APPLICATION NOTE

Driver Circuit for High-Power PIN Diode Switches

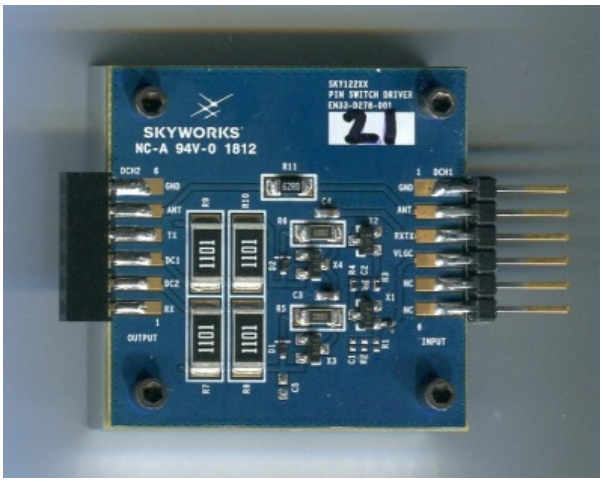
Introduction

The Skyworks High-Power Pin Diode Switch Driver Circuit is a TTL/DTL compatible, DC coupled, high-speed PIN diode bias controller. Part No. EN33-X273

This driver reference design is designed to operate with the Skyworks series of high-power SPDT PIN diode switches. These include:

SKY12207-306LF
SKY12207-478LF
SKY12208-306LF
SKY12208-478LF
SKY12209-478LF
SKY12210-478LF
SKY12211-478LF
SKY12212-478LF
SKY12213-478LF
SKY12215-478LF

This driver is designed to provide forward currents up to 100 mA for each diode, and 28 V reverse bias. It is designed for SPDT switches operating with a CW input a power up to 100 W. The driver utilizes fast switching NPN transistors and Skyworks discrete PIN diodes. The driver is designed to utilize a VDD set to +28 V, but could operate with voltages as low as +5 V.



Features

- High drive current capability (± 50 mA to ± 100 mA)
- 28 V back bias in off state
- Fast switching speed approximately 142 nS
- Low current consumption

Single TTL logic input

Skyworks Green™ products are compliant with all applicable legislation and are halogen-free. For additional information, refer to *Skyworks Definition of Green™*, document number SQ04–0074.

Table 1. Absolute Maximum Ratings[1]

Parameter	Conditions
ANT (+5 V)	–0.5 V to 7 V
RXTX (+28 V)	–0.5 V to 40 V
VLGC	–0.5 V to 7 V
RX drive current	150 mA
TX drive current	150 mA
Operational temperature	–40 to +85°C
Storage temperature	–55 to +125°C

[1] Exposure to maximum rating conditions for extended periods may reduce device reliability. There is no damage to device with only one parameter set at the limit and all other parameters set at or below their nominal value. Exceeding any of the limits listed here may result in permanent damage to the device.

Table 2. Pin Description (INPUT CONNECTOR)

PIN	Conditions	Value
GND	Ground	GROUND
ANT	5 V	INPUT
RXTX	28 V	INPUT
VLGC	Logic Control 0/5 V	INPUT
NC	No connect	
NC	No connect	

Table 3. Pin Description (OUTPUT CONNECTOR)

PIN	Conditions	Value
GND	Ground	GROUND
ANT	5 V	OUTPUT
TX	0V/28 V	OUTPUT
DC1	28V/0 V	OUTPUT
DC2	0V/28 V	OUTPUT
RX	28V/0 V	OUTPUT

Table 4. Truth Table (Switch)

