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# Push-Pull FET Driver with Integrated Oscillator and Programmable Clock Output

## General Description

The MAX5077 is a +4.5V to +15V push-pull, current-fed topology driver subsystem with an integrated oscillator used in telecom module power supplies. The device drives two MOSFETs connected to a center-tapped transformer primary providing secondary-side, isolated, negative or positive voltages. The MAX5077 features a programmable accurate integrated oscillator with a synchronizing clock output to synchronize an external PWM regulator. A single external resistor programs the internal oscillator frequency from 50kHz to 1.5MHz.

The MAX5077 incorporates dual MOSFET drivers with  $\pm 3A$  peak drive currents and 50% duty cycle. The MOSFET drivers generate complementary signals to drive external ground-referenced n-channel MOSFETs.

The MAX5077 clock output frequency is programmable by logic inputs to set the clock output to 1x, 2x, or 4x the MOSFET's driver frequency.

The MAX5077 is available in a 14-pin exposed pad TSSOP package and is specified over the -40°C to +125°C operating temperature range.

## Applications

Current-Fed Power Supplies  
Power-Supply Building Subsystems  
Push-Pull Driver Subsystems

## Features

- ◆ Dedicated Current-Fed, Push-Pull Driver Subsystem
- ◆ Oscillator Frequency Programmable from 50kHz to 1.5MHz
- ◆ Single +4.5V to +15V Supply Voltage Range
- ◆  $\pm 3A$  Peak Gate-Drive Current
- ◆ 1mA Operating Current at 250kHz with No Capacitive Load
- ◆ Selectable Synchronizing Clock Frequency for a Preceding PWM Stage
- ◆ Thermally Enhanced 14-Pin TSSOP
- ◆ -40°C to +125°C Operating Temperature Range

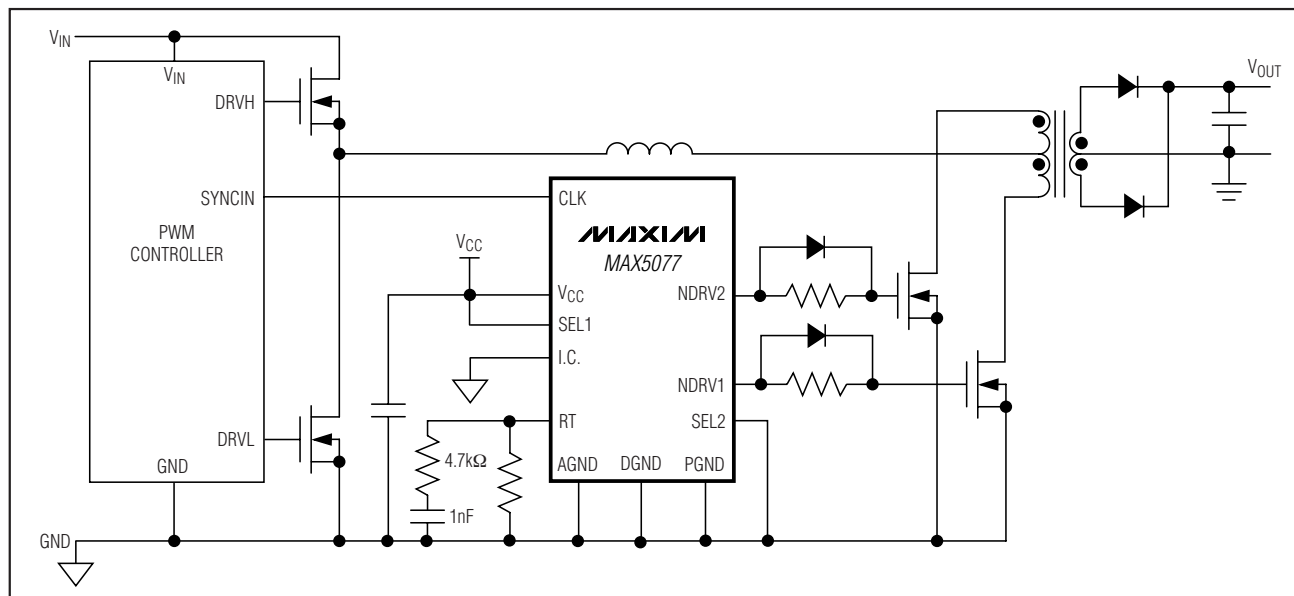
## Ordering Information

| PART       | TEMP RANGE      | PIN-PACKAGE  | PKG CODE |
|------------|-----------------|--------------|----------|
| MAX5077AUD | -40°C to +125°C | 14 TSSOP-EP* | U14E-3   |

\*EP = Exposed paddle.

Pin Configuration appears at end of data sheet.

