

DATA SHEET

# SKY13292-365LF: 4 x 2 Switch Matrix with Tone/Voltage Decoder 250 MHz–2.15 GHz

## Applications

- DBS switching applications, cable modems, cable TV

## Features

- Broadband: 250 MHz–2.15 GHz
- Tone and voltage or mode control switching
- High isolation: 40 dB typ. @ 900 MHz
- Four RF inputs, two RF outputs
- Low current consumption: 8.5 mA typ. @ 5 V
- Miniature QFN-20 4 x 4 mm package
- Lead (Pb)-free and RoHS-compliant MSL-1 @ 260 °C per JEDEC J-STD-020

## Description

The SKY13292-365LF is a four-input to two-output switch in a low-cost QFN-20 4 x 4 mm package. The SKY13292-365LF enables 16 states, directing any of the four inputs to either of the two outputs. Switch states can be selected via tone and voltage signals in conjunction with logic levels applied to mode control inputs. The switch can operate over the temperature range of -40 °C to +85 °C.

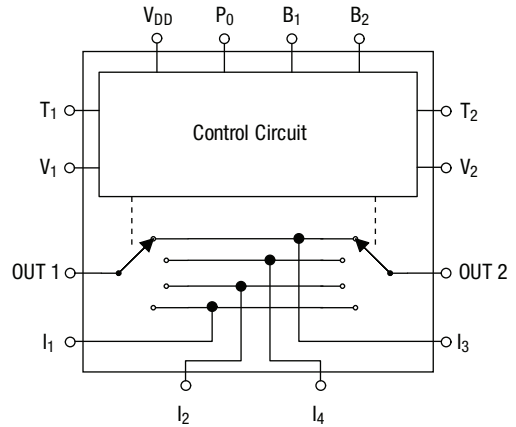
The SKY13292-365LF is available in the lead (Pb)-free, RoHS-compliant, QFN-20 4 x 4 mm plastic package.

**NEW**

Skyworks offers lead (Pb)-free, RoHS (Restriction of Hazardous Substances)-compliant packaging.



## Functional Block Diagram



**Operating Characteristics at 25°C (0, 3 V)**

Parameter	Sym.	Condition	Frequency	Min.	Typ.	Max.	Unit
<b>RF Switch Performance</b>							
Insertion loss			0.25 - 0.95 GHz		7.5	8	dB
			0.95 - 2.15 GHz		9.0	10	dB
Insertion loss flatness			0.25 - 0.95 GHz		0.7	1	dB
			0.95 - 2.15 GHz		2.0	3	dB
Isolation		Normalized to insertion loss	0.25 - 0.95 GHz	38	40		dB
			0.95 - 2.15 GHz	28	30		dB
Return loss		I <sub>1</sub> , I <sub>2</sub> , I <sub>3</sub> , I <sub>4</sub> OUT1, OUT2	0.25 - 2.15 GHz	10	15		dB
				8	10		dB
Input power for 1 dB compression	IP <sub>1</sub> dB		0.25 - 2.15 GHz		15		dBm
<b>Tone/Voltage Detector Performance</b>							
Polarization select input current	I <sub>P1</sub> , I <sub>P2</sub>	V <sub>P1</sub> = 21 V, V <sub>P2</sub> = 21 V			200		μA
Polarization select threshold voltage	V <sub>TP1</sub> , V <sub>TP2</sub>			14	14.5	15	V
Polarization switching time	T <sub>SPOL</sub>				0.9		μs
Tone frequency	T <sub>F1</sub> , T <sub>F2</sub>			7	22	650	kHz
Tone threshold voltage	T <sub>T1</sub> , T <sub>T2</sub>	Without external capacitor	22 kHz	45	170	900	V <sub>pk-pk</sub>
Tone input impedance	T <sub>ZIN1</sub> , T <sub>ZIN2</sub>	Including external 10 nF series capacitor	22 kHz		2		kΩ
<b>Mode Control Performance</b>							
Control input current	I <sub>DIG</sub>	0 V ≤ V <sub>CTRL</sub> ≤ V <sub>DD</sub>			1		μA
Control input low logic level	V <sub>LOW</sub>			0		1	V
Control input high logic level	V <sub>HIGH</sub>			V <sub>DD</sub> - 1	V <sub>DD</sub>	V <sub>DD</sub> + 0.5	V
<b>Power Supply</b>							
Supply voltage	V <sub>DD</sub>			3	5	5.5	V
Supply current	I <sub>DD</sub>				8.5		mA

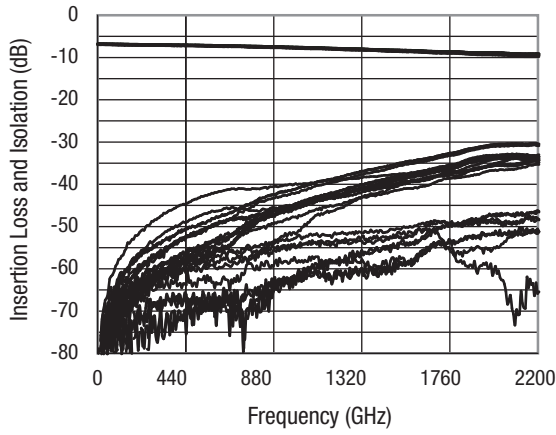
**Typical Operating Conditions**

Parameter	Sym.	Condition	Frequency	Min.	Typ.	Max.	Unit
Tone frequency	T <sub>F1</sub> , T <sub>F2</sub>	V <sub>TF</sub> = 100 mV <sub>pk-pk</sub> , 10 nF external DC block		18	22	26	kHz
Tone threshold voltage <sup>(1)</sup>	T <sub>T1</sub> , T <sub>T2</sub>		22 kHz	100	170	350	mV <sub>pk-pk</sub>

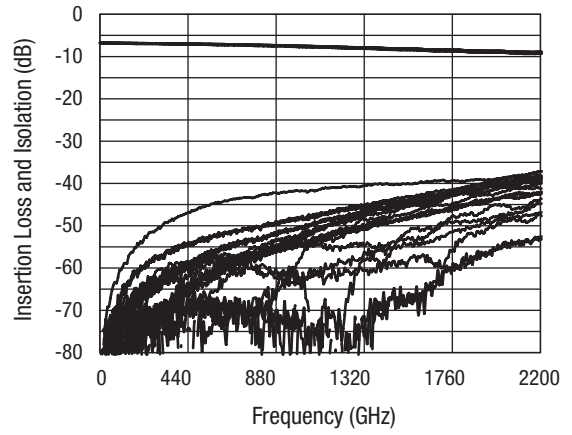
This switch will detect 22 kHz signaling amplitudes across the full specified range of the DiSEqC bus functional specification