Logic Control	State	State
VLCG	ANT-TX	ANT-RX
0	OFF	ON
1	ON	OFF

Table 5. Electrical Specifications T=+25°C, ANT=5 V, RXTX=28 V

Parameter	Conditions	Min	Typ	Max	Unit
DC output current TX,RX			50	100	mA
Reverse bias voltage TX,RX	1 V drop on PIN diode		27		V
Switching speed ANT-TX[1]	TRISE: RF 10% to 90%		142		ns
Switching speed ANT-TX[1]	TFALL: RF 90% to 10%		588		ns
Switching speed ANT-TX[1]	TON: DC 50% to RF 90%		696		ns
Switching speed ANT-TX[1]	TOFF: RF 90% to DC 50%		1650		ns
Switching speed ANT-RX[1]	TRISE: RF 10% to 90%		147		ns
Switching speed ANT-RX[1]	TFALL: RF 90% to 10%		165		ns
Switching speed ANT-RX[1]	TON: DC 50% to RF 90%		1419		ns
Switching speed ANT-RX[1]	TOFF: RF 90% to DC 50%		1061		ns
Pulse repetition freq. PRF	50% duty cycle	DC		100	KHz
Supply current ANT	R11=62 Ω typical		50	100	mA
Supply currents TX, RX	R5, R6 = 2 kΩ		12	15	mA
Logic levels	Logic “0” Logic “1”	0 2	0 3.3 or 5.0	0.5 5.0	V V

[1] Measured when driving the SKY12207-478LF SPDT switch.

Table 6. Recommended Operating Conditions

Parameter	Conditions	Min	Typ	Max	Unit
ANT voltage	Nominal 5 V	4.5	5	5.5	V
ANT current	Set by R11		50		mA
RXTX voltage	Bias voltage	27	28	29	V
RXTX current	Set by R7-R10		50 / diode		mA
VLGC (LOW)	ANT V=5 V nominal	0.0	0.0	0.5	V
VLGC (HIGH)	ANT V=5 V nominal	0.7 * VLGC	VLGC	VLGC	V