## Typical Operating Circuit



# Push-Pull FET Driver with Integrated Oscillator and Programmable Clock Output

## ABSOLUTE MAXIMUM RATINGS

|  |                                   |
|--|-----------------------------------|
| V <sub>CC</sub> to AGND, DGND, PGND            | -0.3V to +18V                     |
| PGND, DGND to AGND                             | -0.3V to +0.3V                    |
| SEL1, SEL2 to DGND                             | -0.3V to +18V                     |
| CLK, RT to AGND                                | -0.3V to +6V                      |
| NDRV1, NDRV2 to PGND                           | -0.3V to (V <sub>CC</sub> + 0.3V) |
| CLK Current                                    | ±20mA                             |
| NDRV1, NDRV2 Peak Current (200ns)              | ±5A                               |
| NDRV1, NDRV2 Reverse Current (Latchup Current) | ±500mA                            |

|   |                 |
|---|-----------------|
| Continuous Power Dissipation (T <sub>A</sub> = +70°C) |                 |
| 14-Pin TSSOP (derate 20.8mW/°C above +70°C)           | 1667mW          |
| Operating Temperature Range                           | -40°C to +125°C |
| Maximum Junction Temperature                          | +150°C          |
| Storage Temperature Range                             | -60°C to +150°C |
| Lead Temperature (soldering, 10s)                     | +300°C          |

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS

(V<sub>CC</sub> = +12V, SEL1 = V<sub>CC</sub>, SEL2 = DGND, R<sub>RT</sub> = 124kΩ, NDRV1 = NDRV2 = open, T<sub>A</sub> = T<sub>J</sub> = -40°C to +125°C, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Note 1)

| PARAMETER                          | SYMBOL            | CONDITIONS  | MIN                         | TYP  | MAX  | UNITS |
|------------------------------------|-------------------|---|-----------------------------|------|------|-------|
| <b>SUPPLY</b>                      |                   |   |                             |      |      |       |
| Input Voltage Supply Range         | V <sub>CC</sub>   |   | 4.5                         |      | 15.0 | V     |
| Static Supply Current              | I <sub>CCST</sub> | SEL2 = SEL1 = DGND, drivers not switching                       |                             | 150  | 320  | μA    |
| Switching Supply Current           | I <sub>CCSW</sub> | SEL2 = DGND, SEL1 = V <sub>CC</sub> , f <sub>OSC</sub> = 250kHz |                             | 1    | 3    | mA    |
| Undervoltage Lockout               | V <sub>UVLO</sub> | V <sub>CC</sub> rising  | 3                           | 3.5  | 4    | V     |
| UVLO Hysteresis                    |                   |   |                             | 300  |      | mV    |
| <b>OSCILLATOR</b>                  |                   |   |                             |      |      |       |
| Frequency Range                    | f <sub>OSC</sub>  | (Note 2)  | 50                          |      | 1500 | kHz   |
| Accuracy                           |                   | f <sub>OSC</sub> = 250kHz, 6V ≤ V <sub>CC</sub> ≤ 15V (Note 3)  | -8                          |      | +10  | %     |
| Oscillator Jitter                  |                   |   |                             | ±0.6 |      | %     |
| CLK Output High Voltage            |                   | I <sub>CLK</sub> = 1mA  | 7V ≤ V <sub>CC</sub> ≤ 15V  | 3.9  | 5.0  | V     |
|                                    |                   |   | 4.5V ≤ V <sub>CC</sub> ≤ 7V | 3.35 | 5.0  |       |
| CLK Output Low Voltage             |                   | I <sub>CLK</sub> = -1mA   |                             |      | 50   | mV    |
| CLK Output Rise Time               |                   | C <sub>CLK</sub> = 30pF   |                             | 35   |      | ns    |
| CLK Output Fall Time               |                   | C <sub>CLK</sub> = 30pF   |                             | 10   |      | ns    |
| <b>GATE DRIVERS (NDRV1, NDRV2)</b> |                   |   |                             |      |      |       |
| Output High Voltage                | V <sub>OH</sub>   | I <sub>NDRV1</sub> = I <sub>NDRV2</sub> = 100mA                 | V <sub>CC</sub> - 0.3       |      |      | V     |
| Output Low Voltage                 | V <sub>OL</sub>   | I <sub>NDRV1</sub> = I <sub>NDRV2</sub> = -100mA                |                             |      | 0.3  | V     |
| Output Peak Current                | I <sub>P</sub>    | Sourcing and sinking  |                             | 3    |      | A     |
| Driver Output Impedance            |                   | NDRV_ sourcing 100mA  |                             | 1.8  | 3    | Ω     |
|                                    |                   | NDRV_ sinking 100mA   |                             | 1.6  | 2.6  |       |
| Latchup Current Protection         |                   | Reverse current at NDRV1/NDRV2                                  |                             | 400  |      | mA    |
| Rise Time                          | t <sub>R</sub>    | C <sub>LOAD</sub> = 2nF   |                             | 10   |      | ns    |
| Fall Time                          | t <sub>F</sub>    | C <sub>LOAD</sub> = 2nF   |                             | 10   |      | ns    |

