*Click here for production status of specific part numbers.*

# MAX2771

# Multiband Universal GNSS Receiver

## General Description

The MAX2771 is a next-generation Global Navigation Satellite System (GNSS) receiver covering E5/L5, L2, E6, E1/L1 bands and GPS, GLONASS, Galileo, QZSS, IRNSS, and BeiDou navigation satellite systems on a single chip.

Designed on Maxim's advanced, low-power SiGe BiCMOS process technology, the MAX2771 offers the highest performance and integration at a low cost. Incorporated on the chip is the complete receiver chain, including a dual-input LNA and mixer, followed by filter, PGA, and multi-bit ADC, along with a fractional-N frequency synthesizer, and crystal oscillator. The total cascaded noise figure of this receiver is as low as 1.4dB.

The MAX2771 completely eliminates the need for external IF filters by implementing on-chip monolithic filters and requires only a few external components to form a complete, low-cost GNSS RF receiver solution.

The MAX2771 is the most flexible receiver on the market. The integrated delta-sigma fractional-N frequency synthesizer allows programming of the IF frequency within a ±30Hz ($f_{XTAL}$ = 32MHz) accuracy while operating with any reference or crystal frequencies that are available in the host system. The ADC outputs CMOS logic levels with one or two quantized bits for both I and Q channels, or up to 3 quantized bits for the I channel. The on-chip ADCs can be bypassed and the analog I and Q signals output for sampling with external ADCs. An analog monitoring feature is provided that allows simultaneous output of the on-chip ADC samples and the I analog signal.

The MAX2771 is packaged in a 5mm x 5mm, 28-pin, TQFN package with an exposed paddle.

## Applications

- Location-Enabled Mobile Handsets
- PNDs (Personal Navigation Devices)
- Telematics (Asset Tracking, Inventory Management)
- Marine/Avionics Navigation
- Software GPS
- Laptops and Netbooks
- Surveying Equipment
- Digital Still Cameras and Camcorders
- Vehicle Tracking and Fleet Management

## Benefits and Features

- Multi-Constellation Support
  - GPS, Galileo, GLONASS, BeiDou, IRNSS, QZSS, SBAS
- Multiband Support
  - L1, L2, L5, E1, E5, E6, B1, B2, B3
- Programmable IF Bandwidths of 2.5MHz, 4.2MHz, 8.7MHz, 16.4MHz, 23.4MHz, 36MHz
  - Supports Wide-Band Carriers for Precision Applications (e.g., GPS L5, Galileo E5)
- Operates in Low IF or Zero IF Mode
  - Programmable IF Center Frequency
- Fractional-N Synthesizer with Integrated VCO Supports Wide Range of Reference Frequencies
- On-Chip LNAs to Support Multiple Bands
- 1.4dB Cascaded Noise Figure and 110dB of Cascaded Gain with Gain Control Range of 59dB from PGA
- Integrated Crystal Oscillator
- Supply Voltage Range: 2.7V to 3.3V
- 28-Pin, RoHS-Compliant, Thin QFN Lead-Free Package (5mm x 5mm)

***Ordering Information*** *appears at end of data sheet.*

*19-100378; Rev 0; 7/18*

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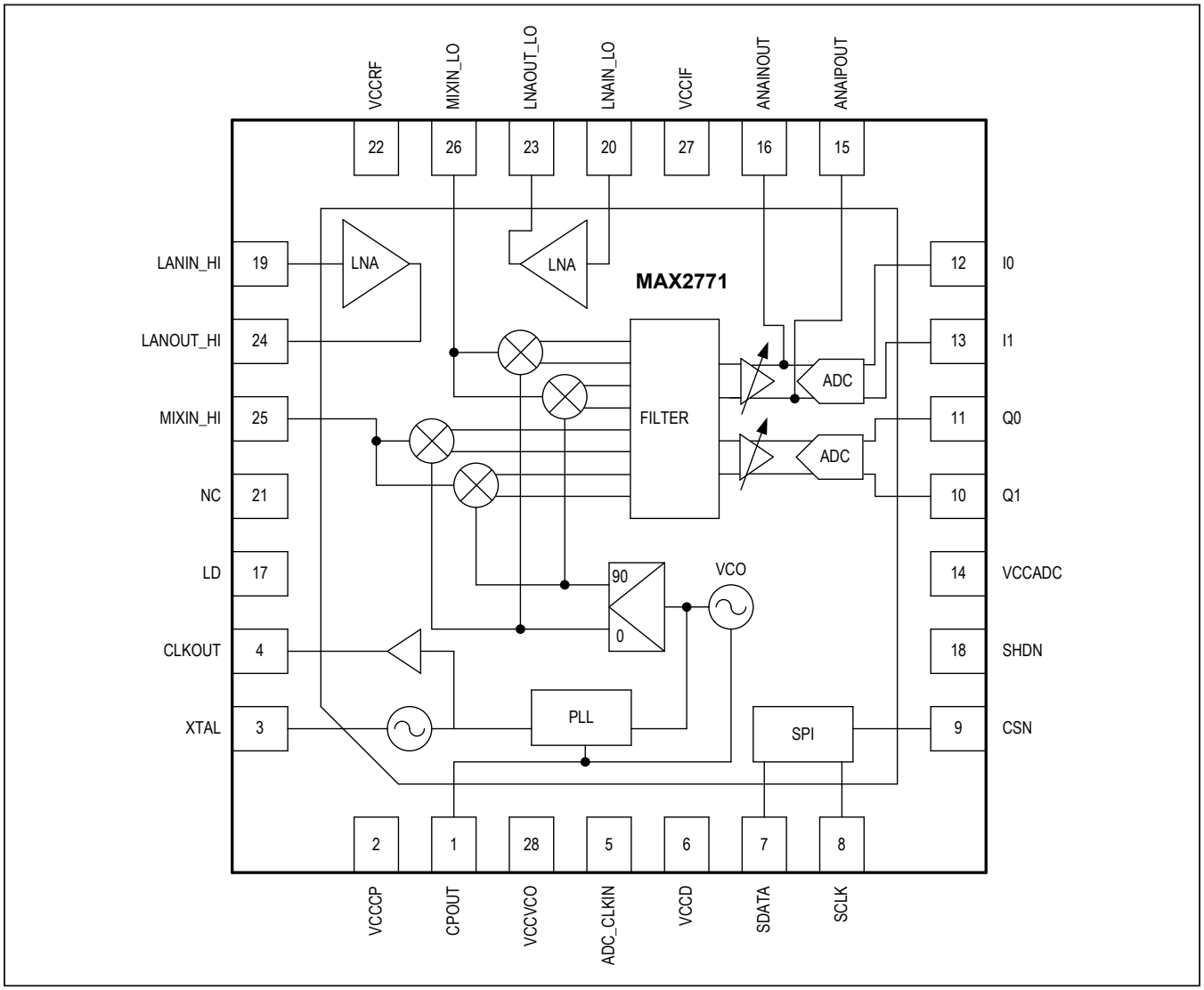
## Block Diagram



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## Absolute Maximum Ratings

VCC to GND .....-0.3V to +4.2V
MIXIN_ to GND .....-0.3V to +0.3V
Other Pins to GND (Note 1) .....-0.3V to $V_{CC}$ + 0.3V
Maximum RF Input Power.....+15dBm
Continuous Power Dissipation
($T_A$ = +70°C, derate 27 mW/°C above +70°C.) .....2500mW

Operating Temperature Range.....-40°C to 85°C
Storage Temperature Range ..... -65°C to +150°C
Junction Temperature.....+150°C
Lead Temperature (Soldering, 10 seconds).....+300°C

**Note 1:** Except for LNAIN_HI, LNAIN_LO, MIXIN_HI, MIXIN_LO, XTAL, LNAOUT_HI and LNAOUT_LO

*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.*

## Package Information

### 28 TQFN-EP

| | |
|---|---|
| Package Code | T2855+8 |
| Outline Number | **21-0140** |
| Land Pattern Number | **90-0023** |

For the latest package outline information and land patterns (footprints), go to **www.maximintegrated.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to **www.maximintegrated.com/thermal-tutorial**.

## Electrical Characteristics

(MAX2771 EV kit, $V_{CC}$ = 2.7V to 3.3V, $T_A$ = -40°C to +85°C. Registers are set to the specified default states. LNA input is driven from a 50Ω source. All RF measurements are done in the analog output mode with ADC bypassed. PGA gain is set to GAININ = 111010 through SPI interface, unless otherwise noted. Maximum IF output load is not to exceed 10kΩ||7.5pF on each pin. Typical values are at $V_{CC}$ = 2.85V and $T_A$ = +25°C, unless otherwise noted. (Note 1))

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| **DC ELECTRICAL CHARACTERISTICS** | | | | | | |
| Supply Voltage | VCC | | 2.7 | 2.85 | 3.3 | V |
| Supply Current | | Default mode, high-band LNA and mixer input is active (Note 2) | | 26 | | mA |
| | | Default mode, low-band LNA and mixer input is active (Note 2) | | 27 | | |
| | | Idle Mode™, IDLE bit is 1, $\overline{SHDN}$ = high | | 5 | | |
| | | Shutdown mode, $\overline{SHDN}$= low | | 200 | | µA |
| Digital Input Logic-High | $V_{IH}$ | Measure at the $\overline{SHDN}$ pin | 1.5 | | | V |
| Digital Input Logic-Low | $V_{IL}$ | Measure at $\overline{SHDN}$ pin | | | 0.4 | V |

*Idle Mode is a trademark of Maxim Integrated Products, Inc.*

## Electrical Characteristics (continued)

(MAX2771 EV kit, $V_{CC}$ = 2.7V to 3.3V, $T_A$ = -40°C to +85°C. Registers are set to the specified default states. LNA input is driven from a 50Ω source. All RF measurements are done in the analog output mode with ADC bypassed. PGA gain is set to GAININ = 111010 through SPI interface, unless otherwise noted. Maximum IF output load is not to exceed 10kΩ||7.5pF on each pin. Typical values are at $V_{CC}$ = 2.85V and $T_A$ = +25°C, unless otherwise noted. (Note 1))

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| **AC ELECTRICAL CHARACTERISTICS/ASCADED RF PERFORMANCE** | | | | | | |
| RF Frequency | | L1 band | | 1575.42 | | MHz |
| RF Frequency - L2/L5 Band | | L2/L5 band | | 1227.6 | | MHz |
| Noise Figure | | High band LNA input active, default mode (Note 3) | | 1.4 | | dB |
| Noise Figure - L2/L5 Band | | L2/L5 band (Note 6). Low-band LNA input active, default mode (Note 3) | | 1.6 | | dB |
| Noise Figure | | Measured at the high-band mixer input | | 10.3 | | dB |
| Noise Figure - L2/L5 Band | | L2/L5 band (Note 6). Measured at the low-band mixer input | | 10.3 | | dB |
| Out-of-Band 3rd-Order Input Intercept Point | | Measured at the high-band mixer input (Note 4) | | -9 | | dBm |
| Out-of-Band 3rd-Order Input Intercept Point - L2/L5 Band | | L2/L5 band (Note 6). Measured at the low-band mixer input (Note 4) | | -9 | | dBm |
| In-Band Mixer Input Referred 1dB Compression Point | | Measured at the high-band mixer input | | -85 | | dBm |
| In-Band Mixer Input Referred 1dB Compression Point – L2/L5 Band | | L2/L5 band (Note 6). Measured at the low-band mixer input | | -85 | | dBm |
| Mixer Input Return Loss | | Measured at high-band mixer input | | 10 | | dB |
| Mixer Input Return Loss - L2/L5 Band | | Measured at low-band mixer input | | 8 | | dB |
| Image Rejection | | | | 25 | | dB |
| Image Rejection - L2/L5 Band | | L2/L5 band (Note 6) | | 25 | | dB |
| Spurs at High-Band LNA Input | | LO leakage | | -101 | | dBm |
| Spurs at Low-Band LNA Input | | L2/L5 band (Note 6). LO leakage | | -101 | | dBm |
| Spurs at High-Band LNA Input | | Reference harmonics leakage | | -103 | | dBm |
| Spurs at Low-Band LNA Input | | L2/L5 band (Note 6). Reference harmonics leakage | | -103 | | dBm |
| Maximum Voltage Gain | | Measured from the high-band mixer input to the baseband analog output | 89 | 96 | 104 | dB |
| Maximum Voltage Gain - L2/L5 Band | | L2/L5 band (Note 6). Measured from the low-band mixer input to the baseband analog output | 89 | 96 | 104 | dB |
| Variable Gain Range | | Measured at high-band mixer input | 53 | 59 | | dB |

## Electrical Characteristics (continued)

(MAX2771 EV kit, $V_{CC}$ = 2.7V to 3.3V, $T_A$ = -40°C to +85°C. Registers are set to the specified default states. LNA input is driven from a 50Ω source. All RF measurements are done in the analog output mode with ADC bypassed. PGA gain is set to GAININ = 111010 through SPI interface, unless otherwise noted. Maximum IF output load is not to exceed 10kΩ||7.5pF on each pin. Typical values are at $V_{CC}$ = 2.85V and $T_A$ = +25°C, unless otherwise noted. (Note 1))

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| **AC ELECTRICAL CHARACTERISTICS/FILTER RESPONSE** | | | | | | |
| Passband Center Frequency | | FBW = 000, FCEN = 1011000 (Note 7) | | 3.9 | | MHz |
| | | FBW = 010, FCEN = 1011000 (Note 7) | | 7.1 | | |
| | | FBW = 001, FCEN = 1101001 (Note 7) | | 7.6 | | |
| Passband 3dB Bandwidth | | FBW = 000 (Note 7) | | 2.5 | | MHz |
| | | FBW = 010 (Note 7) | | 4.2 | | |
| | | FBW = 001 (Note 7) | | 8.7 | | |
| Lowpass 3dB Bandwidth | | FBW = 011, single-sided BW (Note 7) | | 11.7 | | MHz |
| | | FBW = 111, single-sided BW (Note 7) | | 8.2 | | |
| | | FBW = 100, single-sided BW (Note 7) | | 18 | | |
| Stopband Attenuation | | 3rd-order filter, bandwidth = 2.5MHz, measured at 4MHz offset (Note 7) | | 30 | | dB |
| | | 5th-order filter, bandwidth = 2.5MHz, measured at 4MHz offset (Note 7) | | 50 | | |
| Passband Flatness | | FBW = 001, Filter center frequency = 8.9MHz, 5th-order BPF, \|response magnitude at 5.1MHz - response magnitude at 11.6MHz\| (Note 7) | | 3 | | dB |
| **AC ELECTRICAL CHARACTERISTICS/HIGH-BAND LNA** | | | | | | |
| Power Gain | | | | 18 | | dB |
| Noise Figure | | | | 0.9 | | dB |
| Input IP3 | | (Note 5) | | -1.1 | | dBm |
| Output Return Loss | | | | 10 | | dB |
| Input Return Loss | | With external matching circuit components of 5.6nH series inductor and 1.7pF shunt capacitor. | | 10 | | dB |
| **AC ELECTRICAL CHARACTERISTICS/LOW-BAND LNA** | | | | | | |
| Power Gain | | | | 18 | | dB |
| Noise Figure | | | | 0.9 | | dB |
| Input IP3 | | (Note 5) | | -1.1 | | dBm |
| Output Return Loss | | | | 10 | | dB |
| Input Return Loss | | With external matching circuit components of 8.4nH series inductor and 1.1pF shunt capacitor. | | 8 | | dB |

## Electrical Characteristics (continued)

(MAX2771 EV kit, $V_{CC}$ = 2.7V to 3.3V, $T_A$ = -40°C to +85°C. Registers are set to the specified default states. LNA input is driven from a 50Ω source. All RF measurements are done in the analog output mode with ADC bypassed. PGA gain is set to GAININ = 111010 through SPI interface, unless otherwise noted. Maximum IF output load is not to exceed 10kΩ||7.5pF on each pin. Typical values are at $V_{CC}$ = 2.85V and $T_A$ = +25°C, unless otherwise noted. (Note 1))

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| **AC ELECTRICAL CHARACTERISTICS/FREQUENCY SYNTHESIZER** | | | | | | |
| LO Frequency Range | | 0.2V < $V_{TUNE}$ < ($V_{CC}$ - 0.25V), LOBAND = 0 | 1525 | | 1610 | MHz |
| LO Frequency Range—L2/L5 Band | | 0.2V < $V_{TUNE}$ < ($V_{CC}$ - 0.25V), LOBAND = 1 | 1160 | | 1290 | MHz |
| LO Tuning Gain | | | | 70 | | MHz/V |
| LO Tuning Gain - L2/L5 Band | | | | 76 | | MHz/V |
| Reference Input Frequency | | | 8 | | 44 | MHz |
| Main Divider Ratio | | | 36 | | 32,767 | — |
| Reference Divider Ratio | | | 1 | | 1023 | — |
| Charge-Pump Current | | ICP = 0 | | 0.5 | | mA |
| | | ICP = 1 | | 1 | | |
| **AC ELECTRICAL CHARACTERISTICS/TXCO INPUT BUFFER/OUTPUT CLOCK BUFFER** | | | | | | |
| Frequency Range | | Load = 10kΩ||10pF | 8 | | 44 | MHz |
| Output High Level | | With respect to ground, $I_{OH}$ = 10µA (DC-coupled) | 2 | | | V |
| Output Low Level | | With respect to ground, $I_{OL}$ = 10µA (DC-coupled) | | | 0.8 | V |
| Capacitive Slew Current | | Load = 10KΩ||10pF, $f_{CLKOUT}$ = 44MHz | | 11 | | mA |
| Output Load | | | | | 10||10 | KΩ||pF |
| Reference Input Level | | Sine wave | 0.5 | | | $V_{P-P}$ |
| Clock Output Multiply/Divide Range | | x2: max input frequency of 22MHz, x4: max input frequency of 11MHz | /4 | | x4 | — |
| **AC ELECTRICAL CHARACTERISTICS/ADC** | | | | | | |
| ADC Differential Nonlinearity | | AGC enabled, 3-bit output | | ±0.1 | | LSB |
| ADC Integral Nonlinearity | | AGC enabled, 3-bit output | | ±0.1 | | LSB |

**Note 1:** MAX2771 is production tested at $T_A$ = 25ºC. User must program the registers to the specified default settings upon power-up.

