

FEATURES

RF output frequency range: 54 MHz to 4400 MHz
Fractional-N synthesizer and integer-N synthesizer
High resolution 38-bit modulus
Low phase noise, VCO
Programmable divide by 1, 2, 4, 8, 16, 32, or 64 output
Analog and digital power supplies: 3.3 V
Charge pump and VCO power supplies: 5 V typical
Logic compatibility: 1.8 V
Programmable dual modulus prescaler of 4/5 or 8/9
Programmable output power level
RF output mute function
3-wire serial interface
Analog and digital lock detect

APPLICATIONS

**Wireless infrastructure (W-CDMA, TD-SCDMA,
WiMAX, GSM, PCS, DCS, DECT)**
Point to point/multipoint microwave links
Satellites/VSATs
Test equipment/instrumentation
Clock generation

GENERAL DESCRIPTION

The **ADF4355-2** allows implementation of fractional-N or integer-N phase-locked loop (PLL) frequency synthesizers when used with an external loop filter and an external reference frequency. A series of frequency dividers permits operation from 54 MHz to 4400 MHz.

The **ADF4355-2** has an integrated voltage controlled oscillator (VCO) with a fundamental output frequency ranging from 3400 MHz to 6800 MHz. In addition, the VCO frequency is connected to divide by 1, 2, 4, 8, 16, 32, or 64 circuits that allow the user to generate radio frequency (RF) output frequencies as low as 54 MHz. For applications that require isolation, the RF output stage can be muted. The mute function is both pin and software controllable.

Control of all on-chip registers is through a simple 3-wire interface. The **ADF4355-2** operates with analog and digital power supplies, ranging from 3.15 V to 3.45 V, with charge pump and VCO supplies from 4.75 V to 5.25 V. The **ADF4355-2** also contains hardware and software power-down modes.

FUNCTIONAL BLOCK DIAGRAM

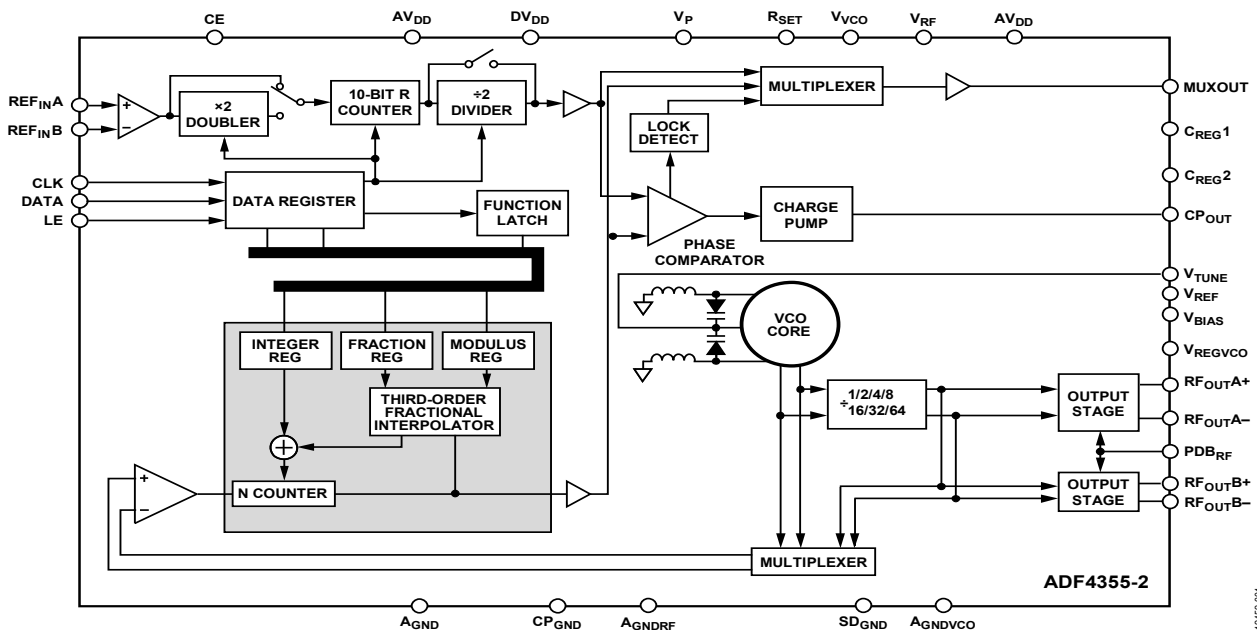


Figure 1.

Rev. C

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REVISION HISTORY

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1/2016—Rev. A to Rev. B

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10/2014—Revision 0: Initial Version

SPECIFICATIONS

$AV_{DD} = DV_{DD} = V_{RF} = 3.3 \text{ V} \pm 5\%$, $4.75 \text{ V} \leq V_P = V_{VCO} \leq 5.25 \text{ V}$, $A_{GND} = CP_{GND} = A_{GNDVCO} = SD_{GND} = A_{GNDRF} = 0 \text{ V}$, $R_{SET} = 5.1 \text{ k}\Omega$, dBm referred to $50 \text{ }\Omega$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted.

Table 1.

| Parameter | Symbol | Min | Typ | Max | Unit | Test Conditions/Comments |
|---|--------------------|-----------------|------------------------------|------------------------------|---------------|---|
| REF _{IN} A/REF _{IN} B CHARACTERISTICS | | | | | | |
| Input Frequency | | | | | | For $f < 10 \text{ MHz}$, ensure slew rate $> 21 \text{ V}/\mu\text{s}$ |
| Single-Ended Mode | | 10 | | 250 | MHz | |
| Differential Mode | | 10 | | 600 | MHz | |
| Doubler Enabled | | | | 100 | MHz | Doubler is set in Register 4, Bit DB26 |
| Input Sensitivity | | | | | | |
| Single-Ended Mode | | 0.4 | | AV_{DD} | V p-p | REF _{IN} A biased at $AV_{DD}/2$; ac coupling ensures $AV_{DD}/2$ bias |
| Differential Mode | | 0.4 | | 1.8 | V p-p | LVDS and LVPECL compatible, REF _{IN} A/REF _{IN} B biased at 2.1 V; ac coupling ensures 2.1 V bias |
| Input Capacitance | | | | | | |
| Single-Ended Mode | | | 6.9 | | pF | |
| Differential Mode | | | 1.4 | | pF | |
| Input Current | | | | ± 60 | μA | Single-ended reference programmed |
| | | | | ± 250 | μA | Differential reference programmed |
| Phase Detector Frequency | | | | 125 | MHz | |
| CHARGE PUMP (CP) | | | | | | |
| Charge Pump Current, Sink/Source | I_{CP} | | | | | $R_{SET} = 5.1 \text{ k}\Omega$ |
| High Value | | | 4.8 | | mA | |
| Low Value | | | 0.3 | | mA | |
| R_{SET} Range | | | 5.1 | | k Ω | Fixed |
| Current Matching | | | 3 | | % | $0.5 \text{ V} \leq V_{CP}^1 \leq V_P - 0.5 \text{ V}$ |
| I_{CP} vs. V_{CP} | | | 3 | | % | $0.5 \text{ V} \leq V_{CP}^1 \leq V_P - 0.5 \text{ V}$ |
| I_{CP} vs. Temperature | | | 1.5 | | % | $V_{CP}^1 = 2.5 \text{ V}$ |
| LOGIC INPUTS | | | | | | |
| Input High Voltage | V_{INH} | 1.5 | | | V | |
| Input Low Voltage | V_{INL} | | | 0.6 | V | |
| Input Current | I_{INH}/I_{INL} | | | ± 1 | μA | |
| Input Capacitance | C_{IN} | | 3.0 | | pF | |
| LOGIC OUTPUTS | | | | | | |
| Output High Voltage | V_{OH} | $DV_{DD} - 0.4$ | 1.8 | | V | 1.8 V output selected |
| | | 1.5 | | | V | |
| Output High Current | I_{OH} | | | 500 | μA | |
| Output Low Voltage | V_{OL} | | | 0.4 | V | $I_{OL}^2 = 500 \text{ }\mu\text{A}$ |
| POWER SUPPLIES | | | | | | |
| Analog Power | AV_{DD} | 3.15 | | 3.45 | V | |
| Digital Power and RF Supply Voltage | DV_{DD}, V_{RF} | | AV_{DD} | | V | Voltages must equal AV_{DD} |
| Charge Pump and VCO Voltage | V_P, V_{VCO} | 4.75 | 5.0 | 5.25 | V | V_P must equal V_{VCO} |
| Charge Pump Supply Power Current | I_P | | 8 | 9 | mA | |
| Digital Power Supply Current + Analog Power Supply Current ³ | DI_{DD}, AI_{DD} | | 62 | 69 | mA | |
| Output Dividers | | | 6 to 36 | | mA | Each output divide by 2 consumes 6 mA |
| Supply Current | I_{VCO} | | 70 | 85 | mA | |
| RF _{OUT} A \pm /RF _{OUT} B \pm Supply Current | $I_{RF_{OUT}X\pm}$ | | 16/20/ 42/55 ⁴ | 20/35/ 50/70 ⁴ | mA | RF output stage is programmable; RF _{OUT} B+/RF _{OUT} B- powered off |
| Low Power Sleep Mode | | | 500 | | μA | Hardware power-down |
| | | | 1000 | | μA | Software power-down |

| Parameter | Symbol | Min | Typ | Max | Unit | Test Conditions/Comments |
|--|--------|--------|------|------|--------|---|
| RF OUTPUT CHARACTERISTICS | | | | | | |
| VCO Frequency Range | | 3400 | | 6800 | MHz | Fundamental VCO range |
| RF Output Frequency | | 53.125 | | 4400 | MHz | |
| VCO Sensitivity | Kv | | 15 | | MHz/V | |
| Frequency Pushing (Open-Loop) | | | 15 | | MHz/V | |
| Frequency Pulling (Open-Loop) | | | 0.5 | | MHz | Voltage standing wave ratio (VSWR) = 2:1 |
| Harmonic Content | | | | | | |
| Second | | | -27 | | dBc | Fundamental VCO output (RF _{OUTA+}) |
| Third | | | -22 | | dBc | Divided VCO output (RF _{OUTA+}) |
| | | | -20 | | dBc | Fundamental VCO output (RF _{OUTA+}) |
| | | | -12 | | dBc | Divided VCO output (RF _{OUTA+}) |
| RF Output Power ⁵ | | | 8 | | dBm | RF _{OUTA+} = 1 GHz |
| | | | 3 | | dBm | RF _{OUTA+} /RF _{OUTA-} = 4.4 GHz |
| RF Output Power Variation | | | ±1 | | dB | RF _{OUTA+} /RF _{OUTA-} = 4.4 GHz |
| RF Output Power Variation (over Frequency) | | | ±3 | | dB | RF _{OUTA+} /RF _{OUTA-} = 1 GHz to 4.4 GHz |
| Level of Signal with RF Output Disabled | | | -60 | | dBm | RF _{OUTA+} /RF _{OUTA-} = 1 GHz, VCO = 4 GHz |
| | | | -30 | | dBm | RF _{OUTA+} /RF _{OUTA-} = 4.4 GHz, VCO = 4.4 GHz |
| NOISE CHARACTERISTICS | | | | | | |
| Fundamental VCO Phase Noise Performance | | | | | | VCO noise in open-loop conditions |
| | | | -116 | | dBc/Hz | 100 kHz offset from 3.4 GHz carrier |
| | | | -136 | | dBc/Hz | 800 kHz offset from 3.4 GHz carrier |
| | | | -138 | | dBc/Hz | 1 MHz offset from 3.4 GHz carrier |
| | | | -155 | | dBc/Hz | 10 MHz offset from 3.4 GHz carrier |
| | | | -113 | | dBc/Hz | 100 kHz offset from 5.0 GHz carrier |
| | | | -133 | | dBc/Hz | 800 kHz offset from 5.0 GHz carrier |
| | | | -135 | | dBc/Hz | 1 MHz offset from 5.0 GHz carrier |
| | | | -153 | | dBc/Hz | 10 MHz offset from 5.0 GHz carrier |
| | | | -110 | | dBc/Hz | 100 kHz offset from 6.8 GHz carrier |
| | | | -130 | | dBc/Hz | 800 kHz offset from 6.8 GHz carrier |
| | | | -132 | | dBc/Hz | 1 MHz offset from 6.8 GHz carrier |
| | | | -150 | | dBc/Hz | 10 MHz offset from 6.8 GHz carrier |
| Normalized In-Band Phase Noise Floor | | | | | | |
| Fractional Channel ⁶ | | | -221 | | dBc/Hz | |
| Integer Channel ⁷ | | | -223 | | dBc/Hz | |
| Normalized 1/f Noise, PN _{1,f} ⁸ | | | -116 | | dBc/Hz | 10 kHz offset; normalized to 1 GHz |
| Integrated RMS Jitter | | | 150 | | fs | |
| Spurious Signals due to Phase Frequency Detector (PFD) Frequency | | | -80 | | dBc | |

¹ V_{CP} is the voltage at the CP_{OUT} pin.

² I_{OL} is the output low current.

³ T_A = 25°C; AV_{DD} = DV_{DD} = V_{RF} = 3.3 V; V_{VCO} = V_P = 5.0 V; prescaler = 4/5; f_{REFIN} = 122.88 MHz; f_{PFD} = 61.44 MHz; and f_{RF} = 1650 MHz.

⁴ The value measured varies between 16, 20, 42, and 55, depending on the RF output stage power programmable level per Bit DB4 and DB5 in Register 6.

⁵ RF output power using the EV-ADF4355-2SD1Z evaluation board measured into a spectrum analyzer, with board and cable losses de-embedded. The EV-ADF4355-2SD1Z RF outputs are pulled up externally using a 7.4 nH inductor. Unused RF output pins are terminated in 50 Ω.

⁶ Use this figure to calculate the phase noise for any application. To calculate in-band phase noise performance as seen at the VCO output, use the following formula: -221 + 10log(f_{PFD}) + 20logN. The value given is the lowest noise mode for the fractional channel.

⁷ Use this figure to calculate the phase noise for any application. To calculate in-band phase noise performance as seen at the VCO output, use the following formula: -223 + 10log(f_{PFD}) + 20logN. The value given is the lowest noise mode for the integer channel.

⁸ The PLL phase noise is composed of 1/f (flicker) noise plus the normalized PLL noise floor. The formula for calculating the 1/f noise contribution at an RF frequency (f_{RF}) and at a frequency offset (f) is given by PN = P_{1,f} + 10log(10 kHz/f) + 20log(f_{RF}/1 GHz). Both the normalized phase noise floor and flicker noise are modeled in the ADIsimPLL design tool.

TIMING CHARACTERISTICS

$AV_{DD} = DV_{DD} = V_{RF} = 3.3\text{ V} \pm 5\%$, $4.75\text{ V} \leq V_P = V_{VCO} \leq 5.25\text{ V}$, $A_{GND} = CP_{GND} = A_{GNDVCO} = SD_{GND} = A_{GNDRF} = 0\text{ V}$, $R_{SET} = 5.1\text{ k}\Omega$, dBm referred to $50\ \Omega$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted.