# Push-Pull FET Driver with Integrated Oscillator and Programmable Clock Output

## ELECTRICAL CHARACTERISTICS (continued)

( $V_{CC} = +12V$ ,  $SEL1 = V_{CC}$ ,  $SEL2 = DGND$ ,  $R_{RT} = 124k\Omega$ ,  $NDRV1 = NDRV2 = \text{open}$ ,  $T_A = T_J = -40^\circ C$  to  $+125^\circ C$ , unless otherwise noted. Typical values are at  $T_A = +25^\circ C$ .) (Note 1)

| PARAMETER          | SYMBOL   | CONDITIONS                      | MIN | TYP | MAX | UNITS   |
|--------------------|----------|---------------------------------|-----|-----|-----|---------|
| <b>SEL_INPUTS</b>  |          |                                 |     |     |     |         |
| Input Current      |          | $0V \leq V_{SEL\_} \leq V_{CC}$ |     |     | 1   | $\mu A$ |
| Input High Voltage | $V_{IH}$ |                                 | 3   | 2.5 |     | V       |
| Input Low Voltage  | $V_{IL}$ |                                 |     | 2   | 1.5 | V       |

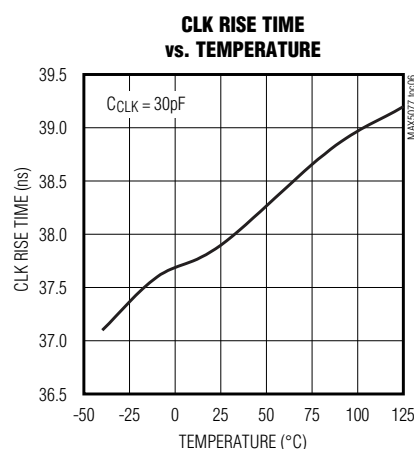
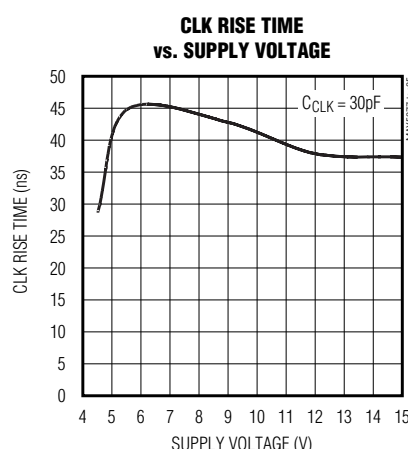
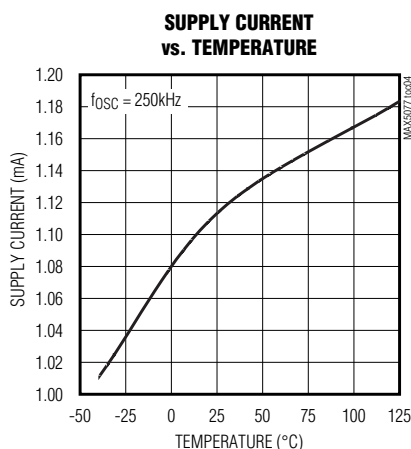
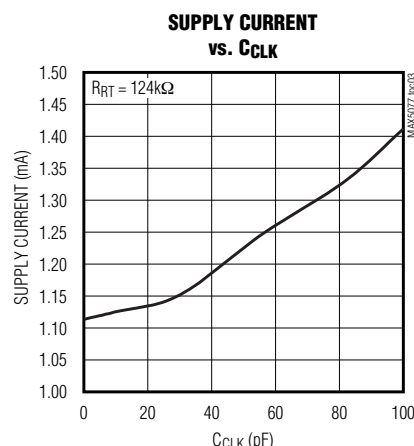
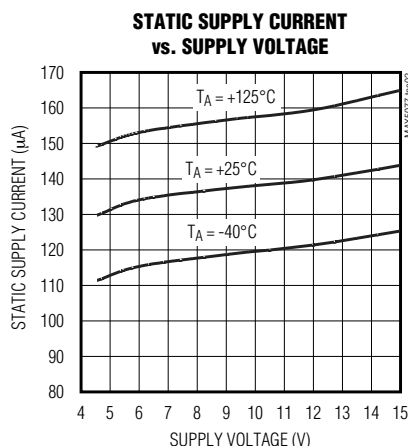
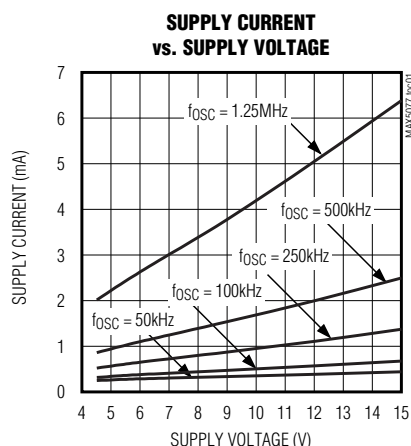
**Note 1:** The MAX5077 is 100% tested at  $T_A = T_J = +125^\circ C$ . All limits over temperature are guaranteed by design.