**Note 2:** Default mode of the IC. PLL is an an integer-N mode with $f_{COMP} = f_{TCXO}/16$ = 1.023MHz and $I_{CP}$ = 0.5mA. The complex IF filter is configured as a 5th-order Butterworth filter with a center frequency of 4MHz and bandwidth of 2.5MHz. Output data is in a 2-bit sign/magnitude format at CMOS logic levels in the I channel only.

**Note 3:** The LNA output connects to the mixer input without a SAW filter between them.

**Note 4:** Two tones are located at 12MHz and 24MHz offset frequencies from the GPS center frequency of 1575.42MHz or 1227.6MHz depending on band. Passive pole at the mixer output is programmed to be 13MHz.

**Note 5:** Measured from the LNA input to the LNA output. Two tones are located at 12MHz and 24MHz offset frequencies from the GPS center frequency of 1575.42MHz or 1227.6MHz depending on band.

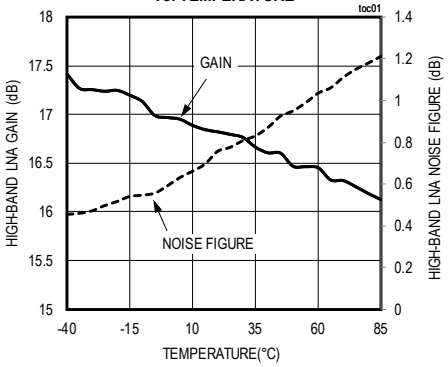
**Note 6:** Same global conditions except tune LO to 1223.508 MHz which means change PLL integer divider ratio to 1196 and program LOBAND bit to 1.

**Note 7:** Filter response measured with PGA gain setting of GAININ = 000100, and mixer pole set to 36 MHz (MIXPOLE = 1).

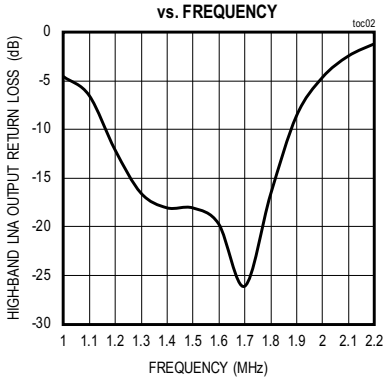
## Typical Operating Characteristics

(MAX2771 EV kit, $V_{CC}$ = 2.7V to 3.3V, $T_A$ = -40°C to +85°C. Registers are set to the default power-up states. LNA input is driven from a 50Ω source. LNA input has specified external matching circuit. All RF measurements are done in the analog output mode with ADC bypassed. PGA gain is set to GAININ = 111010 except for IF filter response plots in which case it is set to GAININ = 000100. For IF filter response plots, MIXPOLE = 1. Maximum IF output load is not to exceed 10kΩ||7.5pF on each pin. Typical values are at $V_{CC}$ = 2.85V and $T_A$ = +25°C, unless otherwise noted.)

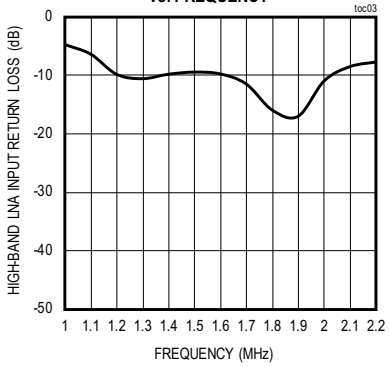
HIGH-BAND LNA GAIN AND NOISE FIGURE vs. TEMPERATURE



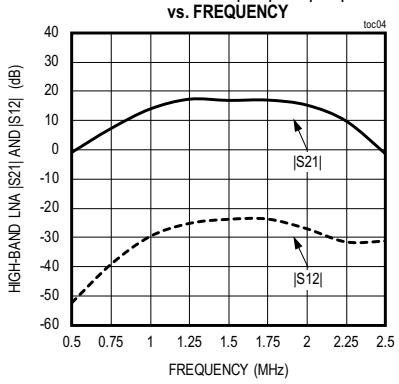

HIGH-BAND LNA OUTPUT RETURN LOSS vs. FREQUENCY



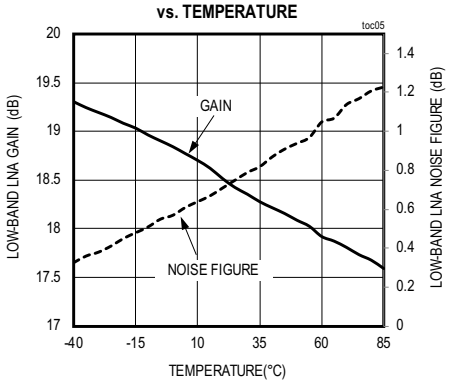

HIGH-BAND LNA INPUT RETURN LOSS vs. FREQUENCY



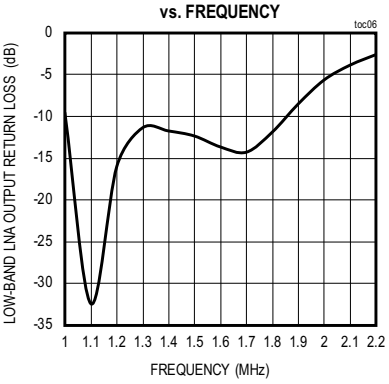

HIGH-BAND LNA |S21| and |S12| vs. FREQUENCY



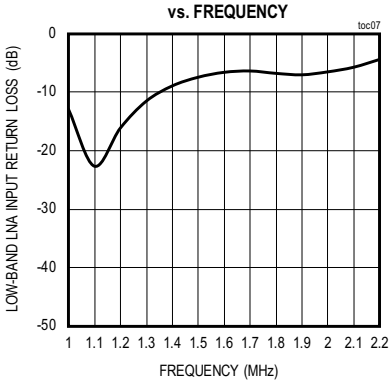

LOW-BAND LNA GAIN AND NOISE FIGURE vs. TEMPERATURE



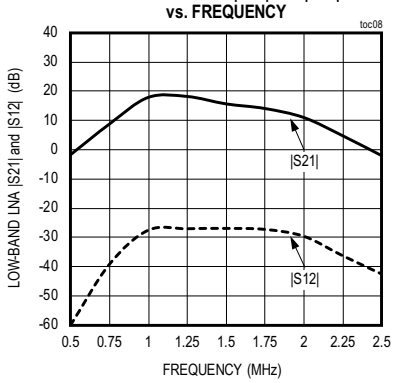

LOW-BAND LNA OUTPUT RETURN LOSS vs. FREQUENCY




LOW-BAND LNA INPUT RETURN LOSS vs. FREQUENCY



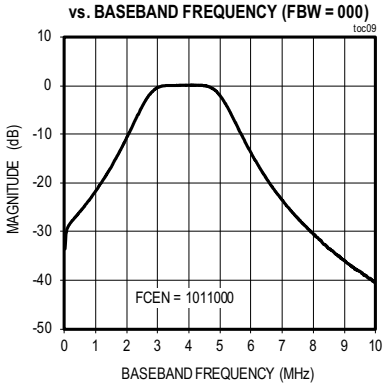

LOW-BAND LNA |S21| and |S12| vs. FREQUENCY



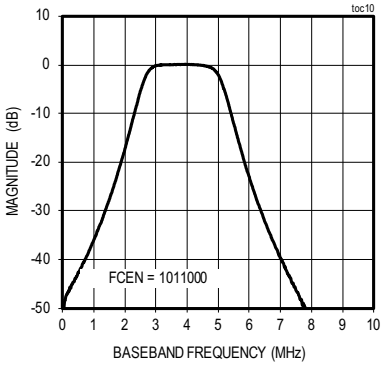
## Typical Operating Characteristics (continued)

(MAX2771 EV kit, $V_{CC}$ = 2.7V to 3.3V, $T_A$ = -40°C to +85°C. Registers are set to the default power-up states. LNA input is driven from a 50Ω source. LNA input has specified external matching circuit. All RF measurements are done in the analog output mode with ADC bypassed. PGA gain is set to GAININ = 111010 except for IF filter response plots in which case it is set to GAININ = 000100. For IF filter response plots, MIXPOLE = 1. Maximum IF output load is not to exceed 10kΩ||7.5pF on each pin. Typical values are at $V_{CC}$ = 2.85V and $T_A$ = +25°C, unless otherwise noted.)

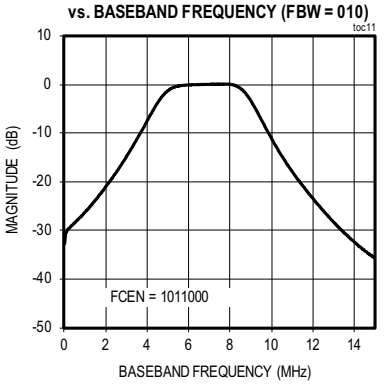
3RD-ORDER POLYPHASE FILTER RESPONSE vs. BASEBAND FREQUENCY (FBW = 000)



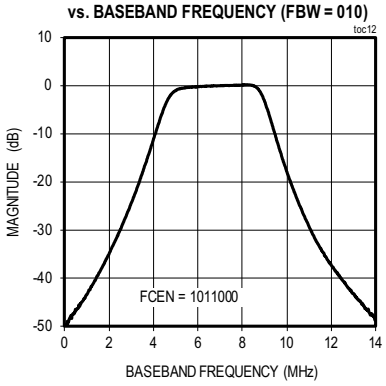

5TH-ORDER POLYPHASE FILTER RESPONSE vs. BASEBAND FREQUENCY (FBW = 000)



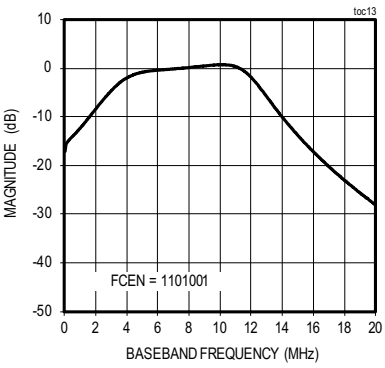

3RD-ORDER POLYPHASE FILTER RESPONSE vs. BASEBAND FREQUENCY (FBW = 010)



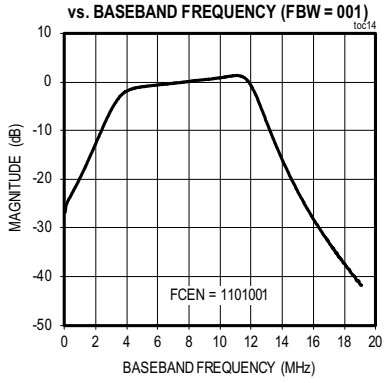

5TH-ORDER POLYPHASE FILTER RESPONSE vs. BASEBAND FREQUENCY (FBW = 010)



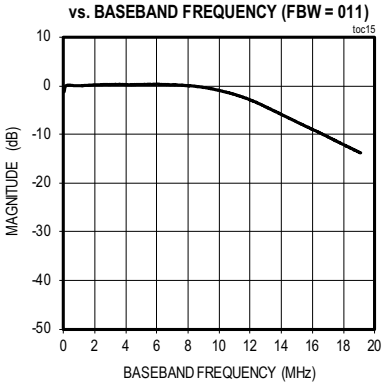

3RD-ORDER POLYPHASE FILTER RESPONSE vs. BASEBAND FREQUENCY (FBW = 001)



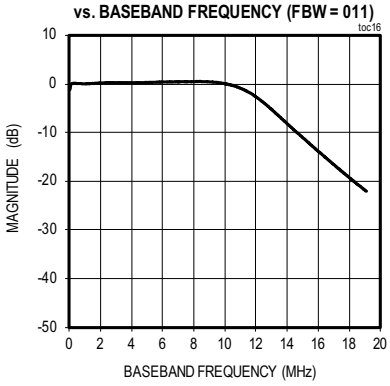

5TH-ORDER POLYPHASE FILTER RESPONSE vs. BASEBAND FREQUENCY (FBW = 001)




3RD-ORDER LOW-PASS FILTER RESPONSE vs. BASEBAND FREQUENCY (FBW = 011)



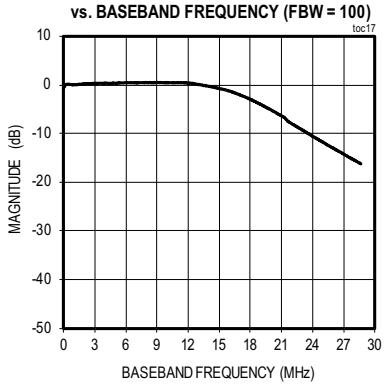

5TH-ORDER LOW-PASS FILTER RESPONSE vs. BASEBAND FREQUENCY (FBW = 011)



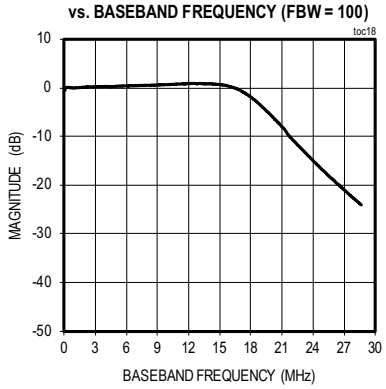
## Typical Operating Characteristics (continued)

(MAX2771 EV kit, $V_{CC}$ = 2.7V to 3.3V, $T_A$ = -40°C to +85°C. Registers are set to the default power-up states. LNA input is driven from a 50Ω source. LNA input has specified external matching circuit. All RF measurements are done in the analog output mode with ADC bypassed. PGA gain is set to GAININ = 111010 except for IF filter response plots in which case it is set to GAININ = 000100. For IF filter response plots, MIXPOLE = 1. Maximum IF output load is not to exceed 10kΩ||7.5pF on each pin. Typical values are at $V_{CC}$ = 2.85V and $T_A$ = +25°C, unless otherwise noted.)