Table 2.

| Parameter | Limit | Unit | Description |
|-----------|---|---------|---|
| f_{CLK} | 50 | MHz max | Serial peripheral interface CLK frequency |
| t_1 | 10 | ns min | LE setup time |
| t_2 | 5 | ns min | DATA to CLK setup time |
| t_3 | 5 | ns min | DATA to CLK hold time |
| t_4 | 10 | ns min | CLK high duration |
| t_5 | 10 | ns min | CLK low duration |
| t_6 | 5 | ns min | CLK to LE setup time |
| t_7 | 20 or $(2/f_{PFD})$, whichever is longer | ns min | LE pulse width |

Timing Diagram

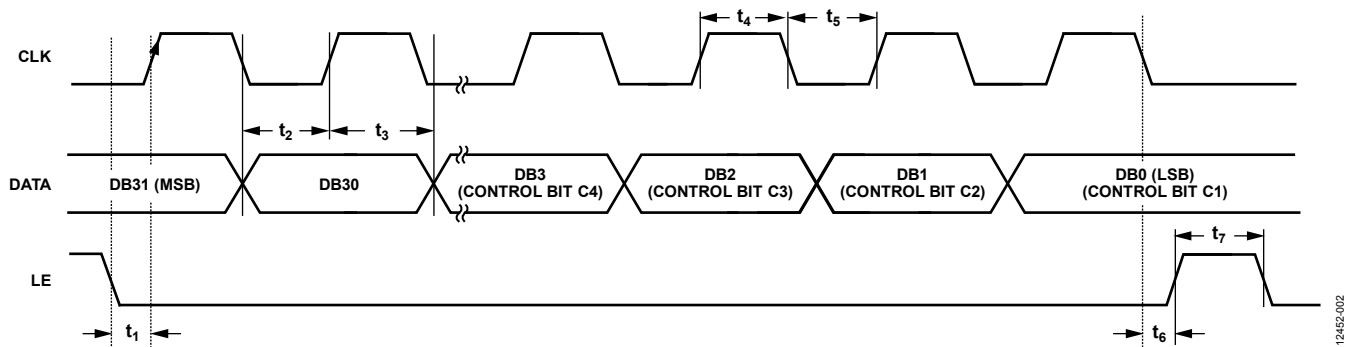


Figure 2. Timing Diagram

12452-002

ABSOLUTE MAXIMUM RATINGS

$T_A = 25^\circ\text{C}$, unless otherwise noted.

Table 3.

| Parameter | Rating |
|---|-----------------------------|
| V_{RF} , DV_{DD} , AV_{DD} to GND ¹ | -0.3 V to +3.6 V |
| AV_{DD} to DV_{DD} | -0.3 V to +0.3 V |
| V_P , V_{VCO} to GND ¹ | -0.3 V to +5.8 V |
| CP_{OUT} to GND ¹ | -0.3 V to $V_P + 0.3$ V |
| Digital Input/Output Voltage to GND ¹ | -0.3 V to $DV_{DD} + 0.3$ V |
| Analog Input/Output Voltage to GND ¹ | -0.3 V to $AV_{DD} + 0.3$ V |
| REF_{INA} , REF_{INB} to GND ¹ | -0.3 V to $AV_{DD} + 0.3$ V |
| REF_{INA} to REF_{INB} | ± 2.1 V |
| Operating Temperature Range | -40°C to +85°C |
| Storage Temperature Range | -65°C to +125°C |
| Maximum Junction Temperature | 150°C |
| θ_{JA} , Thermal Impedance Paddle Soldered to GND ¹ | 27.3°C/W |
| Reflow Soldering | |
| Peak Temperature | 260°C |
| Time at Peak Temperature | 40 sec |
| Electrostatic Discharge (ESD) | |
| Charged Device Model | 1000 V |
| Human Body Model | 2500 V |

¹ GND = $A_{GND} = SD_{GND} = A_{GNDRF} = A_{GNDVCO} = CP_{GND} = 0$ V.

Stresses at or above those listed under Absolute Maximum Ratings may cause permanent damage to the product. This is a stress rating only; functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

The ADF4355-2 is a high performance RF integrated circuit with an ESD rating of 2500 V and is ESD sensitive. Take proper precautions for handling and assembly.

TRANSISTOR COUNT

The transistor count for the ADF4355-2 is 103,665 (CMOS) and 3214 (bipolar).

ESD CAUTION



ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

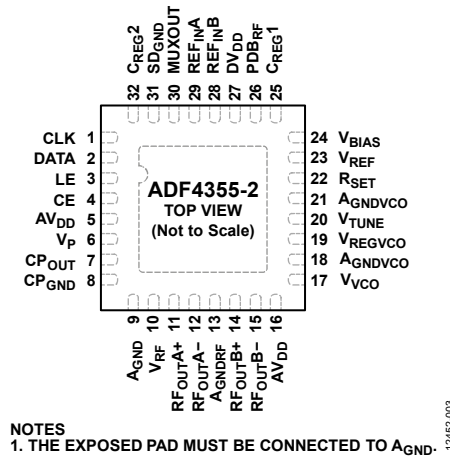


Figure 3. Pin Configuration

Table 4. Pin Function Descriptions

| Pin No. | Mnemonic | Description |
|---------|---------------------|---|
| 1 | CLK | Serial Clock Input. Data is clocked into the 32-bit shift register on the CLK rising edge. This input is a high impedance CMOS input. |
| 2 | DATA | Serial Data Input. The serial data is loaded most significant bit (MSB) first with the four least significant bits (LSBs) as the control bits. This input is a high impedance CMOS input. |
| 3 | LE | Load Enable, CMOS Input. When LE goes high, the data stored in the shift register is loaded into the register that is selected by the four LSBs. |
| 4 | CE | Chip Enable. A logic low on this pin powers down the device and puts the charge pump into three-state mode. A logic high on this pin powers up the device, depending on the status of the power-down bits. |
| 5, 16 | AV _{DD} | Analog Power Supply. These pins range from 3.15 V to 3.45 V. Connect decoupling capacitors to the analog ground plane as close to these pins as possible. AV _{DD} must have the same value as DV _{DD} . |
| 6 | V _P | Charge Pump Power Supply. V _P must have the same value as V _{VCO} . Connect decoupling capacitors to the ground plane as close to this pin as possible. |
| 7 | CP _{OUT} | Charge Pump Output. When enabled, this output provides ±I _{CP} to the external loop filter. The output of the loop filter is connected to V _{TUNE} to drive the internal VCO. |
| 8 | CP _{GND} | Charge Pump Ground. This output is the ground return pin for CP _{OUT} . |
| 9 | A _{GND} | Analog Ground. Ground return pin for AV _{DD} . |
| 10 | V _{RF} | Power Supply for the RF Output. Connect decoupling capacitors to the analog ground plane as close to this pin as possible. V _{RF} must have the same value as AV _{DD} . |
| 11 | RF _{OUTA+} | VCO Output. The output level is programmable. The VCO fundamental output or a divided down version is available. |
| 12 | RF _{OUTA-} | Complementary VCO Output. The output level is programmable. The VCO fundamental output or a divided down version is available. |
| 13 | A _{GNDRF} | RF Output Stage Ground. Ground return pins for the RF output stage. |
| 14 | RF _{OUTB+} | Auxiliary VCO Output. The output level is programmable. The VCO fundamental output or a divided down version is available. |
| 15 | RF _{OUTB-} | Complementary Auxiliary VCO Output. The output level is programmable. The VCO fundamental output or a divided down version is available. |
| 17 | V _{VCO} | Power Supply for the VCO. The voltage on this pin ranges from 4.75 V to 5.25 V. Connect decoupling capacitors to the analog ground plane as close to this pin as possible. |
| 18, 21 | A _{GNDVCO} | VCO Ground. Ground return path for the VCO. |
| 19 | V _{REGVCO} | VCO Compensation Node. Connect decoupling capacitors to the ground plane as close to this pin as possible. Connect this pin directly to V _{VCO} . |
| 20 | V _{TUNE} | Control Input to the VCO. This voltage determines the output frequency and is derived from filtering the CP _{OUT} output voltage. The capacitance at this pin (V _{TUNE} input capacitance) is 9 pF. |

| Pin No. | Mnemonic | Description |
|---------|---------------------------------------|---|
| 22 | R _{SET} | Bias Current Resistor. Connecting a resistor between this pin and ground sets the charge pump output current. |
| 23 | V _{REF} | Internal Compensation Node. DC biased at half the tuning range. Connect decoupling capacitors to the ground plane as close to this pin as possible. |
| 24 | V _{BIAS} | Reference Voltage. Connect a 100 nF decoupling capacitor to the ground plane as close to this pin as possible. |
| 25, 32 | C _{REG1} , C _{REG2} | Outputs from the LDO Regulator. Pin 25 and Pin 32 are the supply voltages to the digital circuits. Nominal voltage of 1.8 V. Decoupling capacitors of 100 nF connected to A _{GND} are required for these pins. |
| 26 | PDB _{RF} | RF Power-Down. A logic low on this pin mutes the RF outputs. This mute function is also software controllable. |
| 27 | DV _{DD} | Digital Power Supply. This pin must be at the same voltage as AV _{DD} . Place decoupling capacitors to the ground plane as close to this pin as possible. |
| 28 | REF _{INB} | Complementary Reference Input. If unused, ac-couple this pin to A _{GND} . |
| 29 | REF _{INA} | Reference Input. |
| 30 | MUXOUT | Multiplexer Output. The multiplexer output allows the digital lock detect, the analog lock detect, scaled RF, or the scaled reference frequency to be externally accessible. |
| 31 | SD _{GND} | Digital Σ - Δ Modulator Ground. Pin 31 is the ground return path for the Σ - Δ modulator. |
| | EP | Exposed Pad. The exposed pad must be connected to A _{GND} . |

TYPICAL PERFORMANCE CHARACTERISTICS

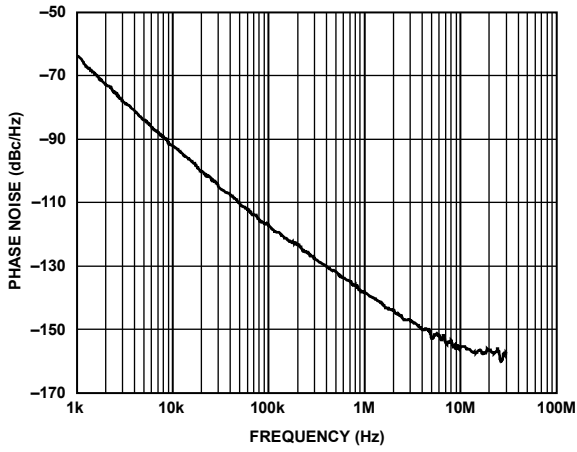


Figure 4. Open-Loop VCO Phase Noise, 3.4 GHz

12452-004

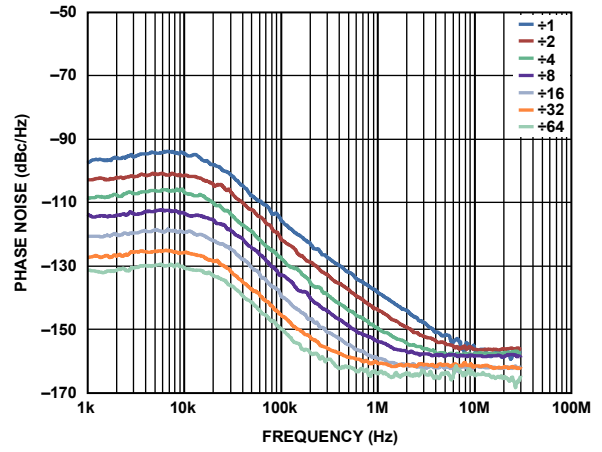


Figure 7. Closed-Loop Phase Noise, RF_{OUTA+} , Fundamental VCO and Dividers, VCO = 3.4 GHz, PFD = 61.44 MHz, Loop Bandwidth = 20 kHz

12452-007

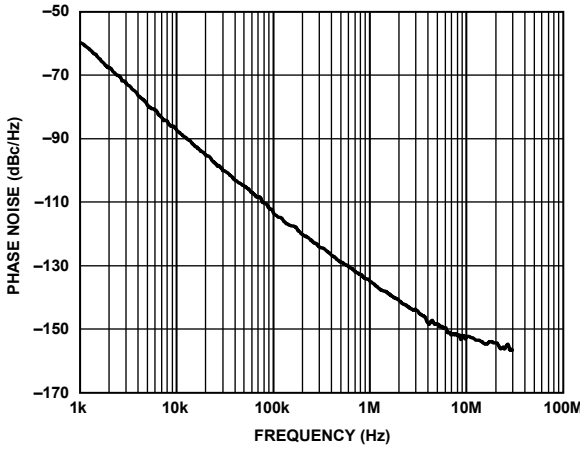


Figure 5. Open-Loop VCO Phase Noise, 5.0 GHz

12452-005

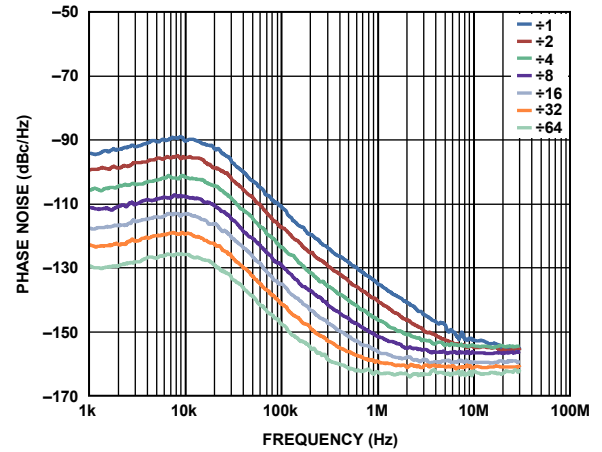


Figure 8. Closed-Loop Phase Noise, RF_{OUTA+} , Fundamental VCO and Dividers, VCO = 5.0 GHz, PFD = 61.44 MHz, Loop Bandwidth = 20 kHz

12452-008

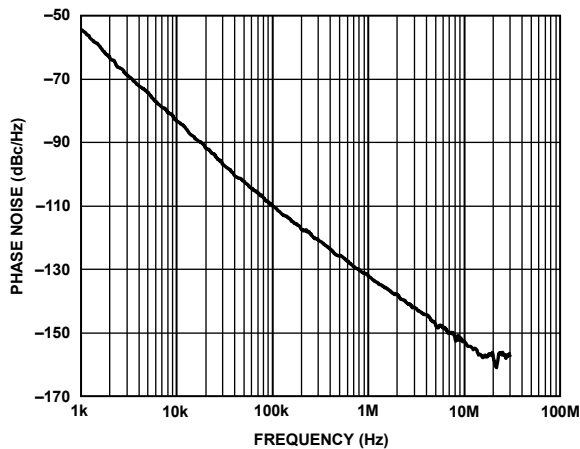


Figure 6. Open-Loop VCO Phase Noise, 6.8 GHz

12452-006

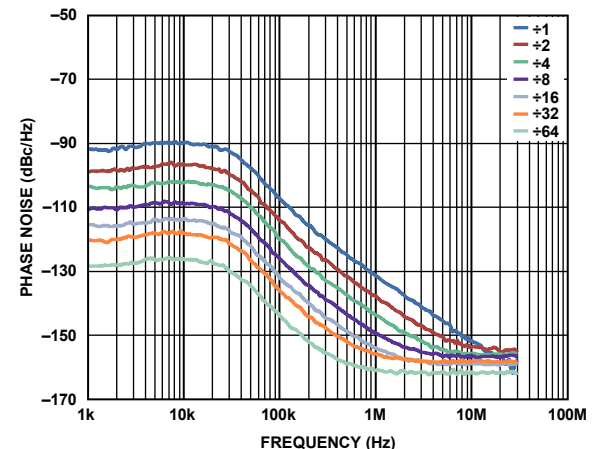


Figure 9. Closed-Loop Phase Noise, RF_{OUTA+} , Fundamental VCO and Dividers, VCO = 6.8 GHz, PFD = 61.44 MHz, Loop Bandwidth = 20 kHz