### Typical Performance Data

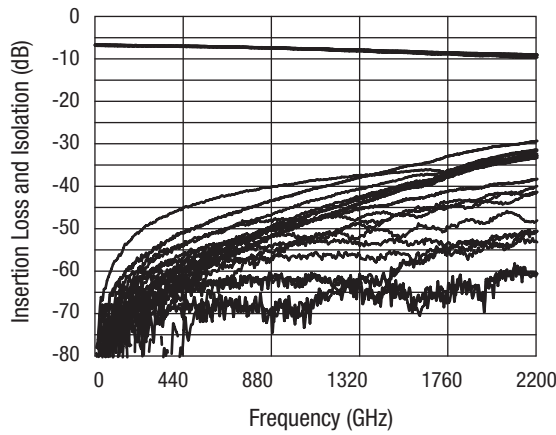
$Z_0 = 50 \Omega$ ,  $T_A = 25 \text{ }^\circ\text{C}$ , unless otherwise noted



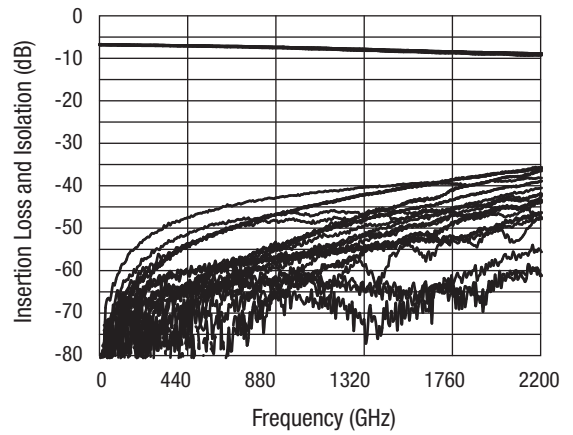
**I<sub>1</sub>\_OUT1 and I<sub>1</sub>\_OUT2 Paths: States 0 to 15**



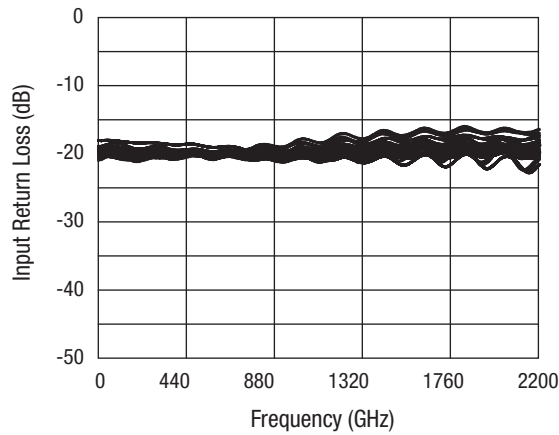
**I<sub>2</sub>\_OUT1 and I<sub>2</sub>\_OUT2 Paths: States 0 to 15**



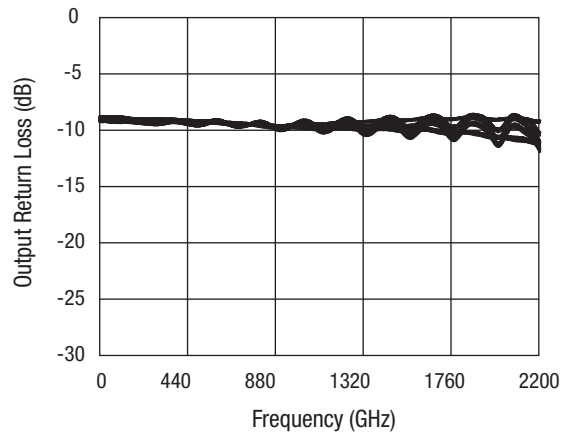
**I<sub>3</sub>\_OUT1 and I<sub>3</sub>\_OUT2 Paths: States 0 to 15**



**I<sub>4</sub>\_OUT1 and I<sub>4</sub>\_OUT2 Paths: States 0 to 15**



**I<sub>1</sub> I<sub>2</sub> I<sub>3</sub> I<sub>4</sub>: States 0 to 15**



**OUT1 and I<sub>2</sub>\_OUT2: States 0 to 15**

### Absolute Maximum Ratings

Characteristic	Value
RF Input Power	15 dBm
Mode Select Input Voltage	5.5 V
Polarization Control Input Voltage	21 V
Supply voltage	5.5 V
Operating temperature	-40 °C to +85 °C
Storage temperature	-65 °C to +150 °C

**CAUTION:** Although this device is designed to be as robust as possible, ESD (Electrostatic Discharge) can damage this device. This device must be protected at all times from ESD. Static charges may easily produce potentials of several kilovolts on the human body or equipment, which can discharge without detection. Industry-standard ESD precautions must be employed at all times.

**NOTE:** Performance is guaranteed only under the conditions listed in the Operating Characteristics and the Typical Operating Conditions tables, and is not guaranteed over the full operating or storage temperature range in the Absolute Maximum Ratings table. Exceeding any of the conditions listed in the Absolute Maximum Ratings table may result in permanent damage to the device. Operation at elevated temperatures may reduce reliability of the device.

