

### Features

- -20 V to -50 V Back Bias
- 50 mA Sinking / Sourcing Current
- Propagation Delay <60 ns Driving 10 pF Capacitive Load
- Quiescent Currents <1 mA
- TTL Logic Control
- Internal Active Pull Down for All Logic Controls
- Internal Power Sequencer Eliminates External Power Sequencing
- 4 mm 16-Lead PQFN Package
- RoHS\* Compliant

### Description

The MADR-011020 switch driver is designed to work with MACOM's high power AlGaAs PIN diode switches. This driver has complementary outputs which can provide up to 50 mA bias current to a SPDT AlGaAs PIN diode switch. An all-off RF state can be achieved with the EN pin of this driver. An extra control C2 with driver select DS are provided to allow two drivers working together to drive a SP3T or SP4T switch.

The back bias voltage can be selected to be any voltage between -20 V and -50 V. This switch driver can be easily controlled by standard TTL logic. With low quiescent current, this driver has a typical delay of <60 ns when driving a 10 pF capacitive load.

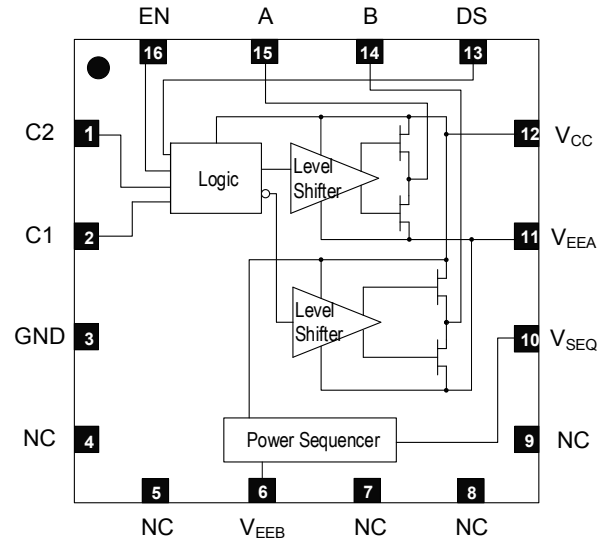
This driver is packaged in a lead-free 4 mm 16-lead PQFN package and is available in tape and reel packaging for high volume applications.

### Ordering Information<sup>1</sup>

Part Number	Package
MADR-011020-TR1000	1000 Piece Reel

1. Reference Application Note M513 for reel size information.

### Functional Schematic



### Pin Configuration

Pin #	Function	Description of Function
1	C2	Logic Control Input
2	C1	Logic Control Input
3	GND	Ground
4,5,7,8,9	NC <sup>2</sup>	No Connection
6	V <sub>EEB</sub>	Negative Bias for Sequencer Die
10	V <sub>SEQ</sub>	Power Sequencer Die Output
11	V <sub>EEA</sub>	Negative Bias for Driver Die
12	V <sub>CC</sub>	Positive Bias
13	DS	Driver Select
14	B	Inverted Driver Output
15	A	Non-inverted Driver Output
16	EN	Enable
17	Paddle <sup>3</sup>	Ground

2. NC pins should be left open.

3. MACOM recommends connecting the exposed pad centered on the package bottom to RF, DC and thermal ground.

\* Restrictions on Hazardous Substances, compliant to current RoHS EU directive.

### Recommended Operating Conditions<sup>4</sup>

Parameter	Test Conditions	Units	Min.	Typ.	Max.
$V_{CC}$	—	V	4.5	5.0	5.5
$V_{EEA}$ and $V_{EEB}$	—	V	-50	—	-20
C1, C2, EN, DS	Logic "0" Logic "1"	V	0.0 2.0	0.0 $V_{CC}$	0.8 $V_{CC}$
$I_{SINK}$ , Sinking Current per Output	—	mA	—	—	50
$I_{SOURCE}$ , Sourcing Current per Output	—	mA	—	—	50
Total Capacitive load per Output	—	pF	—	—	10
Rise / Fall Time of $V_{CC}$ And $V_{EEB}$	—	$\mu$ s	50	—	—
Temperature	—	$^{\circ}$ C	-40	+25	+85

4. Negative bias should be applied to  $V_{EEB}$  (pin 6). The sequencer output  $V_{SEQ}$  should be connected to the driver die negative bias  $V_{EEA}$ . A 47 pF shunt capacitor shall be placed close to pin 11 ( $V_{EEA}$ ).