**Note 2:** Use the following formula to calculate the MAX5077 oscillator frequency:  $f_{OSC} = 10^{12} / (32 \times R_{RT})$ .

**Note 3:** The accuracy of the oscillator's frequency is lower at frequencies greater than 1MHz.

## Typical Operating Characteristics

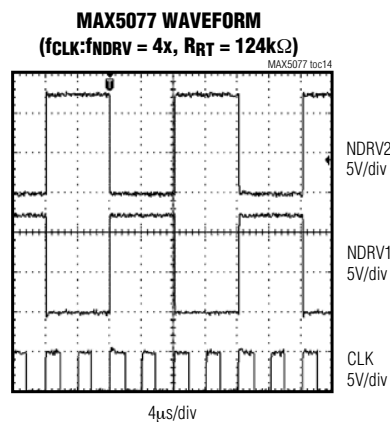
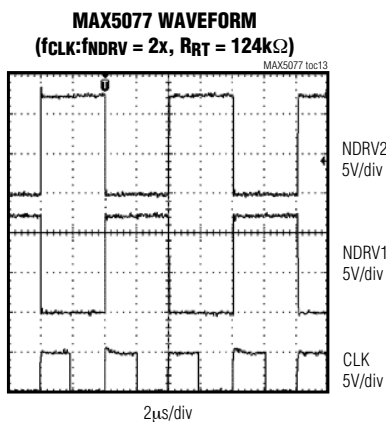
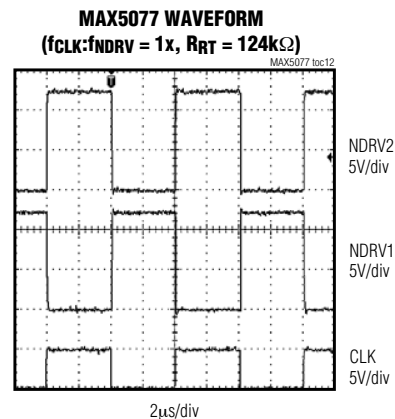
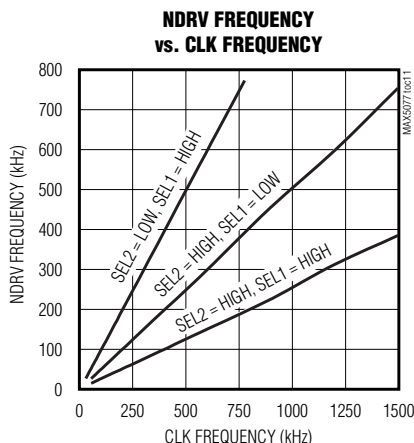
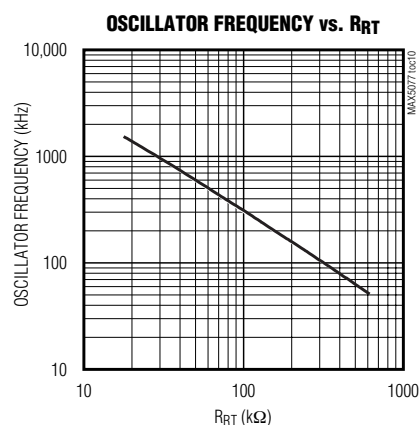
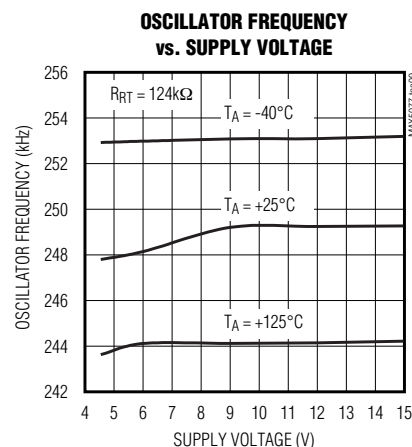
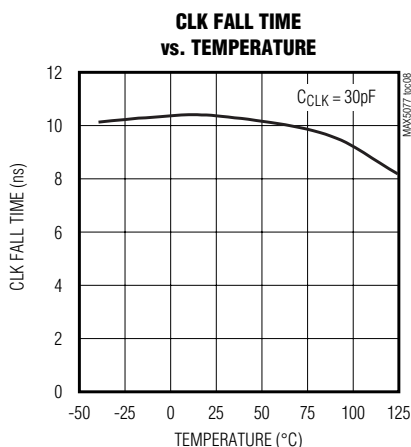
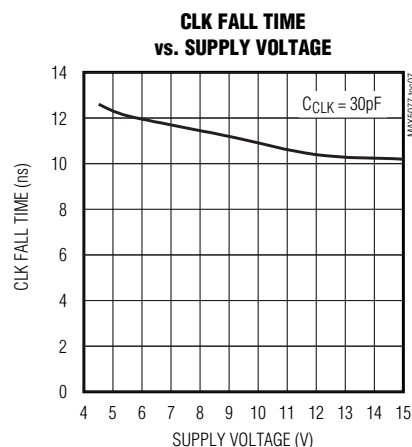
( $V_{CC} = +12V$ ,  $SEL1 = V_{CC}$ ,  $SEL2 = DGND$ ,  $R_{RT} = 124k\Omega$ ,  $NDRV1 = NDRV2 = \text{open}$ ,  $CLK = \text{open}$ .)