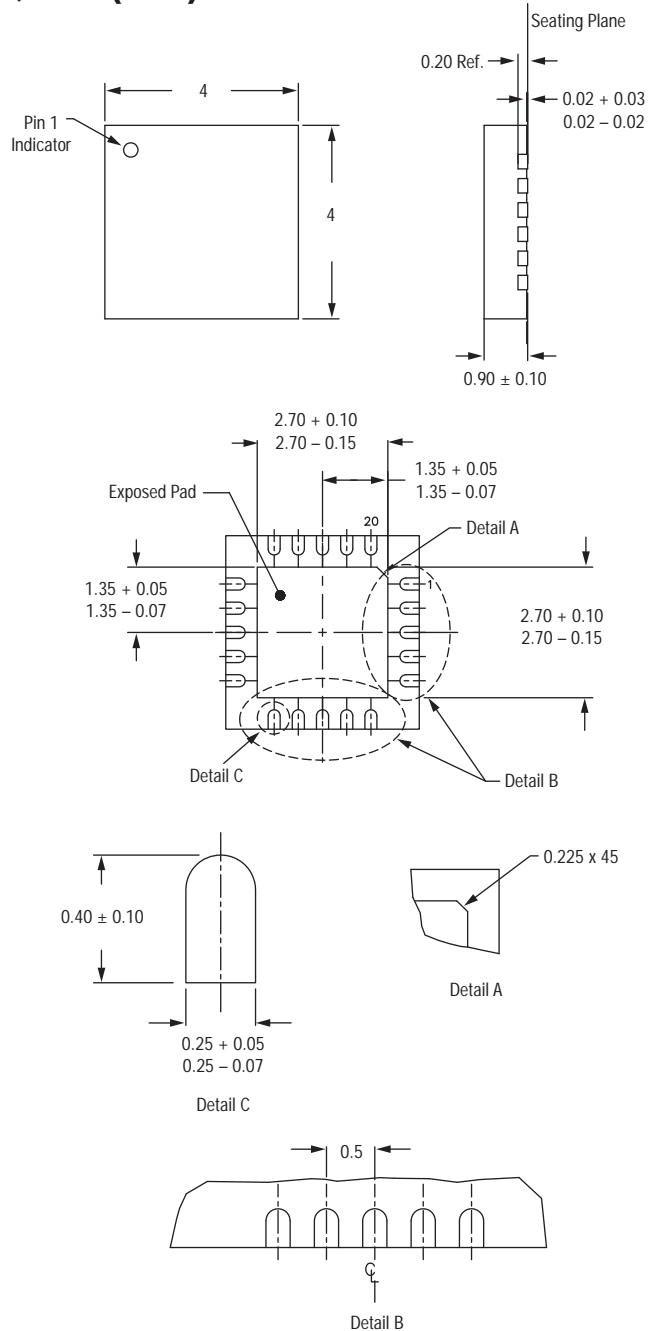
### Recommended Solder Reflow Profiles

Refer to the [“Recommended Solder Reflow Profile”](#) Application Note.

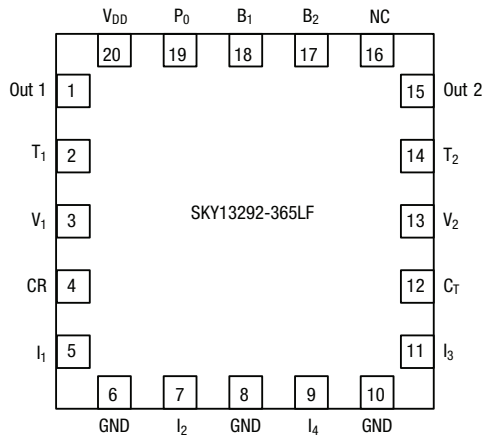
### Tape and Reel Information

Refer to the [“Discrete Devices and IC Switch/Attenuators Tape and Reel Package Orientation”](#) Application Note.

### QFN-20 (4 x 4)



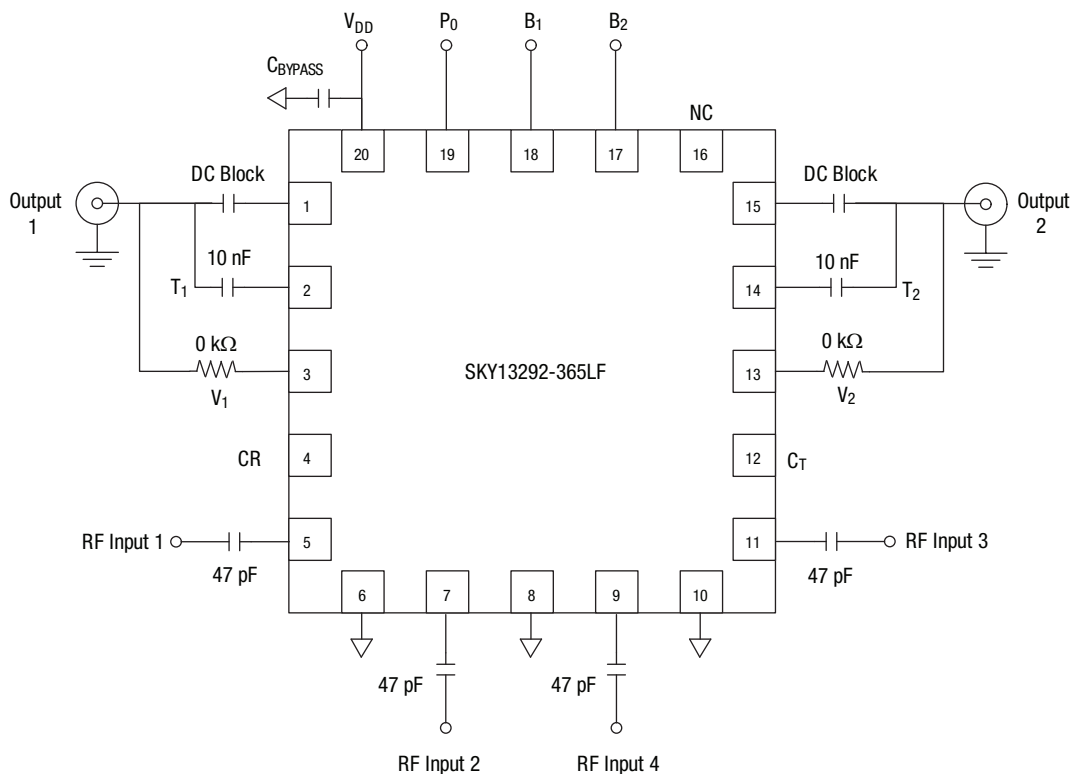
### Pin Out



### Pin Descriptions

Pin Number	Pin Name	Use		Description
1	OUT1	RF	0	RF channel output #1: 250 MHz–2150 MHz
2	T <sub>1</sub>	AC	I	Tone detector input #1
3	V <sub>1</sub>	DC	I	Voltage detector input #1
4	CR	DC	-	No connection. This pin must be left open.
5	I <sub>1</sub>	RF	I	RF Input #1: 250 MHz–2150 MHz
6, 8, 10	GND	GND	0	RF GND
7	I <sub>2</sub>	RF	I	RF Input #2: 250 MHz–2150 MHz
9	I <sub>4</sub>	RF	I	RF Input #4: 250 MHz–2150 MHz
11	I <sub>3</sub>	RF	I	RF Input #3: 250 MHz–2150 MHz
12	C <sub>T</sub>	DC	-	No connection. This pin must be left open.
13	V <sub>2</sub>	DC	I	Voltage detector Input #2
14	T <sub>2</sub>	AC	I	Tone detector input #2
15	OUT2	RF	0	RF channel output #2: 250 MHz–2150 MHz
16	N/C	DC	-	No connection. This pin must be left open.
17	B <sub>2</sub>	DC	I	Mode control input
18	B <sub>1</sub>	DC	I	Mode control input
19	P <sub>0</sub>	DC	I	Mode control input
20	V <sub>DD</sub>	DC	I	Supply voltage: 5 V
Paddle	GND	RF	-	RF GND

### Suggested Applications Circuit



The SKY13292-365LF is controlled by a pair of DC voltage levels, applied to  $V_1$  (pin 3) and  $V_2$  (pin 13), in combination with 22 kHz signal levels applied to  $T_1$  (pin 2) and  $T_2$  (pin 14). These signals are supplied from a set top box, receiver, etc., that is in turn controlled by the user. The configuration of the switch is controlled by the logic levels applied to  $P_0$  (pin 19),  $B_1$  (pin 18) and  $B_2$  (pin 17). The truth tables that describe the function of all of these control signals are elsewhere in this data sheet.

