# 10 V to 180 V Driver for High Power PIN Diode Switches

**MADR-011021**
**Rev. V3**

## Features

- 10 V to 180 V Bias
- 600 mA Sinking Current on Series Outputs
- 100 mA Sinking Current on Shunt Outputs
- Propagation Delay <5 µs Driving 1200 pF Capacitive Load
- Quiescent Current <0.4 mA
- Internal Low Voltage Bias eliminates need for external 5 V supply
- TTL Logic Control
- 6 mm 18-Lead PQFN Package
- RoHS* Compliant

## Applications

- Land Mobile Radio
- MILCOM

## Description

The MADR-011021 four channel switch driver is designed to work with MACOM's Series/Shunt SP4T PIN diode switches (e.g., MASW-011077). This driver has 1 series output and 1 shunt output per channel which can provide up to 600 mA sinking (series), 100 mA sinking (shunt), and 5 mA sourcing bias current.

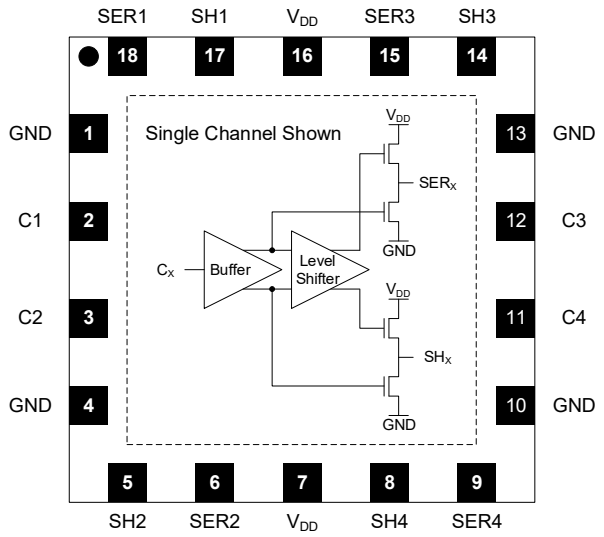
The bias voltage can be selected to be any voltage between 10 V to 180 V. This switch driver can be easily controlled by standard TTL logic. With low quiescent current of <0.4 mA, this driver has a typical delay of <5 µs when driving a 1200 pF capacitive load.

This driver is packaged in a lead-free 6 mm 18-lead PQFN package and is available in tape and reel packaging for high volume applications.

## Ordering Information

| Part Number | Package |
|---|---|
| MADR-011021 | bulk |
| MADR-011021-TR0500 | 500 piece reel |
| MADR-011021-SMB | Sample Board |

## Functional Schematic




## Pin Configuration

| Pin # | Function | Description of Function |
|---|---|---|
| 1,4,10,13 | GND[1] | Ground |
| 2 | C1 | Control 1 Input |
| 3 | C2 | Control 2 Input |
| 5 | SH2 | Shunt 2 Output |
| 6 | SER2 | Series 2 Output |
| 7,16 | $V_{DD}$ | Driver Bias Voltage |
| 8 | SH4 | Shunt 4 Output |
| 9 | SER4 | Series 4 Output |
| 11 | C4 | Control 4 Input |
| 12 | C3 | Control 3 Input |
| 14 | SH3 | Shunt 3 Output |
| 15 | SER3 | Series 3 Output |
| 17 | SH1 | Shunt 1 Output |
| 18 | SER1 | Series 1 Output |
| 19 | Paddle[2] | Ground |

1. All GND pins are internally connected and must be connected externally to system ground.
2. The exposed pad centered on the package bottom must be connected to DC and thermal ground.