12452-009

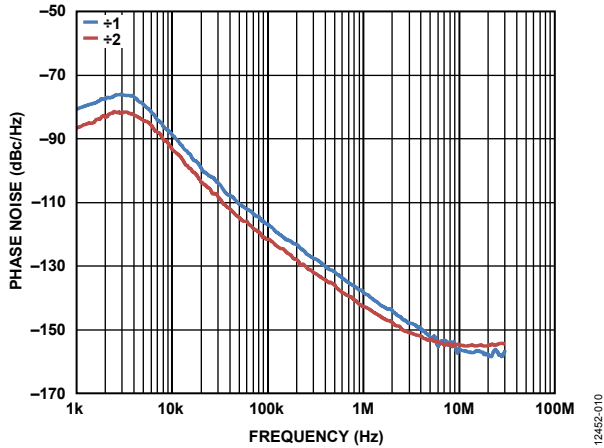


Figure 10. Closed-Loop Phase Noise, RF_{OUTA+} , Fundamental VCO and Divide by 2, VCO = 3.4 GHz, PFD = 61.44 MHz, Loop Bandwidth = 2 kHz

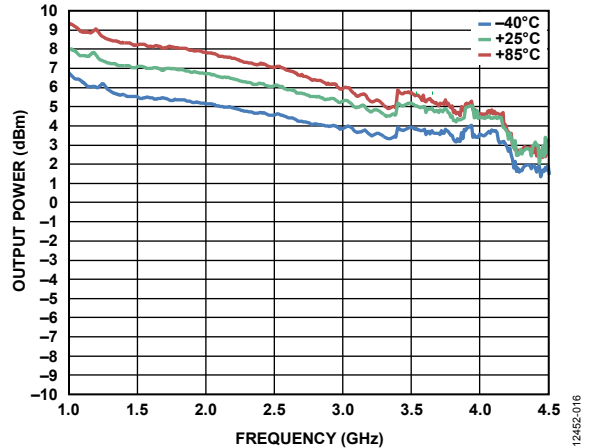


Figure 13. Output Power vs. Frequency, RF_{OUTA+}/RF_{OUTA-} (7.5 nH Inductors, 10 pF Bypass Capacitors, Board Losses De-Embedded)

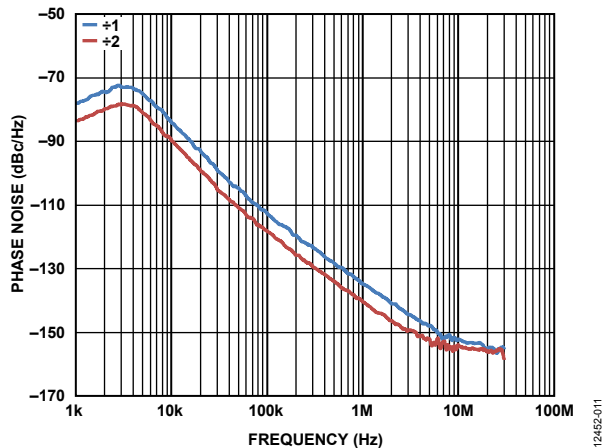


Figure 11. Closed-Loop Phase Noise, RF_{OUTA+} , Fundamental VCO and Divide by 2, VCO = 5.0 GHz, PFD = 61.44 MHz, Loop Bandwidth = 2 kHz

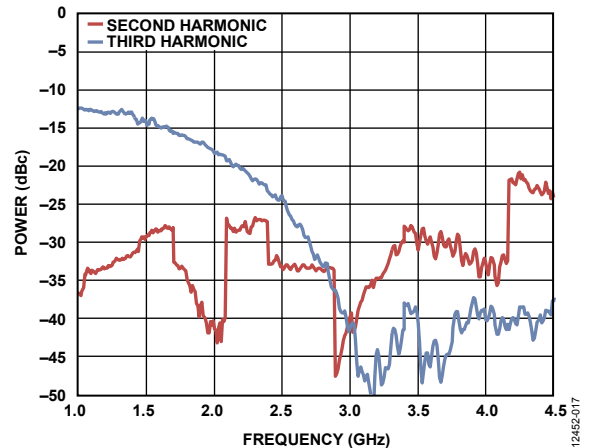


Figure 14. RF_{OUTA+}/RF_{OUTA-} Harmonics vs. Frequency (7.5 nH Inductors, 10 pF Bypass Capacitors, Board Losses De-Embedded)

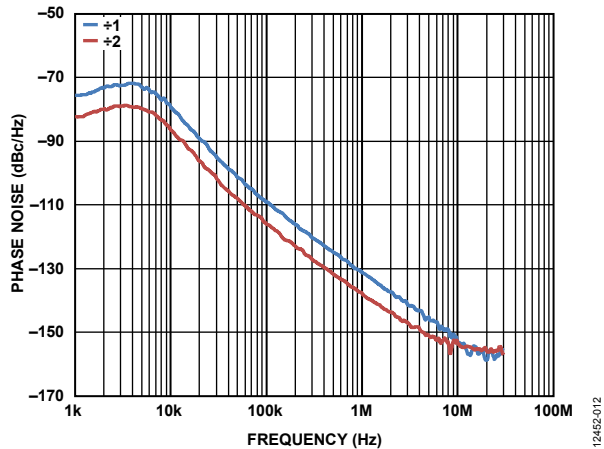


Figure 12. Closed-Loop Phase Noise, RF_{OUTA+} , Fundamental VCO and Divide by 2, VCO = 6.8 GHz, PFD = 61.44 MHz, Loop Bandwidth = 2 kHz

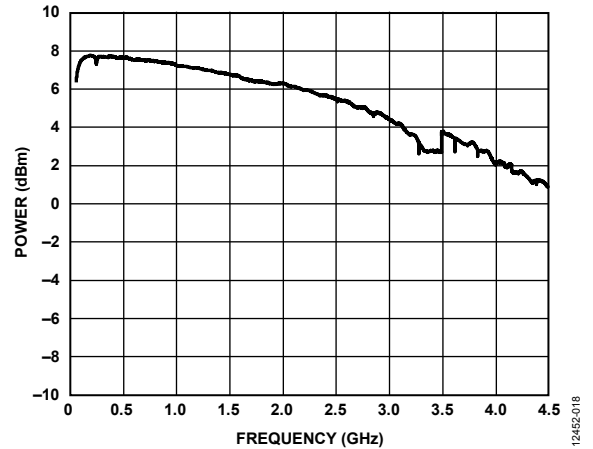


Figure 15. RF_{OUTA+}/RF_{OUTA-} Power vs. Frequency (100 nH Inductors, 100 pF Bypass Capacitors, Board Measurement)

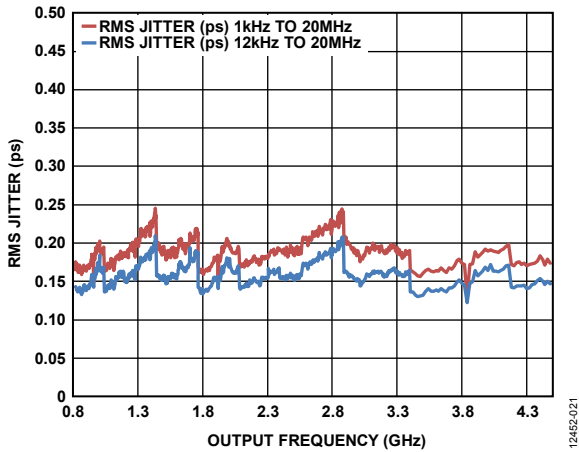


Figure 16. RMS Jitter vs. Output Frequency, PFD Frequency = 61.44 MHz, Loop Filter = 20 kHz

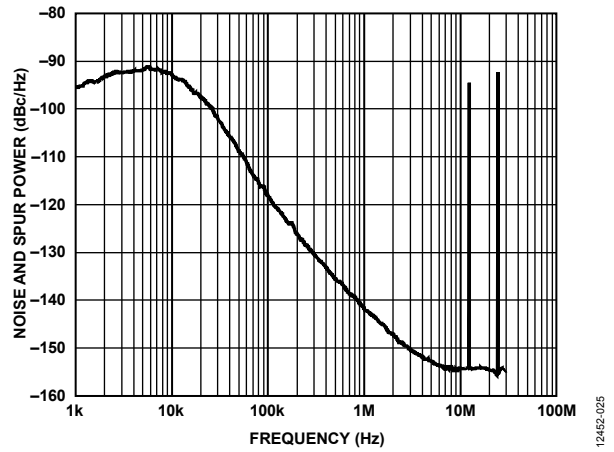


Figure 19. Fractional-N Spur Performance, W-CDMA Band, $RF_{OUTA+} = 2113.5$ MHz, $REF_{IN} = 122.88$ MHz, PFD = 61.44 MHz, Output Divide by 2 Selected, Loop Filter Bandwidth = 2 kHz, Channel Spacing = 20 kHz

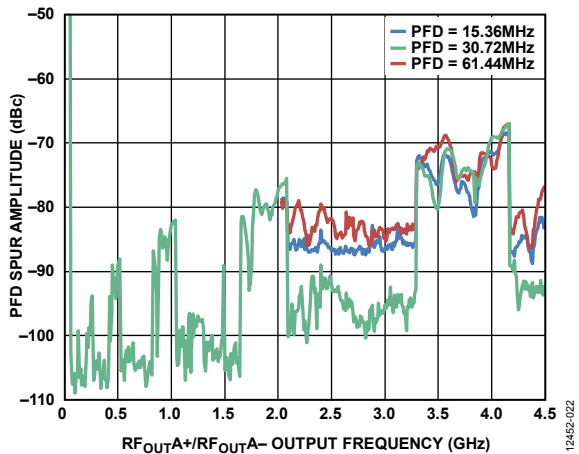


Figure 17. PFD Spur Amplitude vs. RF_{OUTA+}/RF_{OUTA-} Output Frequency, PFD = 15.36 MHz, PFD = 30.72 MHz, PFD = 61.44 MHz, Loop Filter = 20 kHz

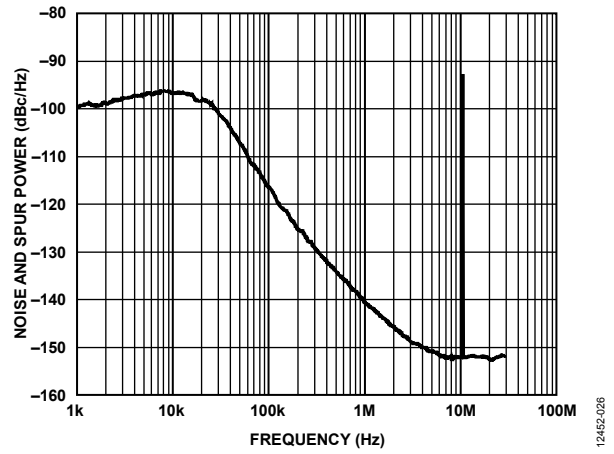


Figure 20. Fractional-N Spur Performance, $RF_{OUTA+} = 2.591$ GHz, $REF_{IN} = 122.88$ MHz, PFD = 61.44 MHz, Output Divide by 2 Selected, Loop Filter Bandwidth = 2 kHz, Channel Spacing = 20 kHz

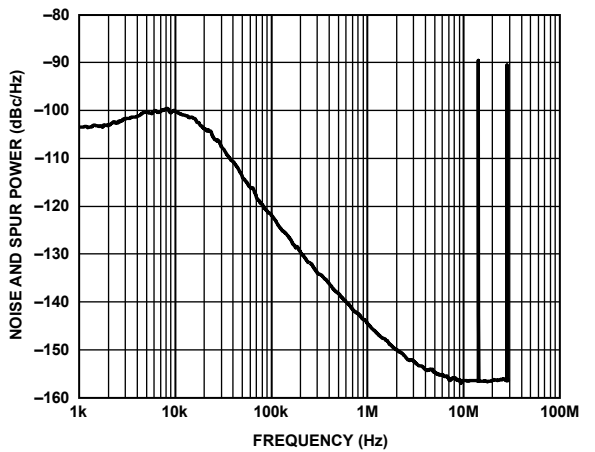


Figure 18. Fractional-N Spur Performance, GSM1800 Band, $RF_{OUTA+} = 1550.2$ MHz, $REF_{IN} = 122.88$ MHz, PFD = 61.44 MHz, Output Divide by 4 Selected, Loop Filter Bandwidth = 2 kHz, Channel Spacing = 20 kHz

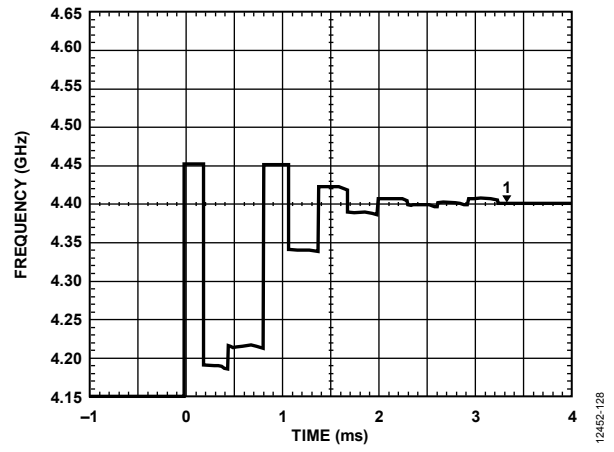


Figure 21. Lock Time for 250 MHz Jump from 4150 MHz to 4400 MHz, Loop Bandwidth = 20 kHz

CIRCUIT DESCRIPTION

REFERENCE INPUT SECTION

Figure 22 shows the reference input stage. The reference input can accept both single-ended and differential signals. Use the reference mode bit (Register 4, Bit DB9) to select the signal. To use a differential signal on the reference input, program this bit high. In this case, SW1 and SW2 are open, SW3 and SW4 are closed, and the current source that drives the differential pair of transistors switches on. The differential signal is buffered and it is provided to an emitter coupled logic (ECL) to CMOS converter. When a single-ended signal is used as the reference, program Bit DB9 in Register 4 to 0. Connect the single-ended reference signal to REF_{IN}A. In this case, SW1 and SW2 are closed, SW3 and SW4 are open, and the current source that drives the differential pair of transistors switches off.

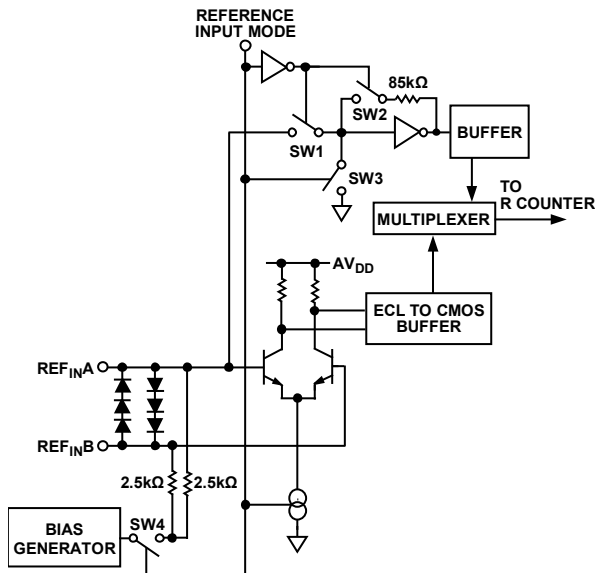


Figure 22. Reference Input Stage

RF N DIVIDER

The RF N divider allows a division ratio in the PLL feedback path. Determine the division ratio by the INT, FRAC1, FRAC2, and MOD2 values that this divider comprises.