### Absolute Maximum Ratings<sup>5,6</sup>

Parameter	Absolute Maximum
$V_{CC}$	$-0.5\text{ V} \leq V_{CC} \leq +7\text{ V}$
$V_{EEA}$ , $V_{EEB}$	$-55\text{ V} \leq V_{EEA}, V_{EEB} \leq +0.5\text{ V}$
C1, C2, EN, DS	$-0.5\text{ V} \leq V_{CC} \leq +7\text{ V}$
Sinking Current per Output	75 mA
Sourcing Current per Output	75 mA
Capacitive Load per Output <sup>7</sup>	12 pF
Operating Temperature	$-40^{\circ}\text{C}$ to $+110^{\circ}\text{C}$
Storage Temperature	$-55^{\circ}\text{C}$ to $+150^{\circ}\text{C}$

5. Exceeding any one or combination of these limits may cause permanent damage to this device.  
 6. MACOM does not recommend sustained operation near these survivability limits.  
 7. Capacitive load above 12 pF can cause peak current exceeding power limit for the MOSFETs in the output buffer.

### Logic Truth Table<sup>8,9</sup>

Inputs				Outputs	
EN	DS	C2	C1	A	B
1	X	X	X	H	H
0	0	0	0	L	H
0	0	0	1	H	L
0	0	1	0	H	H
0	0	1	1	H	H
0	1	0	0	H	H
0	1	0	1	H	H
0	1	1	0	L	H
0	1	1	1	H	L

8. The actual output low voltage can be calculated by:  
 $V_{OL} = V_{EEB} + I_{SINK} \times R_{PULL-Down}$   
 9. The actual output high voltage can be calculated by:  
 $V_{OH} = V_{CC} - I_{SOURCE} \times R_{PULL-Up}$

**-20 V to -50 V Driver for AlGaAs PIN Diode Switches**

Rev. V2

**Electrical Specifications:  $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 5\text{ V}$ ,  $V_{EEB} = -50\text{ V}$** 

Parameter	Test Conditions	Units	Min.	Typ.	Max.
$V_{CC}$ Quiescent Current ( $I_{CC}$ )	$C1 = 5\text{ V}$ , $C2 = DS = EN = 0\text{ V}$	mA	—	0.1	0.15
$V_{EEB}$ Quiescent Current ( $I_{EEB}$ )	$C1 = 5\text{ V}$ , $C2 = DS = EN = 0\text{ V}$	mA	—	0.3	0.35
Control Input Leakage Current ( $I_{CTL}$ ) <sup>10</sup>	Control = 5 V	$\mu\text{A}$	—	20	25
$R_{PULL-UP}$ , Output Pull-up On Resistance	43 mA Load	$\Omega$	—	12	15
$R_{PULL-DOWN}$ , Output Pull-down On Resistance	43 mA Load	$\Omega$	—	12	15
Switching Speed Driving 10 pF Capacitors <sup>11</sup>					
$T_{ON}$	50% control to 90% Voltage	ns	—	40	—
$T_{OFF}$	50% control to 10% Voltage			46	
$T_{RISE}$	10% to 90% Voltage			11	
$T_{FALL}$	90% to 10% Voltage			11	
Switching Speed Driving the MASW-011098 Switch <sup>12</sup>					
$T_{ON}$	50% control to 90% RF	ns	—	35	—
$T_{OFF}$	50% control to 10% RF			50	
$T_{RISE}$	10% to 90% RF			6	
$T_{FALL}$	90% to 10% RF			26	
Power Sequencer Threshold Voltage	Note 13	V	—	2.5	—
Power Sequencer Power On Time	Note 14	$\mu\text{s}$	—	25	—
Driver Die Power Up Time	Note 15	$\mu\text{s}$	—	25	—
Driver Die Power Down Time	Note 16	$\mu\text{s}$	—	25	—

10. This leakage current is due to an active pull-down NMOS FET at the control input.

11. Tested with a 10 pF capacitive load at each output (no current load).

12. MACOM's MASW-011098 is a 13 W SPDT PIN diode switch. Measured at 26 GHz, 20 dBm,  $V_{CC} = +5\text{ V}$ ,  $V_{EEB} = -25\text{ V}$ , and 22 mA forward bias current. Control input was a 0.8 V to 2 V pulse with rise and fall time of 6 ns.