# Push-Pull FET Driver with Integrated Oscillator and Programmable Clock Output

## Typical Operating Characteristics (continued)

( $V_{CC} = +12V$ ,  $SEL1 = V_{CC}$ ,  $SEL2 = DGND$ ,  $R_{RT} = 124k\Omega$ ,  $NDRV1 = NDRV2 = \text{open}$ ,  $CLK = \text{open}$ .)



# Push-Pull FET Driver with Integrated Oscillator and Programmable Clock Output

## Pin Description

| PIN   | NAME  | FUNCTION   |
|-------|-------|--|
| 1, 8  | N.C.  | No Connection. Must be left unconnected.   |
| 2     | SEL1  | CLK Frequency Ratio Select Input. Use SEL1 and SEL2 to set $f_{CLK}$ to $f_{NDRV\_}$ frequency ratio (see Table 1).  |
| 3     | CLK   | Synchronizing Clock Output. Clock output with a $\pm 10\text{mA}$ peak current drive that can be used to synchronize an external PWM regulator. CLK/NDRV_ frequency has a 1x, 2x, or 4x ratio (see the <i>Synchronizing Clock Output</i> section). |
| 4, 14 | I.C.  | Connect to ground. Internal function.  |
| 5     | RT    | Oscillator Timing Resistor Connection. Bypass RT with a series of a $4.7\text{k}\Omega$ resistor and a $1\text{nF}$ capacitor to AGND. Connect a resistor from RT to AGND to set the internal oscillator frequency.                                |
| 6     | AGND  | Analog Ground. Connect AGND to ground plane.   |
| 7     | DGND  | Digital Ground. Connect DGND to ground plane.  |
| 9     | PGND  | Power Ground. Connect to ground plane.   |
| 10    | NDRV1 | Gate Driver 1. Connect NDRV1 to the gate of an external n-channel FET.   |
| 11    | NDRV2 | Gate Driver 2. Connect NDRV2 to the gate of an external n-channel FET.   |
| 12    | VCC   | Power-Supply Input. Bypass VCC to PGND with $0.1\mu\text{F}$ ceramic capacitors.   |
| 13    | SEL2  | CLK Frequency Divisor Input. Use SEL1 and SEL2 to set $f_{CLK}$ to $f_{NDRV\_}$ frequency ratio (see Table 1).   |
| EP    | EP    | Exposed Pad. Internally connected to DGND. Connect exposed pad to ground plane.  |