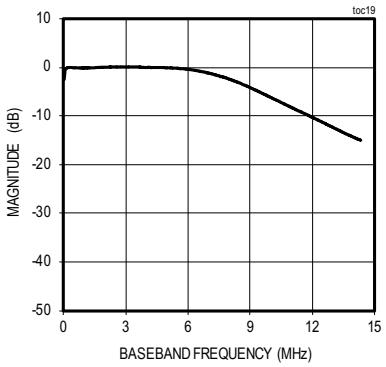
3RD-ORDER LOW-PASS FILTER RESPONSE vs. BASEBAND FREQUENCY (FBW = 100)



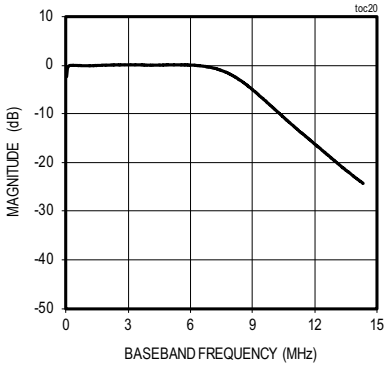

5TH-ORDER LOW-PASS FILTER RESPONSE vs. BASEBAND FREQUENCY (FBW = 100)



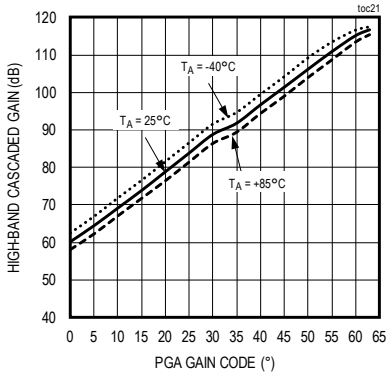

3RD-ORDER LOW-PASS FILTER RESPONSE vs. BASEBAND FREQUENCY (FBW = 111)



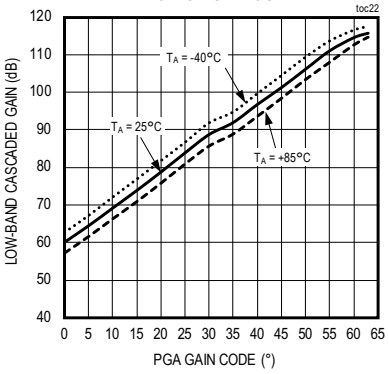

5TH-ORDER LOW-PASS FILTER RESPONSE vs. BASEBAND FREQUENCY (FBW = 111)



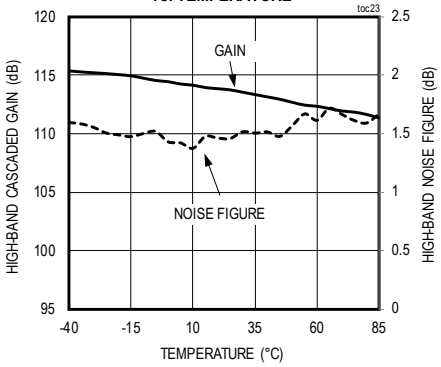

HIGH-BAND CASCADED GAIN vs. PGA GAIN CODE



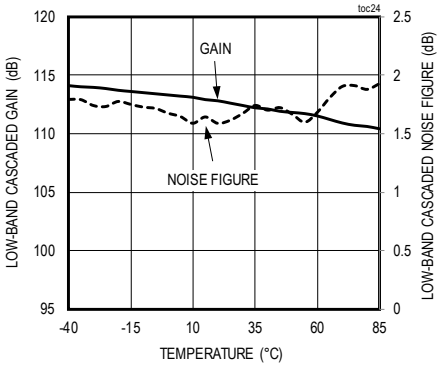

LOW-BAND CASCADED GAIN vs. PGA GAIN CODE




HIGH-BAND CASCADED GAIN AND NOISE FIGURE vs. TEMPERATURE



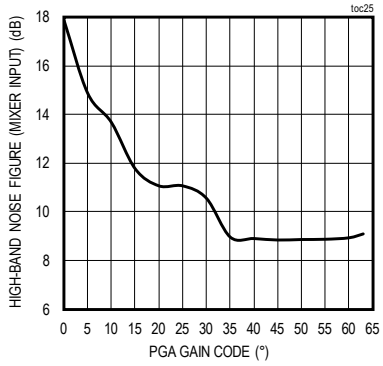

LOW-BAND CASCADED GAIN AND NOISE FIGURE vs. TEMPERATURE



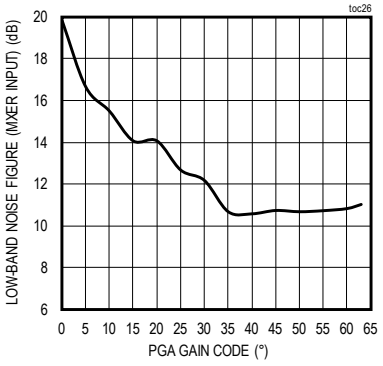
## Typical Operating Characteristics (continued)

(MAX2771 EV kit, $V_{CC}$ = 2.7V to 3.3V, $T_A$ = -40°C to +85°C. Registers are set to the default power-up states. LNA input is driven from a 50Ω source. LNA input has specified external matching circuit. All RF measurements are done in the analog output mode with ADC bypassed. PGA gain is set to GAININ = 111010 except for IF filter response plots in which case it is set to GAININ = 000100. For IF filter response plots, MIXPOLE = 1. Maximum IF output load is not to exceed 10kΩ||7.5pF on each pin. Typical values are at $V_{CC}$ = 2.85V and $T_A$ = +25°C, unless otherwise noted.)

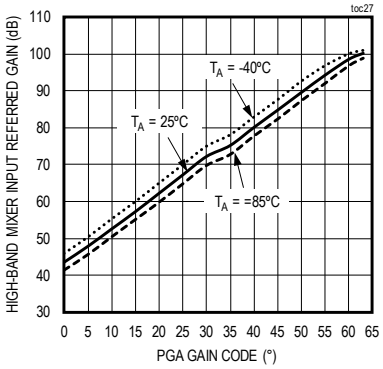
**HIGH-BAND NOISE FIGURE (MIXER INPUT) vs. PGA GAIN CODE**



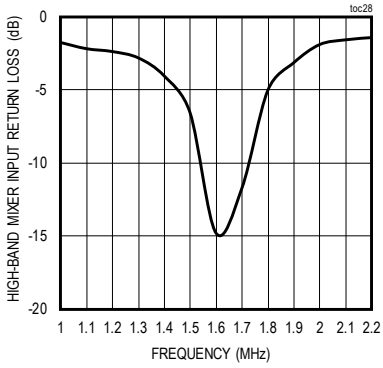

**LOW-BAND NOISE FIGURE (MIXER INPUT) vs. PGA GAIN CODE**



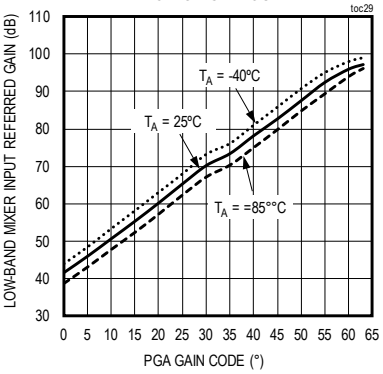

**HIGH-BAND MIXER INPUT REFERRED GAIN vs. PGA GAIN CODE**



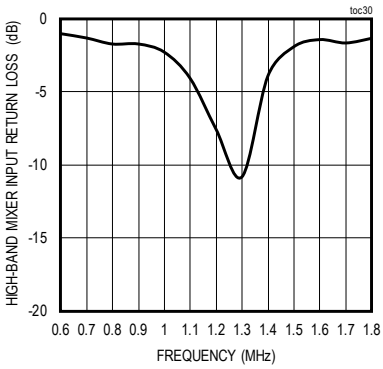

**HIGH-BAND MIXER INPUT RETURN LOSS vs. FREQUENCY**



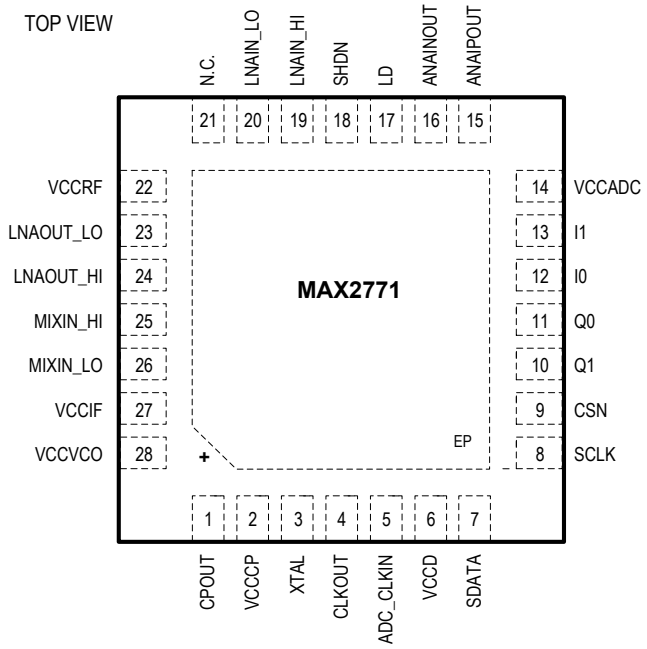

**LOW-BAND MIXER INPUT REFERRED GAIN vs. PGA GAIN CODE**




**LOW-BAND MIXER INPUT RETURN LOSS vs. FREQUENCY**



## Pin Configuration




*CONNECTED EXPOSED PAD TO GROUND

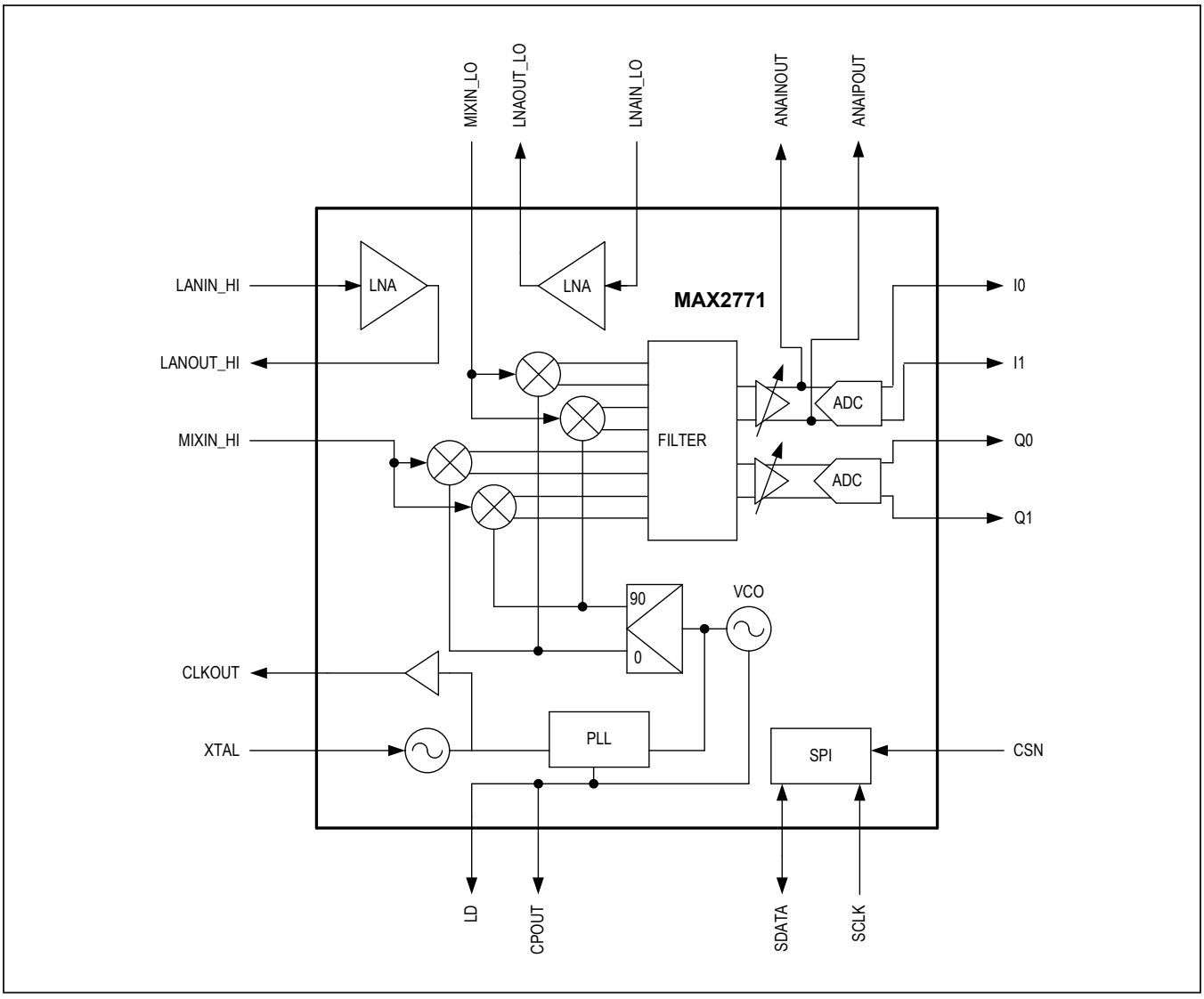
## Pin Description

| PIN | NAME | FUNCTION | TYPE |
|---|---|---|---|
| 1 | CPOUT | Charge-Pump Output. Connect a PLL loop filter as a shunt C and a shunt combination of series R and C (see *Typical Application Circuit*). | Analog output |
| 2 | VCCCP | PLL Charge-Pump Supply Voltage. Bypass to ground with a 100nF capacitor as close as possible to the pin. | Power |
| 3 | XTAL | XTAL or Reference Oscillator Input. Connect to XTAL or a DC-blocking capacitor if a TCXO is used. | Analog input |
| 4 | CLKOUT | Reference Clock Output. | Digital output |
| 5 | ADC_CLKIN | ADC Clock Input. Optionally, the ADCs can be clocked from the clock input on this pin. Refer to *ADC Clock Alignment* section for details. | Digital input |
| 6 | VCCD | Digital Circuitry Supply Voltage. Bypass to ground with a 100nF capacitor as close as possible to the pin. | Power |
| 7 | SDATA | Data Signal of 3-Wire Serial Interface. | Digital Input/ Output |
| 8 | SCLK | Clock Input of 3-Wire Serial Interface. Serial data is clocked in on the rising-edge of the SCLK and output on the falling-edge of SCLK. | Digital Input |
| 9 | CSN | Chip-Select Input of 3-Wire Serial Interface. Set CSN low to select device. Set CS high when the SPI transaction is completed. | Digital Input |

## Pin Description (continued)

| PIN | NAME | FUNCTION | TYPE |
|---|---|---|---|
| 10 | Q1 | Q-Channel Voltage Outputs. Bits 0 and 1 of the Q-channel ADC output or analog differential voltage output. | Digital or analog output |
| 11 | Q0 | Q-Channel Voltage Outputs. Bits 0 and 1 of the Q-channel ADC output or analog differential voltage output. | Digital or analog output |
| 12 | I0 | I-Channel Voltage Outputs. Bits 0 and 1 of the I-channel ADC output or analog differential voltage output. | Digital or analog output |
| 13 | I1 | I-Channel Voltage Outputs. Bits 0 and 1 of the I-channel ADC output or analog differential voltage output. | Digital or analog output |
| 14 | VCCADC | ADC Supply Voltage. Bypass to ground with a 100nF capacitor as close as possible to the pin. | Power |
| 15 | ANAIPOUT | The Analog I+ Channel is Output On This Pin. This is used for the continuous spectrum monitoring function if the ANAIMON bit is set to 1. If continuous spectrum monitoring feature is not required, leave unconnected. | Analog output |
| 16 | ANAINOUT | The Analog I- Channel is Output On This Pin. This is used for the continuous spectrum monitoring function if the ANAIMON bit is set to 1. If continuous spectrum monitoring feature is not required, leave unconnected. | Analog output |
| 17 | LD | Lock-Detector CMOS Logic Output. A logic-high indicates the PLL is locked. | Digital output |
| 18 | SHDN | Operation Control Logic Input. A logic-low shuts off the entire device. | Digital input |
| 19 | LNAIN_HI | High-Band LNA Input Port. Requires external matching circuit of 5.6nH series inductor and 1.7pF shunt capacitor. | Analog input |
| 20 | LNAIN_LO | Low-Band LNA Input Port. Requires external matching circuit of 8.4nH series inductor and 1.1pF shunt capacitor. | Analog input |
| 21 | NC | No Connection. Leave this pin unconnected. | |
| 22 | VCCRF | RF Section Supply Voltage. Bypass to ground with 100nF and 100pF capacitors in parallel as close as possible to the pin. | Power |
| 23 | LNAOUT_LO | Low-Band LNA Output. The LNA output is internally matched to 50Ω for L2/L5 band. | Analog output |
| 24 | LNAOUT_HI | High-Band LNA Output. The LNA output is internally matched to 50Ω for L1 band. | Analog output |
| 25 | MIXIN_HI | High-Band Mixer Input. The mixer input is internally matched to 50Ω for L1 band. | Analog input |
| 26 | MIXIN_LO | Low-Band Mixer Input. The mixer input is internally matched to 50Ω for L2/L5 band. | Analog input |
| 27 | VCCIF | IF Section Supply Voltage. Bypass to ground with a 100nF capacitor as close as possible to the pin. | Power |
| 28 | VCCVCO | VCO Supply Voltage. Bypass to ground with a 100nF capacitor as close as possible to the pin. | Power |

## Functional Diagrams



## Detailed Description

### Default Register Setting

The registers will contain the reset values specified in the *Registers* section of the data sheet upon power-up. It is necessary for certain bit fields in particular registers to be programmed with fixed values that are different from the power-on reset values. These register bit fields and the required values are given in Table 1. These values must be programmed whenever the IC is power-cycled. Note that these bits are described as “Reserved" in the datasheet. Nevertheless, for these reserved bits alone, the values indicated must be programmed.

Table 2 includes the default register bit values with the above specified bits programmed, as in Table 1.