13. When  $V_{CC}$  is below this threshold, the internal power sequencer will pull its output  $V_{SEQ}$  to ground.

14. This is the delay between the moment when  $V_{CC}$  is above the power sequencer threshold to  $V_{SEQ}$  reaches 90% of steady state value. This is measured with a 47 pF shunt capacitor off pin  $V_{EEA}$ .

15. This is the time needed for the driver to function properly after  $V_{CC}$  and  $V_{EEA}$  reach 90% of their stable value.

16. This is the time needed for the internal bias voltages to discharge to 10% of their steady state value after  $V_{CC}$  and  $V_{EEA}$  are powered down.

### Internal Power Sequencer

For normal operation, negative bias should be applied to  $V_{EEB}$  (pin 6). The sequencer output  $V_{SEQ}$  should be connected to the driver die negative bias  $V_{EEA}$ , with a 47 pF shunt capacitor, as shown in the application schematic next page. The voltage rating of this 47 pF capacitor should be sufficient according to the operating  $V_{EEB}$ .

When detected  $V_{CC}$  is above the power sequencer threshold, the negative bias  $V_{EEB}$  will be passed to the driver. When detected  $V_{CC}$  is below the power sequencer threshold, the power sequencer will pull  $V_{EEA}$  to ground to disable the driver.

### Driving SPDT Switches

When driving SPDT switches, use C1 and EN as the control inputs. Output A is the non-inverting output, and output B is the inverting output. The unused controls DS and C2 can be left open due to the internal active pull-down. If an all-off RF state is not required, leaving the EN pin open will automatically enable the driver due to the internal active pull-down. The truth table is simplified as follows when DS and C2 are left open:

#### Truth Table for Driving SPDT

EN	C1	A	B
1	X	H	H
0	0	L	H
0	1	H	L

### Handling Procedures

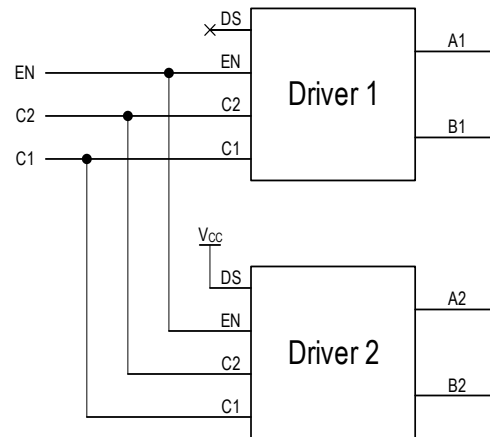
Please observe the following precautions to avoid damage:

### Static Sensitivity

These electronic devices are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these HBM class 1B devices.