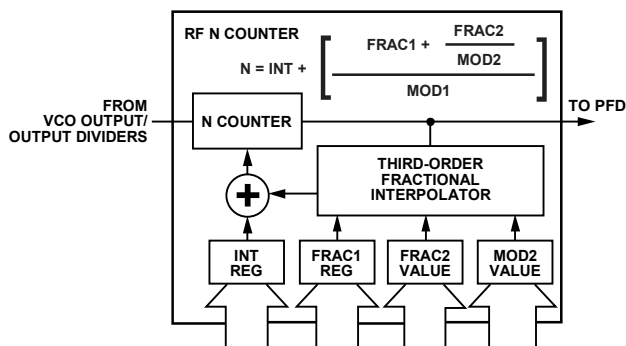


Figure 23. RF N Divider

INT, FRAC, MOD, and R Counter Relationship

The INT, FRAC1, FRAC2, MOD1, and MOD2 values, in conjunction with the R counter, make it possible to generate output frequencies that are spaced by fractions of the PFD frequency (f_{PFD}). For more information, see the RF Synthesizer—A Worked Example section.

Calculate the RF VCO frequency (VCO_{OUT}) by

$$VCO_{OUT} = f_{PFD} \times N \quad (1)$$

where:

VCO_{OUT} is the output frequency of the VCO (without using the output divider).

f_{PFD} is the frequency of the phase frequency detector.

N is the desired value of the feedback counter, N .

Calculate f_{PFD} by

$$f_{PFD} = REF_{IN} \times [(1 + D)/(R \times (1 + T))] \quad (2)$$

where:

REF_{IN} is the reference input frequency.

D is the REF_{IN} doubler bit.

R is the preset divide ratio of the binary 10-bit programmable reference counter (1 to 1023).

T is the REF_{IN} divide by 2 bit (0 or 1).

N comprises

$$N = INT + \frac{FRAC1 + \frac{FRAC2}{MOD2}}{MOD1} \quad (3)$$

where:

INT is the 16-bit integer value (23 to 32,767 for the 4/5 prescaler, 75 to 65,535 for the 8/9 prescaler).

$FRAC1$ is the numerator of the primary modulus (0 to 16,777,215).

$FRAC2$ is the numerator of the 14-bit auxiliary modulus (0 to 16,383).

$MOD2$ is the programmable, 14-bit auxiliary fractional modulus (2 to 16,383).

$MOD1$ is a 24-bit primary modulus with a fixed value of $2^{24} = 16,777,216$.

Equation 3 results in a very fine frequency resolution with no residual frequency error. To apply this formula, take the following steps:

1. Calculate N by dividing VCO_{OUT}/f_{PFD} .
2. The integer value of this number forms INT .
3. Subtract the INT value from the full N value.
4. Multiply the remainder by 2^{24} .
5. The integer value of this number forms $FRAC1$.
6. Calculate $MOD2$ based on the channel spacing (f_{CHSP}) by

$$MOD2 = f_{PFD}/GCD(f_{PFD}, f_{CHSP}) \quad (4)$$

where:

$GCD(f_{PFD}, f_{CHSP})$ is the greatest common divider of the PFD frequency and the channel spacing frequency.

f_{CHSP} is the desired channel spacing frequency.

7. Calculate FRAC2 by the following equation:

$$FRAC2 = [(N - INT) \times 2^{24} - FRAC1] \times MOD2 \quad (5)$$

The FRAC2 and MOD2 fraction results in outputs with zero frequency error for channel spacings when

$$f_{PFD}/GCD(f_{PFD}/f_{CHSP}) < 16,383 \quad (6)$$

where:

- f_{PFD} is the frequency of the phase frequency detector.
- GCD is a greatest common denominator function.
- f_{CHSP} is the desired channel spacing frequency.

If zero frequency error is not required, the MOD1 and MOD2 denominators operate together to create a 38-bit resolution modulus.

INT N Mode

When FRAC1 and FRAC2 = 0, the synthesizer operates in integer-N mode.

R Counter

The 10-bit R counter allows the input reference frequency (REF_{IN}) to be divided down to produce the reference clock to the PFD. Division ratios from 1 to 1023 are allowed.

PHASE FREQUENCY DETECTOR (PFD) AND CHARGE PUMP

The PFD takes inputs from the R counter and N counter and produces an output proportional to the phase and frequency difference between them. Figure 24 is a simplified schematic of the phase frequency detector. The PFD includes a fixed delay element that sets the width of the antibacklash pulse. This pulse ensures that there is no dead zone in the PFD transfer function and provides a consistent reference spur level. Set the phase detector polarity to positive on this device because of the positive tuning of the VCO.

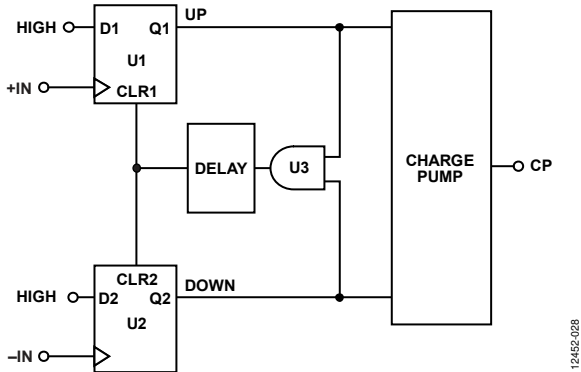


Figure 24. PFD Simplified Schematic

MUXOUT AND LOCK DETECT

The output multiplexer on the ADF4355-2 allows the user to access various internal points on the chip. The M3, M2, and M1 bits in Register 4 control the state of MUXOUT. Figure 25 shows the MUXOUT section in block diagram form.

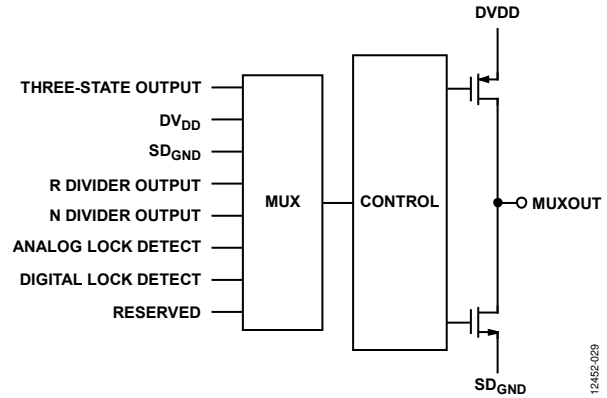


Figure 25. MUXOUT Schematic

INPUT SHIFT REGISTERS

The ADF4355-2 digital section includes a 10-bit R counter, a 16-bit RF integer-N counter, a 24-bit FRAC1 counter, a 14-bit auxiliary fractional counter, and a 14-bit auxiliary modulus counter. Data clocks into the 32-bit shift register on each rising edge of CLK. The data clocks in MSB first. Data transfers from the shift register to one of 12 latches on the rising edge of LE. The state of the four control bits (C4, C3, C2, and C1) in the shift register determines the destination latch. As shown in Figure 2, the four LSBs are DB3, DB2, DB1, and DB0. The truth table for these bits is shown in Table 5. Figure 28 and Figure 29 summarize the programming of the latches.

Table 5. Truth Table for the C4, C3, C2, and C1 Control Bits

| Control Bits | | | | Register |
|--------------|----|----|----|-------------|
| C4 | C3 | C2 | C1 | |
| 0 | 0 | 0 | 0 | Register 0 |
| 0 | 0 | 0 | 1 | Register 1 |
| 0 | 0 | 1 | 0 | Register 2 |
| 0 | 0 | 1 | 1 | Register 3 |
| 0 | 1 | 0 | 0 | Register 4 |
| 0 | 1 | 0 | 1 | Register 5 |
| 0 | 1 | 1 | 0 | Register 6 |
| 0 | 1 | 1 | 1 | Register 7 |
| 1 | 0 | 0 | 0 | Register 8 |
| 1 | 0 | 0 | 1 | Register 9 |
| 1 | 0 | 1 | 0 | Register 10 |
| 1 | 0 | 1 | 1 | Register 11 |
| 1 | 1 | 0 | 0 | Register 12 |

PROGRAM MODES

Table 5 and Figure 28 through Figure 42 show the program modes that must be set up in the ADF4355-2.

The following settings in the ADF4355-2 are double buffered: main fractional value (FRAC1), auxiliary modulus value (MOD2), auxiliary fractional value (FRAC2), reference doubler, reference divide by 2 (RDIV2), R counter value, and charge pump current setting. Two events must occur before the ADF4355-2 uses a new value for any of the double buffered settings. First, the new value must latch into the device by writing to the appropriate register, and second, a new write to Register 0 must be performed.

For example, to ensure that the modulus value loads correctly, every time the modulus value updates, Register 0 must be written to. The RF divider select in Register 6 is also double buffered, but only when DB14 of Register 4 is high.

VCO

The VCO core in the ADF4355-2 consists of four separate VCOs, each of which uses 256 overlapping bands, which allows covering a wide frequency range without a large VCO sensitivity (K_V) and without resultant poor phase noise and spurious performance.

The correct VCO and band are chosen automatically by the VCO and band select logic when Register 0 is updated and auto-calibration is enabled. The VCO V_{TUNE} is disconnected from the output of the loop filter and is connected to an internal reference voltage.

The R counter output is used as the clock for the band select logic. After band selection, normal PLL action resumes. The nominal value of K_V is 15 MHz/V when the N divider is driven from the VCO output, or the K_V value is divided by D. D is the output divider value if the N divider is driven from the RF output divider (chosen by programming Bits[D23:D21] in Register 6).

The VCO shows variation of K_V as the tuning voltage, V_{TUNE} , varies within the band and from band to band. For wideband applications covering a wide frequency range (and changing output dividers), a value of 15 MHz/V provides the most accurate K_V , because this value is closest to the average value. Figure 26 shows how K_V varies with fundamental VCO frequency along with an average value for the frequency band. Users may prefer this figure when using narrow-band designs.

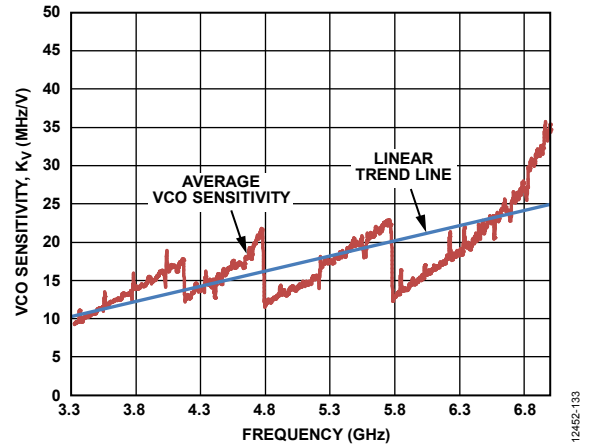


Figure 26. K_V vs. Frequency

OUTPUT STAGE

The RF_{OUTA+} and RF_{OUTA-} pins of the ADF4355-2 connect to the collectors of an NPN differential pair driven by buffered outputs of the VCO, as shown in Figure 27. In this scheme, the ADF4355-2 contains internal 50 Ω resistors connected to the V_{RF} pin. To optimize the power dissipation vs. the output power requirements, the tail current of the differential pair is programmable using Bits[D2:D1] in Register 6. Four current levels can be set. These levels give approximate output power levels of -4 dBm, -1 dBm, +2 dBm, and +5 dBm, respectively, using a 50 Ω resistor to V_{RF} and ac coupling into a 50 Ω load. For accurate power levels, refer to the Typical Performance Characteristics section. With an output power of 5 dBm, an external shunt inductor is necessary to provide higher power levels; however, this addition results in less wideband operation. Terminate the unused complementary output with a similar circuit to the used output.

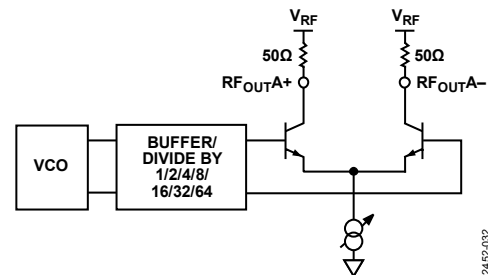


Figure 27. Output Stage

Another feature of the ADF4355-2 is that the supply current to the output stages can shut down until the ADF4355-2 achieves lock as measured by the digital lock detect circuitry. The mute till lock detect (MTLD) bit (DB11) in Register 6 enables this.

The RF_{OUTB+}/RF_{OUTB-} pins are duplicate outputs that can be used independently or in addition to the RF_{OUTA+}/RF_{OUTA-} pins.

Table 6. Total I_{DD} (RF_{OUTA±} Refers to RF_{OUTA+}/RF_{OUTA-})

| Divide By | RF_{OUTA±} Off | RF_{OUTA±} = -4 dBm | RF_{OUTA±} = -1 dBm | RF_{OUTA±} = +2 dBm | RF_{OUTA±} = +5 dBm |
|---|-------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|
| 5 V Supply (I _{VCO} and I _P) | 78 mA | 78 mA | 78 mA | 78 mA | 78 mA |
| 3.3 V Supply (A _{I_{DD}} , D _{I_{DD}} , I _{RF}) | | | | | |
| 1 | 79.8 mA | 101.3 mA | 111.9 mA | 122.7 mA | 132.8 mA |
| 2 | 87.8 mA | 110.1 mA | 120.6 mA | 131.9 mA | 141.9 mA |
| 4 | 97.1 mA | 119.3 mA | 130.1 mA | 141.6 mA | 152.1 mA |
| 8 | 104.9 mA | 127.1 mA | 137.8 mA | 149.2 mA | 159.7 mA |
| 16 | 109.8 mA | 131.8 mA | 142.7 mA | 154.1 mA | 164.6 mA |
| 32 | 113.6 mA | 135.5 mA | 146.5 mA | 157.8 mA | 168.4 mA |
| 64 | 115.9 mA | 137.8 mA | 148.9 mA | 160.1 mA | 170.8 mA |

REGISTER MAPS

REGISTER 0

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|----------|------|------|------|------|------|------|------|------|------|---------|-----------|----------------------------|------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|--------------|-------|-------|-------|
| RESERVED | | | | | | | | | | AUTOCAL | PRESCALER | 16-BIT INTEGER VALUE (INT) | | | | | | | | | | | | | | | | CONTROL BITS | | | |
| DB31 | DB30 | DB29 | DB28 | DB27 | DB26 | DB25 | DB24 | DB23 | DB22 | DB21 | DB20 | DB19 | DB18 | DB17 | DB16 | DB15 | DB14 | DB13 | DB12 | DB11 | DB10 | DB9 | DB8 | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | AC1 | PR1 | N16 | N15 | N14 | N13 | N12 | N11 | N10 | N9 | N8 | N7 | N6 | N5 | N4 | N3 | N2 | N1 | C4(0) | C3(0) | C2(0) | C1(0) |

REGISTER 1

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|----------|------|------|------|---|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|--------------|-------|-------|-------|
| RESERVED | | | | 24-BIT MAIN FRACTIONAL VALUE (FRAC1) DBR ¹ | | | | | | | | | | | | | | | | | | | | | | | | CONTROL BITS | | | |
| DB31 | DB30 | DB29 | DB28 | DB27 | DB26 | DB25 | DB24 | DB23 | DB22 | DB21 | DB20 | DB19 | DB18 | DB17 | DB16 | DB15 | DB14 | DB13 | DB12 | DB11 | DB10 | DB9 | DB8 | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
| 0 | 0 | 0 | 0 | F24 | F23 | F22 | F21 | F20 | F19 | F18 | F17 | F16 | F15 | F14 | F13 | F12 | F11 | F10 | F9 | F8 | F7 | F6 | F5 | F4 | F3 | F2 | F1 | C4(0) | C3(0) | C2(0) | C1(1) |