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

## Electrical Specifications: $T_A$ = 25°C, $V_{DD}$ = 150 V, C1 = C2 = C3 = C4 = 5 V

| Parameter | Test Conditions | Units | Min. | Typ. | Max. |
|---|---|---|---|---|---|
| $V_{DD}$ Quiescent Current | — | µA | — | 225 | 500 |
| $R_{PULL-UP}$, Series/Shunt Pull-up FET On Resistance | 5 mA Load | Ω | — | 87 | — |
| $R_{PULL-DOWN}$, Series Pull-down FET On Resistance | 600 mA Load | Ω | — | 1.7 | 2.0 |
| $R_{PULL-DOWN}$, Shunt Pull-down FET On Resistance | 100 mA Load | Ω | — | 6.3 | 10 |
| Switching Speed Driving 1200 pF: Series[3]<br>$T_{ON}$<br>$T_{OFF}$<br>$T_{RISE}$<br>$T_{FALL}$ | <br>50% control to 95% Voltage<br>50% control to 5% Voltage<br>5% to 95% Voltage<br>95% to 5% Voltage | µs | — | <br>3.0<br>0.8<br>2.3<br>0.4 | — |
| Switching Speed Driving 1200 pF: Shunt[3]<br>$T_{ON}$<br>$T_{OFF}$<br>$T_{RISE}$<br>$T_{FALL}$ | <br>50% control to 95% Voltage<br>50% control to 5% Voltage<br>5% to 95% Voltage<br>95% to 5% Voltage | µs | — | <br>1.8<br>1.2<br>1.6<br>0.6 | — |
| Switching Speed Driving MASW-011077[4]<br>$T_{ON}$<br>$T_{OFF}$<br>$T_{RISE}$<br>$T_{FALL}$ | <br>50% control to 90% RF<br>50% control to 10% RF<br>10% to 90% RF<br>90% to 10% RF | µs | — | <br>9.3<br>4.6<br>4.9<br>2.6 | — |
| Driver Power Up Time | Note 5 | µs | — | 2 | — |
| Driver Power Down Time | Note 6 | µs | — | 2 | — |

3. Tested with a 1200 pF capacitive load (no current load). The control input switched between 0.8 V and 2.0 V with a 5 ns rise/fall time.
4. Tested with MASW-011077 as the load with a 100 Hz repetition rate in Commutating Mode (RFC - RF1/RF2) with a 0 dBm, 500 MHz RF input. The control inputs switched between 0.8 V and 2.0 V with a 5 ns rise/fall time. $V_{DD}$ = 150 V.
5. This is the time needed for the driver to function properly after $V_{DD}$ reaches 90% of its stable value
6. This is the time needed for the internal bias voltages to discharge to 10% of their steady state value after $V_{DD}$ is powered down.

## 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 devices. The device has an ESD ratings for HBM Class 2 (2kV), and CDM Class C3 (1000 V).

## Recommended Operating Conditions[7,8]

| Parameter | Test Conditions | Units | Min. | Typ. | Max. |
|---|---|---|---|---|---|
| $V_{DD}$ | — | V | 10 | — | 180 |
| C1, C2, C3, C4 | Logic "0"<br>Logic "1" | V | 0.0<br>2.0 | 0.0<br>5 | 0.8<br>5.5 |
| $I_{SOURCE}$, Series/Shunt Sourcing Current per Output | — | mA | — | — | 5 |
| $I_{SINK}$, Series Sinking Current per Output | — | mA | — | — | 600 |
| $I_{SINK}$, Shunt Sinking Current per Output | — | mA | — | — | 100 |
| Total Capacitive load per Output | — | pF | — | — | 4000 |
| Repetition Rate | — | Hz | — | 100 | — |
| Operating Temperature | — | °C | -40 | +25 | +85 |

7. MACOM recommends placing a 0.1 µF capacitor between $V_{DD}$ and ground close to the driver. Care should be taken to ensure proper voltage rating of this capacitor.
8. Unused channels should have their control logic input tied to ground with the corresponding series and shunt outputs left open.

## Absolute Maximum Ratings[9,10,12]

| Parameter | Absolute Maximum |
|---|---|
| $V_{DD}$ | -0.3 V ≤ $V_{DD}$ ≤ +190 V |
| Controls | -0.3 V ≤ Controls ≤ +7 V |
| Series Outputs Sinking Current | 650 mA |
| Shunt Outputs Sinking Current | 150 mA |
| Series/Shunt Outputs Sourcing Current | 10 mA |
| Capacitive Load per Output[11] | 4500 pF |
| Maximum Repetition Rate | 150 Hz |
| Operating Temperature | -40°C to +110°C |
| Storage Temperature | -55°C to +150°C |
| Junction Temperature (Tj) | +125°C |

