V_{OUT}= 0 V, current sinking mode	V_{OUT} ~ V_{CC2} V, current sourcing mode
V_{LOW}	V_{HIGH}	V_{OUT} ~ +V_{CC2} V, Current sourcing mode	V_{OUT}= 0 V, current sinking mode
V_{HIGH}	V_{HIGH}	Not recommended state	
V_{LOW}	V_{LOW}	Not recommended state	

Notes:

1) $2V \le V_{HIGH} \le 5V$
2) $0V \le V_{LOW} \le 0.8V$
3) Not recommended state

Control of Symmetrical SP2T Switch

The RFD2T28125-700 can control a symmetrical SP2T series-shunt PIN Diode switch. Each driver section is connected to one series-shunt switch element to provide biasing voltages required in the two operating states: RF State 1 and 2. The RF State of the SP2T is determined by the inputs to the Control signals: CTL1. The Control signal states drives the SP2T into a state where one port is in the Low Loss state while the other port is in the Isolation state.

CTL1	CTL2	RF State	Path J0 to J1	Path J0 to J2	Output A		Output B	
					J1 Bias	B1 Bias	J2 Bias	B2 Bias
V_{HIGH}	V_{LOW}	1	Low Loss	High Isolation	0 V, -100 mA	+28 V, 0 mA	+28 V, +25 mA	0 V, -25 mA
V_{LOW}	V_{HIGH}	2	High Isolation	Low Loss	+28 V, +25 mA	0 V, -25 mA	0 V, -100 mA	+28 V, 0 mA

Notes:

- All other combinations not recommended.
- For single control, connect CTL0 to CTL2 and apply control signal to CTL1 only.

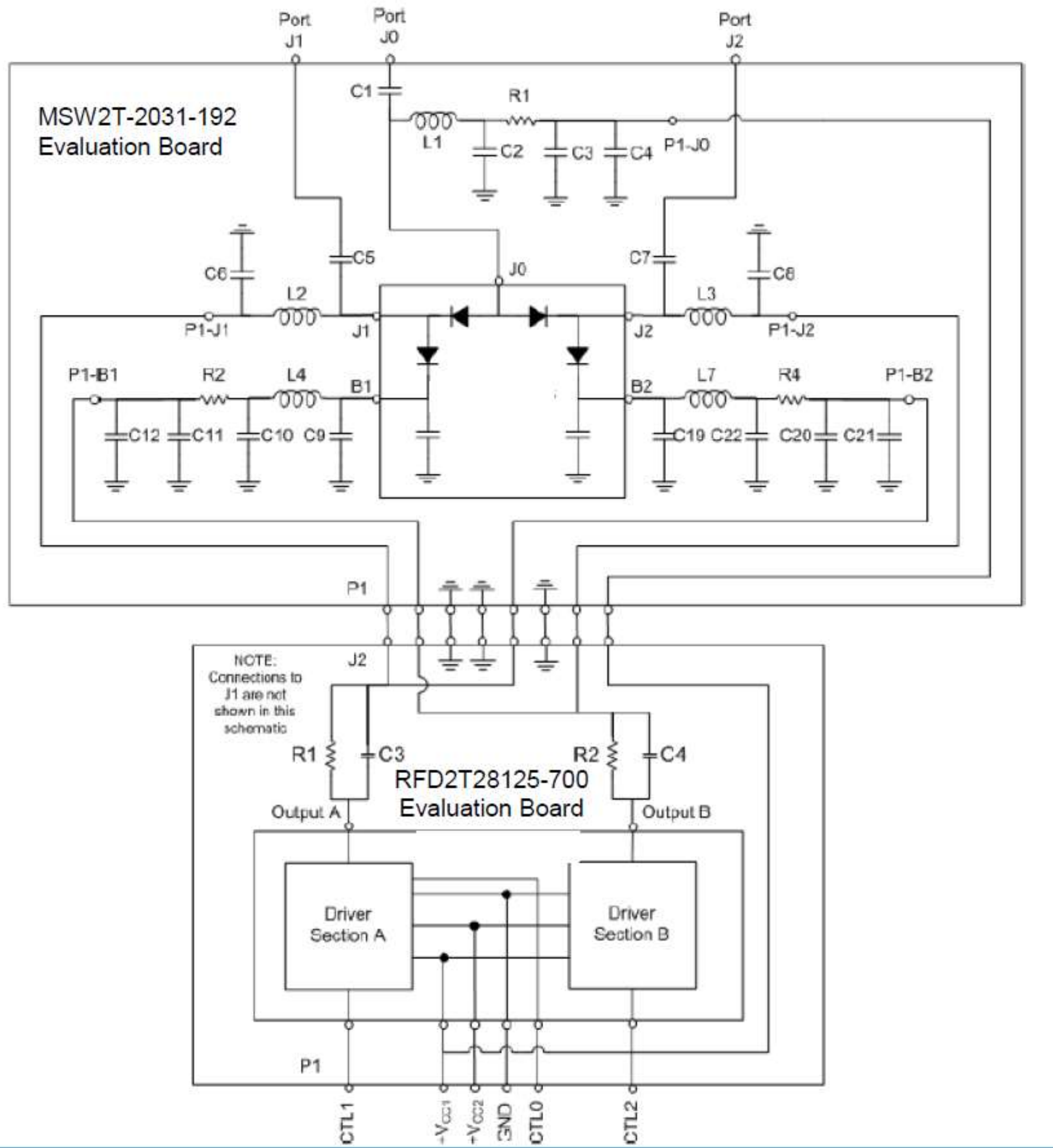
Positive Voltage PIN Diode Switch Driver