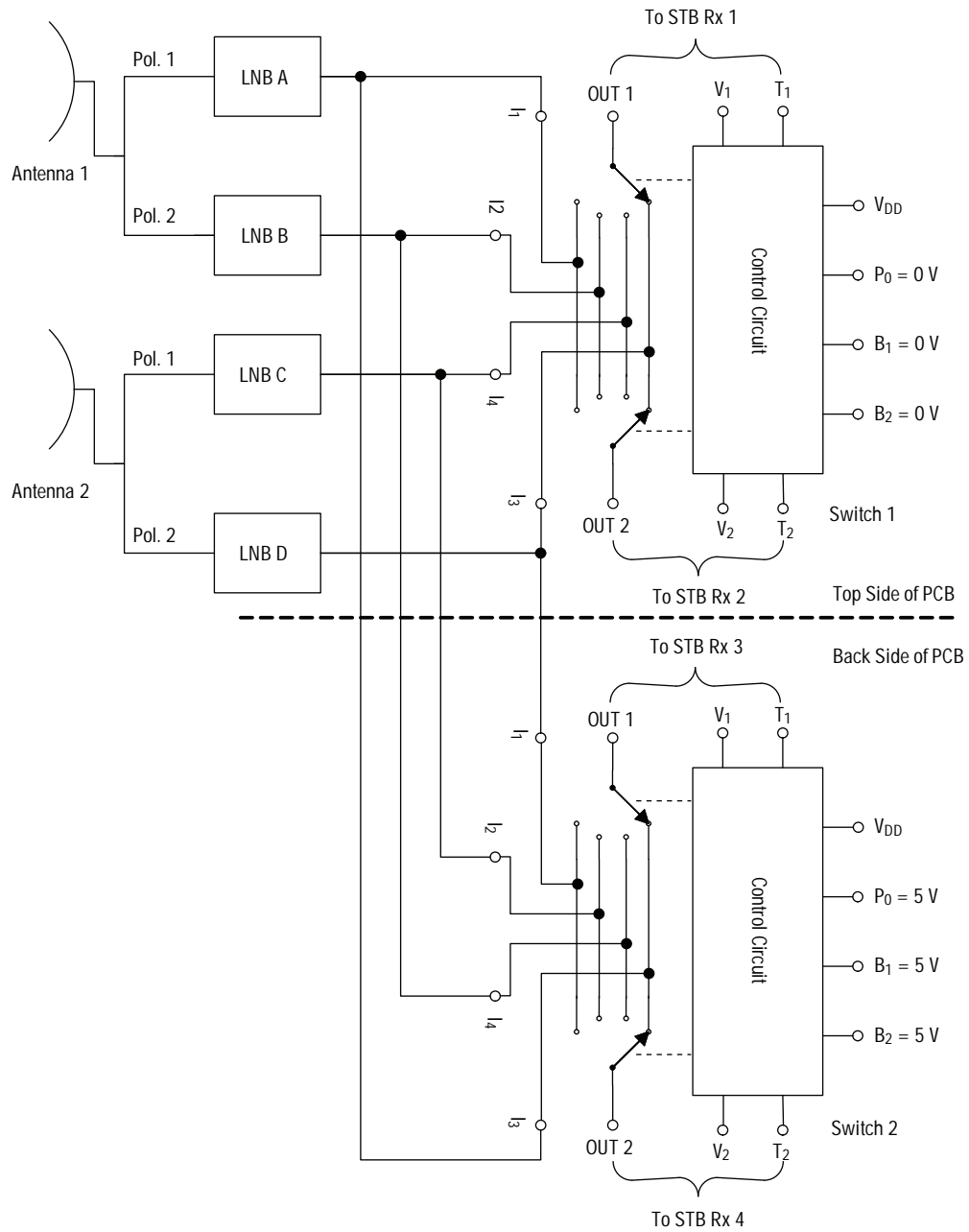
A pair of SKY13292-365LF 4 x 2 switches can be utilized to form a 4 x 4 switch. Figure 2 shows a suggested implementation, in which one of the 4 x 2 switches is mounted on the top side of a printed circuit board, with the second 4 x 2 switch mounted on the back side of the printed circuit board. The four RF input signals, which may come from a variety of sources, but are shown here to come from four separate low noise block converters, are

split and routed directly to the inputs of the top side switch, and through vias to the inputs of the back side switch. With each of the configuration inputs,  $P_0$ ,  $B_1$  and  $B_2$ , of the top side switch held at 0 V, and each of the configuration inputs of the back side switch held at 5 V, the same logic controls from each of the 4 receivers will select any specific input signal.

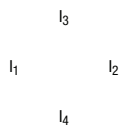
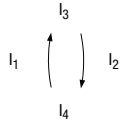
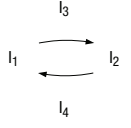
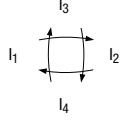
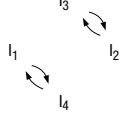
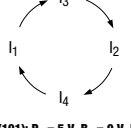
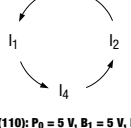
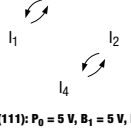
For example, if the user of receiver 1 wishes to receive the signal from antenna 1, polarization 1, through LNB A, that receiver must send a 22 kHz tone and a control voltage greater than the threshold voltage to switch 1. If receiver 3 also wishes to receive the signal from antenna 1, polarization 1, through LNB A, that receiver must also send a 22 kHz tone and a control voltage greater than the threshold voltage to switch 2.

Other logic configurations are possible, as shown in the truth tables in this data sheet.

**4 x 4 Switch Utilizing a SKY13292 on Top Side and a Second SKY13292-365LF on the Back Side of a PCB**



### Truth Table - Mode Controls Summary

	Mode	P <sub>0</sub>	B <sub>1</sub>	B <sub>2</sub>	I <sub>1</sub> (PIN 5)	I <sub>2</sub> (PIN 7)	I <sub>4</sub> (PIN 9)	I <sub>3</sub> (PIN 11)
 <p><b>Mode 0 (000):</b> P<sub>0</sub> = 0 V, B<sub>1</sub> = 0 V, B<sub>2</sub> = 0 V (Default Mode)</p>	0	0	0	0	A	B	C	D
 <p><b>Mode 1 (001):</b> P<sub>0</sub> = 0 V, B<sub>1</sub> = 0 V, B<sub>2</sub> = 5 V</p>	1	0	0	1	A	B	D	C
 <p><b>Mode 2 (010):</b> P<sub>0</sub> = 0 V, B<sub>1</sub> = 5 V, B<sub>2</sub> = 0 V</p>	2	0	1	0	B	A	C	D
 <p><b>Mode 3 (011):</b> P<sub>0</sub> = 0 V, B<sub>1</sub> = 5 V, B<sub>2</sub> = 5 V</p>	3	0	1	1	B	A	D	C
 <p><b>Mode 4 (100):</b> P<sub>0</sub> = 5 V, B<sub>1</sub> = 0 V, B<sub>2</sub> = 0 V</p>	4	1	0	0	C	D	A	B
 <p><b>Mode 5 (101):</b> P<sub>0</sub> = 5 V, B<sub>1</sub> = 0 V, B<sub>2</sub> = 5 V</p>	5	1	0	1	C	D	B	A
 <p><b>Mode 6 (110):</b> P<sub>0</sub> = 5 V, B<sub>1</sub> = 5 V, B<sub>2</sub> = 0 V</p>	6	1	1	0	D	C	A	B
 <p><b>Mode 7 (111):</b> P<sub>0</sub> = 5 V, B<sub>1</sub> = 5 V, B<sub>2</sub> = 5 V</p>	7	1	1	1	D	C	B	A