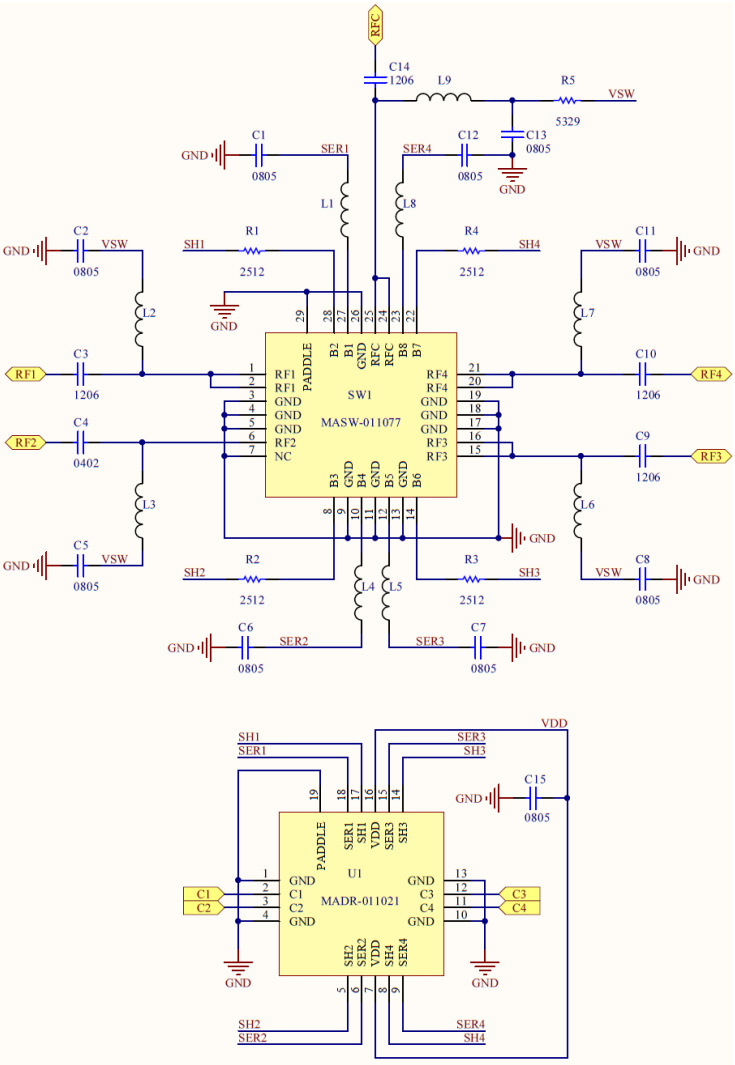
9. Exceeding any one or combination of these limits may cause permanent damage to this device.
10. MACOM does not recommend sustained operation near these survivability limits.
11. Capacitive load above 4500 pF can cause peak currents exceeding the power limit for the MOSFETs in the output buffers.
12. Thermal resistance junction to case Θjc = 25°C/W.

## Logic Truth Table per Channel[13,14,15,16]

| $C_X$ | $SER_X$ | $SH_X$ |
|---|---|---|
| 0 | L | H |
| 1 | H | L |

13. The actual output low voltage can be calculated by: $V_{OL} = I_{SINK} \times R_{PULL\text{-}DOWN}$.
14. The actual output high voltage can be calculated by: $V_{OH} = V_{DD} - I_{SOURCE} \times R_{PULL\text{-}UP}$.
15. '$C_X$' represents C1, C2, C3, or C4.
16. '$SER_X$' and '$SH_X$' represent the corresponding outputs to 'Cx', e.g., C1 and SER1 and SH1.