The RFD2T28125-700 PIN Diode Driver is optimized for use with the MSW2T series of High Power RF SP2T. The driver comprises of two driver sections, each capable of providing both forward and reverse bias currents accompanied with biasing voltages depending on the TTL control signals. Each section of the driver has a dedicated control port, so these sections are controlled and may be operated independently. There are provisions made to enable single control signal operation by externally connecting CTL0 to CTL2.

The driver evaluation board includes a parallel R-C network on the output of each driver section (R1-C3 on Driver A output, R2-C4 on the Driver B output). Each network produces a current spike on the transitions of the driver state, which rapidly extracts stored charge from the PIN diodes which are being forced from the non-conduction to the conduction state. These current spikes accelerate the transition of the switch from one state to the other.

Control of Symmetrical SP2T Switch

The RFD2T28125-700 Switch Driver is capable of controlling a SP2T switch comprising a series-shunt topology. Each driver section is connected to bias a series diode on one side of the switch and the shunt diode on the opposite side of the switch. Driver section A biases the series diode connected between switch ports J0 and J1, as well as the shunt diode connected between switch ports J2 and B2. Driver Section B is connected to control the remaining two diodes.



A typical symmetric switch driver application circuit is shown below. In this circuit, the RFD2T28125-700 driver is used to control the MSW2T-2031-192 symmetrical SP2T. The switch may be controlled to one of two operational states: State 1 and State 2.

State 1

In State 1, the series PIN diode between the J0 and J1 ports is forward biased by applying 0 V to the J1 bias input port (p1-J1). The magnitude of the resultant bias current through the diode is primarily determined by the voltage applied to the J0 bias port (P1-J0), the magnitude of the forward voltage across the PIN diode and the resistance of R1. This current is nominally 100mA. At the same time, the PIN diode connected between J2 and

B2 port is also forward biased by applying a high bias voltage, nominally +28V, to the J2 bias port (P1-J2) and 0V to the B2 bias port (P1-B2). Under this condition, the PIN diode connected between the J0 and J2 ports is reversed biased and the PIN diode connected between the J2 and B2 ports is forward biased. The magnitude of the bias current through this diode is primarily determined by the voltage applied to the J2 bias port, the magnitude of the forward voltage across the PIN diode and the resistance of R4. This current is nominally 25mA.

The series PIN diode which is connected between the J0 and J2 ports must be reverse biased during State 1. The reverse bias voltage must be sufficiently large to maintain the diode in its non-conducting, high impedance state when a large RF signal voltage may be present in the J0 to J1 path. The reverse voltage across this diode is the arithmetic difference of the bias voltage applied to the J2 bias port and the DC forward voltage of the forward biased J0 to J1 series PIN diode.