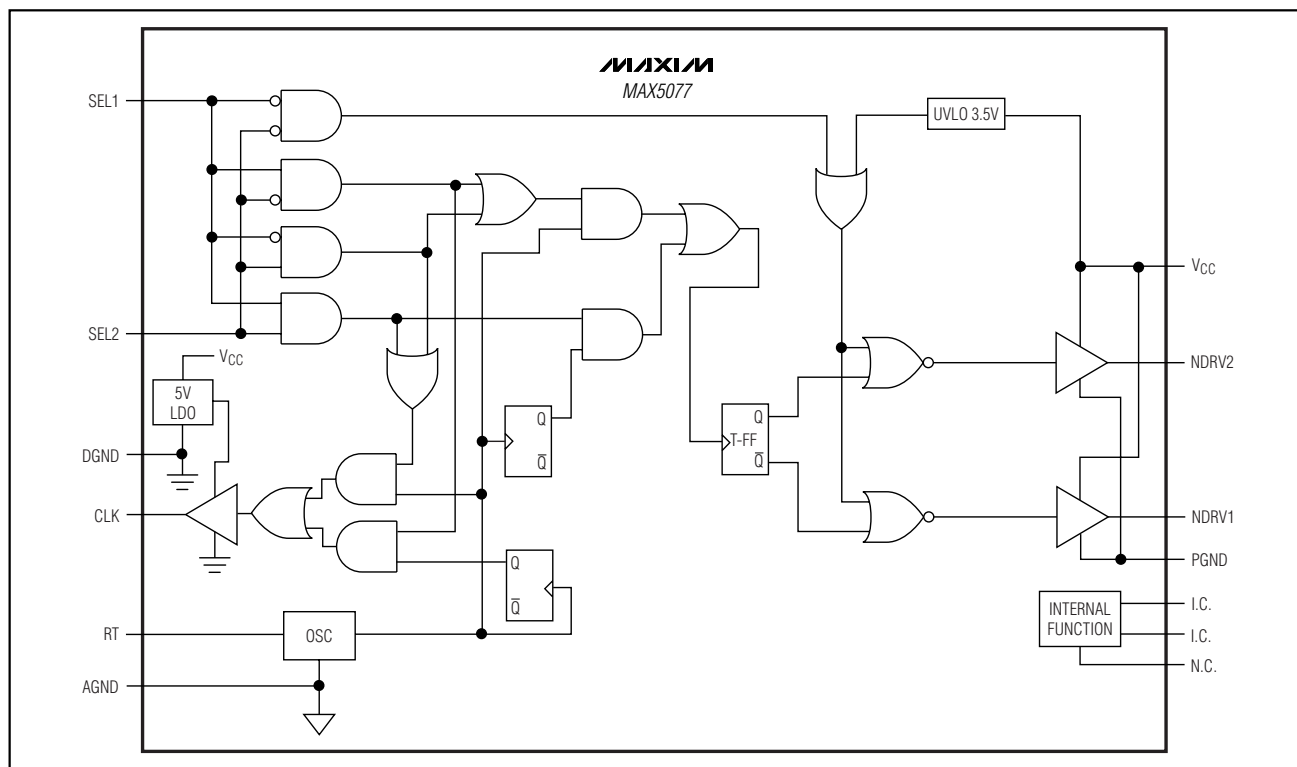


Figure 1. MAX5077 Functional Diagram

# Push-Pull FET Driver with Integrated Oscillator and Programmable Clock Output

## Detailed Description

The MAX5077 is a +4.5V to +15V push-pull, current-fed topology driver subsystem with an integrated oscillator for use in 48V module power supplies.

The MAX5077 features a programmable accurate integrated oscillator with a synchronizing clock output that can be used to synchronize an external PWM stage. A single external resistor programs the internal oscillator frequency from 50kHz to 1.5MHz.

The MAX5077 incorporates dual MOSFET drivers with  $\pm 3A$  peak drive currents and a 50% duty cycle. The MOSFET drivers generate complementary signals to drive external ground-referenced n-channel MOSFETs.

The MAX5077 CLK output frequency is programmable through logic inputs that set the  $f_{CLK}:f_{NDRV\_}$  ratio to 1x, 2x, or 4x.

## Internal Oscillator

An external resistor at  $R_{RT}$  programs the MAX5077's internal oscillator frequency from 50kHz to 1.5MHz. The MAX5077 NDRV1 and NDRV2 switching frequencies are one-half or one-fourth the programmed oscillator frequency with a nominal 50% duty cycle.

Use the following formula to calculate the internal oscillator frequency:

$$f_{OSC} = \frac{10^{12}}{32 \times R_{RT}}$$

where  $f_{OSC}$  is the oscillator frequency and  $R_{RT}$  is a resistor connected from  $R_{RT}$  to AGND in ohms.

Place a series combination of a 4.7k $\Omega$  resistor and a 1nF capacitor from  $R_{RT}$  to AGND for stability and to filter out noise.

When the  $f_{CLK}:f_{NDRV\_}$  ratio is set to 4, the NDRV1 and NDRV2 switching frequency is limited to one-fourth  $f_{OSC}$ . When operating the MAX5077 with the  $f_{CLK}:f_{NDRV\_}$  ratios set to 1 or 2 (see the *Synchronizing Clock Output* section), the NDRV1 and NDRV2 switching frequency is set to one-half  $f_{OSC}$ .

## Synchronizing Clock Output

The MAX5077 provides a buffered clock output that can be used to synchronize the oscillator input of a PWM controller. CLK is powered from an internal 5V regulator and sources/sinks up to 10mA. Two logic inputs (SEL2, SEL1) select CLK output frequency to 1x, 2x, or 4x with respect to NDRV1 and NDRV2 switching frequency (see Table 1 and Figure 2). Drive SEL2 and SEL1 low to disable NDRV1, NDRV2, and CLK outputs. There is a typical 30ns delay from CLK to NDRV $\_$  output.

Table 1. CLK Output Frequency Selection

| SEL2 | SEL1 | $f_{CLK}$                      | $f_{NDRV\_}$  | $f_{CLK}$ to $f_{NDRV}$ RATIO |
|------|------|--------------------------------|---------------|-------------------------------|
| Low  | Low  | NDRV1, NDRV2, and CLK disabled |               |                               |
| Low  | High | $f_{OSC} / 2$                  | $f_{OSC} / 2$ | 1                             |
| High | Low  | $f_{OSC}$                      | $f_{OSC} / 2$ | 2                             |
| High | High | $f_{OSC}$                      | $f_{OSC} / 4$ | 4                             |