## Table 1. Required Register Bit Field Values

| REGISTER ADDRESS | BIT RANGE | BINARY VALUE |
|---|---|---|
| 0x0 | 29:22 | 11111010 |
| 0x9 | 24:22 | 011 |

## Table 2. Default Register Setting

| REGISTER NAME | ADDRESS | DEFAULT |
|---|---|---|
| Configuration 1 | 0x0 | 0xBEA41603 |
| Configuration 2 | 0x1 | 0x20550288 |
| Configuration 3 | 0x2 | 0x0EAFA1DC |
| PLL Configuration | 0x3 | 0x698C0008 |
| PLL Integer Division Ratio | 0x4 | 0x00C00080 |
| PLL Fractional Division Ratio | 0x5 | 0x08000070 |
| DSP Interface | 0x6 | 0x08000000 |
| Clock Configuration 1 | 0x7 | 0x010061B2 |
| Test Mode 1 | 0x8 | 0x01E0F401 |
| Test Mode 2 | 0x9 | 0x00C00002 |
| Clock Configuration 2 | 0xA | 0x010061B0 |

### Low-Noise Amplifier (LNA)

The MAX2771 integrates two low-noise amplifiers, one for the L1 band (high band) and the other for the L2/L5 band (low band). Both inputs require AC coupling capactors. Bits LNAMODE in the Configuration 1 register control the modes of the two LNAs. See Table 3. The high-band LNA input impedance is matched to 50Ω at a frequency of 1575MHz, providing the specified high-band external matching circuit is used. The low-band LNA input impedance is matched to 50Ω at a frequency of 1227MHz, providing the specified low-band external matching circuit is used.

The output of each LNA is brought out to a separate pin. The output impedance of the high-band LNA is matched to 50Ω at frequency of 1575MHz, and the low-band LNA input impedance is matched to 50Ω at a frequency of 1227MHz.

### Mixer

The MAX2771 includes a quadrature mixer to output low-IF, or zero-IF, I and Q signals. There are two inputs to the mixer; one for high-band and the other for low-band. The high-band mixer input impedance is matched to 50Ω at a frequency of 1575MHz, while the low-band mixer input impedance is matched to 50Ω at a frequency of 1227MHz. The quadrature mixer requires a low-side LO injection. The output of the LNA and the input of the mixer are brought off-chip to facilitate the use of a SAW filter. On the MAX2771, the RF signal has been made accessible between the first LNA stage output and mixer input. If filtering is not desired, these pins can be connected through a coupling capacitor. However, filtering introduced at this point has minimal effect on the excellent sensitivity of the receiver. For example, for typical device parameters, a SAW filter with 1dB insertion loss would degrade cascaded NF (and therefore receiver sensitivity) by only about 0.15dB. While no external filtering is required for

## Table 3. LNA Selection

| LNA MODE (CONFIGURATION 1 REGISTER) | MODE |
|---|---|
| 00 | LNA_HI is active |
| 01 | LNA_LO is active |
| 10 | Both LNA_HI and LNA_LO are off |
| 11 | RESERVED |

stand-alone applications, coexistence with cellular or WiFi transmissions in close proximity may require additional filtering to prevent compressing the receiver front-end. The mixer is configured for the desired band by the MIXERMODE[1:0] bits. Refer to Table 4.

## Synthesizer

The MAX2771 integrates a 20-bit, sigma-delta, fractional-N synthesizer allowing the device to tune to a required LO frequency with an accuracy of approximately ±30Hz (when $f_{XTAL}$ ≤ 32MHz). The synthesizer includes a 10-bit reference divider with a divisor range programmable from 1 to 1023, a 15-bit integer portion main divider with a divisor range programmable from 36 to 32767, and also a 20-bit fractional portion main divider. The reference divider is programmable through the RDIV bits in the PLL Integer Division Ratio register, and can accommodate reference frequencies from 8MHz to 44MHz. The reference divider needs to be configured so the Phase Frequency Detector comparison frequency falls between 0.05MHz and 32MHz. In Integer-N mode, if the integer division ratio is divisible by 32, setting the PWRSAV bit of the PLL Configuration Register to 1 will reduce the power consumed by the PLL.

The PLL loop filter is the only external block of the synthesizer. A typical PLL filter is the classic C-R-C network at the charge-pump output. For example, see the *Typical Application Circuit* for the recommended loop filter component values for $f_{COMP}$ = 1.023MHz and loop bandwidth = 56KHz, with charge pump current of 0.5mA and L1 band VCO. To calculate the loop filter component values for different LO frequencies, please refer to the Design Resources section of the MAX2771 product page on the Maxim Integrated website. The desired integer and fractional divider ratios can be calculated by dividing the LO frequency ($f_{LO}$) by $f_{COMP}$. $f_{COMP}$ can be calculated by dividing the TCXO frequency, $f_{TCXO}$, by the PLL reference division ratio, RDIV. For example, let the TCXO frequency be 20MHz, $R_{DIV}$ be 1, and the nominal LO frequency be 1575.42MHz. The following method can be used when calculating divider ratios supporting various reference and comparison frequencies:

$$f_{COMP} = \frac{f_{TCXO}}{RDIV} = \frac{20MHz}{1} = 20MHz$$

$$LO_Frequency_Divider = \frac{f_{LO}}{f_{COMP}} = \frac{1575.42MHz}{20MHz} = 78.771$$

Integer Divider = 78(d) = 000 0000 0100 1110 (binary)

Fractional Divider = 0.771 x $2^{20}$ = 808452 (decimal) = 1100 0101 0110 0000 0100

In the fractional mode, the synthesizer should not be operated with integer division ratios greater than 251.

There are two LO tuning bands provided. These are referred to as the L1 band and L2/L5 band respectively. The L1 band is designed for L1 and Commercial Mobile Satellite Services (CMSS) such as Inmarsat used for SBAS. The L2/L5 band is for L2 and L5 bands. The selection of a band is done by programming the LOBAND bit in the PLL Configuration register. For example, if the desired LO frequency is 1227.6MHz, since this falls into the L2/L5 band, set LOBAND = 1. Assuming the same comparison TCXO frequencies as the previous example, the PLL divider ratio would be set to 1227.6/20 = 61.38.

Integer Divider = 61(d) = 000 0000 0011 1101 (binary)

Fractional Divider = 0.38 x $2^{20}$ = 398459 (decimal) = 0110 0001 0100 0111 1011

The LD output provides an indication of the PLL lock state. Note that the lock detector requires a reference clock in order to operate.

## IF Filter

The IF filter of the receiver can be programmed to be a low pass filter or a complex bandpass filter by setting the bit FCENX bit in the Configuration 1 register to either 0 for low pass filter mode or 1 for bandpass filter mode. See Table 5.

### Table 4. Mixer Selection

| MIXERMODE (CONFIGURATION 1 REGISTER) | MODE |
|---|---|
| 00 | High-band mixer enabled |
| 01 | Low-band mixer enabled |
| 10 | Both mixers disabled |
| 11 | RESERVED |

### Table 5. IF Filter Mode Selection

| FCENX (CONFIGURATION 1 REGISTER) | FILTER MODE |
|---|---|
| 0 | Low Pass |
| 1 | Bandpass |

Also, the IF filter can be configured either as a 3rd-order Butterworth filter for reduced group delay or a 5th-order Butterworth filter for steeper out-of-band rejection by setting the bit F3OR5 either 1 or 0, respectively, in the Configuration 1 register. See Table 6.

The two-sided 3dB corner bandwidth can be selected to be 2.5MHz, 4.2MHz, 8.7MHz, 16.4MHz, 23.4MHz, or 36MHz by programming the FBW bits in the Configuration 1 register. See Table 7. When the FCENX bit in the Configuration 1 register is set to 1, the low-pass filter becomes a complex bandpass filter and the center frequency can be programmed with the FCEN bits in the Configuration 1 register. The IF center frequency is adjustable in 127 steps with the 7-bit FCEN value. Refer to the *Applications* section for information on how to configure the desired IF filter center frequency. If the filter is configured as a low-pass filter, the FCEN bits are ignored and the center frequency of the filter is at 0Hz.

The narrow-band filter settings are designed to pass the first null-to-first null main lobe of narrowband signals such as GPS L1 (2.046MHz) or Beidou B1 (4.092MHz). The 8.7MHz setting is for the GLONASS L1 band. The 16.4MHz setting is for signals having an intermediate bandwidth greater than the narrow band signals, but not as wide as the 20.46MHz wide signals; for example, Galileo E1 (14.3MHz) or Galileo E6 (10.23MHz). The 23.4MHz setting is for the wide-band signals typically having main lobe bandwidth of 20.46MHz. For example, GPS L1 P(Y), modernized GLONASS L3OC, or BeiDou B2. Finally, the 36MHz setting is designed to allow simultaneous reception of two constellations, specifically GPS and GLONASS in either the L1 or L2 bands. Simultaneous reception of GPS L1 and GLONASS L1 provides a greater selection of visible satellites, which in turn allows faster time to fix and a more accurate navigation solution.

## Table 6. IF Filter Order Selection

| F3OR5 (CONFIGURATION 1 REGISTER) | IF FILTER ORDER |
|---|---|
| 0 | 5th order Butterworth |
| 1 | 3rd order Butterworth |

### Programmable Gain Amplifier (PGA)

The MAX2771 integrates a baseband programmable gain amplifier that provides typically 59dB of gain control range. The PGA gain can either be controlled autonomously by the MAX2771 using the AGC function, or be directly controlled by the host through programming of the GAININ bits in the Configuration 3 register. The AGCMODE bits in the Configuration 2 register are used to select the control mode for the PGA gain. The gain can be adjusted with approximately 1 dB resolution.

### Automatic Gain Control (AGC)

The MAX2771 provides a control loop that automatically programs the PGA gain to provide the ADC with an input power that optimally fills the converter and establishes a desired magnitude bit density at its output. The AGC algorithm operates by counting the number of magnitude bits over 512 ADC clock cycles and comparing the magnitude bit count to the reference value provided through a control word (GAINREF) in the Configuration 2 register. The desired magnitude bit density is expressed as a value of GAINREF in a decimal format divided by the counter length of 512. For example, to achieve the magnitude bit density of 33%, which is optimal for a 2-bit converter, program GAINREF to 170, since 170/512 = 33%. See Table 8.

## Table 7. IF Filter Bandwidth Selection

| FBW (CONFIGURATION 1 REGISTER) | BANDWIDTH (DOUBLE-SIDED) |
|---|---|
| 000 | 2.5MHz |
| 010 | 4.2MHz |
| 001 | 8.7MHz |
| 011 (Low-pass mode only) | 23.4MHz |
| 111 (Low-pass mode only) | 16.4MHz |
| 100 (Low-pass mode only) | 36.0MHz |
| All other settings | RESERVED |

## Table 8. Gain Reference Settings

| GAINREF (CONFIGURATION 2 REGISTER) | MAGNITUDE BIT DENSITY REFERENCE |
|---|---|
| 11101010 | 234 |
| 1010100 | 84 |
| 100111010 | 314 |

## ADC

The MAX2771 features an on-chip ADC to digitize the down-converted GNSS signal. The ADC supports the digital output in three different formats: unsigned binary, sign and magnitude, or two's complement format by setting the FORMAT bits in Configuration 2 register. Refer to Table 9. The sampled output is provided in a 2-bit format (1-bit magnitude and 1-bit sign) by default, and also can be configured as 1-bit or 2-bit in both I and Q channels, or 1-bit, 2-bit, or 3-bit in the I channel only. If only the I channel is used, the Q channel can be disabled with the IQEN bits in the Configuration 2 register. See Table 10. MSB bits are output on the I1 or Q1 pins and LSB bits are output on the I0 or Q0 pins, for I or Q channel, respectively. In the case of 3-bit output data format, the MSB is output on I1, the second bit is on I0, and the LSB is on Q1. The Q ADC must be enabled in 3-bit output data mode by setting the IQEN bit to 1. The number of bits of the ADC can be configured through the BITS field in the Configuration 2 register. See Table 11. Figure 1 illustrates the ADC quantization levels for 2-bit and 3-bit cases and also describes the sign/magnitude data mapping. The variable T = 1 designates the location of the magnitude threshold for the 2-bit case. Also refer to Table 12. The maximum ADC sampling rate is 44MHz.

### Table 9. ADC Output Data Format Settings

| FORMAT (CONFIGURATION 2 REGISTER) | ADC OUTPUT DATA FORMAT |
|---|---|
| 00 | Unsigned Binary |
| 01 | Sign and Magnitude |
| 1X | Two's Complement Binary |

### Table 10. IQ Channels Enable Settings

| IQEN (CONFIGURATION 2 REGISTER) | ENABLED CHANNEL |
|---|---|
| 0 | I channel only |
| 1 | Both I and Q channels |

### Table 11. ADC Output Bits Setting

| BITS (CONFIGURATION 2 REGISTER) | NUMBER OF BITS IN THE ADC |
|---|---|
| 000 | 1 bit |
| 010 | 2 bits |
| 100 | 3 bits |

### Table 12. Output Data Format

| INTEGER VALUE | SIGN/MAGNITUDE | | | UNSIGNED BINARY | | | TWO'S COMPLEMENT BINARY | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1b | 2b | 3b | 1b | 2b | 3b | 1b | 2b | 3b |
| 7 | 0 | 01 | 011 | 1 | 11 | 111 | 0 | 01 | 011 |
| 5 | 0 | 01 | 010 | 1 | 11 | 110 | 0 | 01 | 010 |
| 3 | 0 | 00 | 001 | 1 | 10 | 101 | 0 | 00 | 001 |
| 1 | 0 | 00 | 000 | 1 | 10 | 110 | 0 | 00 | 000 |
| -1 | 1 | 10 | 100 | 0 | 01 | 011 | 1 | 11 | 111 |
| -3 | 1 | 10 | 101 | 0 | 01 | 010 | 1 | 11 | 110 |
| -5 | 1 | 11 | 110 | 0 | 00 | 001 | 1 | 10 | 101 |
| -7 | 1 | 11 | 111 | 0 | 00 | 000 | 1 | 10 | 100 |

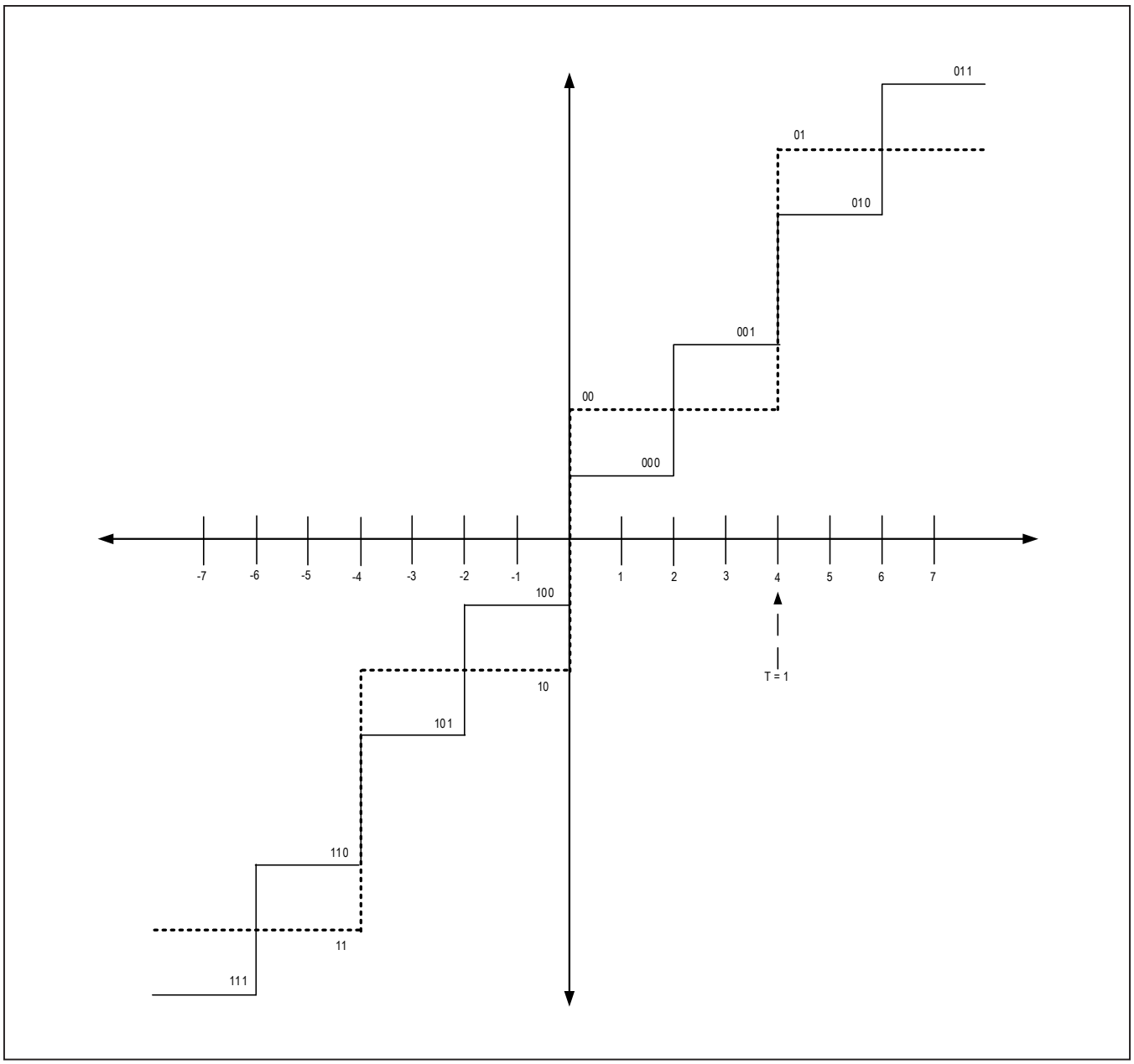



*Figure 1. ADC Quantization Levels for 2 and 3-Bit Cases*

### ADC Fractional Clock Divider

A 12-bit fractional clock divider is located in the clock path prior to the ADC and can be used to generate an ADC clock that is a fraction of the reference input clock. In fractional divider mode, the instantaneous division ratio alternates between integer division ratios to achieve the required fraction. For example, if the fractional output clock is 4.5 times lower frequency than the input clock, an average division ratio of 4.5 is achieved through an equal series of alternating divide-by-4 and divide-by-5 periods. The fractional division ratio is given by:

$$f_{OUT}/f_{IN} = LCOUNT/(4096 - MCOUNT + LCOUNT)$$

where LCOUNT and MCOUNT are the 12-bit counter values in the Clock Configuration 2 register. The fractional division ratio cannot exceed 0.5. This divider can be enabled or bypassed by using the FCLKIN bit in the Clock Configuration 1 register. Also the sampling clock, ADCCLK, can be taken either before or after the Reference Clock Divider/Multiplier depending on the ADCCLK bit setting. Refer to Table 13. Note that REFCLK in this table is possibly the output of the refclk fractional divider.