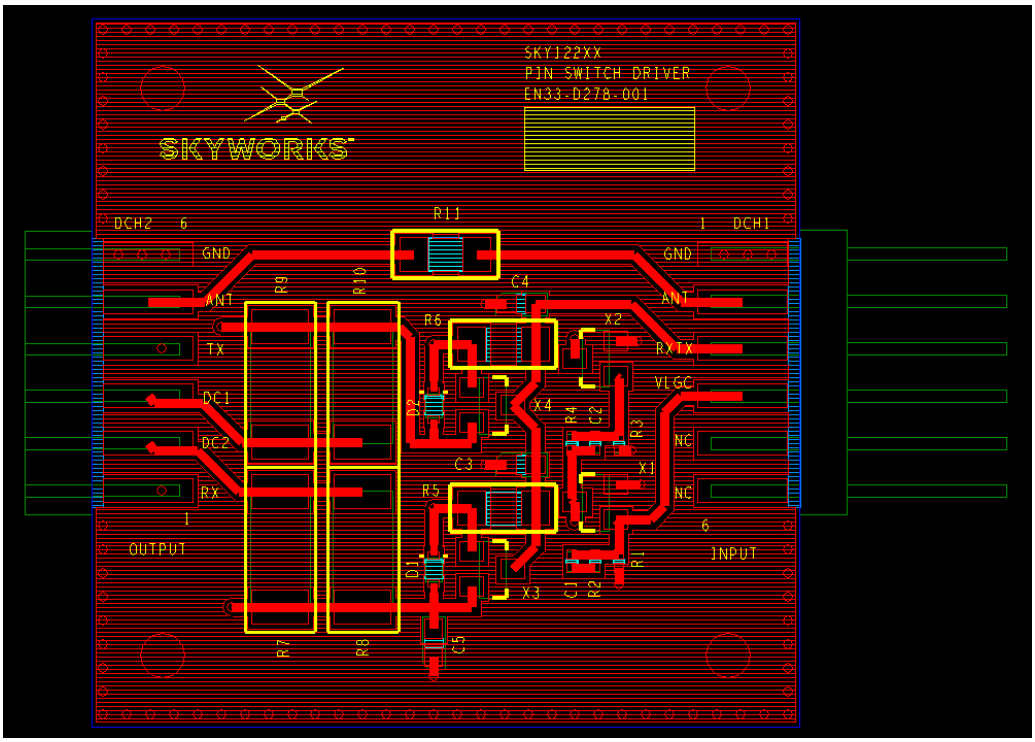


Figure 1. Circuit Board 1.5 in x 1.5 in

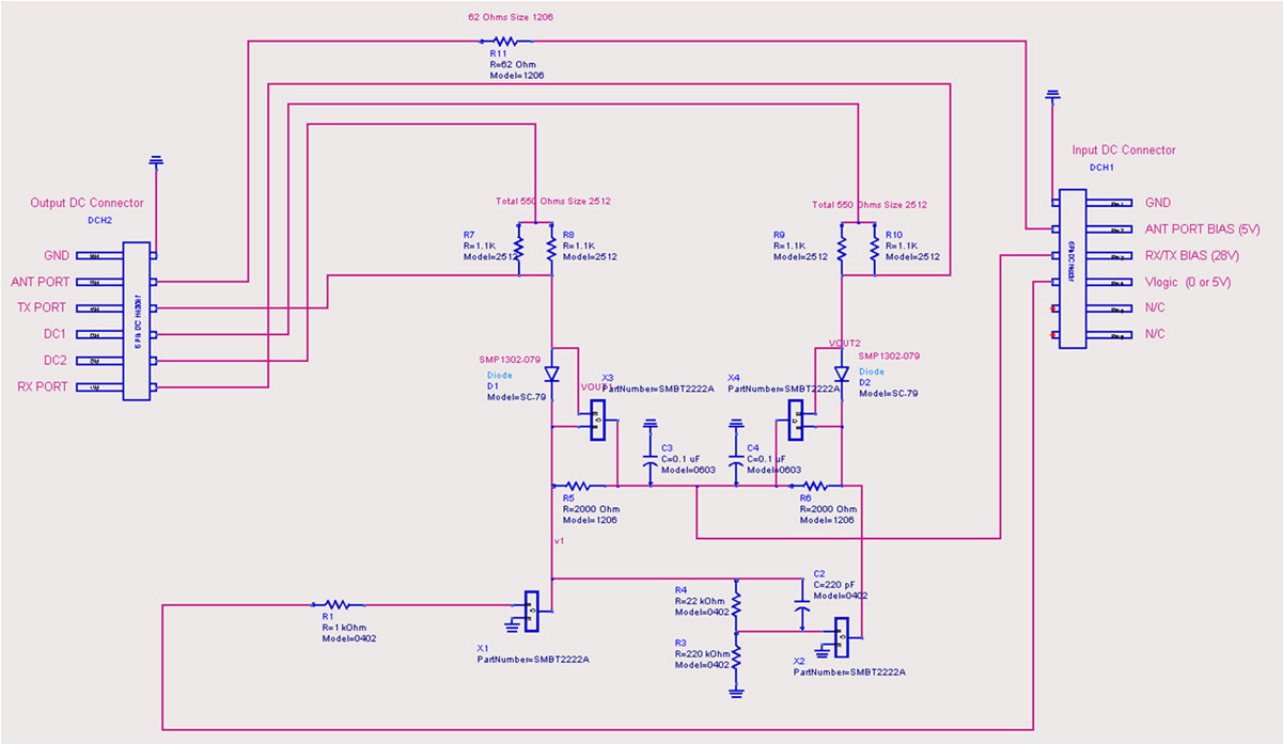


Figure 2. Application Circuit Schematic

Table 7. Driver Board Bill of Materials (Board: EN33-D278-001)

Component	Value	QTY/Board	Size	Manufacturer	Mfr Part Number	Characteristics
C1	DNP	1				Do not place
C2	220 pF	1	0402			
C3, C4	0.1 µF	2	0603			
C5	DNP					Do not place
D1, D2		2	SC-79	Skyworks	SMP1302-079LF	Silicon PIN diode
Heat Sink		1	1.5x1.5 in	Skyworks	ENG031312RMP1	Aluminum: 0.25 inch thick
PCB		1	1.5x1.5 in	Skyworks	EN33-D278-001	R4003: thickness 62 mil
R1	1 kΩ	1	0402			50 V, 0.1 W, ± 5%
R11	62 Ω	1	1206	Panasonic	ERJP08F62R0V	200 V, 0.75 W, ± 1% Notes 2, 8
R2	DNP	1				Do not place
R3	220 kΩ	1	0402			50 V, 0.1W, ± 5%
R4	22 kΩ	1	0402			50 V, 0.1 W, ± 5%
R5, R6	2 kΩ	1	1206	Rohm	ESR18EZPF2001	200 V, 0.33 W, +/-1%
R7, R8, R9, R10	1.1 kΩ	4	2512	Multicomp	MCPWR12FTEA1101	500 V, 1.5 W, ± 1% Notes 6, 7, 8
Screws		4	2-56			Length = 0.25 inch
X1, X2, X3, X4		4	SOT23	Infineon	SMBT2222A	NPN silicon switching transistor