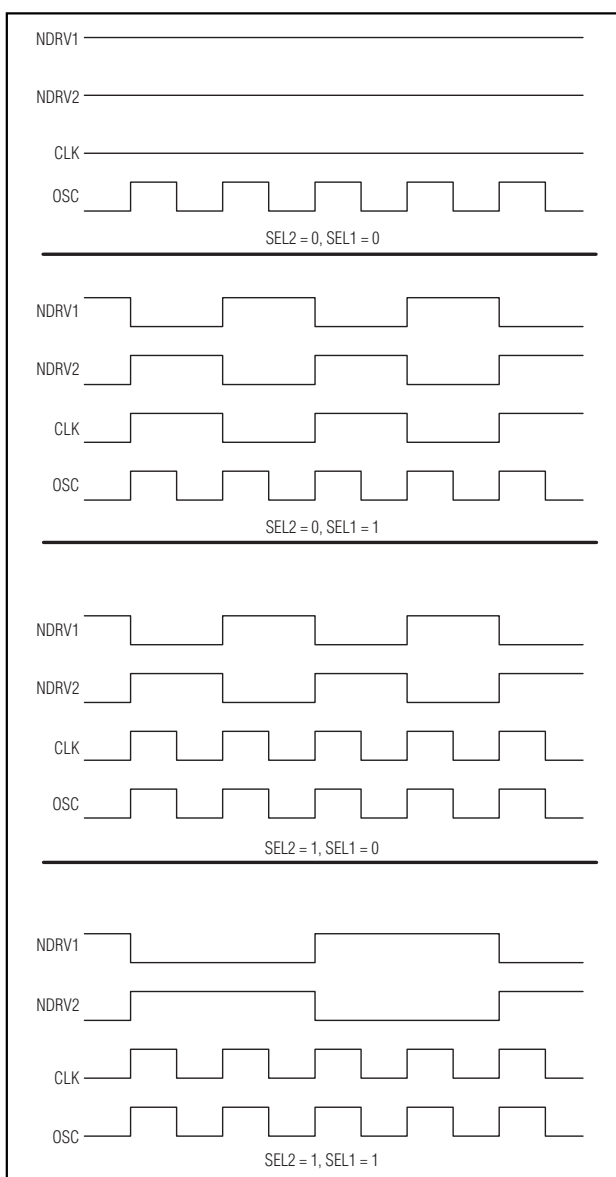


Figure 2. MAX5077 CLK Timing Diagram

# Push-Pull FET Driver with Integrated Oscillator and Programmable Clock Output

## Applications Information

### Supply Bypassing

Pay careful attention to bypassing and grounding the MAX5077. Peak supply and output currents may exceed 3A when driving large MOSFETs. Ground shifts due to insufficient device grounding may also disturb other circuits sharing the same ground-return path. Any series inductance in the VCC, NDRV1, NDRV2, and/or GND paths can cause noise due to the very high di/dt when switching the MAX5077 with any capacitive load. Place one or more 0.1μF ceramic capacitors in parallel as close to the device as possible to bypass VCC to PGND. Use a ground plane to minimize ground-return resistance and inductance. Place the external MOSFETs as close as possible to the MAX5077 to further minimize board inductance and AC path impedance.

### Power Dissipation

Power dissipation of the MAX5077 is a function of the sum of the quiescent current and the output current (either capacitive or resistive load). Maintain the sum of the currents so the maximum power dissipation limit is not exceeded. The power dissipation (P<sub>DISS</sub>) due to the quiescent switching supply current (I<sub>CCSW</sub>) can be calculated as:

$$P_{DISS} = V_{CC} \times I_{CCSW}$$

For capacitive loads, use the following equation to estimate the power dissipation:

$$P_{LOAD} = 2 \times C_{LOAD} \times V_{CC}^2 \times f_{NDRV\_}$$

where C<sub>LOAD</sub> is the capacitive load at NDRV1 and NDRV2, V<sub>CC</sub> is the supply voltage, and f<sub>NDRV\_</sub> is the MAX5077 NDRV\_ switching frequency.

Calculate the total power dissipation (P<sub>T</sub>) as follows:

$$P_T = P_{DISS} + P_{LOAD}$$

## Layout Recommendations

The MAX5077 drivers source and sink large currents that can create very fast rise and fall edges at the gate of the switching MOSFETs. The high di/dt can cause unacceptable ringing if the trace lengths and impedances are not well controlled. Use the following PC board layout guidelines when designing with the MAX5077:

- Place one or more 0.1μF decoupling ceramic capacitors from VCC to PGND as close to the device as possible. Connect VCC and all ground pins to large copper areas. Place one bulk capacitor of 10μF on the PC board with a low-impedance path to the VCC input and PGND of the MAX5077.
- Two AC current loops form between the device and the gates of the driven MOSFETs. The MOSFET looks like a large capacitance from gate to source when the gate pulls low. The current loop is from the MOSFET gate to NDRV1/NDRV2 of the MAX5077, to PGND, and to the source of the MOSFETs. When the gate of the MOSFET is pulled high, the current is from the VCC terminal of the decoupling capacitor, to VCC of the MAX5077, to NDRV1/NDRV2, to the MOSFET gate and source. Both charging current and discharging current loops are important. Minimize the physical distance and the impedance in these AC current paths.
- Keep the device as close to the MOSFET as possible.