Moreover, it is possible to take the ADC clock from outside the IC. If the EXTADCCLK bit in the Clock Configuration 1 register is 1, the ADC clock will be taken from the ADC_CLKIN pin instead of using the internally generated clock. This allows simple synchronization of multiple MAX2771 ICs to a common ADC sampling clock.

### ADC Clock Alignment

In the case where multiple MAX2771 devices are used in a system, and the ADCs are being clocked at the same rate, which is some fraction of the reference clock frequency, the ADC outputs of the devices will not necessarily be aligned in time. A baseband that is processing the outputs of multiple devices may need to include additional logic to align the ADC samples from each device.

To allow simple synchronization of the ADCs of each device, the ability to clock the ADCs from an externally applied clock is provided. If the EXTADCCLK bit in the Clock Configuration 1 register is 1, the ADC clock will be taken from the ADC_CLKIN pin instead of using the internally generated clock. In a multiple MAX2771 scenario, all devices are assumed to be running off the same TCXO clock. One device would be designated as the clock source and configured to output its ADC clock on its CLKOUT pin. This clock signal can then be buffered and distributed through an external clock tree. The buffered clocks are then input on the ADC_CLKIN pins of all MAX2771 devices (including the clock source), and all devices are configured to use this external clock as their ADC clock. Alternatively, the source of the clock may not necessarily be a MAX2771 but could be some clock source elsewhere in the system.

### DSP Interface

GNSS data is output from the ADC as the four logic signals (bit0, bit1, bit2, and bit3) that represent sign/magnitude, unsigned binary, or two's complement binary data in the I (bit0 and bit1) and Q (bit2 and bit3) channels. The resolution of the ADC can be set up to 3 bits per channel. For example, the 2-bit I and Q data in sign/magnitude format is mapped as follows: bit0 = ISIGN, bit1 = IMAG, bit2 = QSIGN, and bit3 = QMAG. The data can be serialized in 16-bit segments of bit0, followed by bit1, bit2, and bit3. The number of bits to be serialized is controlled by the bits STRMBITS in the Configuration 3 register. This selects between bit0; bit0 and bit1; bit0 and bit2; and bit0, bit1, bit2, and bit3 cases. If only bit0 is serialized, the data stream consists of bit0 data only. If a serialization of bit0 and bit1 (or bit2) is selected, the stream data pattern consists of 16 bits of bit0 data, followed by 16 bits of bit1 (or bit2) data. This, in turn, is followed by 16 bits of bit0 data, and so on. In this case, the serial clock must be at least twice as fast as the ADC clock. If a 4-bit serialization of bit0, bit1, bit2, and bit3 is chosen, the serial clock must be at least four times faster than the ADC clock.

## Table 13. Frequency of ADC Sampling Clock vs. Reference Clock

| FCLKIN (FRACTIONAL CLOCK DIVISION RATIO REGISTER) | ADCCLK (FRACTIONAL CLOCK DIVISION RATIO REGISTER) | SAMPLING CLOCK FREQUENCY |
|---|---|---|
| 0 | 0 | /2,/4,x2,x4 REFCLK |
| 0 | 1 | REFCLK |
| 1 | 0 | /2,/4,x2,x4 REFCLK x Fractional_Ratio |
| 1 | 1 | REFCLK * Fractional_Ratio |

The ADC data is loaded, in parallel, into four holding registers that correspond to four ADC outputs. Holding registers are 16 bits long and are clocked by the ADC clock. At the end of the 16-bit ADC cycle, the data is transferred into four shift registers and shifted serially to the output during the next 16-bit ADC cycle. Shift registers are clocked by a serial clock that must be chosen fast enough so that all data is shifted out before the next set of data is loaded from the ADC. An all-zero pattern follows the data after all valid ADC data are streamed to the output. A DATASYNC signal is used to signal the beginning of each valid 16-bit data slice. In addition, there is a TIME_SYNC signal that is output every 128 to 16,384 cycles of the ADC clock.

Given that the serial clock has to run multiple times faster than the ADC clock, the use of the DSP interface is limited to narrowband signals that don't require a high ADC sampling clock frequency.

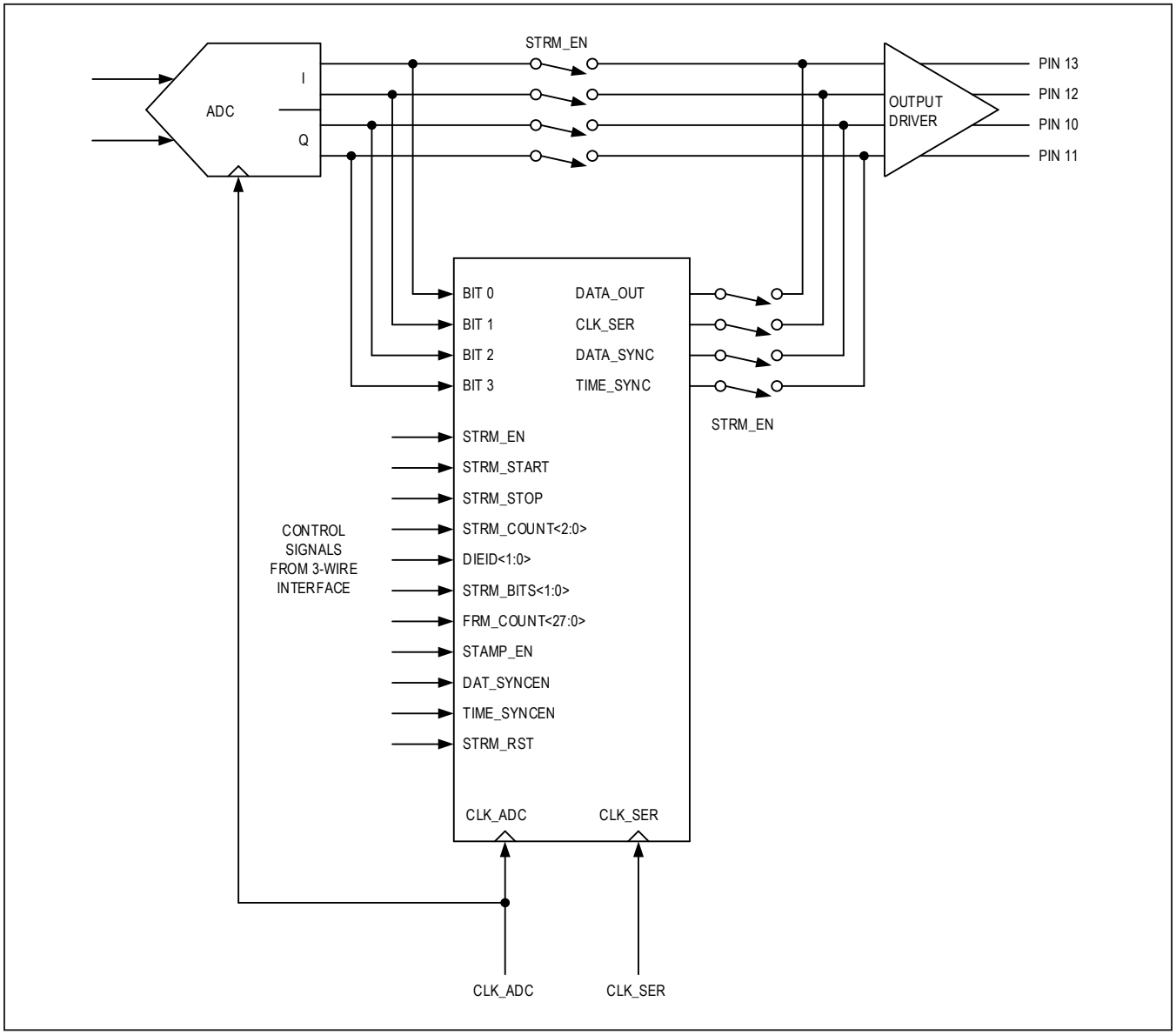



*Figure 2. DSP Interface Top Level Connectivity and Control Signals*

## Reference Clock

The crystal clock input on pin 3 is used to generate internal clocks and a reference clock that is output to the baseband. The block diagram illustrating the clock distribution is shown in Figure 3. There is a 12-bit fractional pre-divider that optionally allows division of the XTAL clock by some fractional amount. In the fractional divider mode, the instantaneous division ratio alternates between integer division ratios to achieve the required fraction. For example, if the fractional output clock is 4.5 times lower frequency than the input clock, an average division ratio of 4.5 is achieved through an equal series of alternating divide-by-4 and divide-by-5 periods. The fractional division ratio is given by:

$$f_{OUT}/f_{IN} = LCOUNT/(4096 - MCOUNT + LCOUNT)$$

where LCOUNT and MCOUNT are the 12-bit counter values in the Clock Configuration 1 register. The fractional division ratio cannot exceed 0.5. This divider can be enabled or bypassed by setting the PREFRACDIV_SEL bit in the Clock Configuration 2 register to either 0 or 1.

The reference clock can then be optionally divided by either two or four, or multiplied by two or four. This is determined by the REFCLK bits in the PLL Configuration Register. Refer to Table 14. This table ignores the fractional ratio. The maximum frequency of the pre-divided reference clock is 22MHz if the x2 option is selected, and 11MHz if the x4 option is selected. The ADC sampling clock can then be generated by a second fractional divider. This is described in the section on the ADC. The CLKOUT signal to the baseband can be selected to either be the output of the integer divider/multiplier block or the ADC clock. This selection is done through the CLKOUT_SEL bit in the Clock Configuration 2 register.

The ADC clock can either be selected to be the internally generated clock, or taken from outside the IC. The EXTADCCLK register bit selects whether the ADCs are clocked from the internally generated clock, or use the clock provided on the ADC_CLKIN pin. This feature allows multiple MAX2771 devices connected to a common baseband IC to have synchronized ADC outputs.

The maximum clock frequency for any of these clocks is 44MHz.

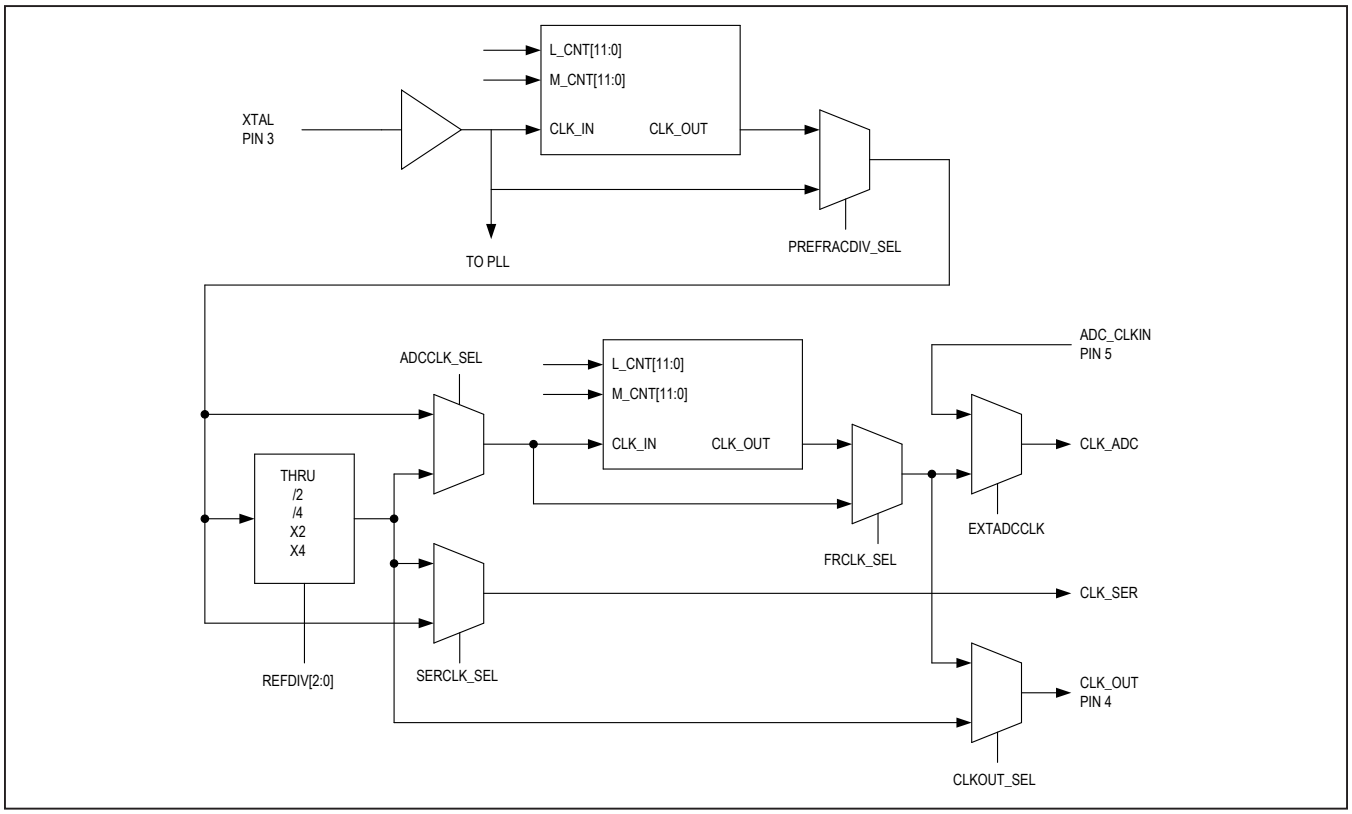



*Figure 3. Clock Distribution*

## Table 14. Reference Divider Settings

| REFDIV (PLL CONFIGURATION REGISTER) | CLOCK OUTPUT |
|---|---|
| 000 | XTAL frequency x2 |
| 001 | XTAL frequency ÷4 |
| 010 | XTAL frequency ÷2 |
| 011 | XTAL frequency |
| 100 | XTAL frequency x4 |

### Serial Interface

A serial interface is used to program the MAX2771 for configuring the different operating modes. The serial interface is controlled by three signals: SCLK (serial clock), CSN (chip select), and SDATA (serial data). The interface is based on the industry-standard Serial Peripheral Interface (SPI). The MAX2771 is a SPI slave and the device responsible for programming the MAX2771, such as a microprocessor or baseband controller, is the SPI master. The SPI master will be referred to henceforth as the “host”. The host is responsible for driving SCLK, CSN, and SDATA. The MAX2771 only drives SDATA at certain times during the transaction so as to avoid bus contention with the master.

The transfer of a set of data between host and MAX2771 is referred to as a “SPI transaction”. An SPI transaction consists of 48 SCLK pulses. The base value of SCLK is low. Data on SDATA is output on the falling edge of SCLK and is sampled on the rising edge of SCLK by both host and the MAX2771.

The SDATA line is normally tri-stated by both the host and the MAX2771. It can only be driven by the MAX2771 during the latter part of a Read SPI transaction provided that CSN = 0. SDATA is driven by the host during the entire SPI transaction in the case of Write transactions, and only during the first part of Read transactions.