### Driving SP3T and SP4T Switches

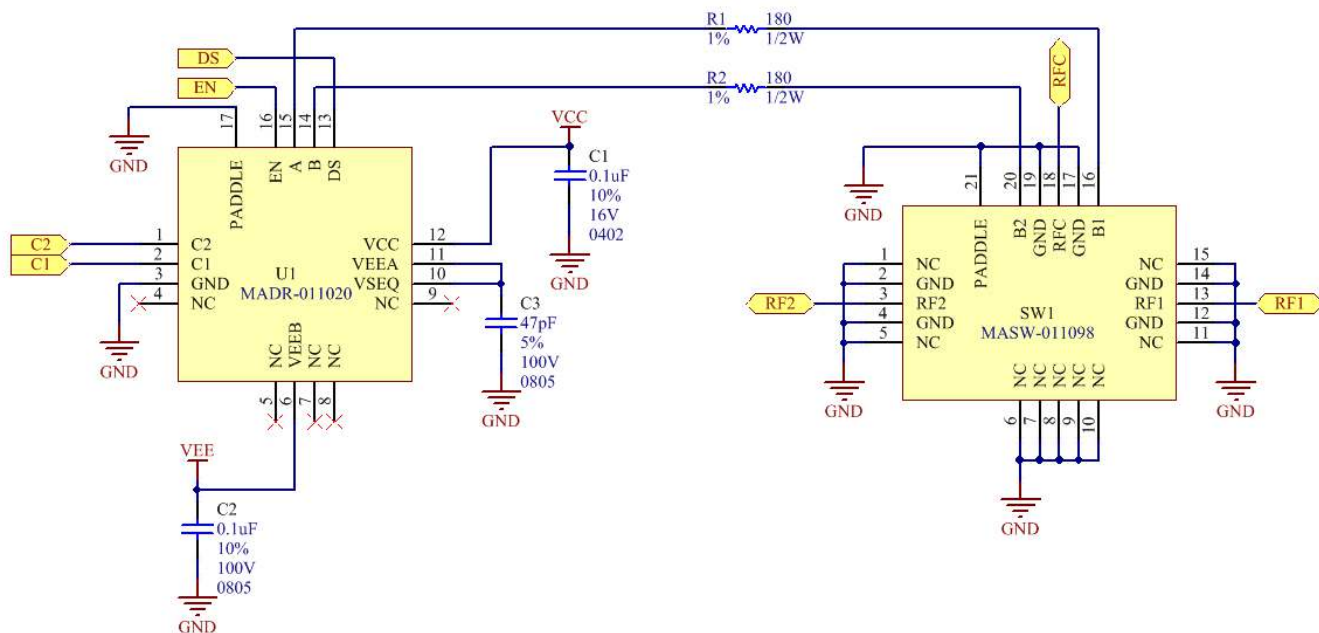
Two drivers are needed to drive a SP3T or SP4T switch. The DS pin of the first driver can be left open due to the internal active pull-down. Connect the DS pin of the second driver to  $V_{CC}$ . See the figure below for how to connect C1, C2, and EN. The combined truth table is below:



#### Truth Table for Driving SP3T and SP4T

Inputs			Outputs			
EN	C2	C1	A1	B1	A2	B2
1	X	X	H	H	H	H
0	0	0	L	H	H	H
0	0	1	H	L	H	H
0	1	0	H	H	L	H
0	1	1	H	H	H	L

### Application Schematic Driving MASW-011098 <sup>17, 18</sup>



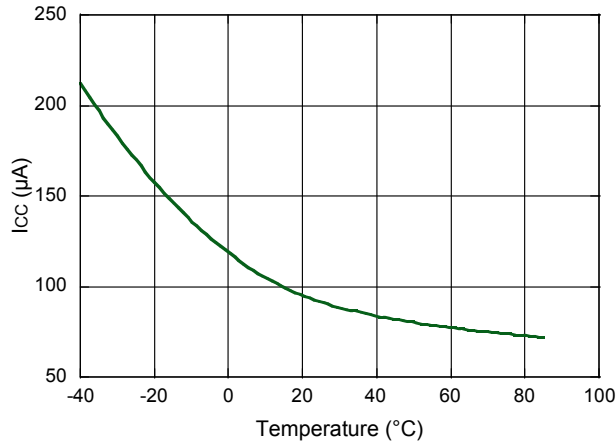
### Parts List <sup>18</sup>

Part	Value
U1	MADR-011020, -20 V to -50 V Driver
U2	MASW-011098, Ka-Band High Power Reflective SPDT PIN Switch
R1, R2	Resistor, 0805, 180, 1%, 1/2 W
C1	Capacitor, 0402, 16 V, X7R, 10%, 0.1 $\mu$ F
C2	Capacitor, 0805, 100 V, X7R, 10%, 47 pF
C3	Capacitor, 0805, 100 V, X7R, 10%, 0.1 $\mu$ F