The minimum voltage required to maintain the series diode between J0 and J2 out of conduction is a function of the magnitude of the RF voltage present, the standing wave present at the series diode's anode, the frequency of the RF signal and the characteristics of the series diode, among other factors. Minimum control voltage required to maintain the series diode between J0 and J2 out of conduction is a function of the magnitude of the RF voltage present, the standing wave present at the series diode's anode, the frequency of the RF signal and the characteristics of the series diode, among other factors. Minimum control voltages for several signal frequencies are shown in the table "Minimum Reverse Bias Voltage", assuming the input power to the J0 or J1 port to be 100W CW and the VSWR on the J0-J1 path to be 1.5:1.

State 2

In State 2, the series PIN diode between ports J0 and J2 is forward biased by applying 0V to the Port J2 via (P1-J2). The magnitude of the resultant bias current through the diode is primarily determined by the voltage applied to J0 bias port (P1-J0), the magnitude of the forward voltage across the PIN diode and the resistance of R1. This current is nominally 100mA. At the same time, the PIN diode connected between J2 and B2 ports is reversed biased by applying a high bias voltage, nominally +28 V or greater, to the B2 bias port (P1-B2). A high voltage, nominally +28V, or greater, is also applied to the J1 bias port (P1-J1). Under this condition, the PIN diode connected between the J0 and J1 ports are reversed biased, thereby isolating the J1 RF port from the RF signal path between J0 and J2. The reversed voltage across this diode is the arithmetic difference of the bias voltage applied to the J1 bias port and the DC forward voltage of the forward-biased J0 to J2 series PIN diode. As described above, the minimum voltage required to maintain the series diode on the J0 to J1 side of the switch out of conduction is a function of the magnitude of the RF voltage present, the standing wave present at the diode's anode, the frequency of the RF signal and the characteristics of the series diode, among other factors.

Calculation of Resistor Values

The magnitude of the forward bias current applied to the series diodes is set by the magnitude of the supply voltage $+V_{CC1}$ Which is nominally +5V, the value of resistor R1 and the forward voltage of the series diode, V_{DIODE} , among other factors. Given the desired current value, the resistance is given by the formula:

$$R1 = (+V_{CC1} - V_{DIODE})/I_{BIAS}$$

The magnitude of the current through the shunt diode is set by the magnitude of the supply voltage $+V_{CC2}$, the value of resistor in series with the shunt diode (R2 or R4) and the forward voltage of the shunt diode, V_{DIODE}, among other factors. Given the desired current value, this resistance is given by the formula:

$$RSHUNT = (+V_{CC2} - 0.3 - V_{DIODE})/ I_{BIAS}$$

Single Control Operation

The logic level available at the output CTL0 is the complement of the control voltage applied to input CTL1. For single control operation via input CTL1, the customer should connect CTL0 (pin 4) directly to control input CTL2 (pin 3) on the PCB.

Control of Asymmetrical SP2T Switch

The RFD2T28125-700 Switch Driver can control an Asymmetrical SP2T which comprised of a Transmit (Tx) side of the switch of a series diode and a Receive (Rx) side consisting of a series-shunt element. Each driver section is connected to bias a series diode on one side of the switch. The output of driver Section A which controls the series diode on the Tx side of the switch, also controls the shunt diode on the Rx side of the switch. Driver Section B controls the series diode on the Rx side of the switch only.

A typical asymmetrical switch driver application circuit is shown below. In this circuit, the RFD2T28125-700 driver is shown connected to the MSW2T-2000-199. The switch may be controlled to one of two operational states, which are called the Transit and Receive States. In the descriptions of these states, it is assumed that $+V_{CC1}$= +5.0V and $+V_{CC2}$= +28V.

CTL1 (note 1)	CTL2 (note 1,2)	RF State	Path Tx (J1) to ANT (J2)	Path ANT (J2) to Rx (J3)	Output A		Output B
					Tx (J1) Bias	DC Bias	Rx (J3) Bias
V_{HIGH}	V_{LOW}	Tx	Low Loss	High Isolation	0V,-100mA	0V,-25mA	+28V,+25mA
V_{LOW}	V_{HIGH}	Rx	High Isolation	Low Loss	+28V,+25mA	+28V,0mA	0V,-100mA

Note:
1) All other combinations are not recommended.
2) For single control, connect CTL0 to CTL2 and apply control signal to CTL1 only.