REGISTER 2

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|--|------|------|------|------|------|------|------|------|------|------|------|------|------|--|------|------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|--------------|-------|-------|-------|
| 14-BIT AUXILIARY FRACTIONAL VALUE (FRAC2) DBR ¹ | | | | | | | | | | | | | | 14-BIT AUXILIARY MODULUS VALUE (MOD2) DBR ¹ | | | | | | | | | | | | | | CONTROL BITS | | | |
| DB31 | DB30 | DB29 | DB28 | DB27 | DB26 | DB25 | DB24 | DB23 | DB22 | DB21 | DB20 | DB19 | DB18 | DB17 | DB16 | DB15 | DB14 | DB13 | DB12 | DB11 | DB10 | DB9 | DB8 | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
| F14 | F13 | F12 | F11 | F10 | F9 | F8 | F7 | F6 | F5 | F4 | F3 | F2 | F1 | M14 | M13 | M12 | M11 | M10 | M9 | M8 | M7 | M6 | M5 | M4 | M3 | M2 | M1 | C4(0) | C3(0) | C2(1) | C1(0) |

REGISTER 3

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|----------|---------------|--------------|--------------|---|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|--------------|-------|-------|-------|
| RESERVED | SD LOAD RESET | PHASE RESYNC | PHASE ADJUST | 24-BIT PHASE VALUE (PHASE) DBR ¹ | | | | | | | | | | | | | | | | | | | | | | | | CONTROL BITS | | | |
| DB31 | DB30 | DB29 | DB28 | DB27 | DB26 | DB25 | DB24 | DB23 | DB22 | DB21 | DB20 | DB19 | DB18 | DB17 | DB16 | DB15 | DB14 | DB13 | DB12 | DB11 | DB10 | DB9 | DB8 | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
| 0 | SD1 | PR1 | PA1 | P24 | P23 | P22 | P21 | P20 | P19 | P18 | P17 | P16 | P15 | P14 | P13 | P12 | P11 | P10 | P9 | P8 | P7 | P6 | P5 | P4 | P3 | P2 | P1 | C4(0) | C3(0) | C2(1) | C1(1) |

REGISTER 4

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|----------|--------|------|------|------------------------------------|------------------------|-----------------------------------|------|------|------|------|------|------|------|------|------|-------------|----------------------------------|----------|-----------|-------------|------|----------------|---------------|--------------|-----|-----|-----|-------|-------|-------|-------|
| RESERVED | MUXOUT | | | REFERENCE DOUBLER DBR ¹ | RDIV2 DBR ¹ | 10-BIT R COUNTER DBR ¹ | | | | | | | | | | DOUBLE BUFF | CURRENT SETTING DBR ¹ | REF MODE | MUX LOGIC | PD POLARITY | PD | CP THREE-STATE | COUNTER RESET | CONTROL BITS | | | | | | | |
| DB31 | DB30 | DB29 | DB28 | DB27 | DB26 | DB25 | DB24 | DB23 | DB22 | DB21 | DB20 | DB19 | DB18 | DB17 | DB16 | DB15 | DB14 | DB13 | DB12 | DB11 | DB10 | DB9 | DB8 | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
| 0 | 0 | M3 | M2 | M1 | RD2 | RD1 | R10 | R9 | R8 | R7 | R6 | R5 | R4 | R3 | R2 | R1 | D1 | CP4 | CP3 | CP2 | CP1 | U6 | U5 | U4 | U3 | U2 | U1 | C4(0) | C3(1) | C2(0) | C1(0) |

REGISTER 5

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|----------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|--------------|-----|-------|-------|-------|-------|
| RESERVED | | | | | | | | | | | | | | | | | | | | | | | | | | | | CONTROL BITS | | | | | |
| DB31 | DB30 | DB29 | DB28 | DB27 | DB26 | DB25 | DB24 | DB23 | DB22 | DB21 | DB20 | DB19 | DB18 | DB17 | DB16 | DB15 | DB14 | DB13 | DB12 | DB11 | DB10 | DB9 | DB8 | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | C4(0) | C3(1) | C2(0) | C1(1) |

REGISTER 6

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|----------|-------------|----------------|----------|------|------|------|-----------------|--------------------------------|---------------------------|------|------|------|------|------|------|------|------|------|----------|------|----------|----------------------|---------------------|------------------|-----------------|--------------|-----|-------|-------|-------|-------|
| RESERVED | GATED BLEED | NEGATIVE BLEED | RESERVED | | | | FEEDBACK SELECT | RF DIVIDER SELECT ² | CHARGE PUMP BLEED CURRENT | | | | | | | | | | RESERVED | MTLD | RESERVED | AUX RF OUTPUT ENABLE | AUX RF OUTPUT POWER | RF OUTPUT ENABLE | RF OUTPUT POWER | CONTROL BITS | | | | | |
| DB31 | DB30 | DB29 | DB28 | DB27 | DB26 | DB25 | DB24 | DB23 | DB22 | DB21 | DB20 | DB19 | DB18 | DB17 | DB16 | DB15 | DB14 | DB13 | DB12 | DB11 | DB10 | DB9 | DB8 | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
| 0 | BL10 | BL9 | 1 | 0 | 1 | 0 | D13 | D12 | D11 | D10 | BL8 | BL7 | BL6 | BL5 | BL4 | BL3 | BL2 | BL1 | 0 | D8 | 0 | D6 | D5 | D4 | D3 | D2 | D1 | C4(0) | C3(1) | C2(1) | C1(0) |

¹DBR = DOUBLE BUFFERED REGISTER—BUFFERED BY THE WRITE TO REGISTER 0.
²DBB = DOUBLE BUFFERED BITS—BUFFERED BY A WRITE TO REGISTER 0 WHEN BIT DB14 OF REGISTER 4 IS HIGH.

Figure 28. Register Summary (Register 0 to Register 6)

12452-2/34

REGISTER 7

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|----------|------|------|------|------|------|------|------|------|------|---------|----------|------|------|------|------|------|------|------|------|------|----------------|----------|---------------------|----------|--------------|-----|-----|-----|-------|-------|-------|-------|
| RESERVED | | | | | | | | | | LE SYNC | RESERVED | | | | | | | | | | LD CYCLE COUNT | LOL MODE | FRAC-N LD PRECISION | LDO MODE | CONTROL BITS | | | | | | | |
| DB31 | DB30 | DB29 | DB28 | DB27 | DB26 | DB25 | DB24 | DB23 | DB22 | DB21 | DB20 | DB19 | DB18 | DB17 | DB16 | DB15 | DB14 | DB13 | DB12 | DB11 | DB10 | DB9 | DB8 | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 | |
| 0 | 0 | 0 | 1 | 0 | 0 | LE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | LD5 | LD4 | LOL | LD3 | LD2 | LD1 | C4(0) | C3(1) | C2(1) | C1(1) |

REGISTER 8

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|----------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|--------------|-------|-------|-------|-------|
| RESERVED | | | | | | | | | | | | | | | | | | | | | | | | | | | | CONTROL BITS | | | | |
| DB31 | DB30 | DB29 | DB28 | DB27 | DB26 | DB25 | DB24 | DB23 | DB22 | DB21 | DB20 | DB19 | DB18 | DB17 | DB16 | DB15 | DB14 | DB13 | DB12 | DB11 | DB10 | DB9 | DB8 | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 | |
| 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | C4(1) | C3(0) | C2(0) | C1(0) |

REGISTER 9

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-------------------|------|------|------|------|------|------|------|---------|------|------|------|------|------|------|------|-------------------------|------|------|------|------|--------------------------|-----|-----|-----|--------------|-----|-----|-------|-------|-------|-------|
| VCO BAND DIVISION | | | | | | | | TIMEOUT | | | | | | | | AUTOMATIC LEVEL TIMEOUT | | | | | SYNTHESIZER LOCK TIMEOUT | | | | CONTROL BITS | | | | | | |
| DB31 | DB30 | DB29 | DB28 | DB27 | DB26 | DB25 | DB24 | DB23 | DB22 | DB21 | DB20 | DB19 | DB18 | DB17 | DB16 | DB15 | DB14 | DB13 | DB12 | DB11 | DB10 | DB9 | DB8 | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
| VC8 | VC7 | VC6 | VC5 | VC4 | VC3 | VC2 | VC1 | TL10 | TL9 | TL8 | TL7 | TL6 | TL5 | TL4 | TL3 | TL2 | TL1 | AL5 | AL4 | AL3 | AL2 | AL1 | SL5 | SL4 | SL3 | SL2 | SL1 | C4(1) | C3(0) | C2(0) | C1(1) |

REGISTER 10

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|----------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-------------------|------|------|------|------|------|-----|-----|----------------|------------|--------------|-----|-------|-------|-------|-------|
| RESERVED | | | | | | | | | | | | | | | | ADC CLOCK DIVIDER | | | | | | | | ADC CONVERSION | ADC ENABLE | CONTROL BITS | | | | | |
| DB31 | DB30 | DB29 | DB28 | DB27 | DB26 | DB25 | DB24 | DB23 | DB22 | DB21 | DB20 | DB19 | DB18 | DB17 | DB16 | DB15 | DB14 | DB13 | DB12 | DB11 | DB10 | DB9 | DB8 | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | AD8 | AD7 | AD6 | AD5 | AD4 | AD3 | AD2 | AD1 | AE2 | AE1 | C4(1) | C3(0) | C2(1) | C1(0) |

REGISTER 11

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|----------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|--------------|-------|-------|-------|
| RESERVED | | | | | | | | | | | | | | | | | | | | | | | | | | | | CONTROL BITS | | | |
| DB31 | DB30 | DB29 | DB28 | DB27 | DB26 | DB25 | DB24 | DB23 | DB22 | DB21 | DB20 | DB19 | DB18 | DB17 | DB16 | DB15 | DB14 | DB13 | DB12 | DB11 | DB10 | DB9 | DB8 | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | C4(1) | C3(0) | C2(1) | C1(1) |

REGISTER 12

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|--------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|----------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|--------------|-------|-------|-------|
| RESYNC CLOCK | | | | | | | | | | | | | | | | RESERVED | | | | | | | | | | | | CONTROL BITS | | | |
| DB31 | DB30 | DB29 | DB28 | DB27 | DB26 | DB25 | DB24 | DB23 | DB22 | DB21 | DB20 | DB19 | DB18 | DB17 | DB16 | DB15 | DB14 | DB13 | DB12 | DB11 | DB10 | DB9 | DB8 | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
| P16 | P15 | P14 | P13 | P12 | P11 | P10 | P9 | P8 | P7 | P6 | P5 | P4 | P3 | P2 | P1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | C4(1) | C3(1) | C2(0) | C1(0) |

Figure 29. Register Summary (Register 7 to Register 12)

12462-035

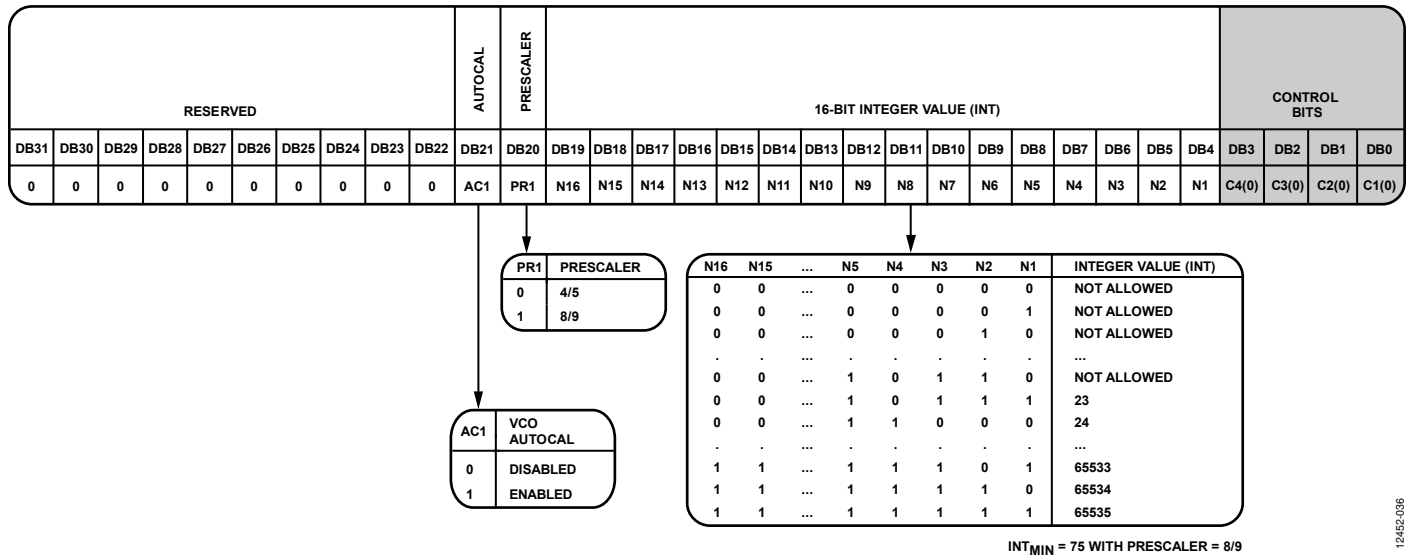


Figure 30. Register 0

REGISTER 0

Control Bits

With Bits[C4:C1] set to 0000, Register 0 is programmed. Figure 30 shows the input data format for programming this register.

Reserved

Bits[DB31:DB22] are reserved and must be set to 0.

Automatic Calibration (Autocalibration)

Write to Register 0 to enact (by default) the VCO autocalibration, and to choose the appropriate VCO and VCO subband. Write 1 to the AC1 bit (Bit DB21) to enable the autocalibration, which is the recommended mode of operation.

Set the AC1 bit to 0 to disable the autocalibration, which leaves the ADF4355-2 in the same band it was already in when Register 0 is updated.

Disable the autocalibration only for fixed frequency applications, phase adjust applications, or very small (<10 kHz) frequency jumps. Toggling autocalibration is also required when changing frequency (see the Frequency Update Sequence section for additional details).

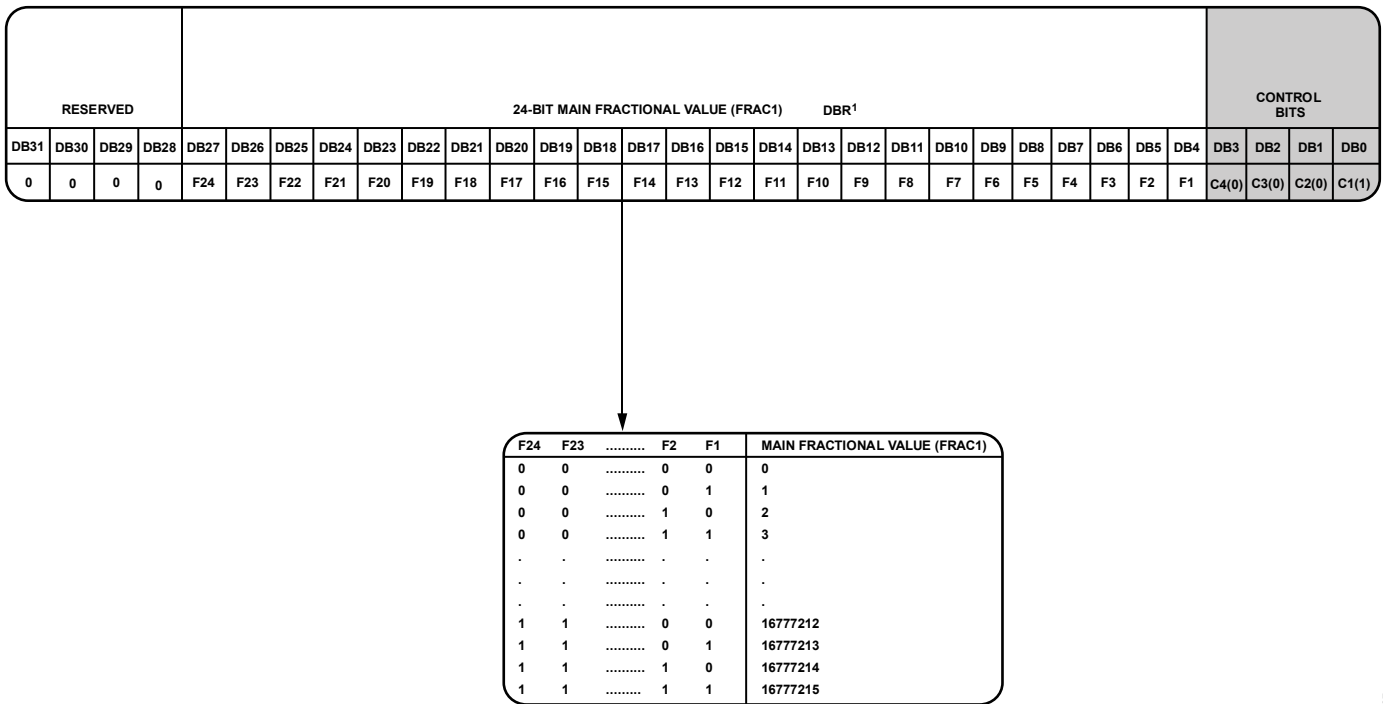
Prescaler Value

The dual modulus prescaler (P/P + 1), along with the INT, FRACx, and MODx counters, determines the overall division ratio from the VCO output to the PFD input. The PR1 bit (Bit DB20) in Register 0 sets the prescaler value.