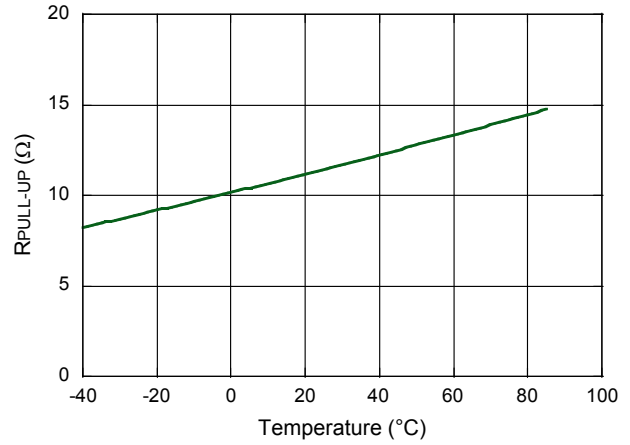
17. If all-off state is not needed, just leave C2, DS, and EN floating and use C1 as the switch control. See the Truth Table for Driving SPDT on the previous page. If all-off state is needed, leave C2 and DS floating, and use C1 and EN as the switch controls.
18. The voltage rating for C2 and C3 should be at least two times of VEE.

### Typical Performance Curves

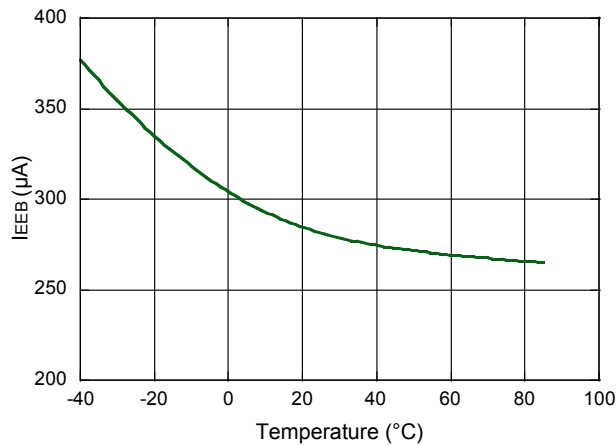
**$V_{CC}$  Quiescent Current ( $I_{CC}$ ):  $V_{CC} = +5\text{ V}$ ,  $V_{EEB} = -50\text{ V}$**



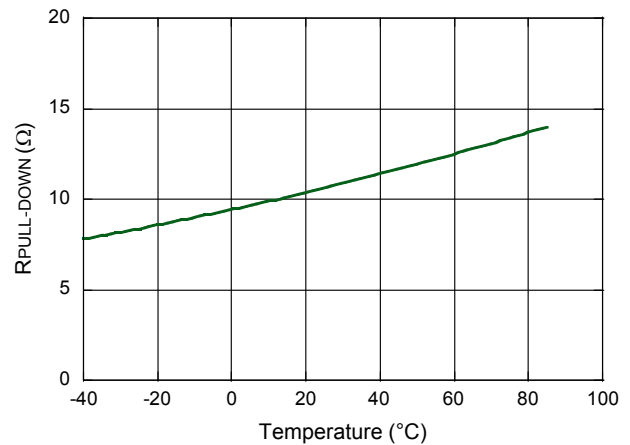
**Output Pull-up On Resistance<sup>19</sup>:  $V_{CC} = +5\text{ V}$**



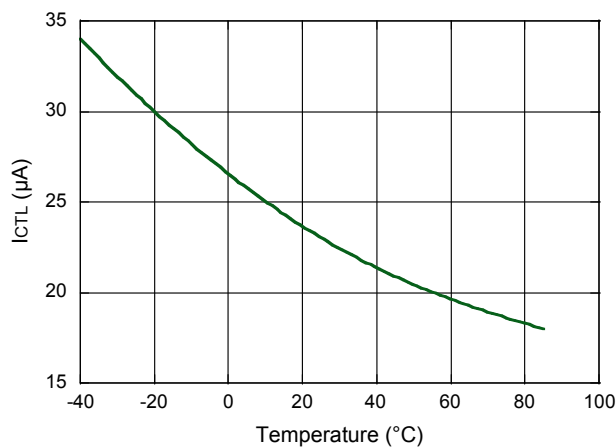
**$V_{EEB}$  Quiescent ( $I_{EEB}$ ):  $V_{CC} = +5\text{ V}$ ,  $V_{EEB} = -50\text{ V}$**