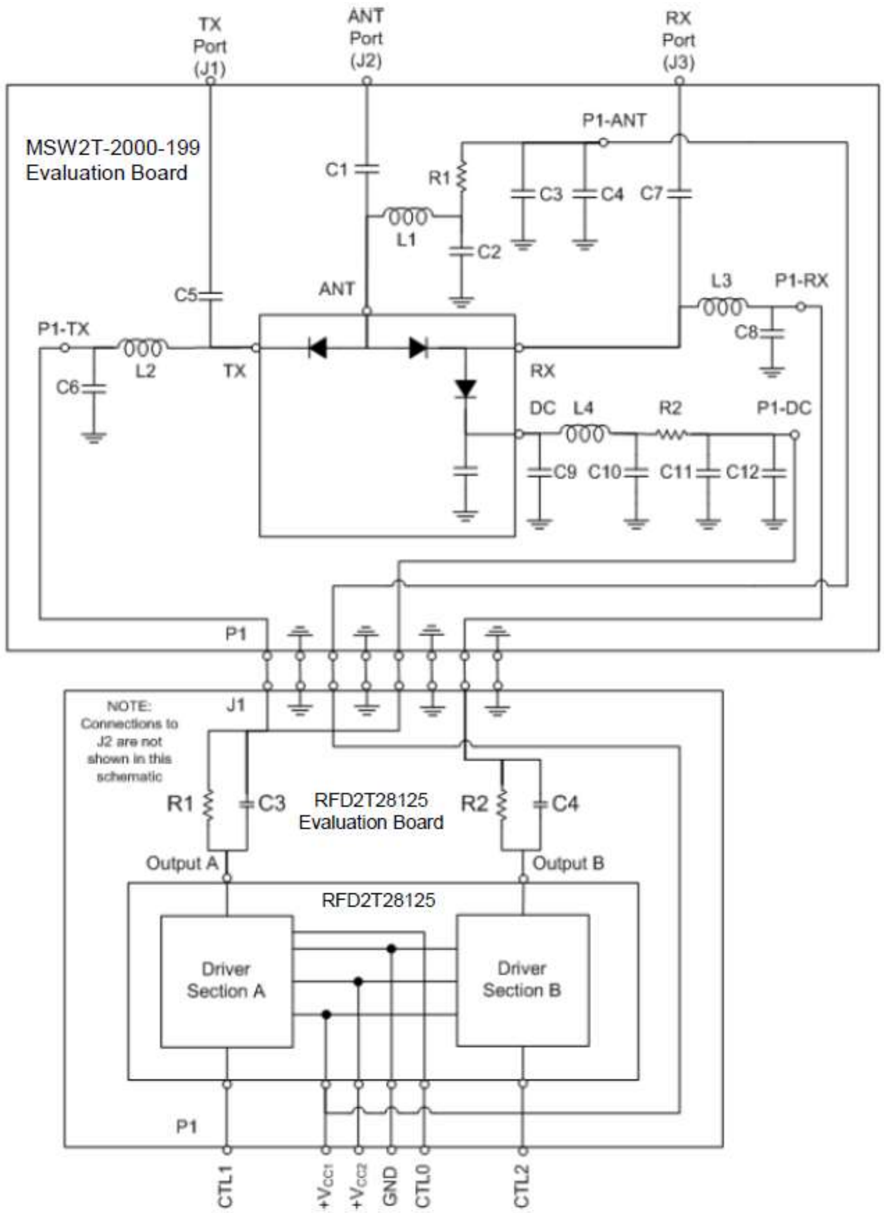
Transit (Tx) State

In the Tx State, the series PIN diode between the ANT and Tx ports is forward biased by applying 0V to the Tx bias input port (P1-1). The magnitude of the resultant bias current through the diode is primarily determined by the voltage applied to the ANT bias port (P1-3), the magnitude of the forward voltage across the PIN diode and the resistance of R1. This current is nominally 100mA. At the same time, the PIN diode connected between Rx and DC ports is also forward biased by applying a higher bias voltage, nominally +28V, to the Rx bias port (P1-7) and 0V to the DC bias port (P1-5). Under this condition, the PIN diode connected between the ANT and Rx port is the Rx and DC ports is forward biased. The magnitude of the bias current through this diode is primarily determined by the voltage applied to the Rx bias port, the magnitude of the forward voltage across the PIN diode and the resistance of R2. This current is nominally +25mA.