## Application Schematic Driving MASW-011077



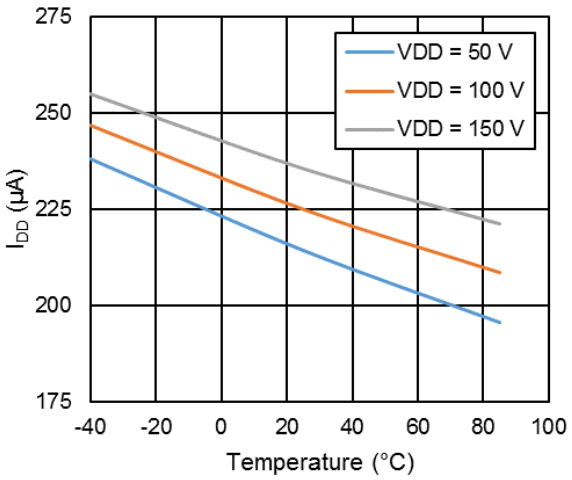

17. A VDD RC filtering network is optional but not a requirement for this driver.

## Parts List

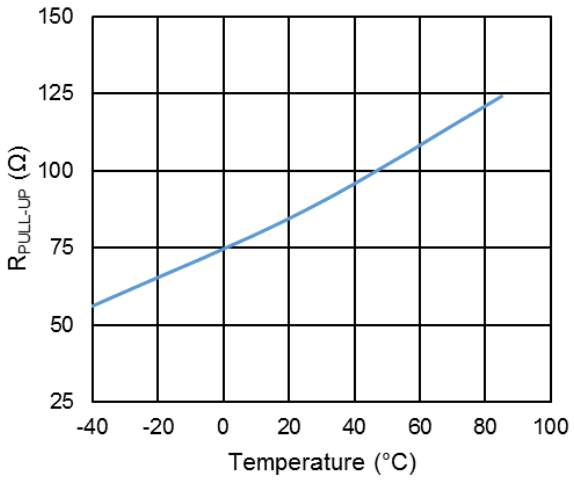
| Part | Value |
|---|---|
| U1 | MADR-011021, MACOM, 10 V to 180 V Driver |
| SW1 | MASW-011077, MACOM, SP4T Switch |
| L1 - L9 | Inductor, 520 nH, MCI, 22-6042-CCPAS-27-42-48 |
| R1 - R4 | Resistor, 82 Ω, 2512, 1%, 2 W |
| R5 | Resistor, 9.1 Ω, 5329, 5%, 5 W |
| C1, C2, C5, C6, C7, C8, C11, C12, C13 | Capacitor, 1000 pF, 0805, 5%, 250 V |
| C3, C9, C10, C14 | Capacitor, 270 pF, 1206, 5%, 200 V |
| C4 | Capacitor, 270 pF, 0402, 5%, 50 V |
| C15 | Capacitor, 0.1 µF, 0805, 10%, 250 V |

## Typical Performance Curves[16]

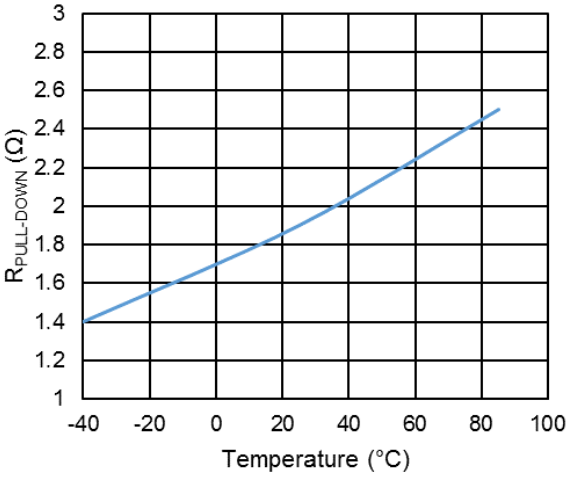
***Quiescent $I_{DD}$: All Controls = +5 V***