Application Notes:

[1] Forward Bias Diode Voltage: Vf is 1.0V @ 50 mA.

[2] For a 50 mA load current on the ANT line, R1=62 Ω @ ANT V = 5.0 V, nominal power dissipation in the 62 Ω resistor is 4V x 0.050A = 200 mW. For a 100 mA load current on the ANT line, R1=31 Ω @ ANT V = 5.0 V, nominal power dissipation in the 31 Ω resistor is 4 V x 0.100 A = 400 mW.

[3] Reverse Bias is ~ 27 V (28 V supply minus approximately 1 V on the diode).

[4] The voltage at the ANT port common anode will be approximately 1 V. For the SKY12210-478LF and the SKY12212-478LF the voltage at the ANT port common anode will be approximately 2 V in ANT-TX mode.

[5] The current in through the back-biased diodes will be the leakage current for the diodes.

[6] For all switch types, except SKY12209-478LF and SKY12211-478LF, DC1 connection is not used on series-shunt/series SPDT's. Therefore, DC1 resistors R9 and R10 are not needed. These resistors are utilized only in the series-shunt/series-shunt symmetrical switches to facilitate the RF current to the second shunt diode.

[7] Two pair of 2512 size resistors (R7, R8) and (R9, R10) are independently combined in parallel to handle the power dissipated on the DC1 and/or DC2 ports. For a 50 mA load current on the RXTX line, Rtotal = 550 Ω (Two 1.1 k Ω resistors in parallel) with an RXTX voltage = 28.0 V, the nominal power dissipation in the equivalent 550 Ω resistor is 27 V x 0.050 A = 1.35 W. For a 100 mA load current on the RXTX line, Rtotal = 280 Ω (Two 560 Ω resistors in parallel) with a RXTX V = 28.0V, the nominal power dissipation in the equivalent 280 Ω resistor is 27 V x 0.100 A = 2.7 W.

[8] For SKY12210-478LF, SKY12212-478LF and SKY12215-478LF; the values of R7, R8 and R11 are changed to provide 100 mA of DC current. For a 100 mA load current on the RXTX line, Rtotal = 280 Ω (560 Ω in parallel) with a RXTX V = 28.0 V, the nominal power dissipation in the equivalent 280 Ω resistor is 27 V x 0.10 A = 2.7 W. To provide 100 mA of current to the switch ANT pin, the value of R11 is set to 31 Ω with a 5 V bias on the driver ANT pin.

Driver Performance Data T = +25 °C, ANT = 5 V, RXTX = 28 V

Figure 3 shows the "no load" voltage vs. time response of the driver circuit operating with a 0 to 5 V VLGC signal and 0 to +28 V bias on RXTX. The PRF is set to 100 KHz. The blue trace is the TX bias output pulse with a max voltage output of +28 V. The red trace is RX bias output pulse and with a max voltage output of +28 V. The gold trace is VLGC pulse of 0 to 5 V.