The Rx series PIN diode, which is connected between the ANT and Rx ports, must be reverse biased during the transmit state. The reverse bias voltage must be sufficiently large to maintain the diode in its non-conducting, high impedance state when large RF signal voltage may be present in the ANT to Tx path. The reverse voltage across this diode is the arithmetic difference of the bias voltage applied to the Rx bias port and the DC forward voltage of the forward biased transmit series PIN diode.

The minimum voltage required to maintain the series diode on the Rx side of the switch out of conduction is a function of the magnitude of the RF voltage present, the standing wave present at the Rx series diode's anode, the frequency of the RF signal and the characteristics of the series diode, among other factors. The Minimum control voltages for several signal frequencies are shown in the table “Minimum Reverse Bias Voltage”, assuming the input power to the Rx or ANT port to be 100W (CW) and the VSWR on the ANT-Tx path to be 1.5:1.

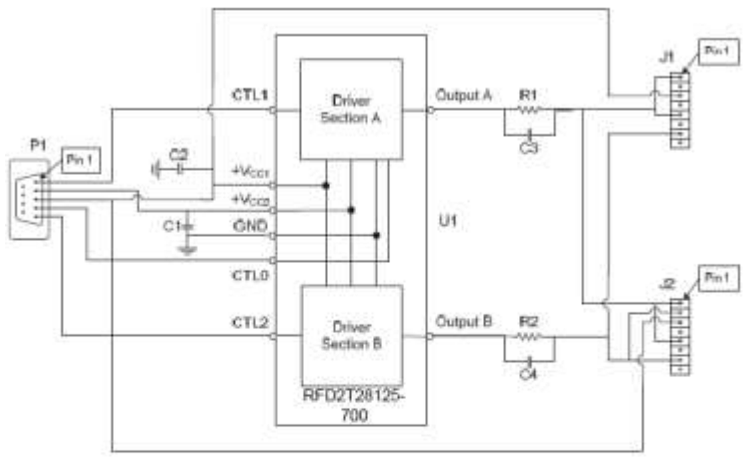
If performance of the switch under larger input signals is to be evaluated, an adequate heat sink must be properly attached to the evaluation board, and several of the passive components on the evaluation board must be changed in order to safely handle the dissipated power as well as the high bias voltage necessary for proper performance. Contact the factory for recommended components and heat sink requirements.

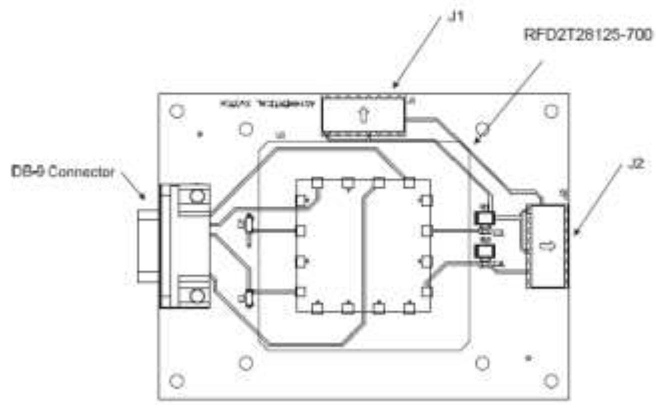


Receive (Rx) State

In the Rx state, the series Pin diode between the ANT and Rx ports is forward biased by applying 0V to the Rx bias input port (P1-7). The magnitude of the resultant bias current through the diode is primarily determined by the voltage applied to the ANT bias port (P1-3), the magnitude of the forward voltage across the PIN diode and the resistance of r1. This current is nominally 100mA. At the same time, the PIN diode connected between Rx and DC ports is reverse biased by applying a high voltage, nominally +28V, to the DC bias port (P1-5). A high voltage, nominally +28V, is also applied to the Tx bias port (P1-1). Under this condition, the PIN diode connected between the ANT and Tx port is reverse biased thus isolating the Tx RF port from the Rx signal path. The reverse voltage across this diode is the arithmetic difference of the bias voltage applied to the Tx bias port and the DC forward voltage of the forward biased receive series PIN diode. The minimum voltage required to maintain the series diode on the TX side of the switch out of conduction is a function of the magnitude of the RF voltage present, the standing wave present at the Rx series diode's anode, the frequency of the RF signal and the characteristics of the Tx series diode, among other factors. For typical receive level signals, this diode is held out of conductions with a relatively small reverse bias voltage.