Operating at CML levels, the prescaler takes the clock from the VCO output and divides it down for the counters. It is based on a synchronous 4/5 core. When the prescaler is set to 4/5, the maximum RF frequency allowed is 7 GHz. The prescaler limits the INT value; therefore, if P is 4/5, N_{MIN} is 23, and if P is 8/9, N_{MIN} is 75.

16-Bit Integer Value

The 16 INT bits (Bits[DB19:DB4]) set the INT value, which determines the integer part of the feedback division factor. The INT value is used in Equation 3 (see the INT, FRAC, MOD, and R Counter Relationship section). All integer values from 23 to 32,767 are allowed for the 4/5 prescaler. For the 8/9 prescaler, the minimum integer value is 75, and the maximum value is 65,535.



¹DBR = DOUBLE BUFFERED REGISTER—BUFFERED BY THE WRITE TO REGISTER 0.

Figure 31. Register 1

REGISTER 1

Control Bits

With Bits[C4:C1] set to 0001, Register 1 is programmed. Figure 31 shows the input data format for programming this register.

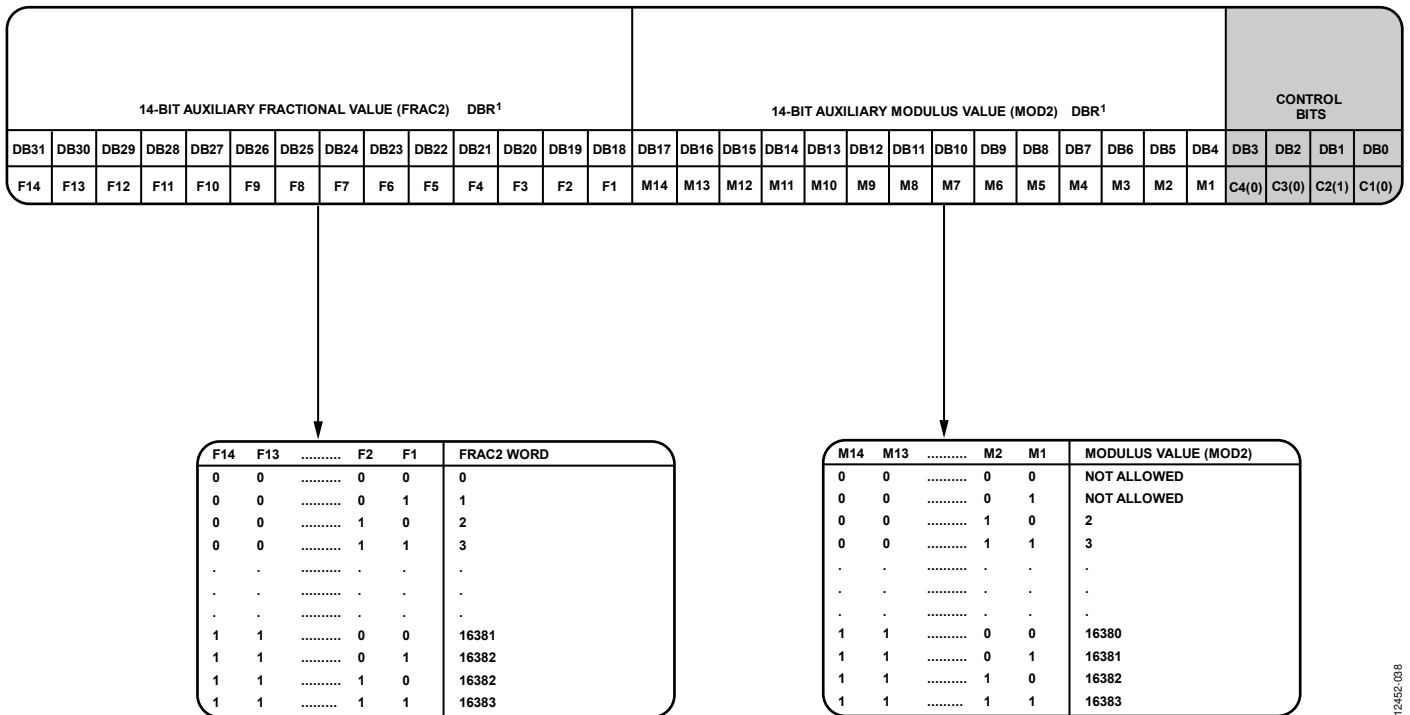
Reserved

Bits[DB31:DB28] are reserved and must be set to 0.

24-Bit Main Fractional Value

The 24 FRAC1 bits (Bits[DB27:DB4]) set the numerator of the fraction that is input to the sigma-delta (Σ - Δ) modulator. This fraction, along with the INT value, specifies the new frequency channel that the synthesizer locks to, as shown in the RF Synthesizer—A Worked Example section. FRAC1 values from 0 to (MOD1 – 1) cover channels over a frequency range equal to the PFD reference frequency.

124452-037



¹DBR = DOUBLE BUFFERED REGISTER—BUFFERED BY THE WRITE TO REGISTER 0.

Figure 32. Register 2

REGISTER 2

Control Bits

With Bits[C4:C1] set to 0010, Register 2 is programmed. Figure 32 shows the input data format for programming this register.

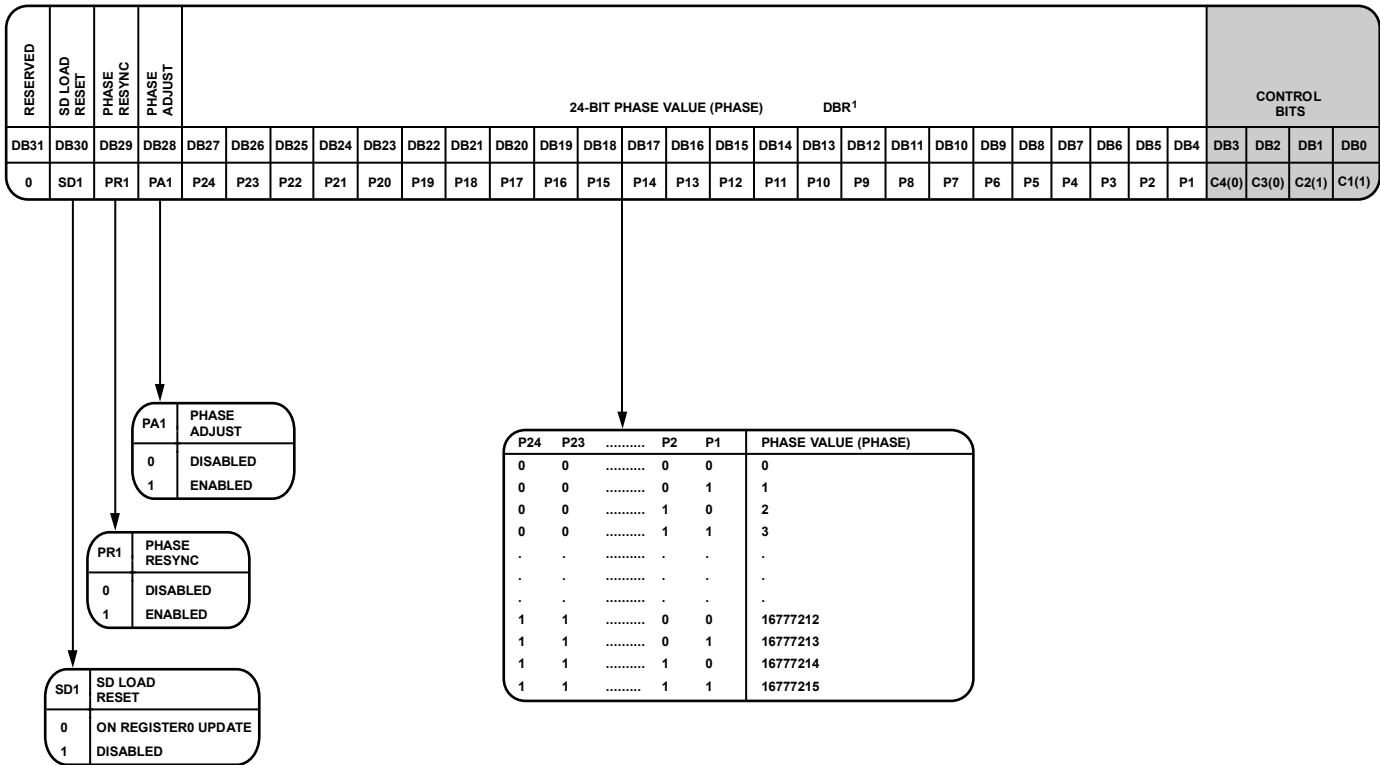
14-Bit Auxiliary Fractional Value (FRAC2)

The 14-bit auxiliary fractional value (Bits[DB31:DB18]) controls the auxiliary fractional word. FRAC2 must be less than the MOD2 value programmed in Register 2.

14-Bit Auxiliary Modulus Value (MOD2)

The 14-bit auxiliary modulus value (Bits[DB17:DB4]) sets the auxiliary fractional modulus. Use MOD2 to correct any residual error due to the main fractional modulus.

12452-008



¹DBR = DOUBLE BUFFERED REGISTER—BUFFERED BY THE WRITE TO REGISTER 0.

Figure 33. Register 3

REGISTER 3

Control Bits

With Bits[C4:C1] set to 0011, Register 3 is programmed. Figure 33 shows the input data format for programming this register.

Reserved

Bit DB31 is reserved and must be set to 0.

SD Load Reset

When writing to Register 0, the Σ-Δ modulator resets. For applications in which the phase is continually adjusted, this may not be desirable; therefore, in these cases, the Σ-Δ reset can be disabled by writing a 1 to the SD1 bit (Bit DB30).

Phase Resync

To use the phase resynchronization feature, the PR1 bit (Bit DB29) must be set to 1. If unused, the bit can be programmed to 0. The phase resync timer must also be used in Register 12 to ensure that the resynchronization feature is applied after PLL has settled to the final frequency. If the PLL has not settled to the final frequency, phase resync may not function correctly. Resynchronization is useful in phased array and beam forming applications. It ensures repeatability of output phase when programming the same frequency. In phase critical applications that use frequencies requiring the output divider (<3400 MHz), it is necessary to feed the N divider with the divided VCO frequency as distinct from the fundamental VCO frequency.

This is achieved by programming the D13 bit (Bit DB24) in Register 6 to 0, which ensures divided feedback to the N divider. Phase resynchronization only operates when FRAC2 = 0.

For resync applications, enable the SD load reset in Register 3 by setting DB30 to 0.

Phase Adjust

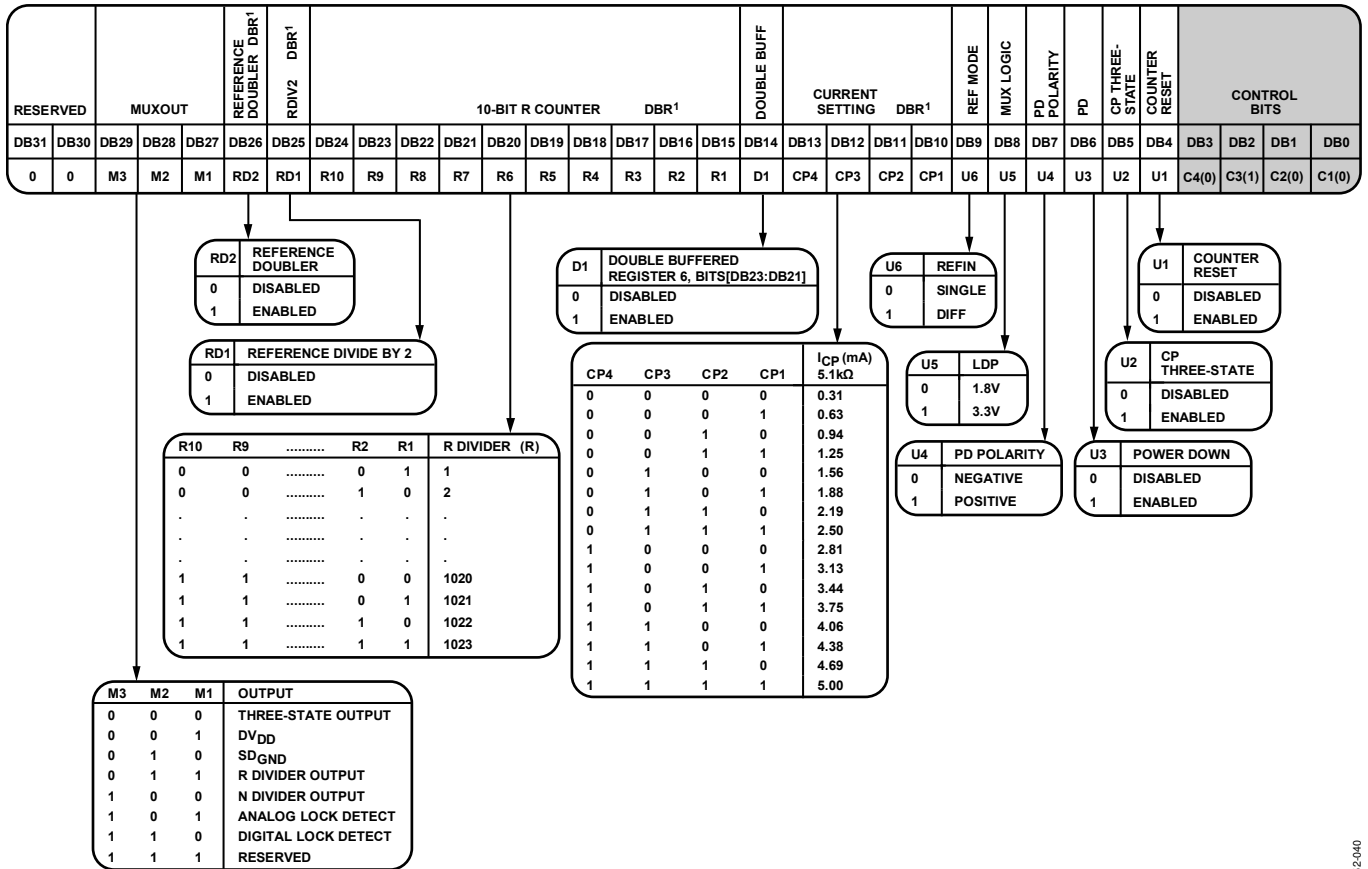
To adjust the relative output phase of the ADF4355-2 on each Register 0 update, set the PA1 bit (Bit DB28) to 1. This feature differs from the resynchronization feature in that it is useful when adjustments to phase are made continually in an application. For this function, disable the VCO autocalibration by setting the AC1 bit (Bit DB21) in Register 0 to 1, and disable the SD load reset by setting the SD1 bit (Bit DB30) in Register 3 to 1. Note that phase resync and phase adjust cannot be used simultaneously.