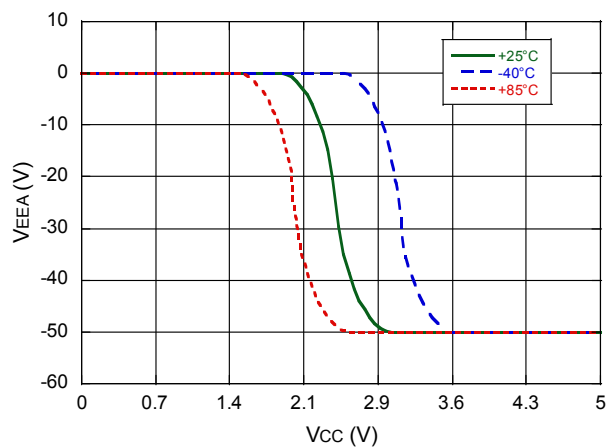
**Output Pull-down On Resistance<sup>19</sup>:  $V_{CC} = +5\text{ V}$**



**Control Leakage Current ( $I_{CTL}$ ):  $V_{CC} = C = +5\text{ V}$ ,  $V_{EEB} = -$**



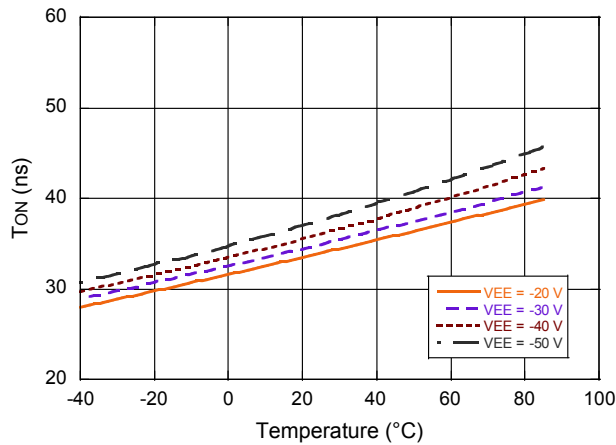
**Power Sequencer Threshold:**



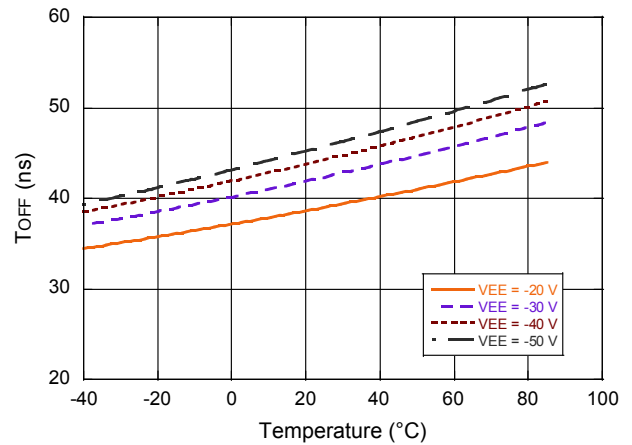
19. The output on resistance does not change with different  $V_{EEB}$  voltage levels.

### Typical Performance Curves<sup>20</sup>

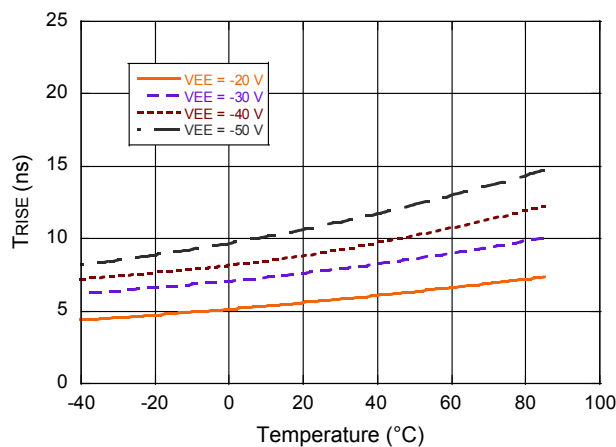
Switching Speed Driving 10 pF Capacitors:  $T_{ON}$



