

## Fast Time Division Duplex (TDD) Transmission Using an Upconverting Mixer with a High Side Switch – Design Note 480

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### Introduction

Many wireless infrastructure time division duplex (TDD) transmit applications require fast on/off switching of the transmitter, typically within one to five microseconds. There are several different ways to implement fast Tx on/off switching, including the use of RF switches in the signal path, or on/off switching of the supply voltage for different stages of the transmitter chain. The advantages of the latter method are low cost, very good performance and power saving during the Tx off-time. In particular, a good place to apply supply switching is at the transmit upconverting mixer because this removes both the transmit signal and all other mixing products from the mixer RF output.

The LT<sup>®</sup>5579 high performance upconverting mixer fits various TDD and Burst Mode<sup>®</sup> transmitter applications with output frequencies up to 3.8GHz. Fast on/off supply voltage ( $V_{CC}$ ) switching for the LT5579 is as simple as

adding an external high side power supply switch (note that this technique is equally effective for the lower frequency upconverting mixer, LT5578).

### High Side $V_{CC}$ Switch for a Burst Mode Transmitter Using the LT5579 Mixer

The high side  $V_{CC}$  switch circuit in Figure 1 uses a P-channel MOSFET (IRLML6401) with an  $R_{DS(ON)}$  of less than  $0.1\Omega$ . An N-channel enhancement mode FET (2N7002), connected from the drain of IRLML6401 to ground, further improves fall time. The 2N7002's  $R_{DS(ON)}$  is less than  $4\Omega$ , which is sufficient for this application.

The input driver for the high side  $V_{CC}$  switch is a high speed CMOS inverter (MC74HC1G04) capable of driving capacitive loads. The IRLML6401 input capacitance is typically 830pF and the 2N7002 input capacitance is

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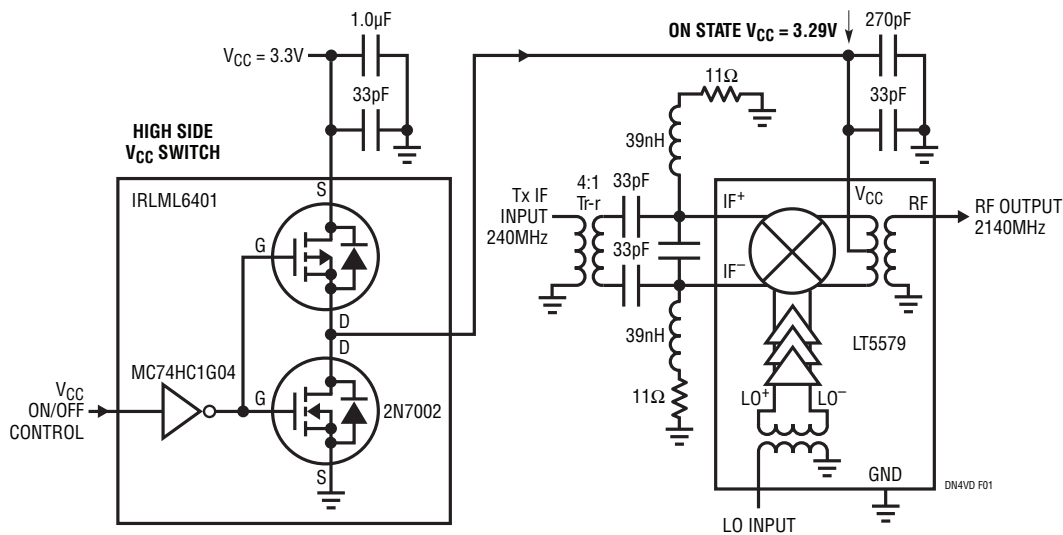


Figure 1. Upconverting Mixer with High Side  $V_{CC}$  Switch

under 50pF. For faster rise times, two high speed CMOS drivers can be used in parallel. Likewise, for faster fall times, a different N-channel MOSFET with lower on-resistance can be used.

With the LT5579 supply current of 220mA, the power supply voltage drop across the MOSFET is only 11mV. The response time of the high side  $V_{CC}$  switch is shown in Figure 2. Total turn-on time is only 650ns and total turn-off time is 500ns. These measurements were performed using two RF bypass capacitors at the mixer  $V_{CC}$  pin (33pF and 270pF). Higher value RF bypass capacitors can be used, which would result in correspondingly slower rise/fall times.

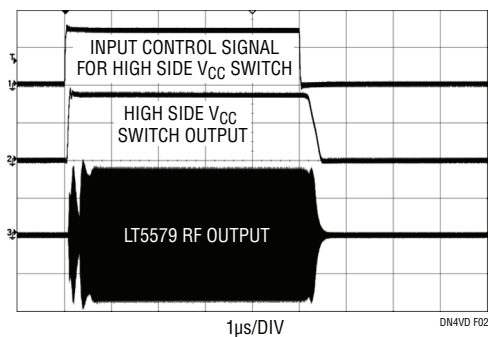


Figure 2.  $V_{CC}$  Turn-On and Turn-Off Waveforms

The LT5579 upconverting mixer circuit shown in Figure 1 was optimized and tested at an RF output frequency of 2140MHz. The RF output envelope in Figure 2 shows a dip about 300ns after the  $V_{CC}$  switch turns on, followed by another, smaller dip at about the 500ns point. Both dips represent the mixer's internal feedback circuit reaction to the ramping supply voltage.

LO leakage to the RF output of the LT5579 was measured at -40dBm when  $V_{CC}$  is on and -46dBm for  $V_{CC}$  off. The LO port of the LT5579 is internally matched and has a return loss of 10dB to 18dB over a frequency range of 1100MHz to 3200MHz.

When the LT5579 mixer is in the off state, the return loss of the LO port is about 3dB to 5dB across the same frequency range of 1100MHz to 3200MHz. It is advisable to use an LO injection VCO with a buffered output for better reverse isolation, and to avoid any VCO pulling while the LO port impedance changes when switching between the on and off states.

### Conclusion

LT5579 and LT5578 mixers without an ENABLE pin can be used in TDD applications with external  $V_{CC}$  switching. Using only three parts (IRLML6401, 2N7002 and an MC74HC1G04), a high performance high side  $V_{CC}$  switch allows turn-on and turn-off in under 1µs.

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