**General Truth Table**

State	Tone and Voltage Inputs (see notes)				Signal Paths
	T <sub>1</sub>	V <sub>1</sub>	T <sub>2</sub>	V <sub>2</sub>	
1	No tone	V <sub>LOW</sub>	No tone	V <sub>LOW</sub>	D → OUT1, D → OUT2
2	No tone	V <sub>LOW</sub>	No tone	V <sub>HIGH</sub>	D → OUT1, B → OUT2
3	No tone	V <sub>LOW</sub>	22 kHz tone	V <sub>LOW</sub>	D → OUT1, C → OUT2
4	No tone	V <sub>LOW</sub>	22 kHz tone	V <sub>HIGH</sub>	D → OUT1, A → OUT2
5	No tone	V <sub>HIGH</sub>	No tone	V <sub>LOW</sub>	B → OUT1, D → OUT2
6	No tone	V <sub>HIGH</sub>	No tone	V <sub>HIGH</sub>	B → OUT1, B → OUT2
7	No tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>LOW</sub>	B → OUT1, C → OUT2
8	No tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>HIGH</sub>	B → OUT1, A → OUT2
9	22 kHz tone	V <sub>LOW</sub>	No tone	V <sub>LOW</sub>	C → OUT1, D → OUT2
10	22 kHz tone	V <sub>LOW</sub>	No tone	V <sub>HIGH</sub>	C → OUT1, B → OUT2
11	22 kHz tone	V <sub>LOW</sub>	22 kHz tone	V <sub>LOW</sub>	C → OUT1, C → OUT2
12	22 kHz tone	V <sub>LOW</sub>	22 kHz tone	V <sub>HIGH</sub>	C → OUT1, A → OUT2
13	22 kHz tone	V <sub>HIGH</sub>	No tone	V <sub>LOW</sub>	A → OUT1, D → OUT2
14	22 kHz tone	V <sub>HIGH</sub>	No tone	V <sub>HIGH</sub>	A → OUT1, B → OUT2
15	22 kHz tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>LOW</sub>	A → OUT1, C → OUT2
16	22 kHz tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>HIGH</sub>	A → OUT1, A → OUT2

## Notes

"No tone": no 22 kHz tone present.

"22 kHz tone": 22 kHz tone present with amplitude greater than 100 mV (pk-pk).

V<sub>LOW</sub> ≤ 14 V.

V<sub>HIGH</sub> ≥ 15 V.

### Truth Table - Tone and Voltage Controls

#### Mode 0 (000): P<sub>0</sub> = 0 V, B<sub>1</sub> = 0 V, B<sub>2</sub> = 0 V (Default State)

State	Tone and Voltage Inputs (see notes)				Signal Paths
	T <sub>1</sub>	V <sub>1</sub>	T <sub>2</sub>	V <sub>2</sub>	
1	No tone	V <sub>LOW</sub>	No tone	V <sub>LOW</sub>	I <sub>3</sub> → OUT1, I <sub>3</sub> → OUT2
2	No tone	V <sub>LOW</sub>	No tone	V <sub>HIGH</sub>	I <sub>3</sub> → OUT1, I <sub>2</sub> → OUT2
3	No tone	V <sub>LOW</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>3</sub> → OUT1, I <sub>4</sub> → OUT2
4	No tone	V <sub>LOW</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>3</sub> → OUT1, I <sub>1</sub> → OUT2
5	No tone	V <sub>HIGH</sub>	No tone	V <sub>LOW</sub>	I <sub>2</sub> → OUT1, I <sub>3</sub> → OUT2
6	No tone	V <sub>HIGH</sub>	No tone	V <sub>HIGH</sub>	I <sub>2</sub> → OUT1, I <sub>2</sub> → OUT2
7	No tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>2</sub> → OUT1, I <sub>4</sub> → OUT2
8	No tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>2</sub> → OUT1, I <sub>1</sub> → OUT2
9	22 kHz tone	V <sub>LOW</sub>	No tone	V <sub>LOW</sub>	I <sub>4</sub> → OUT1, I <sub>3</sub> → OUT2
10	22 kHz tone	V <sub>LOW</sub>	No tone	V <sub>HIGH</sub>	I <sub>4</sub> → OUT1, I <sub>2</sub> → OUT2
11	22 kHz tone	V <sub>LOW</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>4</sub> → OUT1, I <sub>4</sub> → OUT2
12	22 kHz tone	V <sub>LOW</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>4</sub> → OUT1, I <sub>1</sub> → OUT2
13	22 kHz tone	V <sub>HIGH</sub>	No tone	V <sub>LOW</sub>	I <sub>1</sub> → OUT1, I <sub>3</sub> → OUT2
14	22 kHz tone	V <sub>HIGH</sub>	No tone	V <sub>HIGH</sub>	I <sub>1</sub> → OUT1, I <sub>2</sub> → OUT2
15	22 kHz tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>1</sub> → OUT1, I <sub>4</sub> → OUT2
16	22 kHz tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>1</sub> → OUT1, I <sub>1</sub> → OUT2