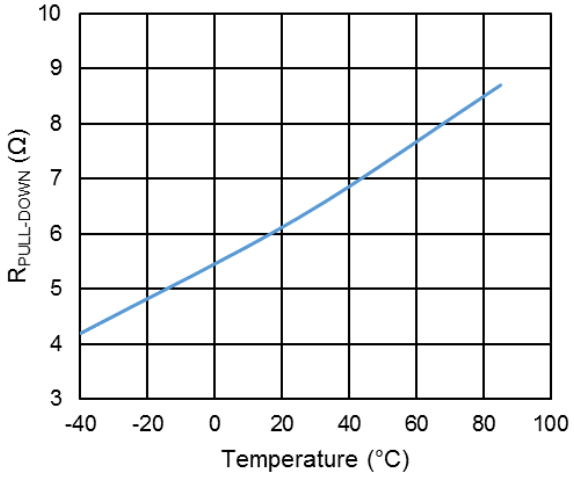

***Series/Shunt Pull-Up On Resistance[17]***




***Series Pull-Down On Resistance[17]***



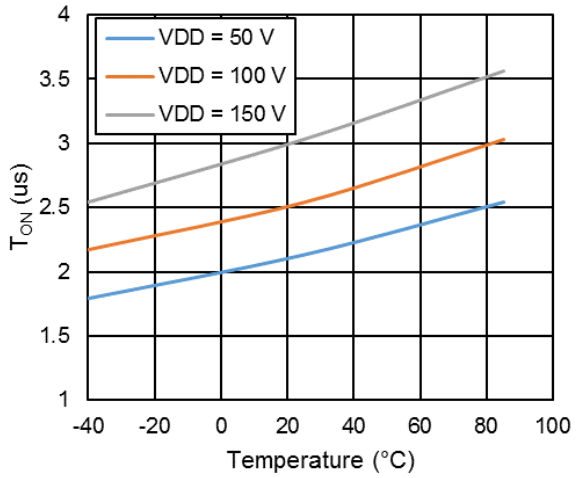

***Shunt Pull-Down On Resistance[17]***



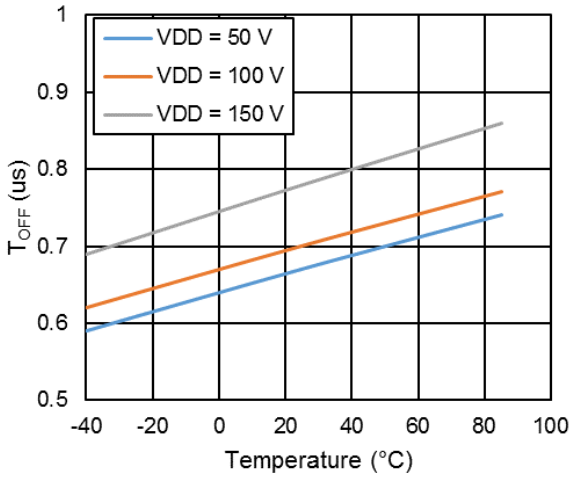

16. $V_{DD}$ = 150 V unless otherwise specified.
17. Pull-Up and Pull-Down On Resistances do not change with different $V_{DD}$ levels.

## Typical Performance Curves[18]

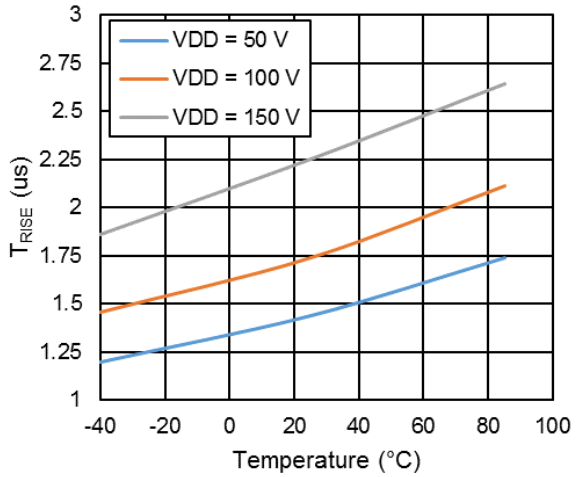
***Series Switching Speed Driving 1200 pF Capacitors: $T_{ON}$***