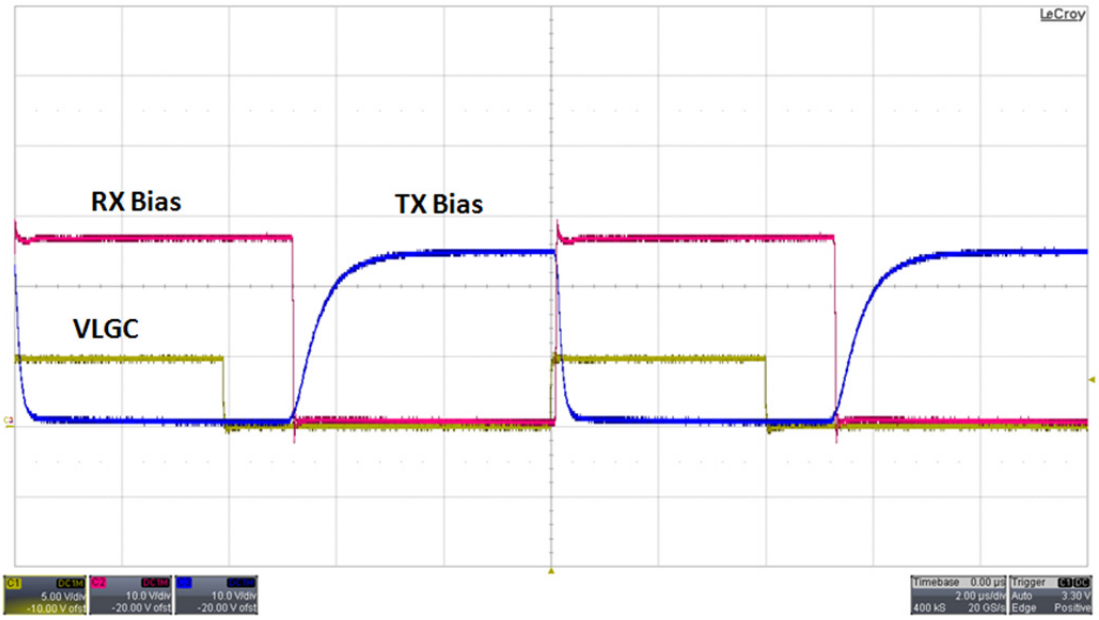


Figure 3. Driver Circuit, Voltage vs. Time

Driver + Switch Performance Data, ANT=5 V, RXTX=28 V, T=+25°C

The Skyworks driver circuit is designed to work with the Skyworks family of high-power PIN switches and mates directly to the Skyworks PIN switch evaluation board EN31-D625-003, as shown in Figure 4. The standard bill of materials for the SKY12207-478LF evaluation board is shown in Table 8 and represented in the schematic in Figure 5.

The exact bill of material will vary from switch type and frequency of operation. See switch data sheets for specific bill of materials. The total bill of materials for the switch RF evaluation board and driver circuit board is the sum of the components listed in Tables 7 and 8.

Table 8. SKY12207-478LF Evaluation Board Bill of Materials without Driver

Component	Value	QTY/Board	Size	Manufacturer	Manufacturer's Part Number	Characteristics
R1S	0 Ω	1	0603	Rohm	MCR03EZPJ000	MCR03EZPJ000
R2S, R3S[1]	540 Ω	2				Axial (off board)
C1S to C6S, C9S	1000 pF	7	0603	TDK	C1608C0G1H102JT	C0G, 50 V, ± 5%
C8S	1 µF	1	0603	TDK	C1608C0G1H102JT	X7R, 50 V, ± 10%
L1S, L2S, L5S	22 nH	3	0603	Taiyo Yuden	C1608C0G1H102JT	± 5%, SRF 1600 MHz
L3S	560 nH	1	0603	CoilCraft	0603LS-561XJLB	± 5%, SRF 525 MHz

[1] Components not to be used when connected to EN33-X273 driver board.