#### Mode 1 (001): P<sub>0</sub> = 0 V, B<sub>1</sub> = 0 V, B<sub>2</sub> = 5 V

State	Tone and Voltage Inputs (see notes)				Signal Paths
	T <sub>1</sub>	V <sub>1</sub>	T <sub>2</sub>	V <sub>2</sub>	
1	No tone	V <sub>LOW</sub>	No tone	V <sub>LOW</sub>	I <sub>4</sub> → OUT1, I <sub>4</sub> → OUT2
2	No tone	V <sub>LOW</sub>	No tone	V <sub>HIGH</sub>	I <sub>4</sub> → OUT1, I <sub>2</sub> → OUT2
3	No tone	V <sub>LOW</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>4</sub> → OUT1, I <sub>3</sub> → OUT2
4	No tone	V <sub>LOW</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>4</sub> → OUT1, I <sub>1</sub> → OUT2
5	No tone	V <sub>HIGH</sub>	No tone	V <sub>LOW</sub>	I <sub>2</sub> → OUT1, I <sub>4</sub> → OUT2
6	No tone	V <sub>HIGH</sub>	No tone	V <sub>HIGH</sub>	I <sub>2</sub> → OUT1, I <sub>2</sub> → OUT2
7	No tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>2</sub> → OUT1, I <sub>3</sub> → OUT2
8	No tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>2</sub> → OUT1, I <sub>1</sub> → OUT2
9	22 kHz tone	V <sub>LOW</sub>	No tone	V <sub>LOW</sub>	I <sub>3</sub> → OUT1, I <sub>4</sub> → OUT2
10	22 kHz tone	V <sub>LOW</sub>	No tone	V <sub>HIGH</sub>	I <sub>3</sub> → OUT1, I <sub>2</sub> → OUT2
11	22 kHz tone	V <sub>LOW</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>3</sub> → OUT1, I <sub>3</sub> → OUT2
12	22 kHz tone	V <sub>LOW</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>3</sub> → OUT1, I <sub>1</sub> → OUT2
13	22 kHz tone	V <sub>HIGH</sub>	No tone	V <sub>LOW</sub>	I <sub>1</sub> → OUT1, I <sub>4</sub> → OUT2
14	22 kHz tone	V <sub>HIGH</sub>	No tone	V <sub>HIGH</sub>	I <sub>1</sub> → OUT1, I <sub>2</sub> → OUT2
15	22 kHz tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>1</sub> → OUT1, I <sub>3</sub> → OUT2
16	22 kHz tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>1</sub> → OUT1, I <sub>1</sub> → OUT2

Notes

"No tone": no 22 kHz tone present.

"22 kHz tone": 22 kHz tone present with amplitude greater than 100 mV (pk-pk).

V<sub>LOW</sub> ≤ 14 V.

V<sub>HIGH</sub> ≥ 15 V

**Mode 2 (010): P<sub>0</sub> = 0 V, B<sub>1</sub> = 5 V, B<sub>2</sub> = 0 V**

State	Tone and Voltage Inputs (see notes)				Signal Paths
	T <sub>1</sub>	V <sub>1</sub>	T <sub>2</sub>	V <sub>2</sub>	
1	No tone	V <sub>LOW</sub>	No tone	V <sub>LOW</sub>	I <sub>3</sub> → OUT1, I <sub>3</sub> → OUT2
2	No tone	V <sub>LOW</sub>	No tone	V <sub>HIGH</sub>	I <sub>3</sub> → OUT1, I <sub>1</sub> → OUT2
3	No tone	V <sub>LOW</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>3</sub> → OUT1, I <sub>4</sub> → OUT2
4	No tone	V <sub>LOW</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>3</sub> → OUT1, I <sub>2</sub> → OUT2
5	No tone	V <sub>HIGH</sub>	No tone	V <sub>LOW</sub>	I <sub>1</sub> → OUT1, I <sub>3</sub> → OUT2
6	No tone	V <sub>HIGH</sub>	No tone	V <sub>HIGH</sub>	I <sub>1</sub> → OUT1, I <sub>1</sub> → OUT2
7	No tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>1</sub> → OUT1, I <sub>4</sub> → OUT2
8	No tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>1</sub> → OUT1, I <sub>2</sub> → OUT2
9	22 kHz tone	V <sub>LOW</sub>	No tone	V <sub>LOW</sub>	I <sub>4</sub> → OUT1, I <sub>3</sub> → OUT2
10	22 kHz tone	V <sub>LOW</sub>	No tone	V <sub>HIGH</sub>	I <sub>4</sub> → OUT1, I <sub>1</sub> → OUT2
11	22 kHz tone	V <sub>LOW</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>4</sub> → OUT1, I <sub>4</sub> → OUT2
12	22 kHz tone	V <sub>LOW</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>4</sub> → OUT1, I <sub>2</sub> → OUT2
13	22 kHz tone	V <sub>HIGH</sub>	No tone	V <sub>LOW</sub>	I <sub>2</sub> → OUT1, I <sub>3</sub> → OUT2
14	22 kHz tone	V <sub>HIGH</sub>	No tone	V <sub>HIGH</sub>	I <sub>2</sub> → OUT1, I <sub>1</sub> → OUT2
15	22 kHz tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>2</sub> → OUT1, I <sub>4</sub> → OUT2
16	22 kHz tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>2</sub> → OUT1, I <sub>2</sub> → OUT2

**Mode 3 (011): P<sub>0</sub> = 0 V, B<sub>1</sub> = 5 V, B<sub>2</sub> = 5 V**

State	Tone and Voltage Inputs (see notes)				Signal Paths
	T <sub>1</sub>	V <sub>1</sub>	T <sub>2</sub>	V <sub>2</sub>	
1	No tone	V <sub>LOW</sub>	No tone	V <sub>LOW</sub>	I <sub>4</sub> → OUT1, I <sub>4</sub> → OUT2
2	No tone	V <sub>LOW</sub>	No tone	V <sub>HIGH</sub>	I <sub>4</sub> → OUT1, I <sub>1</sub> → OUT2
3	No tone	V <sub>LOW</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>4</sub> → OUT1, I <sub>3</sub> → OUT2
4	No tone	V <sub>LOW</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>4</sub> → OUT1, I <sub>2</sub> → OUT2
5	No tone	V <sub>HIGH</sub>	No tone	V <sub>LOW</sub>	I <sub>1</sub> → OUT1, I <sub>4</sub> → OUT2
6	No tone	V <sub>HIGH</sub>	No tone	V <sub>HIGH</sub>	I <sub>1</sub> → OUT1, I <sub>1</sub> → OUT2
7	No tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>1</sub> → OUT1, I <sub>3</sub> → OUT2
8	No tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>1</sub> → OUT1, I <sub>2</sub> → OUT2
9	22 kHz tone	V <sub>LOW</sub>	No tone	V <sub>LOW</sub>	I <sub>3</sub> → OUT1, I <sub>4</sub> → OUT2
10	22 kHz tone	V <sub>LOW</sub>	No tone	V <sub>HIGH</sub>	I <sub>3</sub> → OUT1, I <sub>1</sub> → OUT2
11	22 kHz tone	V <sub>LOW</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>3</sub> → OUT1, I <sub>3</sub> → OUT2
12	22 kHz tone	V <sub>LOW</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>3</sub> → OUT1, I <sub>2</sub> → OUT2
13	22 kHz tone	V <sub>HIGH</sub>	No tone	V <sub>LOW</sub>	I <sub>2</sub> → OUT1, I <sub>4</sub> → OUT2
14	22 kHz tone	V <sub>HIGH</sub>	No tone	V <sub>HIGH</sub>	I <sub>2</sub> → OUT1, I <sub>1</sub> → OUT2
15	22 kHz tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>2</sub> → OUT1, I <sub>3</sub> → OUT2
16	22 kHz tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>2</sub> → OUT1, I <sub>2</sub> → OUT2

## Notes

"No tone": no 22 kHz tone present.