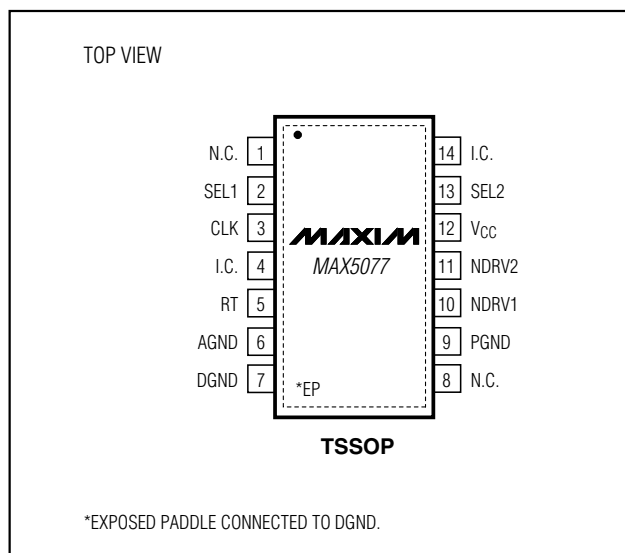
# Push-Pull FET Driver with Integrated Oscillator and Programmable Clock Output

**MAX5077**

## Pin Configuration

## Chip Information

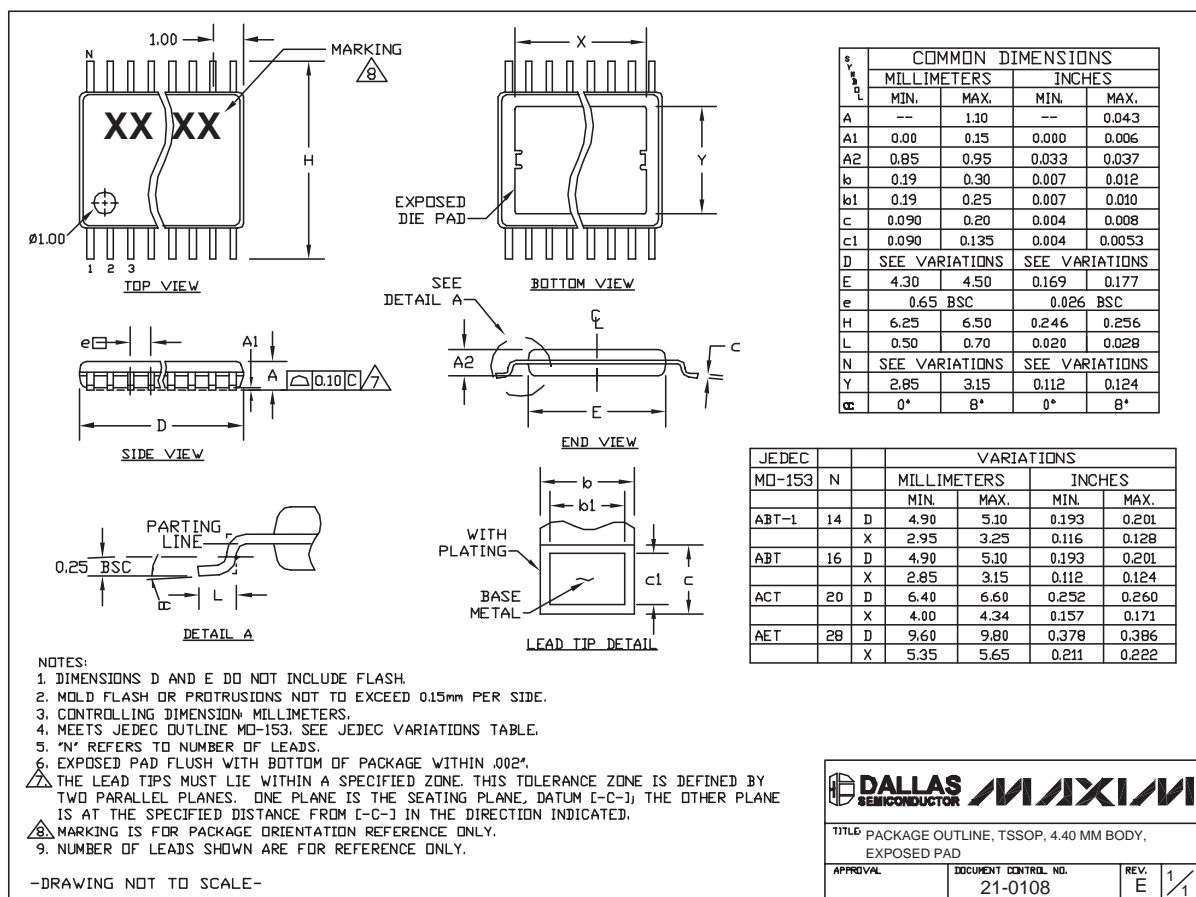
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# Push-Pull FET Driver with Integrated Oscillator and Programmable Clock Output

## Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)



## Revision History

Pages changed at Rev 1: 1, 2, 5, 6, 9

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