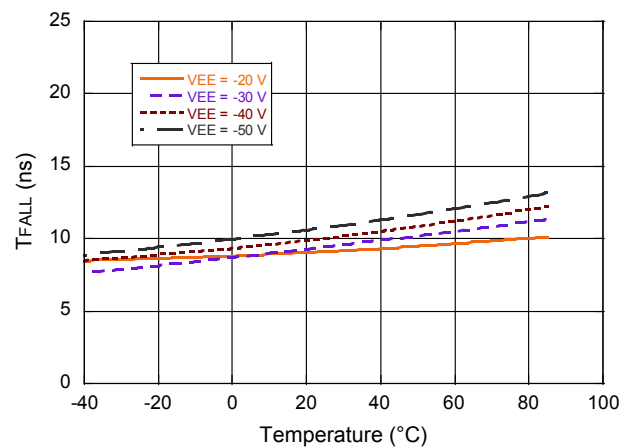
Switching Speed Driving 10 pF Capacitors:  $T_{OFF}$



Switching Speed Driving 10 pF Capacitors:  $T_{RISE}$



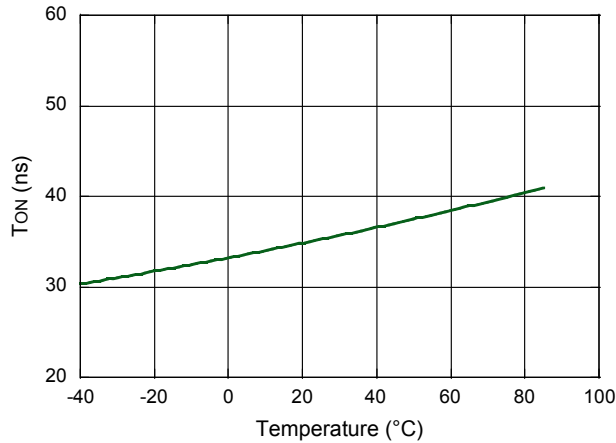
Switching Speed Driving 10 pF Capacitors:  $T_{FALL}$



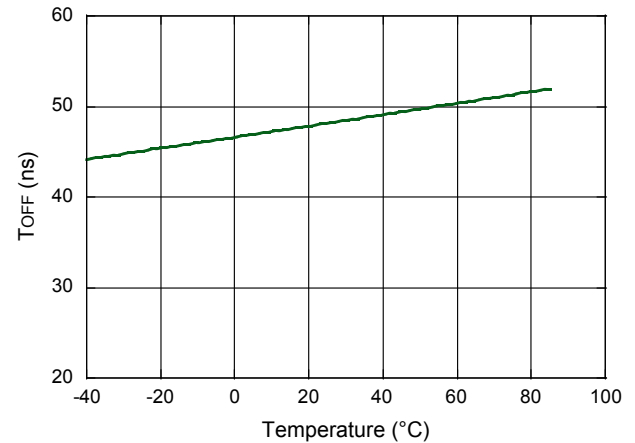
20. Tested with a 10 pF capacitor at each output (no current load),  $V_{CC} = +5$  V, 0.8 V to 2 V control with rise and fall time of 6 ns.

### Typical Performance Curves<sup>21</sup>

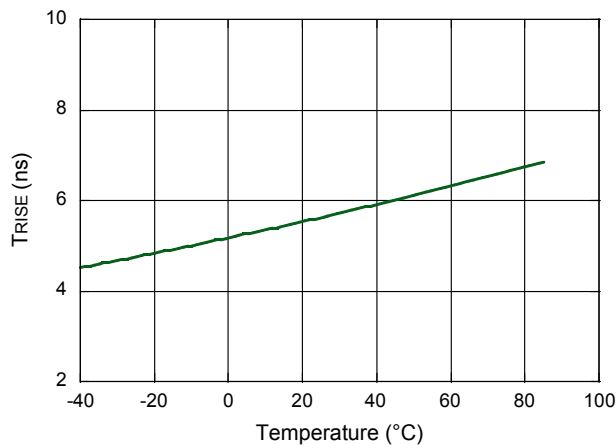
Switching Speed Driving MASW-011098:  $T_{ON}$