24-Bit Phase Value

The phase of the RF output frequency can adjust in 24-bit steps; from 0° (0) to 360° (2²⁴ - 1). For phase adjust applications, the phase is set by

$$(Phase\ Value/16,777,216) \times 360^\circ$$

When the phase value is programmed to Register 3, each subsequent adjustment of Register 0 increments the phase by the value in this equation.



¹DBR = DOUBLE BUFFERED REGISTER—BUFFERED BY THE WRITE TO REGISTER 0.

Figure 34. Register 4

REGISTER 4

Control Bits

With Bits[C4:C1] set to 0100, Register 4 is programmed. Figure 34 shows the input data format for programming this register.

Reserved

Bits[DB31:DB30] are reserved and must be set to 0.

MUXOUT

The on-chip multiplexer (MUXOUT) is controlled by Bits[DB29:DB27]. For additional details, see Figure 34.

Reference Doubler

Setting the RD2 bit (Bit DB26) to 0 feeds the REF_{IN} signal directly to the 10-bit R counter, disabling the doubler. Setting this bit to 1 multiplies the reference frequency by a factor of 2 before feeding it into the 10-bit R counter. When the doubler is disabled, the REF_{IN} falling edge is the active edge at the PFD input to the fractional synthesizer. When the doubler is enabled, both the rising and falling edges of the reference frequency become active edges at the PFD input.

The maximum allowable reference frequency when the doubler is enabled is 100 MHz.

RDIV2

Setting the RDIV2 bit (Bit DB25) to 1 inserts a divide by 2 toggle flip-flop between the R counter and PFD, which extends the maximum reference frequency input rate. This function provides a 50% duty cycle signal at the PFD input.

10-Bit R Counter

The 10-bit R counter divides the input reference frequency (REF_{IN}) to produce the reference clock to the PFD. Division ratios range from 1 to 1023.

Double Buffer

The D1 bit (Bit DB14) enables or disables double buffering of the RF divider select bits (Bits[DB23:DB21]) in Register 6. The section explains how double buffering works.

Charge Pump Current Setting

The CP4 to CP1 bits (Bits[DB13:DB10]) set the charge pump current. Set this value to the charge pump current for which the loop filter is designed (see Figure 34). For the lowest spurs, the 0.9 mA setting is recommended.

12452-040

Reference Mode

The ADF4355-2 permits use of either differential or single-ended reference sources. For differential sources, set the reference mode bit (Bit DB9) to 1, and set it to 0 for single-ended sources.

For optimum integer boundary spur performance, use the single-ended setting for all references up to 250 MHz (even if using a differential reference signal). Use the differential setting for reference frequencies above 250 MHz.

Level Select

To assist with logic compatibility, MUXOUT is programmable to two logic levels. Set the U5 bit (Bit DB8) to 0 to select 1.8 V logic, and set it to 1 to select 3.3 V logic.

Phase Detector Polarity

The U4 bit (Bit DB7) sets the phase detector polarity. When a passive loop filter or a noninverting active loop filter is used, set DB7 to 1 (positive). If an active filter with an inverting characteristic is used, set this bit to 0 (negative).

Power-Down

The U3 bit (Bit DB6) sets the programmable power-down mode. Setting DB6 to 1 performs a power-down. Setting DB6 to 0 returns the synthesizer to normal operation. In software power-down mode, the ADF4355-2 retains all information in its registers. The register contents are only lost if the supply voltages are removed.

When power-down activates, the following events occur:

- The synthesizer counters are forced to their load state conditions.
- The VCO powers down.
- The charge pump is forced into three-state mode.
- The digital lock detect circuitry resets.
- The RF_{OUTA+}/RF_{OUTA-} and RF_{OUTB+}/RF_{OUTB-} output stages are disabled.
- The input registers remain active and capable of loading and latching data.

Charge Pump Three-State

Setting the U2 bit (Bit DB5) to 1 puts the charge pump into three-state mode. Set DB5 to 0 for normal operation.

Counter Reset

The U1 bit (Bit DB4) resets the R counter, N counter, and VCO band select of the ADF4355-2. When DB4 is set to 1, the RF synthesizer N counter and R counter and the VCO band select are reset. For normal operation, set DB4 to 0. Toggling counter reset (Bit DB4) is also required when changing frequency (see the Frequency Update Sequence section for additional details).

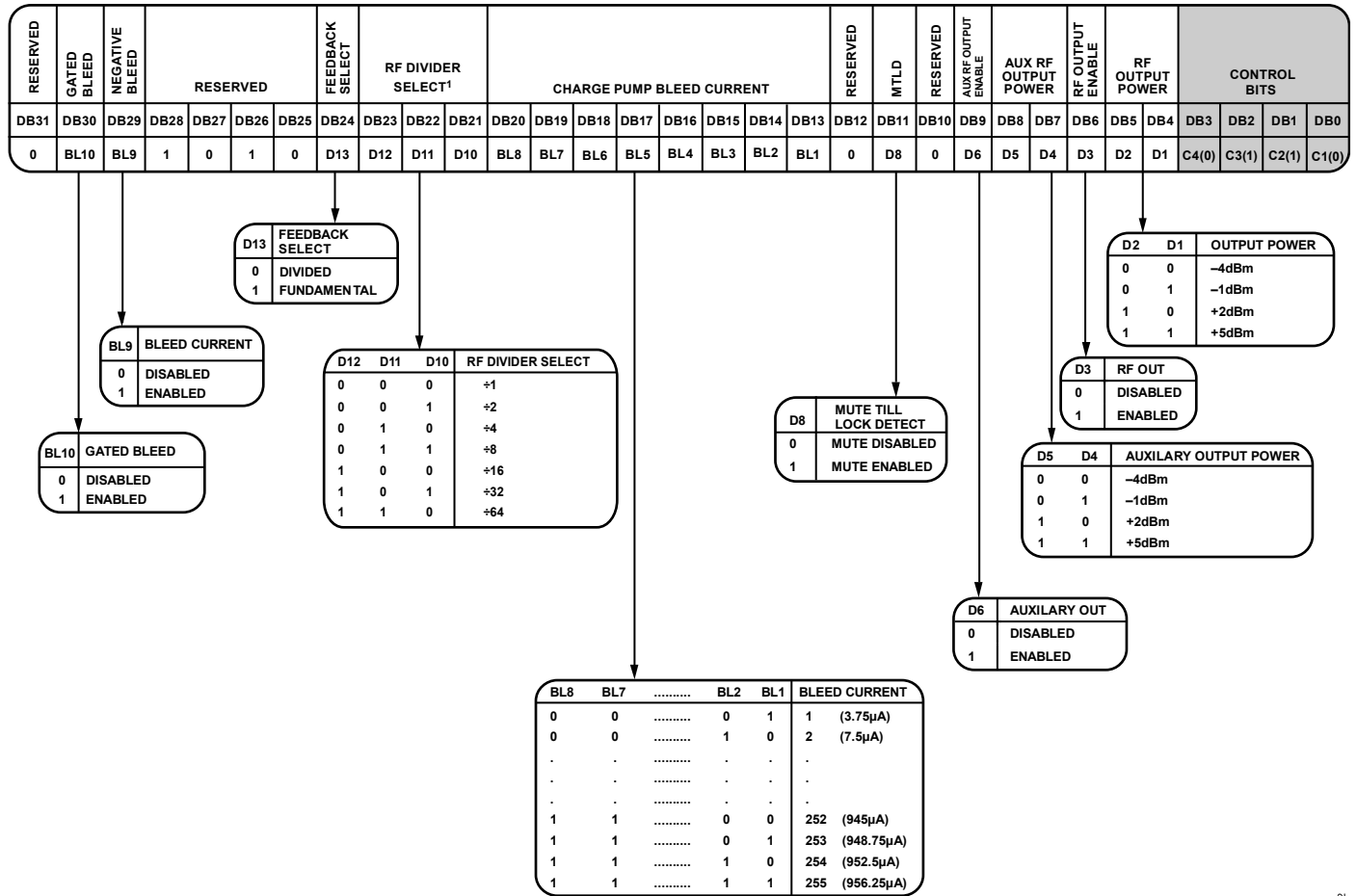
REGISTER 5

The bits in Register 5 are reserved and must be programmed as described in Figure 35, using a hexadecimal word of 0x00800025.

| RESERVED | | | | | | | | | | | | | | | | | | | | | | | | | | | | CONTROL BITS | | | | |
|----------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|--------------|-------|-------|-------|-------|
| DB31 | DB30 | DB29 | DB28 | DB27 | DB26 | DB25 | DB24 | DB23 | DB22 | DB21 | DB20 | DB19 | DB18 | DB17 | DB16 | DB15 | DB14 | DB13 | DB12 | DB11 | DB10 | DB9 | DB8 | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | C4(0) | C3(1) | C2(0) | C1(1) |

Figure 35. Register 5 (0x00800025)

12452-041



¹BITS[DB23:DB21] ARE BUFFERED BY A WRITE TO REGISTER 0 WHEN THE DOUBLE BUFFER BIT IS ENABLED, BIT DB14 OF REGISTER 4.

Figure 36. Register 6

REGISTER 6

Control Bits

With Bits[C4:C1] set to 0110, Register 6 is programmed. Figure 36 shows the input data format for programming this register.

Reserved

Bit DB31 is reserved and must be set to 0.

Gated Bleed

Bleed currents can be used for improving phase noise and spurs. However, due to a potential impact on lock time, the gated bleed bit, BL10 (Bit DB30), if set to 1, ensures bleed currents are not switched on until the digital lock detect asserts logic high. Note that this function requires digital lock detect to be enabled.

Negative Bleed

Use of constant negative bleed is recommended for most applications because it improves the linearity of the charge pump, leading to lower noise and spurious than if the negative bleed is left off. To enable negative bleed, write 1 to BL9 (Bit DB29), and to disable negative bleed, write 0 to BL9 (Bit DB29).

Use negative bleed only when operating in fractional-N mode, that is, $FRAC1 = FRAC2 = 0$. Do not use negative bleed for f_{PPD} greater than 100 MHz.

Reserved

Bits[DB28:DB25] are reserved and must be set to 1010.

Feedback Select

D13 (Bit DB24) selects the feedback from the output of the VCO to the N counter. When D13 is set to 1, the signal is taken directly from the VCO. When this bit is set to 0, the signal is taken from the output of the output dividers. The dividers enable coverage of the wide frequency band (54 MHz to 4.4 GHz). When the divider is enabled and the feedback signal is taken from the output, the RF output signals of two separately configured PLLs are in phase. Divided feedback is useful in some applications where the positive interference of signals is required to increase the power.

Divider Select

D12 to D10 (Bits[DB23:DB21]) select the value of the RF output divider (see Figure 36).

Charge Pump Bleed Current

BL8 to BL1 (Bits[DB20:DB13]) control the level of the bleed current added to the charge pump output. This current optimizes the phase noise and spurious levels from the device.

Tests have shown that the optimal bleed set is the following:

$$4/N < I_{BLEED}/I_{CP} < 10/N$$

where:

I_{BLEED} is the value of constant negative bleed applied to the charge pump, which is set by the contents of Bits[BL8:BL1].
 I_{CP} is the value of charge pump current setting, Bits[DB13:DB10] of Register 4.

N is the value of the feedback counter from the VCO to the PFD.

Reserved

Bit DB12 is reserved and must be set to 0.

Mute Till Lock Detect

When D8 (Bit DB11) is set to 1, the supply current to the RF output stage is shut down until the device achieves lock, as determined by the digital lock detect circuitry.

Reserved

Bit DB10 is reserved and must be set to 0.

Auxiliary RF Output Enable

Bit DB9 enables or disables the auxiliary frequency RF output (RF_{OUTB+}/RF_{OUTB-}). When DB9 is set to 1, the auxiliary frequency RF output is enabled. When DB10 is set to 0, the auxiliary RF output is disabled.

Auxiliary RF Output Power

Bits[DB8:DB7] set the value of the auxiliary RF output power level (see Figure 43).

RF Output Enable

Bit DB6 enables or disables the primary RF output (RF_{OUTA+}/RF_{OUTA-}). If DB6 is set to 0, the primary RF output is disabled; if DB6 is set to 1, the primary RF output is enabled.

Output Power

Bits[DB5:DB4] set the value of the primary RF output power level (see Figure 43).

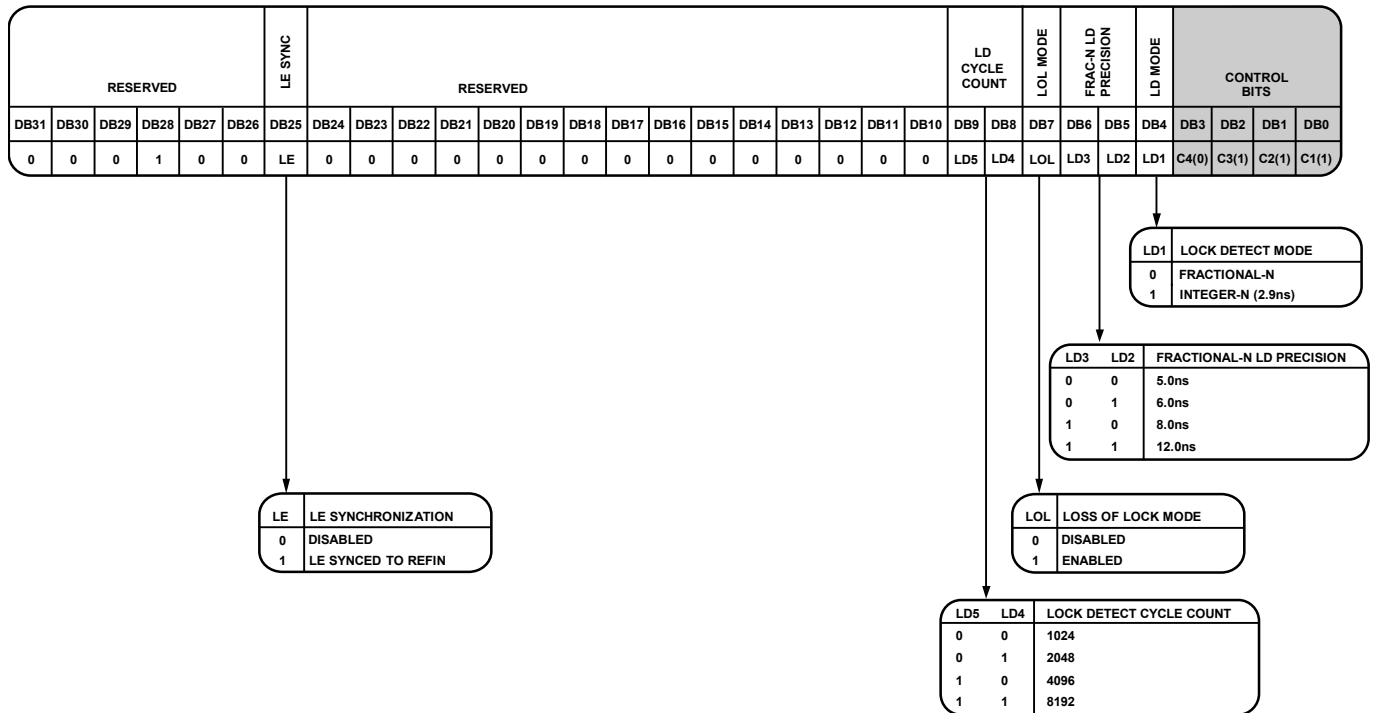


Figure 37. Register 7

REGISTER 7

Control Bits

With Bits[C4:C1] set to 0111, Register 7 is programmed. Figure 37 shows the input data format for programming this register.