The first 12 bits transferred from host to the MAX2771 during an SPI transaction contain the address of the register to be accessed. The first 8 bits are always zero, while the last four bits are the address of the register. The 13th bit transferred from master to MAX2771 is the R/W bit. If R/W = 1, the transaction is a read and the MAX2771 will drive SDATA in the latter part of the transaction. If R/W = 0, the transaction is a write, and the host will continue to drive SDATA for the remainder of the transaction. The 14th through 16th bits are turnaround bits that are denoted $T_A$. The purpose of these bits is to allow time for the bus to change direction in the case of a read and so avoid any possible contention for the bus. In the case of a read transaction, the host releases SDATA during this interval, and the MAX2771 does not yet start driving SDATA. In the case of a write transaction, the host can continue to drive SDATA during this interval. The value of the bits is irrelevant (don’t care). The remaining bits of the transaction are the data bits. The number of data bits will always be a 32 since all the registers in the MAX2771 are 32-bits wide.

Figure 4 shows a register read transaction. In this example, a 32 bit register is read by the host. The host first asserts CSN, begins driving SDATA with the register address preceded by 8 zeros and starts toggling SCLK. The MAX2771 samples the bits on SDATA on the rising edge of SCLK. After the address is output, the host outputs a R/W bit having value of 1 indicating this a read transaction. The next three bits are the TA bits during which the host releases the SDATA line. In this figure, SDATA is shown as tri-stated during this bit interval to emphasize that nothing is actively driving it. The MAX2771 can be configured to resistively pull up SDATA, pull it down, or apply a bus-hold during periods when it is not driving the bus. The MAX2771 then starts driving SDATA and outputting the 32 bits of the addressed register starting from the most significant bit. After the last bit has been output, the MAX2771 tri-states SDATA, and the host subsequently brings CSN high completing the transaction.

Figure 5 shows a register write transaction. In this example, a 32-bit register is written by the host. The host first asserts CSN, begins driving SDATA with the register address preceded by 8 zeros and starts toggling SCLK. The MAX2771 samples the bits on SDATA on the rising edge of SCLK. After the address is output, the host outputs a R/W bit having value of 0 indicating this a write transaction. The next bits are the TA bits. Since this is a write, the host may choose to continue driving SDATA during this interval. The next 32 SCLKs, the host outputs the 32-bit data to be written to the addressed register starting from the most significant bit. After the last bit has been output, the host tri-states SDATA, and subsequently brings CSN high completing the transaction.

If the host does not assert CSN, the MAX2771 will ignore any activity on SCLK or SDATA. This allows multiple MAX2771 devices to be connected to the SPI and controlled by one host. Only the MAX2771 that has its CSN input asserted will react to the host.

Figure 6 illustrates the timing relationships between the three signals of the three-wire interface. Refer to Table 15.

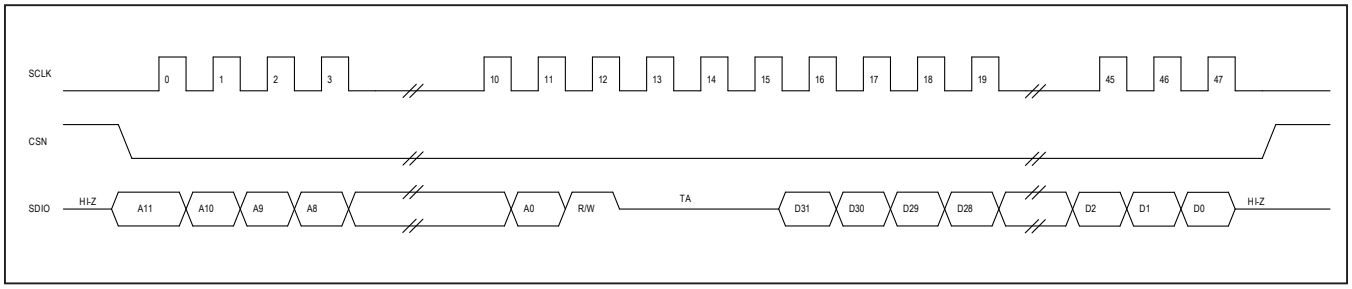



*Figure 4. Register Read Functional Timing*

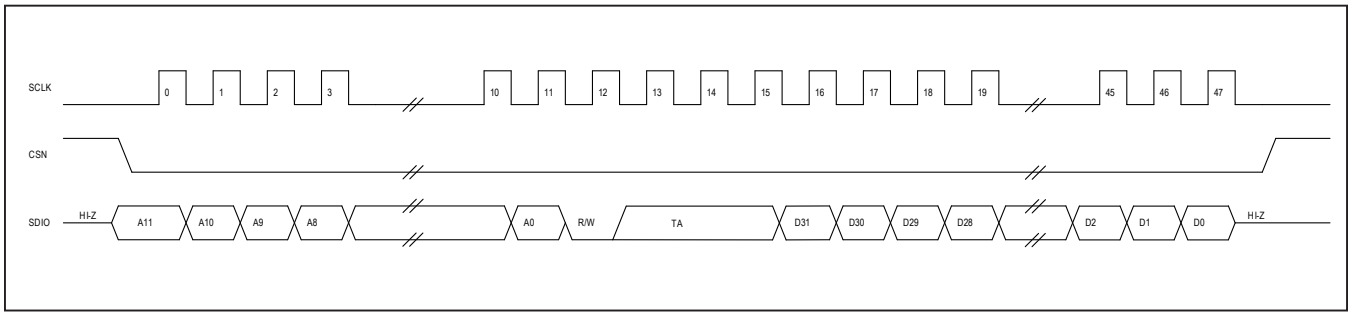



*Figure 5. Register Write Functional Timing*

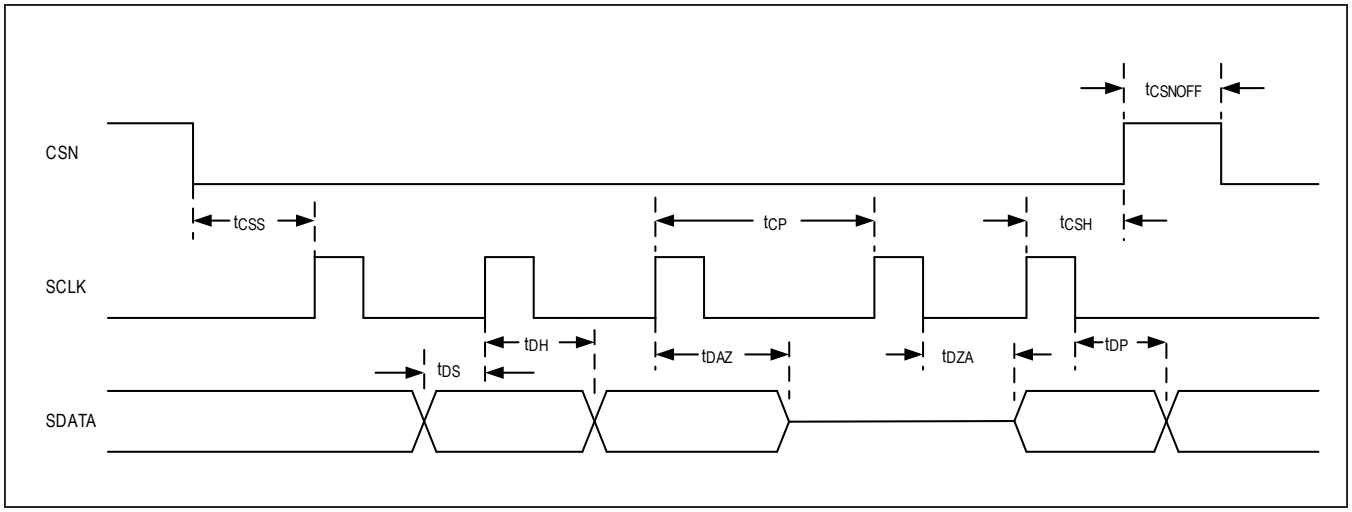



*Figure 6. Three-Wire Interface Timing Diagram*

## Table 15. Serial Interface Timing Requirements

| SYMBOL | PARAMETER | MIN | MAX | UNITS |
|---|---|---|---|---|
| $t_{CSS}$ | Falling edge of CSN to rising edge of the first SCLK pulse | 10 | | ns |
| $t_{DS}$ | Data in to SCLK setup time | 10 | | ns |
| $t_{DH}$ | Data in to SCLK hold time | 10 | | ns |
| $t_{CP}$ | SCLK period | 250 | | ns |
| $t_{DAZ}$ | SCLK falling edge to SDATA tri-stated | | 25 | ns |
| $t_{DZA}$ | SCLK falling edge to SDATA active | | 25 | ns |
| $t_{CSH}$ | Last SCLK rising edge to rising edge of CSN | 10 | | ns |
| $t_{DP}$ | SCLK falling edge to data out propagation delay | | 25 | ns |
| $t_{CSNOFF}$ | CSN rising edge to next SPI transaction CSN falling edge | 100 | | ns |

## Register Map

| ADDRESS | NAME | MSB | | | | | | | LSB |
|---|---|---|---|---|---|---|---|---|---|
| REGISTER_BLOCK | | | | | | | | | |
| 0x00 | Configuration 1[31:24] | CHIPEN | IDLE | RESERVED[3:0] | | | | RESERVED[3:2] | |
| | Configuration 1[23:16] | RESERVED[1:0] | | RESERVED[1:0] | | RESERVED[1:0] | | MIX POLE | LNA MODE [1] |
| | Configuration 1[15:8] | LNA MODE [0] | MIXERMODE[1:0] | | FCEN[6:2] | | | | |
| | Configuration 1[7:0] | FCEN[1:0] | | FBW[2:0] | | | F3OR5 | FCENX | FGAIN |
| 0x01 | Configuration 2[31:24] | RE SERVED | RESERVED[1:0] | | ANA IMON | IQEN | GAINREF[11:9] | | |
| | Configuration 2[23:16] | GAINREF[8:1] | | | | | | | |
| | Configuration 2[15:8] | GAIN REF[0] | SPI_SDIO_CON-FIG[1:0] | | AGCMODE[1:0] | | FORMAT[1:0] | | BITS[2] |
| | Configuration 2[7:0] | BITS[1:0] | | DRVCFG[1:0] | | RE SERVED | RE SERVED | DIEID[1:0] | |
| 0x02 | Configuration 3[31:24] | RESERVED[3:0] | | | | GAININ[5:2] | | | |
| | Configuration 3[23:16] | GAININ[1:0] | | RE SERVED | HILOAD-EN | RE SERVED | RE SERVED | RE SERVED | RE SERVED |
| | Configuration 3[15:8] | FHIPEN | RE SERVED | PGAIEN | PGA QEN | STR MEN | STRM START | STRM STOP | RE SERVED [2] |
| | Configuration 3[7:0] | RESERVED[1:0] | | STRMBITS[1:0] | | STAM PEN | TIME SYN CEN | DATA SYN CEN | STR MRST |
| 0x03 | PLL Configuration[31:24] | REFDIV[2:0] | | | LOBAND | RE SERVED | RE SERVED | RE SERVED | REF OUTEN |
| | PLL Configuration[23:16] | RE SERVED | RESERVED[1:0] | | IXTAL[1:0] | | RESERVED[4:2] | | |
| | PLL Configuration[15:8] | RESERVED[1:0] | | RE-SERVED | RESERVED[2:0] | | | ICP | RE SERVED |
| | PLL Configuration[7:0] | RE SERVED | RESERVED[2:0] | | | INT_PLL | PWR SAV | RE SERVED | RE SERVED |

## Register Map (continued)

| ADDRESS | NAME | MSB | | | | | | | LSB |
|---|---|---|---|---|---|---|---|---|---|
| 0x04 | PLL Integer Division Ratio [31:24] | RESERVED[3:0] | | | | NDIV[14:11] | | | |
| | PLL Integer Division Ratio [23:16] | NDIV[10:3] | | | | | | | |
| | PLL Integer Division Ratio [15:8] | NDIV[2:0] | | | RDIV[9:5] | | | | |
| | PLL Integer Division Ratio [7:0] | RDIV[4:0] | | | | RESERVED[2:0] | | | |
| 0x05 | PLL Fractional Division Ratio [31:24] | RESERVED[3:0] | | | | FDIV[19:16] | | | |
| | PLL Fractional Division Ratio [23:16] | FDIV[15:8] | | | | | | | |
| | PLL Fractional Division Ratio [15:8] | FDIV[7:0] | | | | | | | |
| | PLL Fractional Division Ratio [7:0] | RESERVED[3:0] | | | | RE-SERVED | RE-SERVED | RE-SERVED | RE-SERVED |
| 0x06 | RESERVED [31:24] | RESERVED[3:0] | | | | RESERVED[27:24] | | | |
| | RESERVED [23:16] | RESERVED[23:16] | | | | | | | |
| | RESERVED [15:8] | RESERVED[15:8] | | | | | | | |
| | RESERVED [7:0] | RESERVED[7:0] | | | | | | | |
| 0x07 | Clock Configuration 1[31:24] | RESERVED[2:0] | | | EXTA DCCLK | REFCLK_L_CNT[11:8] | | | |
| | Clock Configuration 1 [23:16] | REFCLK_L_CNT[7:0] | | | | | | | |
| | Clock Configuration 1 [15:8] | REFCLK_M_CNT[11:4] | | | | | | | |
| | Clock Configuration 1 [7:0] | REFCLK_M_CNT[3:0] | | | | FCLKIN | ADCCLK | RE SERVED | MODE |
| 0x08 | Test Mode 1[31:24] | RE SERVED | RE SERVED | RESERVED[1:0] | | RESERVED[3:0] | | | |
| | Test Mode 1[23:16] | RESERVED[3:0] | | | | RESERVED[3:0] | | | |
| | Test Mode 1[15:8] | RESERVED[3:0] | | | | RE SERVED | RESERVED[4:2] | | |
| | Test Mode 1[7:0] | RESERVED[1:0] | | RE-SERVED | RE-SERVED | RE-SERVED | RE-SERVED | RE-SERVED | RE SERVED |

## Register Map (continued)

| ADDRESS | NAME | MSB | | | | | | | LSB |
|---|---|---|---|---|---|---|---|---|---|
| 0x09 | Test Mode 2[31:24] | RE SERVED | RE SERVED | RD_ CALC | RESERVED[3:0] | | | | RE SERVED [2] |
| | Test Mode 2[23:16] | RESERVED[1:0] | | RE SERVED | RE SERVED | RESERVED[1:0] | | RE SERVED | RE SERVED |
| | Test Mode 2[15:8] | RE SERVED | RE SERVED | RE SERVED | RESERVED[4:0] | | | | |
| | Test Mode 2[7:0] | RESERVED[4:0] | | | | | RE-SERVED | RE-SERVED | RE-SERVED |
| 0x0A | Clock Configuration 2 [31:24] | RESERVED[2:0] | | | RE SERVED | ADCCLK_L_CNT[11:8] | | | |
| | Clock Configuration 2 [23:16] | ADCCLK_L_CNT[7:0] | | | | | | | |
| | Clock Configuration 2 [15:8] | ADCCLK_M_CNT[11:4] | | | | | | | |
| | Clock Configuration 2 [7:0] | ADCCLK_M_CNT[3:0] | | | | PRE FRAC DIV_SEL | CLK-OUT_ SEL | RESERVED[1:0] | |

## Register Details

### Configuration 1 (0x0)

Configures RF and IF sections

| BIT | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
|---|---|---|---|---|---|---|---|---|
| Field | CHIPEN | IDLE | RESERVED[3:0] | | | | RESERVED[3:2] | |
| Reset | 0x1 | 0x0 | 0x8 | | | | 0x8 | |
| Access Type | Write, Read | Write, Read | Write, Read | | | | Write, Read | |

| BIT | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED[1:0] | | RESERVED[1:0] | | RESERVED[1:0] | | MIXPOLE | LNA MODE[1] |
| Reset | 0x8 | | 0x2 | | 0x1 | | 0x0 | 0x0 |
| Access Type | Write, Read | | Write, Read | | Write, Read | | Write, Read | Write, Read |

| BIT | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 |
|---|---|---|---|---|---|---|---|---|
| Field | LNA MODE[0] | MIXERMODE[1:0] | | FCEN[6:2] | | | | |
| Reset | 0x0 | 0x0 | | 0x58 | | | | |
| Access Type | Write, Read | Write, Read | | Write, Read | | | | |

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Field | FCEN[1:0] | | FBW[2:0] | | | F3OR5 | FCENX | FGAIN |
| Reset | 0x58 | | 0x0 | | | 0x0 | 0x1 | 0x1 |
| Access Type | Write, Read | | Write, Read | | | Write, Read | Write, Read | Write, Read |

| BITFIELD | BITS | DESCRIPTION | DECODE |
|---|---|---|---|
| CHIPEN | 31 | Chip enable. Set to 1 to enable the chip and 0 to disable the chip except for the serial bus. | 0x0: Disable chip<br>0x1: Enable chip |
| IDLE | 30 | Idle enable | 0x0: Operating mode<br>0x1: Idle mode |
| RESERVED | 29:26 | Reserved: Write 1111 to this bitfield. | RESERVED |
| RESERVED | 25:22 | Reserved: Write 1010 to this bitfield. | RESERVED |
| RESERVED | 21:20 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 19:18 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| MIXPOLE | 17 | Mixer pole selection. Set to 1 to put the passive filter pole at mixer output at 36MHz or set to 0 to put the pole at 13MHz. | 0x0: Mixer pole at 13MHz<br>0x1: Mixer pole at 36MHz |