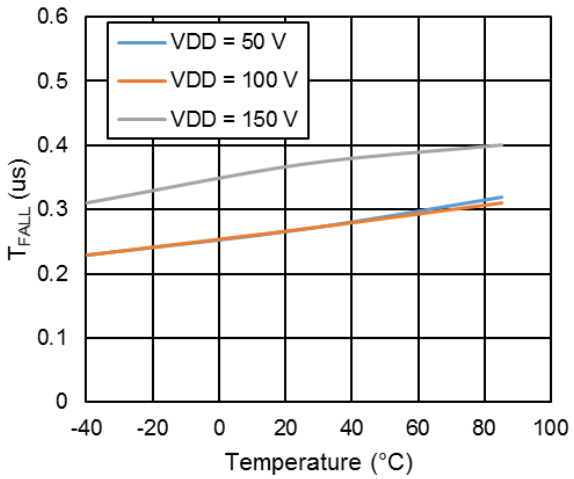

***Series Switching Speed Driving 1200 pF Capacitors: $T_{OFF}$***




***Series Switching Speed Driving 1200 pF Capacitors: $T_{RISE}$***



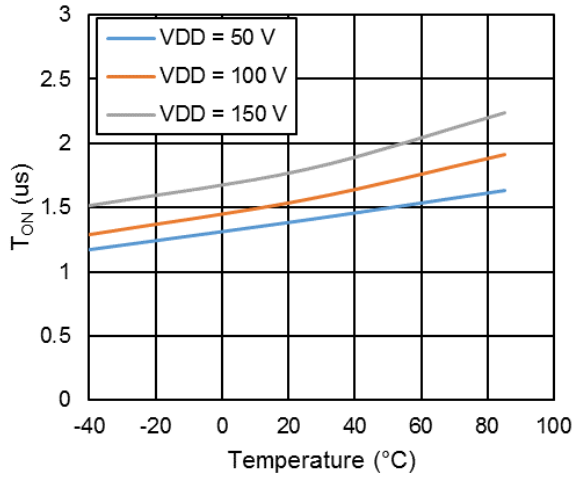

***Series Switching Speed Driving 1200 pF Capacitors: $T_{FALL}$***



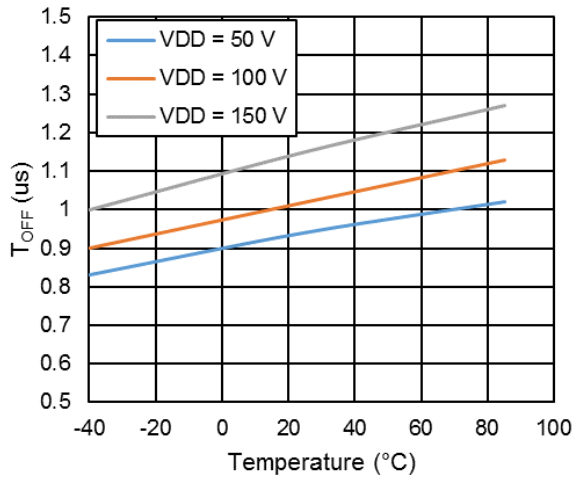

18. Tested with a 1200 pF capacitive load (no current load). The control input switched between 0.8 V and 2.0 V with a 5 ns rise/fall time.

## Typical Performance Curves[19]

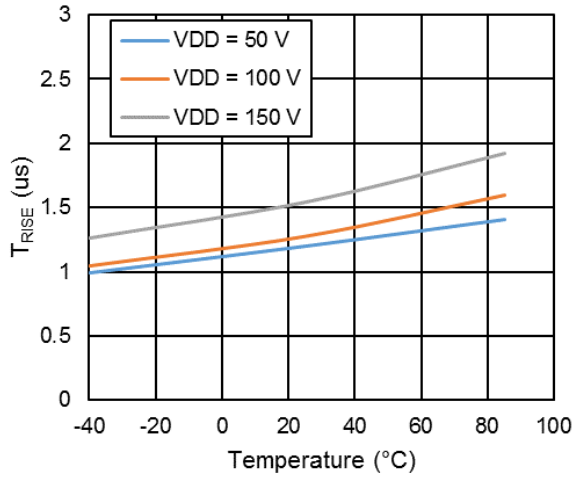
***Shunt Switching Speed Driving 1200 pF Capacitors: $T_{ON}$***