The values of the reactive components which comprise the bias decoupling networks as well as the signal path DC blocking are shown in the table RF Bias Network Component Values.





The RFD2T28125-700 evaluation board allows for the full exercise of the driver to control either a symmetrical or asymmetrical SP2T. In addition to the RFD2T28125-700 driver, the evaluation board contains several passive components. C1 and C2 (680pF, 200V) are bypass capacitors for the +V_{CC2} and +V_{CC1} supply voltages, respectively. R1 (22Ω, 1/2W) and C4 (680pF, 250V) may be used to perform the same function for the Output B.

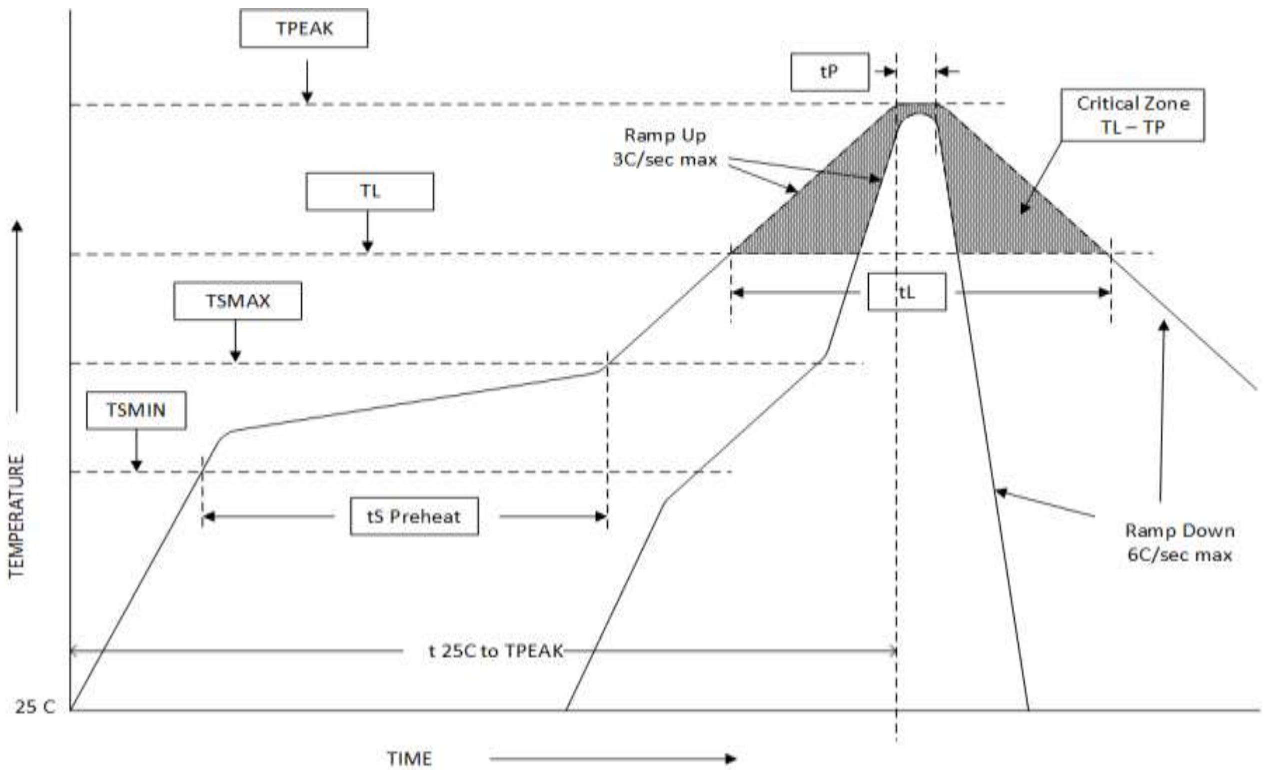
There are three multi-pin connectors on the board. The P1 connector is a DB-9 style male connector which facilitates connection of the TTL control signals, supply voltages and ground to the evaluation board. The J1 connector is a 16 pin female style header which can be used to connect directly to the male header on the symmetrical switch evaluation boards. The pin out of these connectors is shown in the tables below. Please note that the RFD2T28125-700 evaluation board is intended to operate only one high power PIN diode switch at a time. It is not recommended to simultaneously connect evaluation boards to J1 and J2.