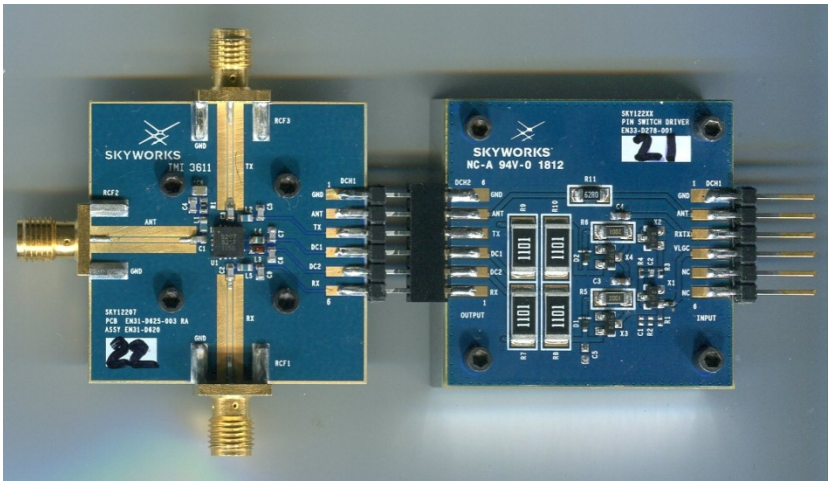


Figure 4. Skyworks High-Power PIN switch Evaluation Board + Driver Circuit

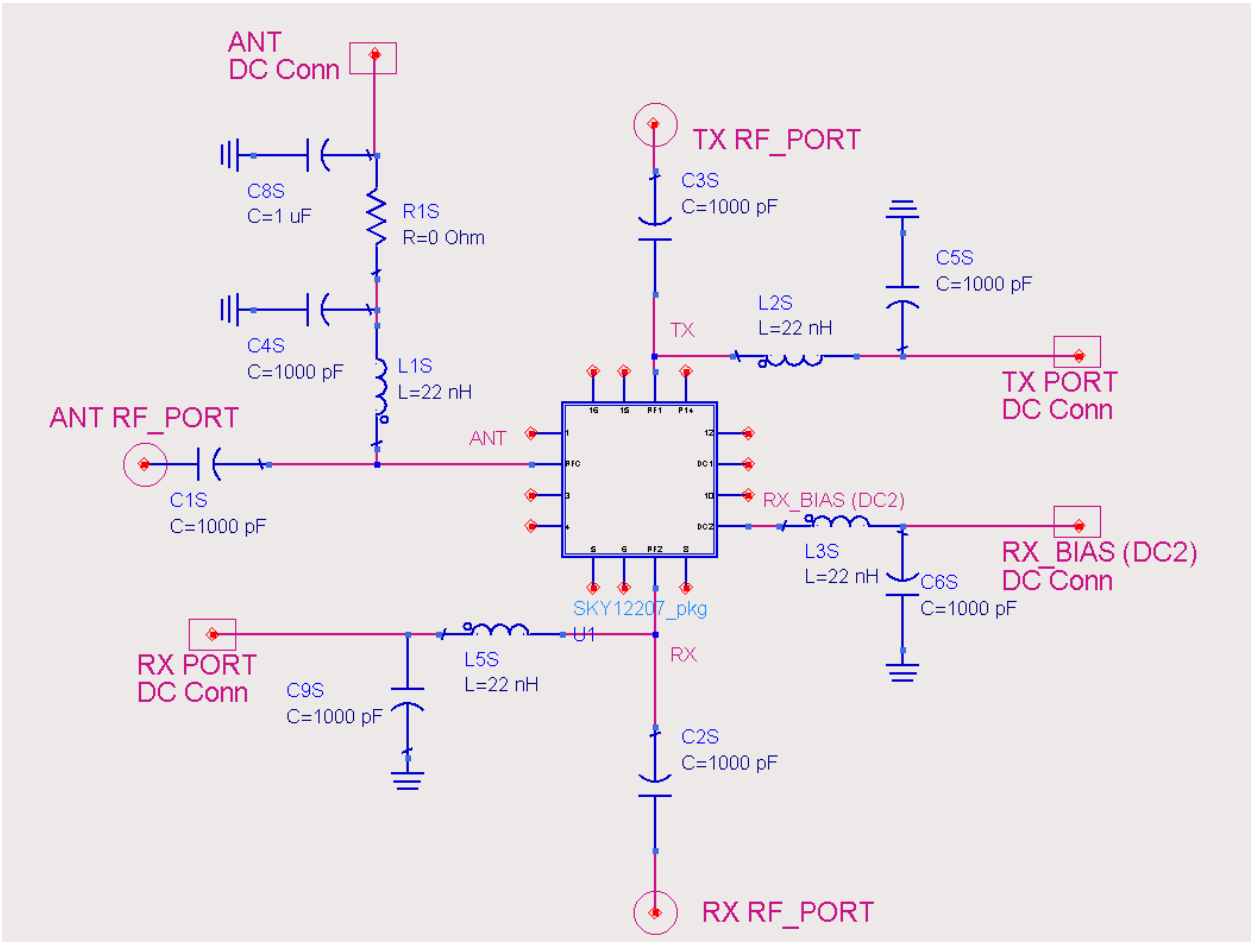


Figure 5. Skyworks High Power PIN switch Evaluation Board Circuit: EN31-D625-003

Figure 6 shows the RF pulse measurement performance of the driver circuit connected to the SKY12207-478LF 50 Watt High Power PIN Diode T/R switch. The VLGC is switched 0 to 5 V, which switches RXTX from 0 to 28 V. The RF frequency is 2.6 GHz. The PRF (pulse rate frequency) is 100 KHz. Measurements are made with 2 to 3 GHz SMA band pass filters on TX and RX RF ports.