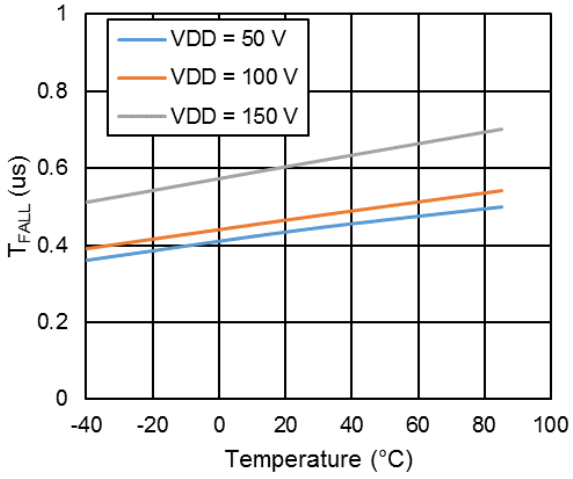

***Shunt Switching Speed Driving 1200 pF Capacitors: $T_{OFF}$***




***Shunt Switching Speed Driving 1200 pF Capacitors: $T_{RISE}$***



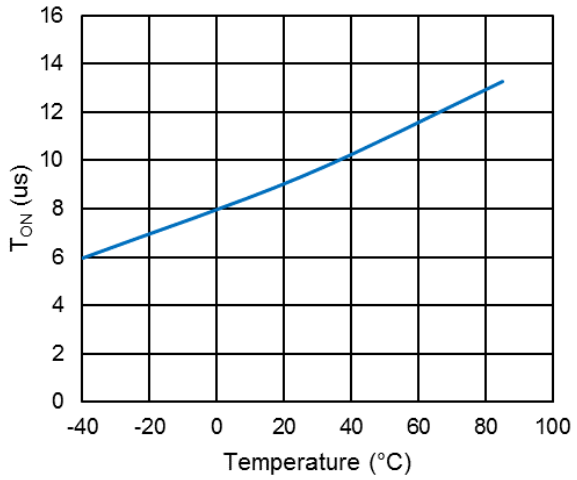

***Shunt Switching Speed Driving 1200 pF Capacitors: $T_{FALL}$***



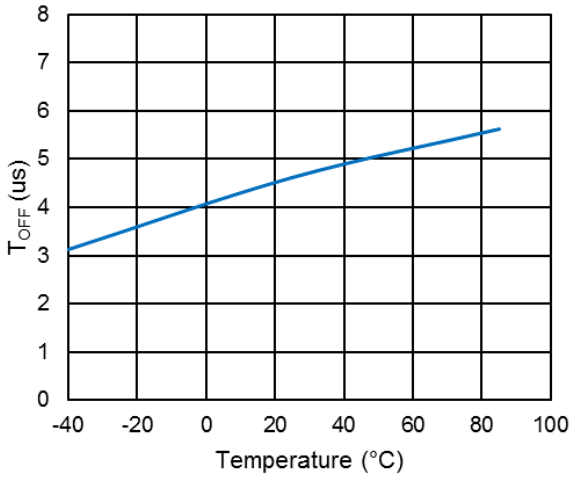

19. Tested with a 1200 pF capacitive load (no current load). The control input switched between 0.8 V and 2.0 V with a 5 ns rise/fall time.

## Typical Performance Curves[20]

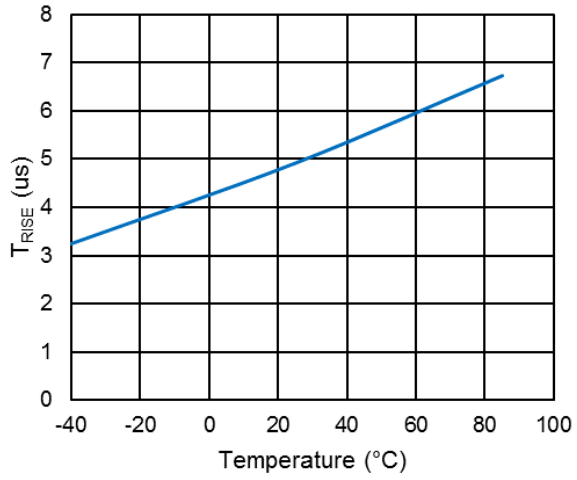
***Switching Speed Driving MASW-011077 Switch: $T_{ON}$***