Assembly Instructions

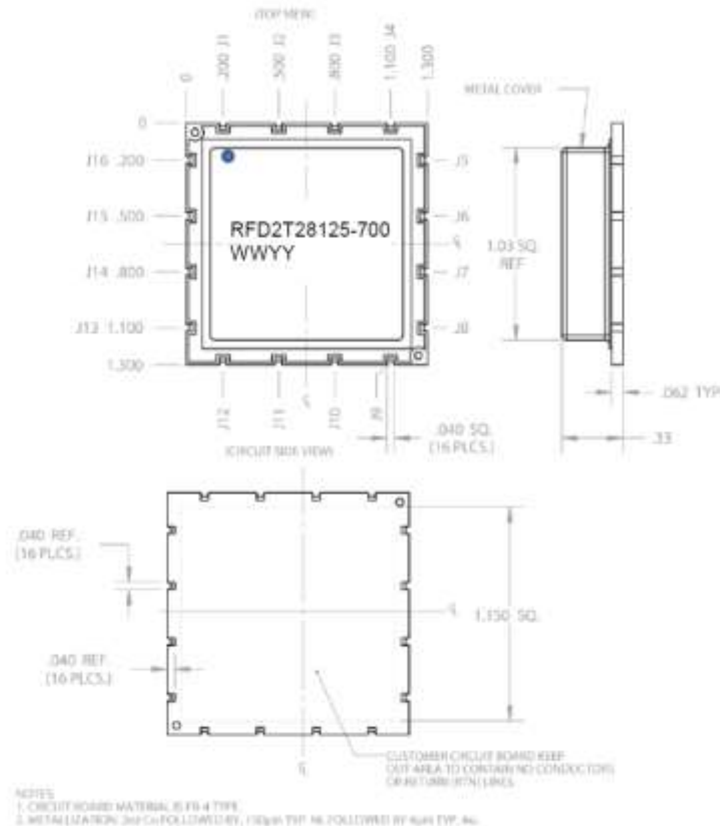
Profile Parameter	Sn-Pb Assembly Technique	RoHS Assembly Technique
Average ramp-up rate (T_L to T_P)	3^oC/sec (max)	3^oC/sec (max)
Preheat Temp Min (T_{smin}) Temp Max (T_{smax}) Time (min to max) (t_s)	 100^oC 150^oC 60 – 120 sec	 100^oC 150^oC 60 – 180 sec
T_{smax} to T_L Ramp up Rate		 3^oC/sec (max)
Peak Temp (T_P)	225^oC $+0^oC$ / -5^oC	260^oC $+0^oC$ / -5^oC
Time within 5^oC of Actual Peak Temp (T_P)	10 to 30 sec	20 to 40 sec
Time Maintained Above: Temp (T_L) Time (t_L)	 183^oC 60 to 150 sec	 217^oC 60 to 150 sec
Ramp Down Rate	6^oC/sec (max)	6^oC/sec (max)
Time 25^oC to T_P	6 minutes (max)	8 minutes (max)

The RFD2T28125-700 may be attached to the printed circuit card using solder reflow procedures using either RoHS or Sn63/ Pb37 type solders per the Table and Temperature Profile Graph shown above.

Solder Re-Flow Time-Temperature Profile



RFD2T28125-700 Package Outline Drawing



Part Number Ordering Detail:

The RFD2T28125-700 PIN Switch High Voltage Driver is available in the following format:

Part Number	Description	Packaging
RFD2T28125-700	SP2T Positive Voltage Switch Driver	Gel-Pack
RFD2T28125-700-EVB	RFD2T28125-700 Evaluation Board	Box