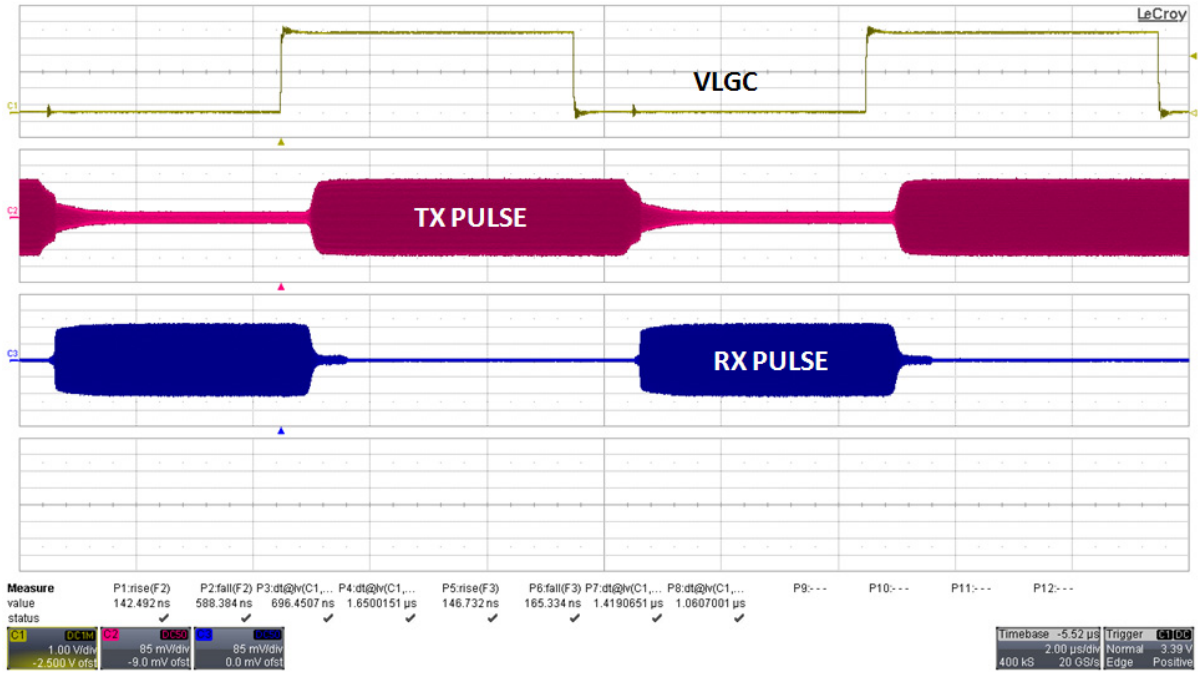


Figure 6. Skyworks High Power PIN switch Evaluation Board + Driver Circuit

Summary

The Skyworks high-power PIN diode switch driver reference design circuit is a TTL/DTL compatible, DC coupled, high-speed PIN diode bias controller. It is designed to operate with the Skyworks series of high-power SPDT PIN diode switches. Samples of the PIN diode driver and switches are available from Skyworks.

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