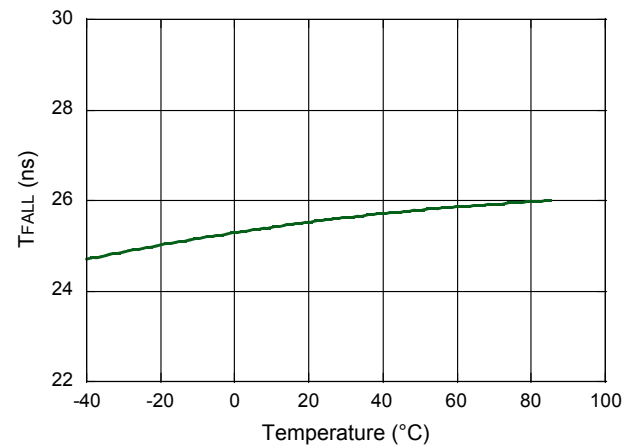
Switching Speed Driving MASW-011098:  $T_{OFF}$



Switching Speed Driving MASW-011098:  $T_{RISE}$



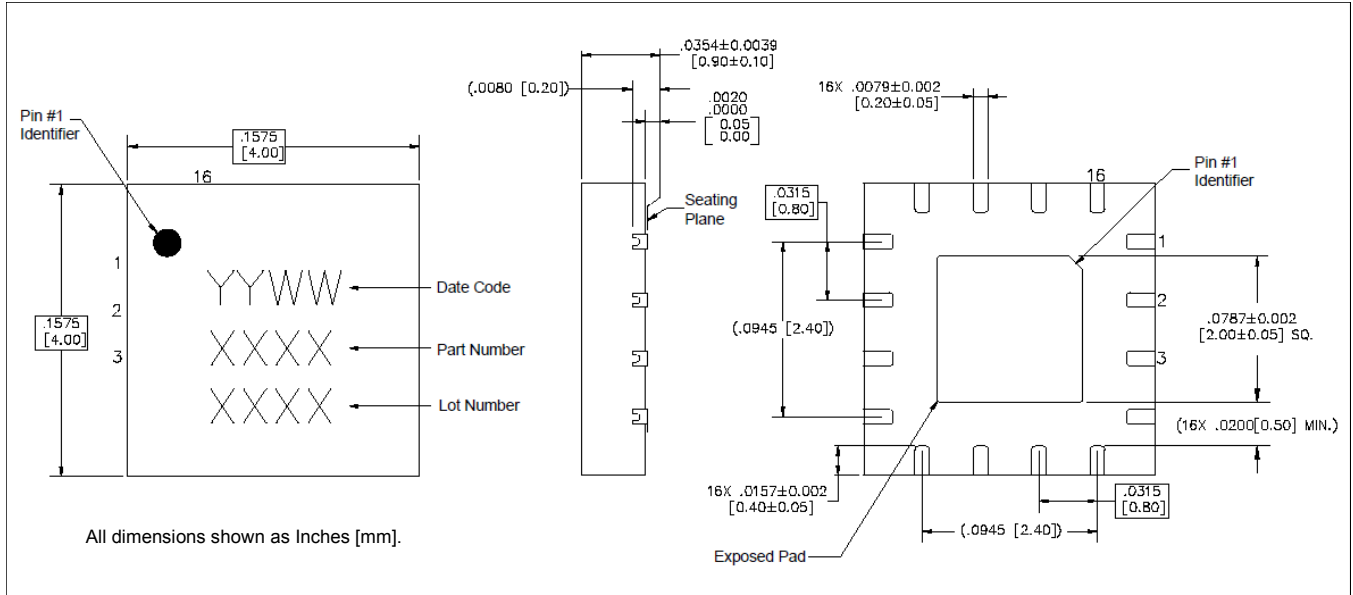
Switching Speed Driving MASW-011098:  $T_{FALL}$



21. MACOM's MASW-011098 is a 13 W SPDT PIN diode switch. Measured at 26 GHz, 20 dBm,  $V_{CC} = +5$  V,  $V_{EEB} = -25$  V, and 22 mA forward bias current. Control input was a 0.8 V to 2 V pulse with rise and fall time of 6 ns.



### Lead-Free 4 mm 16-Lead PQFN<sup>†</sup>



<sup>†</sup> This is not a JEDEC standard package.  
 JEDEC moisture sensitivity level TBD.  
 Plating is NiPdAu.

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