**Configuration 1 (0x0) (continued)**

| BITFIELD | BITS | DESCRIPTION | DECODE |
|---|---|---|---|
| LNAMODE | 16:15 | LNA mode selection | 0x0: High band LNA is active<br>0x1: Low band LNA is active<br>0x2: Both LNAs disabled<br>0x3: RESERVED |
| MIXERMODE | 14:13 | Mixer mode selection | 0x0: High band mixer enabled<br>0x1: Low band mixer enabled<br>0x2: Both mixers disabled<br>0x3: RESERVED |
| FCEN | 12:6 | IF filter center frequency setting. Refer to *Applications* section for details on usage. | |
| FBW | 5:3 | IF filter bandwidth selection. | 0x0: 2.5 MHz<br>0x1: 8.7 MHz<br>0x2: 4.2 MHz<br>0x3: 23.4 MHz (lowpass mode only)<br>0x4: 36.0 MHz (lowpass mode only)<br>0x5: RESERVED<br>0x6: RESERVED<br>0x7: 16.4 MHz (lowpass mode only) |
| F3OR5 | 2 | Filter order selection | 0x0: 5th order filter<br>0x1: 3rd order filter |
| FCENX | 1 | Polyphase filter selection | 0x0: Lowpass filter<br>0x1: Complex bandpass filter |
| FGAIN | 0 | IF filter gain setting | 0x0: Filter gain reduced 6dB<br>0x1: Normal filter gain |

## Configuration 2 (0x1)

Configures AGC and output sections

| BIT | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED | RESERVED[1:0] | | ANAIMON | IQEN | GAINREF[11:9] | | |
| Reset | 0x0 | 0x1 | | 0x0 | 0x0 | 170 | | |
| Access Type | Write, Read | Write, Read | | Write, Read | Write, Read | Write, Read | | |

| BIT | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|
| Field | GAINREF[8:1] | | | | | | | |
| Reset | 170 | | | | | | | |
| Access Type | Write, Read | | | | | | | |

| BIT | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 |
|---|---|---|---|---|---|---|---|---|
| Field | GAINREF[0] | SPI_SDIO_CONFIG[1:0] | | AGCMODE[1:0] | | FORMAT[1:0] | | BITS[2] |
| Reset | 170 | 0x0 | | 0x0 | | 0x1 | | 0x2 |
| Access Type | Write, Read | Write, Read | | Write, Read | | Write, Read | | Write, Read |

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Field | BITS[1:0] | | DRVCFG[1:0] | | RESERVED | RESERVED | DIEID[1:0] | |
| Reset | 0x2 | | 0x0 | | 0x1 | 0x0 | 0x0 | |
| Access Type | Write, Read | | Write, Read | | Write, Read | Write, Read | Read Only | |

| BITFIELD | BITS | DESCRIPTION | DECODE |
|---|---|---|---|
| RESERVED | 31 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 30:29 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| ANAIMON | 28 | Enables continuous spectrum monitoring by routing analog I outputs to pins | 0x0: Monitoring disabled<br>0x1: Monitoring enabled |
| IQEN | 27 | I and Q channels enable | 0x0: I channel only enabled<br>0x1: Both I and Q channels enabled |
| GAINREF | 26:15 | AGC gain reference value expressed by the number of MSB counts<br>(magnitude bit density) | |
| SPI_SDIO_CONFIG | 14:13 | SPI SDIO pin configuration when tri-stated | 0x0: Nothing applied<br>0x1: Pull-down resistor applied<br>0x2: Pull-up resistor applied<br>0x3: Bus-hold applied |

**Configuration 2 (0x1) (continued)**

| BITFIELD | BITS | DESCRIPTION | DECODE |
|---|---|---|---|
| AGCMODE | 12:11 | AGC mode control | 0x0: Independent I and Q<br>0x1: Reserved<br>0x2: Gain set by programming of GAININ bits<br>0x3: Reserved |
| FORMAT | 10:9 | Output data format | 0x0: Unsigned binary<br>0x1: Sign and magnitude<br>0x2: Two's complement binary<br>0x3: Two's complement binary |
| BITS | 8:6 | Number of bits in the ADC | 0x0: 1 bit<br>0x1: Reserved<br>0x2: 2 bits<br>0x3: Reserved<br>0x4: 3 bits<br>0x5: Reserved<br>0x6: Reserved<br>0x7: Reserved |
| DRVCFG | 5:4 | output driver configuration | 0x0: CMOS logic<br>0x1: Reserved<br>0x2: Analog outputs (ADC bypass mode)<br>0x3: Analog outputs (ADC bypass mode) |
| RESERVED | 3 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 2 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| DIEID | 1:0 | Identifies version of IC | |

## Configuration 3 (0x2)

Configures support and test functions for IF filter and AGC

| BIT | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED[3:0] | | | | GAININ[5:2] | | | |
| Reset | 0x0 | | | | 0x3A | | | |
| Access Type | Write, Read | | | | Write, Read | | | |

| BIT | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|
| Field | GAININ[1:0] | | RESERVED | HILOADEN | RESERVED | RESERVED | RESERVED | RESERVED |
| Reset | 0x3A | | 0x1 | 0x0 | 0x1 | 0x1 | 0x1 | 0x1 |
| Access Type | Write, Read | | Write, Read | Write, Read | Write, Read | Write, Read | Write, Read | Write, Read |

| BIT | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 |
|---|---|---|---|---|---|---|---|---|
| Field | FHIPEN | RESERVED | PGAIEN | PGAQEN | STRMEN | STRM START | STRMSTOP | RE SERVED[2] |
| Reset | 0x1 | 0x0 | 0x1 | 0x0 | 0x0 | 0x0 | 0x0 | 0x7 |
| Access Type | Write, Read | Write, Read | Write, Read | Write, Read | Write, Read | Write, Read | Write, Read | Write, Read |

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED[1:0] | | STRMBITS[1:0] | | STAMPEN | TIME SYNCEN | DATA SYNCEN | STRMRST |
| Reset | 0x7 | | 0x1 | | 0x1 | 0x1 | 0x0 | 0x0 |
| Access Type | Write, Read | | Write, Read | | Write, Read | Write, Read | Write, Read | Write, Read |

| BITFIELD | BITS | DESCRIPTION | DECODE |
|---|---|---|---|
| RESERVED | 31:28 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| GAININ | 27:22 | PGA gain value programming in steps of approximately 1dB per LSB. | |
| RESERVED | 21 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| HILOADEN | 20 | Enable output driver to drive high loads | 0x0: Disable high load<br>0x1: Enable high load |
| RESERVED | 19 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 18 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 17 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 16 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| FHIPEN | 15 | Enable of highpass coupling between filter and PGA. | 0x0: Disable coupling<br>0x1: Enable coupling |
| RESERVED | 14 | Reserved: DO NOT CHANGE VALUE | RESERVED |

**Configuration 3 (0x2) (continued)**

| BITFIELD | BITS | DESCRIPTION | DECODE |
|---|---|---|---|
| PGAIEN | 13 | I-channel PGA enable | 0x0: Disable I channel PGA<br>0x1: Enable I channel PGA |
| PGAQEN | 12 | Q-channel PGA enable | 0x0: Disable Q channel PGA<br>0x1: Enable Q channel PGA |
| STRMEN | 11 | Enable DSP interface for serial streaming of data. Configures the IC such that the DSP interface is inserted in the signal path. | 0x0: Disable DSP interface<br>0x1: Enable DSP interface |
| STRMSTART | 10 | The rising edge of this bit enables data streaming to the output. It also enables clock, data sync, and frame sync outputs. | |
| STRMSTOP | 9 | The rising edge of this bit disables data streaming to the output. It also disables clock, data sync, and frame sync outputs. | |
| RESERVED | 8:6 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| STRMBITS | 5:4 | Number of bits streamed | 0x0: Reserved<br>0x1: I MSB, I LSB<br>0x2: Reserved<br>0x3: I MSB, I LSB, Q MSB, Q LSB |
| STAMPEN | 3 | Enables the insertion of the frame number at the beginning of each frame. If disabled, only the ADC data is streamed to the output. | 0x0: Disable frame number insertion<br>0x1: Enable frame number insertion |
| TIME SYNCEN | 2 | Enables the output of the time sync pulses at all times when streaming is enabled by the STRMEN command. Otherwise, the time sync pulses are available only when data streaming is active at the output; for example, in the time intervals bound by the STRM-START and STRMSTOP commands. | |
| DATA SYNCEN | 1 | Enables the sync pulses at the DATASYNC output. Each pulse is coincident with the beginning of the 16-bit data word that corresponds to a given output bit. | |
| STRMRST | 0 | This command resets all the counters irrespective of the timing within the stream cycle. | |

## PLL Configuration (0x3)

PLL, VCO and CLK configuration

| BIT | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
|---|---|---|---|---|---|---|---|---|
| Field | REFDIV[2:0] | | | LOBAND | RESERVED | RESERVED | RESERVED | REFOUTEN |
| Reset | 0x3 | | | 0x0 | 0x1 | 0x0 | 0x0 | 0x1 |
| Access Type | Write, Read | | | Write, Read | Write, Read | Write, Read | Write, Read | Write, Read |

| BIT | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED | RESERVED[1:0] | | IXTAL[1:0] | | RESERVED[4:2] | | |
| Reset | 0x1 | 0x0 | | 0x1 | | 0x10 | | |
| Access Type | Write, Read | Write, Read | | Write, Read | | Write, Read | | |

| BIT | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED[1:0] | | RESERVED | RESERVED[2:0] | | | ICP | RESERVED |
| Reset | 0x10 | | 0x0 | 0x0 | | | 0x0 | 0x0 |
| Access Type | Write, Read | | Write, Read | Write, Read | | | Write, Read | Write, Read |

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED | RESERVED[2:0] | | | INT_PLL | PWRSAV | RESERVED | RESERVED |
| Reset | 0x0 | 0x0 | | | 0x1 | 0x0 | 0x0 | 0x0 |
| Access Type | Write, Read | Write, Read | | | Write, Read | Write, Read | Write, Read | Write, Read |

| BITFIELD | BITS | DESCRIPTION | DECODE |
|---|---|---|---|
| REFDIV | 31:29 | Clock output divider ratio | 0x0: XTAL frequency x2<br>0x1: XTAL frequency /4<br>0x2: XTAL frequency /2<br>0x3: XTAL frequency<br>0x4: XTAL frequency x4<br>0x5: Reserved<br>0x6: Reserved<br>0x7: Reserved |
| LOBAND | 28 | Local Oscillator band selection | 0x0: L1 band<br>0x1: L2/L5 band |
| RESERVED | 27 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 26 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 25 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| REFOUTEN | 24 | Output clock buffer enable | 0x0: Disable clock buffer<br>0x1: Enable clock buffer |

**PLL Configuration (0x3) (continued)**

| BITFIELD | BITS | DESCRIPTION | DECODE |
|---|---|---|---|
| RESERVED | 23 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 22:21 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| IXTAL | 20:19 | Current programming for XTAL oscillator/buffer | 0x0: Reserved<br>0x1: Normal current<br>0x2: Reserved<br>0x3: High current |
| RESERVED | 18:14 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 13 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 12:10 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| ICP | 9 | Charge pump current selection | 0x0: 0.5 mA<br>0x1: 1 mA |
| RESERVED | 8 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 7 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 6:4 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| INT_PLL | 3 | PLL mode control. Selects either integer-N or fractional-N PLL mode. | 0x0: Fractional-N PLL<br>0x1: Integer-N PLL |
| PWRSAV | 2 | Enable PLL power-save mode | 0x0: Disable PLL power-save mode<br>0x1: Enable PLL power-save mode |
| RESERVED | 1 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 0 | Reserved: DO NOT CHANGE VALUE | RESERVED |

## PLL Integer Division Ratio (0x4)

PLL main and reference division ratios, other controls

| BIT | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED[3:0] | | | | NDIV[14:11] | | | |
| Reset | 0x0 | | | | 1536 | | | |
| Access Type | Write, Read | | | | Write, Read | | | |

| BIT | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|
| Field | NDIV[10:3] | | | | | | | |
| Reset | 1536 | | | | | | | |
| Access Type | Write, Read | | | | | | | |

| BIT | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 |
|---|---|---|---|---|---|---|---|---|
| Field | NDIV[2:0] | | | RDIV[9:5] | | | | |
| Reset | 1536 | | | 16 | | | | |
| Access Type | Write, Read | | | Write, Read | | | | |

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Field | RDIV[4:0] | | | | | RESERVED[2:0] | | |
| Reset | 16 | | | | | 0x0 | | |
| Access Type | Write, Read | | | | | Write, Read | | |

| BITFIELD | BITS | DESCRIPTION | DECODE |
|---|---|---|---|
| RESERVED | 31:28 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| NDIV | 27:13 | PLL integer division ratio | |
| RDIV | 12:3 | PLL reference division ratio | |
| RESERVED | 2:0 | Reserved: DO NOT CHANGE VALUE | RESERVED |

## PLL Fractional Division Ratio (0x5)

PLL fractional division ratio, other controls

| BIT | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED[3:0] | | | | FDIV[19:16] | | | |
| Reset | 0x0 | | | | 0x80000 | | | |
| Access Type | Write, Read, Dual | | | | Write, Read | | | |

| BIT | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|
| Field | FDIV[15:8] | | | | | | | |
| Reset | 0x80000 | | | | | | | |
| Access Type | Write, Read | | | | | | | |

| BIT | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 |
|---|---|---|---|---|---|---|---|---|
| Field | FDIV[7:0] | | | | | | | |
| Reset | 0x80000 | | | | | | | |
| Access Type | Write, Read | | | | | | | |

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED[3:0] | | | | RESERVED | RESERVED | RESERVED | RESERVED |
| Reset | 0x7 | | | | 0x0 | 0x0 | 0x0 | 0x0 |
| Access Type | Write, Read, Dual | | | | Write, Read | Write, Read | Write, Read | Write, Read |

| BITFIELD | BITS | DESCRIPTION | DECODE |
|---|---|---|---|
| RESERVED | 31:28 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| FDIV | 27:8 | PLL fractional division ratio | |
| RESERVED | 7:4 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 3 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 2 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 1 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 0 | Reserved: DO NOT CHANGE VALUE | RESERVED |

## RESERVED (0x6)

Reserved

| BIT | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED[3:0] | | | | RESERVED[27:24] | | | |
| Reset | 0x0 | | | | 0x8000000 | | | |
| Access Type | Write, Read, Dual | | | | Write, Read | | | |

| BIT | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED[23:16] | | | | | | | |
| Reset | 0x8000000 | | | | | | | |
| Access Type | Write, Read | | | | | | | |

| BIT | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED[15:8] | | | | | | | |
| Reset | 0x8000000 | | | | | | | |
| Access Type | Write, Read | | | | | | | |

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED[7:0] | | | | | | | |
| Reset | 0x8000000 | | | | | | | |
| Access Type | Write, Read | | | | | | | |

| BITFIELD | BITS | DESCRIPTION | DECODE |
|---|---|---|---|
| RESERVED | 31:28 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 27:0 | Reserved: DO NOT CHANGE VALUE | RESERVED |

## Clock Configuration 1 (0x7)

Clock Configuration

| BIT | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED[2:0] | | | EXTADCCLK | REFCLK_L_CNT[11:8] | | | |
| Reset | 0x0 | | | 0x0 | 256 | | | |
| Access Type | Write, Read | | | Write, Read | Write, Read | | | |

| BIT | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|
| Field | REFCLK_L_CNT[7:0] | | | | | | | |
| Reset | 256 | | | | | | | |
| Access Type | Write, Read | | | | | | | |

| BIT | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 |
|---|---|---|---|---|---|---|---|---|
| Field | REFCLK_M_CNT[11:4] | | | | | | | |
| Reset | 1563 | | | | | | | |
| Access Type | Write, Read | | | | | | | |

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Field | REFCLK_M_CNT[3:0] | | | | FCLKIN | ADCCLK | RESERVED | MODE |
| Reset | 1563 | | | | 0x0 | 0x0 | 0x1 | 0x0 |
| Access Type | Write, Read | | | | Write, Read | Write, Read | Write, Read | Write, Read |

| BITFIELD | BITS | DESCRIPTION | DECODE |
|---|---|---|---|
| RESERVED | 31:29 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| EXTADCCLK | 28 | Selects either internally generated or externally applied clock as ADC sampling clock | 0x0: Use internally generated clock<br>0x1: Use clock provided on ADC_CLKIN pin |
| REFCLK_L_CNT | 27:16 | Sets the value for the L counter | |
| REFCLK_M_CNT | 15:4 | Sets the value for the M counter | |
| FCLKIN | 3 | Fractional clock divider selection | 0x0: Bypass ADC clock divider<br>0x1: Take ADC clock from fractional divider |
| ADCCLK | 2 | ADC clock selection | 0x0: Use output of reference clock divider/multiplier<br>0x1: Bypass reference clock divider/multiplier |
| RESERVED | 1 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| MODE | 0 | DSP interface mode selection | |