"22 kHz tone": 22 kHz tone present with amplitude greater than 100 mV (pk-pk).

V<sub>LOW</sub> ≤ 14 V.V<sub>HIGH</sub> ≥ 15 V

**Mode 4 (100): P<sub>0</sub> = 5 V, B<sub>1</sub> = 0 V, B<sub>2</sub> = 0 V**

State	Tone and Voltage Inputs (see notes)				Signal Paths
	T <sub>1</sub>	V <sub>1</sub>	T <sub>2</sub>	V <sub>2</sub>	
1	No tone	V <sub>LOW</sub>	No tone	V <sub>LOW</sub>	I <sub>2</sub> → OUT1, I <sub>2</sub> → OUT2
2	No tone	V <sub>LOW</sub>	No tone	V <sub>HIGH</sub>	I <sub>2</sub> → OUT1, I <sub>3</sub> → OUT2
3	No tone	V <sub>LOW</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>2</sub> → OUT1, I <sub>1</sub> → OUT2
4	No tone	V <sub>LOW</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>2</sub> → OUT1, I <sub>4</sub> → OUT2
5	No tone	V <sub>HIGH</sub>	No tone	V <sub>LOW</sub>	I <sub>3</sub> → OUT1, I <sub>2</sub> → OUT2
6	No tone	V <sub>HIGH</sub>	No tone	V <sub>HIGH</sub>	I <sub>3</sub> → OUT1, I <sub>3</sub> → OUT2
7	No tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>3</sub> → OUT1, I <sub>1</sub> → OUT2
8	No tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>3</sub> → OUT1, I <sub>4</sub> → OUT2
9	22 kHz tone	V <sub>LOW</sub>	No tone	V <sub>LOW</sub>	I <sub>1</sub> → OUT1, I <sub>2</sub> → OUT2
10	22 kHz tone	V <sub>LOW</sub>	No tone	V <sub>HIGH</sub>	I <sub>1</sub> → OUT1, I <sub>3</sub> → OUT2
11	22 kHz tone	V <sub>LOW</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>1</sub> → OUT1, I <sub>1</sub> → OUT2
12	22 kHz tone	V <sub>LOW</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>1</sub> → OUT1, I <sub>4</sub> → OUT2
13	22 kHz tone	V <sub>HIGH</sub>	No tone	V <sub>LOW</sub>	I <sub>4</sub> → OUT1, I <sub>2</sub> → OUT2
14	22 kHz tone	V <sub>HIGH</sub>	No tone	V <sub>HIGH</sub>	I <sub>4</sub> → OUT1, I <sub>3</sub> → OUT2
15	22 kHz tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>4</sub> → OUT1, I <sub>1</sub> → OUT2
16	22 kHz tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>4</sub> → OUT1, I <sub>4</sub> → OUT2

**Mode 5 (101): P<sub>0</sub> = 5 V, B<sub>1</sub> = 0 V, B<sub>2</sub> = 5 V**

State	Tone and Voltage Inputs (see notes)				Signal Paths
	T <sub>1</sub>	V <sub>1</sub>	T <sub>2</sub>	V <sub>2</sub>	
1	No tone	V <sub>LOW</sub>	No tone	V <sub>LOW</sub>	I <sub>2</sub> → OUT1, I <sub>2</sub> → OUT2
2	No tone	V <sub>LOW</sub>	No tone	V <sub>HIGH</sub>	I <sub>2</sub> → OUT1, I <sub>4</sub> → OUT2
3	No tone	V <sub>LOW</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>2</sub> → OUT1, I <sub>1</sub> → OUT2
4	No tone	V <sub>LOW</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>2</sub> → OUT1, I <sub>3</sub> → OUT2
5	No tone	V <sub>HIGH</sub>	No tone	V <sub>LOW</sub>	I <sub>4</sub> → OUT1, I <sub>2</sub> → OUT2
6	No tone	V <sub>HIGH</sub>	No tone	V <sub>HIGH</sub>	I <sub>4</sub> → OUT1, I <sub>4</sub> → OUT2
7	No tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>4</sub> → OUT1, I <sub>1</sub> → OUT2
8	No tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>4</sub> → OUT1, I <sub>3</sub> → OUT2
9	22 kHz tone	V <sub>LOW</sub>	No tone	V <sub>LOW</sub>	I <sub>1</sub> → OUT1, I <sub>2</sub> → OUT2
10	22 kHz tone	V <sub>LOW</sub>	No tone	V <sub>HIGH</sub>	I <sub>1</sub> → OUT1, I <sub>4</sub> → OUT2
11	22 kHz tone	V <sub>LOW</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>1</sub> → OUT1, I <sub>1</sub> → OUT2
12	22 kHz tone	V <sub>LOW</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>1</sub> → OUT1, I <sub>3</sub> → OUT2
13	22 kHz tone	V <sub>HIGH</sub>	No tone	V <sub>LOW</sub>	I <sub>3</sub> → OUT1, I <sub>2</sub> → OUT2
14	22 kHz tone	V <sub>HIGH</sub>	No tone	V <sub>HIGH</sub>	I <sub>3</sub> → OUT1, I <sub>4</sub> → OUT2
15	22 kHz tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>LOW</sub>	I <sub>3</sub> → OUT1, I <sub>1</sub> → OUT2
16	22 kHz tone	V <sub>HIGH</sub>	22 kHz tone	V <sub>HIGH</sub>	I <sub>3</sub> → OUT1, I <sub>3</sub> → OUT2

Notes  
 "No tone": no 22 kHz tone present.  
 "22 kHz tone": 22 kHz tone present with amplitude greater than 100 mV (pk-pk).  
 V<sub>LOW</sub> ≤ 14 V.  
 V<sub>HIGH</sub> ≥ 15 V