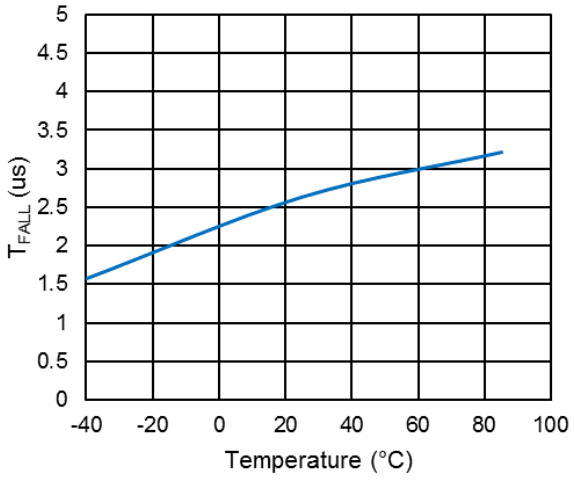

***Switching Speed Driving MASW-011077 Switch: $T_{OFF}$***




***Switching Speed Driving MASW-011077 Switch: $T_{RISE}$***

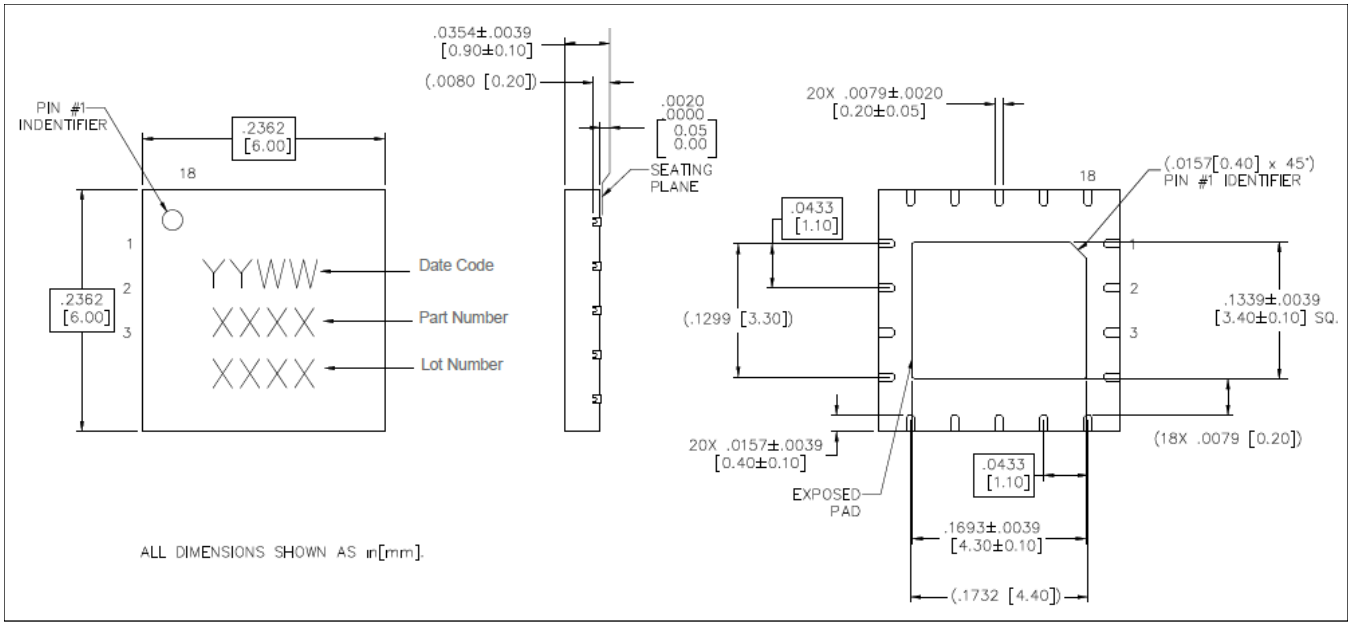



***Switching Speed Driving MASW-011077 Switch: $T_{FALL}$***




20. Tested with MASW-011077 as the load with a 100 Hz repetition rate in Commutating Mode (RFC - RF1/RF2) with a 0 dBm, 500 MHz RF input. The control inputs switched between 0.8 V and 2.0 V with a 5 ns rise/fall time. $V_{DD}$ = 150 V.

## *Lead-Free* 6 mm 18-Lead PQFN†




† This is not a JEDEC standard package.
JEDEC moisture sensitivity level MSL 3.
Plating is NiPdAuAg.