## Test Mode 1 (0x8)

RESERVED

| BIT | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED | RESERVED | RESERVED[1:0] | | RESERVED[3:0] | | | |
| Reset | 0x0 | 0x0 | 0x0 | | 0x1 | | | |
| Access Type | Write, Read | Write, Read | Write, Read | | Write, Read | | | |

| BIT | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED[3:0] | | | | RESERVED[3:0] | | | |
| Reset | 0xE | | | | 0x0 | | | |
| Access Type | Write, Read | | | | Write, Read | | | |

| BIT | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED[3:0] | | | | RESERVED | RESERVED[4:2] | | |
| Reset | 0xF | | | | 0x0 | 0x10 | | |
| Access Type | Write, Read | | | | Write, Read | Write, Read, Dual | | |

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED[1:0] | | RESERVED | RESERVED | RESERVED | RESERVED | RESERVED | RESERVED |
| Reset | 0x10 | | 0x0 | 0x0 | 0x0 | 0x0 | 0x0 | 0x1 |
| Access Type | Write, Read, Dual | | Write, Read | Write, Read | Write, Read | Write, Read | Write, Read | Write, Read |

| BITFIELD | BITS | DESCRIPTION | DECODE |
|---|---|---|---|
| RESERVED | 31 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 30 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 29:28 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 27:24 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 23:20 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 19:16 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 15:12 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 11 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 10:6 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 5 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 4 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 3 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 2 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 1 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 0 | Reserved: DO NOT CHANGE VALUE | RESERVED |

## Test Mode 2 (0x9)

RESERVED

| BIT | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED | RESERVED | RD_CALC | RESERVED[3:0] | | | | RE SERVED[2] |
| Reset | 0x0 | 0x0 | 0x0 | 0x0 | | | | 0x0 |
| Access Type | Write Only | Write, Read | Write, Read | Write, Read | | | | Write, Read |

| BIT | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED[1:0] | | RESERVED | RESERVED | RESERVED[1:0] | | RESERVED | RESERVED |
| Reset | 0x0 | | 0x0 | 0x0 | 0x0 | | 0x0 | 0x0 |
| Access Type | Write, Read | | Write, Read | Write, Read | Write, Read | | Write, Read | Write, Read |

| BIT | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED | RESERVED | RESERVED | RESERVED[4:0] | | | | |
| Reset | 0x0 | 0x0 | 0x0 | 0x00 | | | | |
| Access Type | Write, Read | Write, Read | Write, Read | Write, Read, Dual | | | | |

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED[4:0] | | | | | RESERVED | RESERVED | RESERVED |
| Reset | 0x00 | | | | | 0x0 | 0x1 | 0x0 |
| Access Type | Write, Read, Dual | | | | | Write, Read | Write, Read | Write, Read |

| BITFIELD | BITS | DESCRIPTION | DECODE |
|---|---|---|---|
| RESERVED | 31 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 30 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RD_CALC | 29 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 28:25 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 24:22 | Reserved: Write 011 to this bitfield. | RESERVED |
| RESERVED | 21 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 20 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 19:18 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 17 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 16 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 15 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 14 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 13 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 12:8 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 7:3 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 2 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 1 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 0 | Reserved: DO NOT CHANGE VALUE | RESERVED |

## Clock Configuration 2 (0xA)

Clock Configuration

| BIT | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
|---|---|---|---|---|---|---|---|---|
| Field | RESERVED[2:0] | | | RESERVED | ADCCLK_L_CNT[11:8] | | | |
| Reset | 0x0 | | | 0x0 | 256 | | | |
| Access Type | Write, Read | | | Write, Read | Write, Read | | | |

| BIT | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|
| Field | ADCCLK_L_CNT[7:0] | | | | | | | |
| Reset | 256 | | | | | | | |
| Access Type | Write, Read | | | | | | | |

| BIT | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 |
|---|---|---|---|---|---|---|---|---|
| Field | ADCCLK_M_CNT[11:4] | | | | | | | |
| Reset | 1563 | | | | | | | |
| Access Type | Write, Read | | | | | | | |

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Field | ADCCLK_M_CNT[3:0] | | | | PRE FRACDIV_ SEL | CLKOUT_ SEL | RESERVED[1:0] | |
| Reset | 1563 | | | | 0x0 | 0x0 | 0x0 | |
| Access Type | Write, Read | | | | Write, Read | Write, Read | Write, Read | |

| BITFIELD | BITS | DESCRIPTION | DECODE |
|---|---|---|---|
| RESERVED | 31:29 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| RESERVED | 28 | Reserved: DO NOT CHANGE VALUE | RESERVED |
| ADCCLK_ L_CNT | 27:16 | Sets the value for the L counter | |
| ADCCLK_ M_CNT | 15:4 | Sets the value for the M counter | |
| PRE FRACDIV_ SEL | 3 | Fractional clock divider selection | 0x0: Bypass fractional clock divider<br>0x1: Enable fractional divider |
| CLKOUT_ SEL | 2 | CLKOUT selection | 0x0: Integer divider/multiplier output<br>0x1: ADC clock |
| RESERVED | 1:0 | Reserved: DO NOT CHANGE VALUE | RESERVED |

## Applications Information

### IF Filter Center Frequency Configuration

The FCEN bits in the Configuration 1 register are used to set the center frequency of the IF filter when it is configured as a bandpass filter. The following equations are used to calculate the required setting of FCEN to obtain the target center frequency. The center frequency should not be set higher than 9MHz for any filter bandwidth.

For FBW = 000 corresponding to a 2.5MHz filter bandwidth, the center frequency is calculated using the following equation:

$$F_{CENTER} = \left(\frac{128 - FCEN}{2}\right) \times 0.195MHz$$

For FBW = 010 corresponding to a 4.2MHz filter bandwidth, the center frequency is calculated using the following equation:

$$F_{CENTER} = \left(\frac{128 - FCEN}{2}\right) \times 0.355MHz$$

For FBW = 001 corresponding to a 8.7MHz filter bandwidth, the center frequency is calculated using the following equation:

$$F_{CENTER} = \left(\frac{128 - FCEN}{2}\right) \times 0.66MHz$$

Here are some examples: If FBW = 000, and FCEN[6:0] = 1011000, then the 2.5MHz wide filter will be centered at approximately [(128 – 88)/2](0.195) MHz = 3.9MHz.

If FBW = 001, and FCEN = 1101001, then the 8.7MHz wide filter will be centered at approximately

[(128 – 105)/2](0.66) MHz = 7.6MHz.

The calculations give approximate center frequencies. The center frequency needs to be tuned empirically.

### Operation for Wideband Signals

Some signals used for precision GNSS or modernized GNSS have wide bandwidths. For example, the GPS L1 P(Y) signal has a main lobe (first null spacing) of 20.46 MHz, and the Galileo E6 signal is 10.23 MHz wide. For such wideband signals, the use of the wideband lowpass filter is recommended so as to fit the entire main lobe of the signal within the passband of the filter and by doing so, avoid reducing the SNR.

First, the LO frequency has to be tuned to the center of the wanted signal so as to down-convert the signal to DC. For the case of the GPS L1 P(Y) signal, the required LO frequency is 1575.42MHz. As an example, assume the TXCO frequency is 16.368 MHz. Assume the PLL reference division ratio (RDIV) = 16 giving a comparision frequency of 1.023 MHz. This allows use of the Integer-N PLL. Set the INT_PLL bit in the PLL Configuration register to 1. The PLL integer division ratio (NDIV) needs to be set to 1575.42/1.023 = 1540.

The IF filter is configured as a low pass 5$^{th}$-order Butterworth 23.4MHz filter. Configure FBW = 011, F3OR5 = 0, and FCENX = 0. The FCEN bits can be left untouched since they are ignored for the lowpass filter case. Set the filter pole at the mixer output to 36MHz by setting MIXPOLE = 1. The ADC sampling rate should be set to a few MHz beyond the double-sided passband of the IF filter which is 23.4MHz in this case. This is to avoid degradation due to aliasing of noise. The offset frequency (from the 3dB corner frequency) at which the attenuation is 20dB is 18.5MHz. Hence, an ADC sampling rate of at least two times this, or 37MHz, is required. With a 16.368MHz TCXO clock, it is not possible, given the limitations on fractional division ratio and maximum frequency of the clock multiplier, to generate a 37MHz clock internally. The ADC clock is, therefore, provided from an external source on the ADC_CLKIN pin and the EXTADCLK register bit set to use the externally applied ADC clock.

As a second example, assume reception of the Galileo E5a signal is desired. This has a bandwidth of 20.46MHz and is centered at a frequency of 1176.45MHz. Since this frequency is in the L2/L5 band, the LOBAND bit in the PLL Configuration register must be set to 1. Assuming the same TXCO and reference division ratios as in the prior example, this means the integer division ratio must be 1150. Again, since the center frequency is an integer multiple of 1.023MHz, the PLL can be operated as an Integer-N PLL. (The use of a 1.023MHz comparison frequency is convenient since most GNSS carrier frequencies will be integer multiples of 1.023MHz.) Since this is also a 20.46MHz wide signal, the IF filter settings and ADC clock configuration are the same as the prior example.

For a final example, consider reception of the Galileo E1 signal. This is 14.3MHz wide and centered at the frequency of 1575.42MHz. Assuming the same conditions as the prior examples, the synthesizer will be programmed identically to the first example. The IF filter will be programmed identically to the first example except for the bandwidth. The 16.4MHz wide filter setting should be used instead (FBW = 111). An ADC sampling rate of at least 26MHz is required. In this case, it is decided to simply multiply the TXCO clock by 2 giving an ADC clock frequency of 32.7MHz.

## Determining AGC Gain Setpoint

When the MAX2771 PGA gain is determined by the AGC, the user may wish to know what the actual gain value determined by the AGC is. This is not directly readable through a SPI register. However, it can be determined indirectly through the following method. Bypass the on-chip ADCs, and measure the noise power or noise power density at the analog monitoring output. Say it is -68.5dBm/Hz for example. Then switch the AGC to fixed mode where the PGA gain is determined by the value programmed into the register. Remeasure the noise power density. Say it is -63.3dBm/Hz. Then take the difference between these two readings, rounding off to the nearest dB, and compare to the 58dB setting of the PGA. In this example, the delta between the two readings (rounded off) is 5dB, so we know the set point must be 58 – 5 = 53dB.

## PCB Layout Considerations

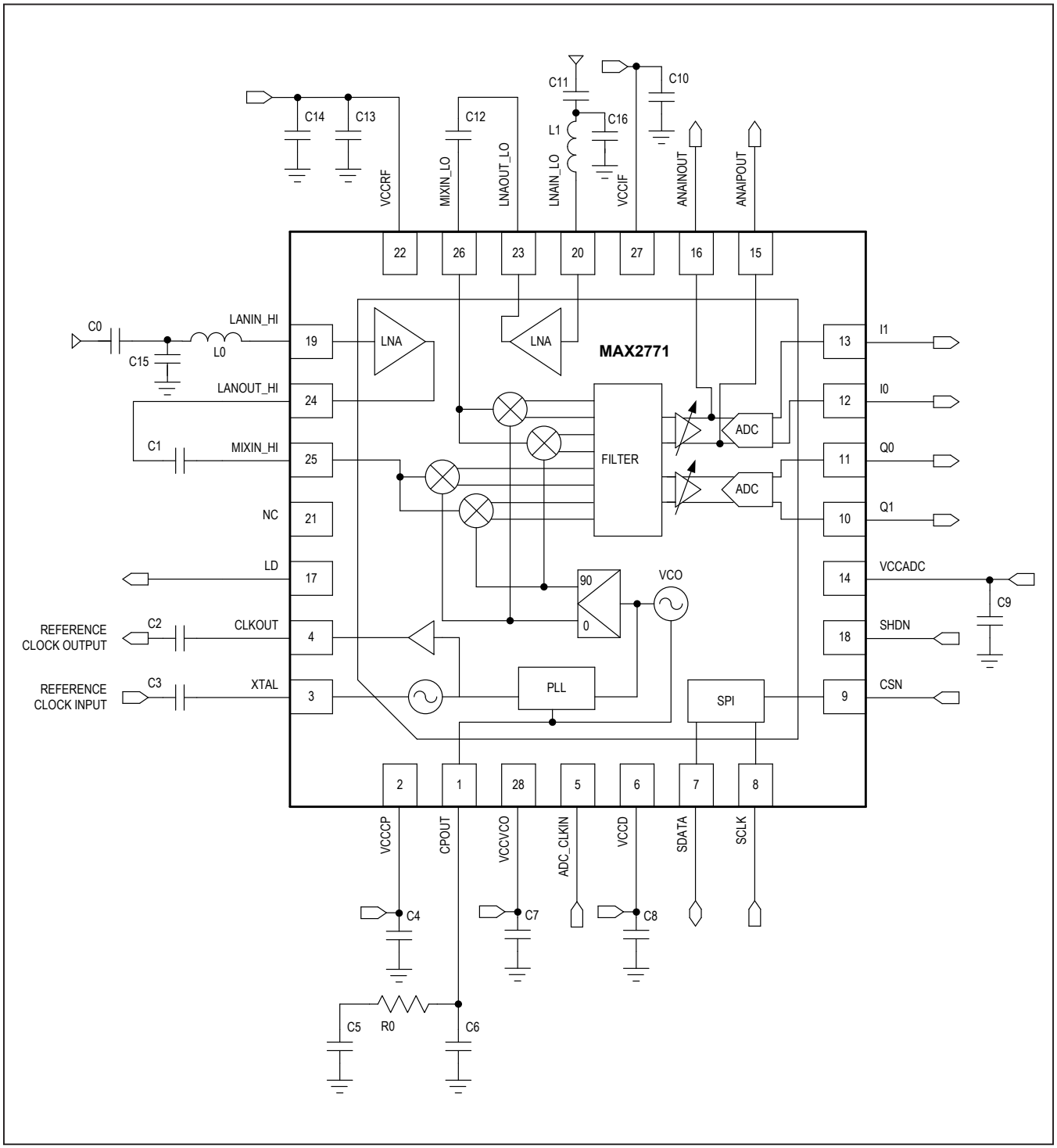
The MAX2771 EV kit can be used as a starting point for layout. For best performance, take into consideration grounding and routing of RF, baseband, and power supply lines. Make connections from vias to the ground plane as short as possible. On the high impedance ports, keep traces short to minimize shunt capacitance. EV kit Gerber files are available on the MAX2771 product page of the Maxim Integrated website.

## Power-Supply Layout

To minimize coupling between different sections of the IC, a star power-supply routing configuration with a large decoupling capacitor at a central VCC_ node is recommended. The VCC_ traces branch out from this node, each going to a separate VCC_ node in the circuit. Place a bypass capacitor as close as possible to each supply pin. This arrangement provides local decoupling at each VCC_ pin. Use at least one via per bypass capacitor for a low inductance ground connection. Do not share the capacitor ground vias with any other branch. Refer to the application note General Layout Guidelines for RF and Mixed-Signal PCBs, available on the MAX2771 product page for more information.

## Typical Application Circuit

### Circuit 1



## Table 16. External Component List

| DESIGNATION | QUANTITY | DESCRIPTION |
|---|---|---|
| C0, C11 | 2 | 0.47nF AC-coupling capacitors |
| C5 | 1 | 0.75nF PLL loop filter capacitor |
| C6 | 1 | 15pF PLL loop filter capacitor |
| C4, C7, C8, C9, C10, C13 | 6 | 0.1µF supply voltage bypass capacitor |
| C2, C3 | 2 | 10nF AC-coupling capacitor |
| C1, C12 | 2 | 0.47nF AC-coupling capacitor |
| C14 | 1 | 0.1nF supply voltage bypass capacitor |
| R0 | 1 | 15kΩ PLL loop filter resistor |
| L0 | 1 | 5.6 nH RF matching inductor for high-band LNA inputs |
| L1 | 1 | 8.4 nH RF matching inductor for low-band LNA input |
| C15 | 1 | 1.7 pF RF matching capacitor for high-band LNA input |
| C16 | 1 | 1.1 pF RF matching capacitor for low-band LNA input |

## Ordering Information

| PART NUMBER | TEMP RANGE | PIN-PACKAGE |
|---|---|---|
| MAX2771ETI+ | -40°C to +85°C | 28 TQFN-EP* |

*+Denotes a lead(Pb)-free/RoHS-compliant package.*
**EP = Exposed pad.*

## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|---|---|---|---|
| 0 | 7/18 | Initial release | — |

For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim Integrated's website at www.maximintegrated.com.

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