**Mode 6 (110):  $P_0 = 5\text{ V}$ ,  $B_1 = 5\text{ V}$ ,  $B_2 = 0\text{ V}$** 

State	Tone and Voltage Inputs (see notes)				Signal Paths
	$T_1$	$V_1$	$T_2$	$V_2$	
1	No tone	$V_{\text{LOW}}$	No tone	$V_{\text{LOW}}$	$I_1 \rightarrow \text{OUT1}$ , $I_1 \rightarrow \text{OUT2}$
2	No tone	$V_{\text{LOW}}$	No tone	$V_{\text{HIGH}}$	$I_1 \rightarrow \text{OUT1}$ , $I_3 \rightarrow \text{OUT2}$
3	No tone	$V_{\text{LOW}}$	22 kHz tone	$V_{\text{LOW}}$	$I_1 \rightarrow \text{OUT1}$ , $I_2 \rightarrow \text{OUT2}$
4	No tone	$V_{\text{LOW}}$	22 kHz tone	$V_{\text{HIGH}}$	$I_1 \rightarrow \text{OUT1}$ , $I_4 \rightarrow \text{OUT2}$
5	No tone	$V_{\text{HIGH}}$	No tone	$V_{\text{LOW}}$	$I_3 \rightarrow \text{OUT1}$ , $I_1 \rightarrow \text{OUT2}$
6	No tone	$V_{\text{HIGH}}$	No tone	$V_{\text{HIGH}}$	$I_3 \rightarrow \text{OUT1}$ , $I_3 \rightarrow \text{OUT2}$
7	No tone	$V_{\text{HIGH}}$	22 kHz tone	$V_{\text{LOW}}$	$I_3 \rightarrow \text{OUT1}$ , $I_2 \rightarrow \text{OUT2}$
8	No tone	$V_{\text{HIGH}}$	22 kHz tone	$V_{\text{HIGH}}$	$I_3 \rightarrow \text{OUT1}$ , $I_4 \rightarrow \text{OUT2}$
9	22 kHz tone	$V_{\text{LOW}}$	No tone	$V_{\text{LOW}}$	$I_2 \rightarrow \text{OUT1}$ , $I_1 \rightarrow \text{OUT2}$
10	22 kHz tone	$V_{\text{LOW}}$	No tone	$V_{\text{HIGH}}$	$I_2 \rightarrow \text{OUT1}$ , $I_3 \rightarrow \text{OUT2}$
11	22 kHz tone	$V_{\text{LOW}}$	22 kHz tone	$V_{\text{LOW}}$	$I_2 \rightarrow \text{OUT1}$ , $I_2 \rightarrow \text{OUT2}$
12	22 kHz tone	$V_{\text{LOW}}$	22 kHz tone	$V_{\text{HIGH}}$	$I_2 \rightarrow \text{OUT1}$ , $I_4 \rightarrow \text{OUT2}$
13	22 kHz tone	$V_{\text{HIGH}}$	No tone	$V_{\text{LOW}}$	$I_4 \rightarrow \text{OUT1}$ , $I_1 \rightarrow \text{OUT2}$
14	22 kHz tone	$V_{\text{HIGH}}$	No tone	$V_{\text{HIGH}}$	$I_4 \rightarrow \text{OUT1}$ , $I_3 \rightarrow \text{OUT2}$
15	22 kHz tone	$V_{\text{HIGH}}$	22 kHz tone	$V_{\text{LOW}}$	$I_4 \rightarrow \text{OUT1}$ , $I_2 \rightarrow \text{OUT2}$
16	22 kHz tone	$V_{\text{HIGH}}$	22 kHz tone	$V_{\text{HIGH}}$	$I_4 \rightarrow \text{OUT1}$ , $I_4 \rightarrow \text{OUT2}$

**Mode 7 (111):  $P_0 = 5\text{ V}$ ,  $B_1 = 5\text{ V}$ ,  $B_2 = 5\text{ V}$** 

State	Tone and Voltage Inputs (see notes)				Signal Paths
	$T_1$	$V_1$	$T_2$	$V_2$	
1	No tone	$V_{\text{LOW}}$	No tone	$V_{\text{LOW}}$	$I_1 \rightarrow \text{OUT1}$ , $I_1 \rightarrow \text{OUT2}$
2	No tone	$V_{\text{LOW}}$	No tone	$V_{\text{HIGH}}$	$I_1 \rightarrow \text{OUT1}$ , $I_4 \rightarrow \text{OUT2}$
3	No tone	$V_{\text{LOW}}$	22 kHz tone	$V_{\text{LOW}}$	$I_1 \rightarrow \text{OUT1}$ , $I_2 \rightarrow \text{OUT2}$
4	No tone	$V_{\text{LOW}}$	22 kHz tone	$V_{\text{HIGH}}$	$I_1 \rightarrow \text{OUT1}$ , $I_3 \rightarrow \text{OUT2}$
5	No tone	$V_{\text{HIGH}}$	No tone	$V_{\text{LOW}}$	$I_4 \rightarrow \text{OUT1}$ , $I_1 \rightarrow \text{OUT2}$
6	No tone	$V_{\text{HIGH}}$	No tone	$V_{\text{HIGH}}$	$I_4 \rightarrow \text{OUT1}$ , $I_4 \rightarrow \text{OUT2}$
7	No tone	$V_{\text{HIGH}}$	22 kHz tone	$V_{\text{LOW}}$	$I_4 \rightarrow \text{OUT1}$ , $I_2 \rightarrow \text{OUT2}$
8	No tone	$V_{\text{HIGH}}$	22 kHz tone	$V_{\text{HIGH}}$	$I_4 \rightarrow \text{OUT1}$ , $I_3 \rightarrow \text{OUT2}$
9	22 kHz tone	$V_{\text{LOW}}$	No tone	$V_{\text{LOW}}$	$I_2 \rightarrow \text{OUT1}$ , $I_1 \rightarrow \text{OUT2}$
10	22 kHz tone	$V_{\text{LOW}}$	No tone	$V_{\text{HIGH}}$	$I_2 \rightarrow \text{OUT1}$ , $I_4 \rightarrow \text{OUT2}$
11	22 kHz tone	$V_{\text{LOW}}$	22 kHz tone	$V_{\text{LOW}}$	$I_2 \rightarrow \text{OUT1}$ , $I_2 \rightarrow \text{OUT2}$
12	22 kHz tone	$V_{\text{LOW}}$	22 kHz tone	$V_{\text{HIGH}}$	$I_2 \rightarrow \text{OUT1}$ , $I_3 \rightarrow \text{OUT2}$
13	22 kHz tone	$V_{\text{HIGH}}$	No tone	$V_{\text{LOW}}$	$I_3 \rightarrow \text{OUT1}$ , $I_1 \rightarrow \text{OUT2}$
14	22 kHz tone	$V_{\text{HIGH}}$	No tone	$V_{\text{HIGH}}$	$I_3 \rightarrow \text{OUT1}$ , $I_4 \rightarrow \text{OUT2}$
15	22 kHz tone	$V_{\text{HIGH}}$	22 kHz tone	$V_{\text{LOW}}$	$I_3 \rightarrow \text{OUT1}$ , $I_2 \rightarrow \text{OUT2}$
16	22 kHz tone	$V_{\text{HIGH}}$	22 kHz tone	$V_{\text{HIGH}}$	$I_3 \rightarrow \text{OUT1}$ , $I_3 \rightarrow \text{OUT2}$

## Notes

"No tone": no 22 kHz tone present.

"22 kHz tone": 22 kHz tone present with amplitude greater than 100 mV (pk-pk).

 $V_{\text{LOW}} \leq 14\text{ V}$ . $V_{\text{HIGH}} \geq 15\text{ V}$ .

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