Reserved

Bits[DB31:DB29] are reserved and must be set to 0. Bit DB28 is reserved and must be set to 1. Bits[DB27:DB26] are reserved and must be set to 0.

LE Sync

When set to 1, Bit DB25 ensures that the LE edge is synchronized internally with the rising edge of reference input frequency. This synchronization prevents the rare event of reference and RF dividers loading at the same time as a falling edge of reference frequency, which can lead to longer lock times.

Reserved

Bits[DB24:DB10] are reserved and must be set to 0.

Fractional-N Lock Detect Count (LDC)

LD5 and LD4 (Bits[DB9:DB8]) set the number of consecutive cycles counted by the lock detect circuitry before asserting lock detect high. See Figure 37 for details.

Loss of Lock Mode

Set LOL (Bit DB7) to 1 when the application is a fixed frequency application in which the reference (REF_{IN}) is likely to be removed, such as a clocking application. The standard lock detect circuit assumes that REF_{IN} is always present; however, this may not be the case with clocking applications. To enable this functionality, set DB7 to 1. Loss of lock mode does not function reliably when using a differential REF_{IN} mode.

Fractional-N Lock Detect Precision (LDP)

LD3 and LD2 (Bits[DB6:DB5]) set the precision of the lock detect circuitry in fractional-N mode. LDP is available at 5 ns, 6 ns, 8 ns, or 12 ns. If bleed currents are used, use 12 ns.

Lock Detect Mode (LDM)

If LD1 (Bit DB4) is set to 0, each reference cycle is set by fractional-N lock detect precision as described in the Fractional-N Lock Detect Count (LDC) section. If DB4 is set to 1, each reference cycle is 2.9 ns long, which is more appropriate for integer-N applications.

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|----------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-----|-----|--------------|-----|-----|-----|-------|-------|-------|-------|
| RESERVED | | | | | | | | | | | | | | | | | | | | | | | | CONTROL BITS | | | | | | | |
| DB31 | DB30 | DB29 | DB28 | DB27 | DB26 | DB25 | DB24 | DB23 | DB22 | DB21 | DB20 | DB19 | DB18 | DB17 | DB16 | DB15 | DB14 | DB13 | DB12 | DB11 | DB10 | DB9 | DB8 | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
| 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | C4(1) | C3(0) | C2(0) | C1(0) |

Figure 38. Register 8 (0x102D0428)

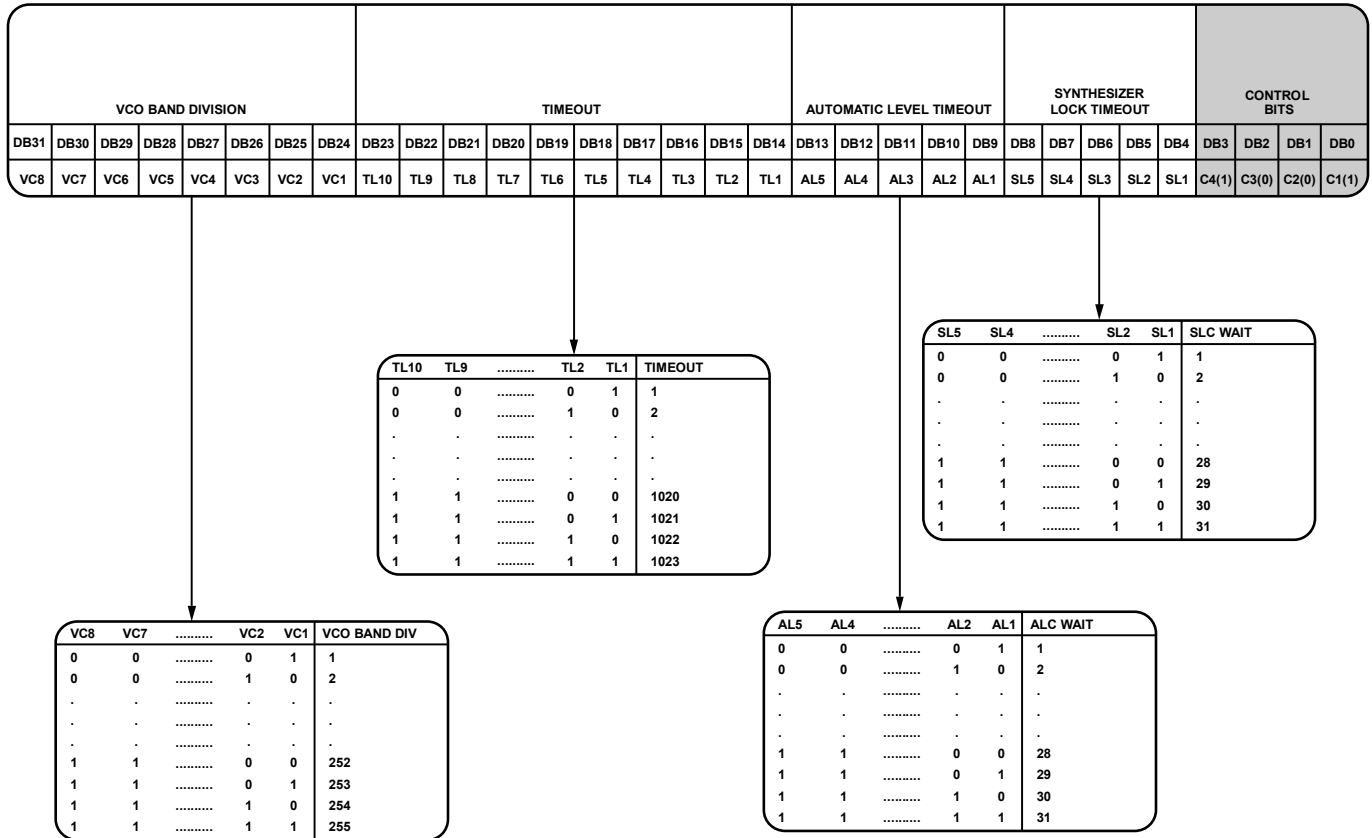


Figure 39. Register 9

REGISTER 8

The bits in this register are reserved and must be programmed as described in Figure 38, using a hexadecimal word of 0x102D0428.

REGISTER 9

Control Bits

With Bits[C4:C1] set to 1001, Register 9 is programmed. Figure 39 shows the input data format for programming this register.

VCO Band Division

VC8 to VC1 (Bits[DB31:DB24]) set the value of the VCO band division clock. Determine the value of this clock by PFD/(band division × 16) such that the result is <150 kHz.

Timeout

TL10 to TL1 (Bits[DB23:DB14]) set the timeout value for the VCO band select. Use this value as a variable in the other VCO calibration settings.

Automatic Level Calibration (ALC) Timeout

AL5 to AL1 (Bits[DB13:DB9]) set the timer value used for the automatic level calibration of the VCO. This function combines the PFD frequency, the timeout variable, and ALC wait variable. Choose ALC such that the following equation is always greater than 50 μs.

$$(Timeout \times ALC\ Wait / PFD\ Frequency) > 50 \mu s$$

Synthesizer Lock Timeout

SL5 to SL1 (Bits[DB8:DB4]) set the synthesizer lock timeout value. Use this value to allow the V_{TUNE} force to settle on the V_{TUNE} pin. The value must be 20 μs. Calculate the value using the following equation:

$$(Timeout \times Synthesizer\ Lock\ Timeout / PFD\ Frequency) > 20 \mu s$$

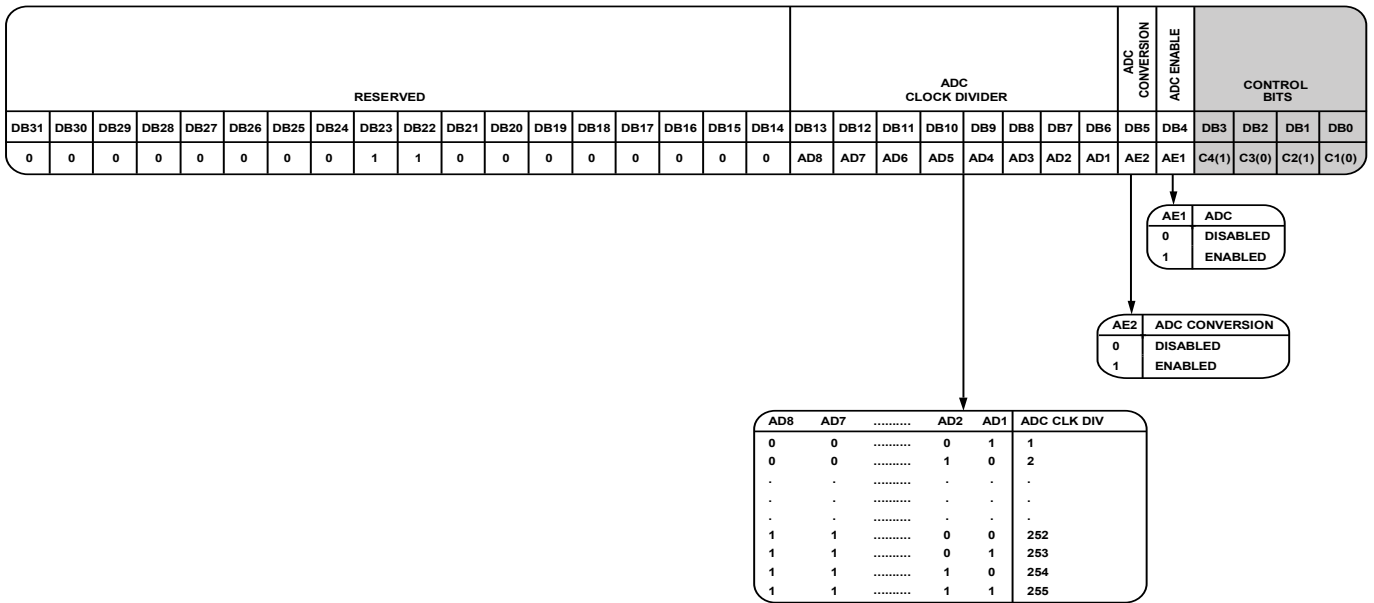


Figure 40. Register 10

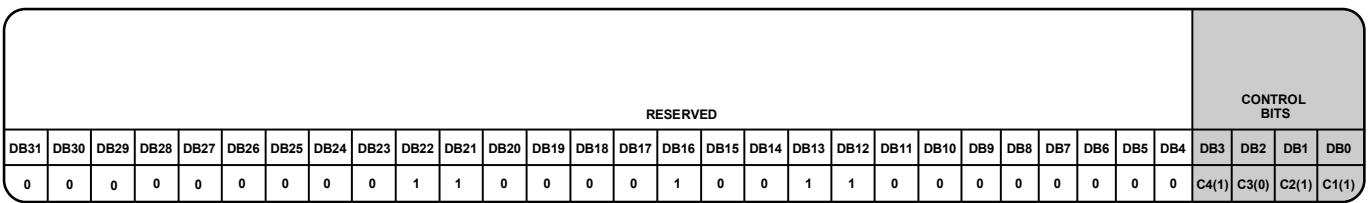


Figure 41. Register 11 (0x0061300B)

REGISTER 10

Control Bits

With Bits[C4:C1] set to 1010, Register 10 is programmed. Figure 40 shows the input data format for programming this register.

Reserved

Bits[DB31:DB14] are reserved. Bits[DB23:DB22] must be set to 11, but all other bits in this range must be set to 0.

ADC Clock Divider (ADC_CLK_DIV)

An on-board analog-to-digital converter (ADC) determines the V_{TUNE} setpoint relative to the ambient temperature of the ADF4355-2 environment. The ADC ensures that the initial tuning voltage in any application is chosen correctly to avoid any temperature drift issues.

The ADC uses a clock that is equal to the output of the R counter (or the PFD frequency) divided by ADC_CLK_DIV.

AD8 to AD1 (Bits[DB13:DB6]) set the value of this divider. On power-up, the R counter is not programmed; however, in these power-up cases, it defaults to R = 1.

Choose the ADC_CLK_DIV value such that

$$ADC_CLK_DIV = \text{ceiling}(((f_{PFD}/100,000) - 2)/4)$$

where ceiling() is a function to round up to the nearest integer.

For example, for f_{PFD} = 61.44 MHz, set ADC_CLK_DIV = 154 so that the ADC clock frequency is 99.417 kHz. If ADC_CLK_DIV is greater than 255, set it to 255.

ADC Conversion Enable

AE2 (Bit DB5) ensures that the ADC performs a conversion when a write to Register 10 is performed. It is recommended to enable this mode.

ADC Enable

When set to 1, AE1 (Bit DB4) powers up the ADC for the temperature dependent V_{TUNE} calibration. It is recommended to always use this function.

REGISTER 11

The bits in this register are reserved and must be programmed as described in Figure 41 using a hexadecimal word of 0x0061300B.

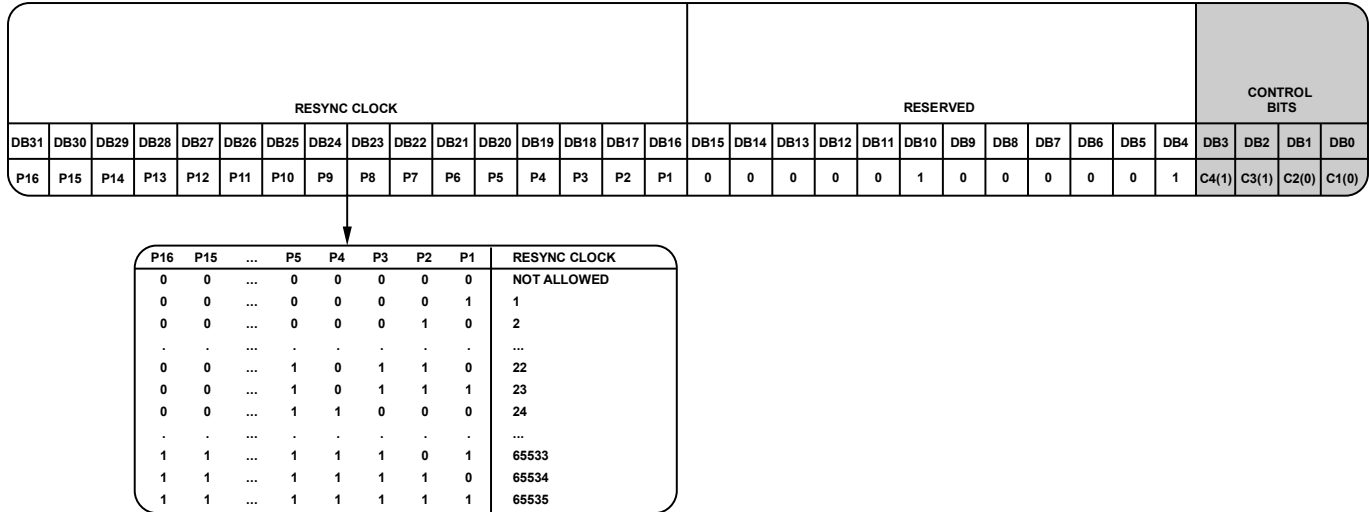


Figure 42. Register 12

REGISTER 12

Control Bits

With Bits[C4:C1] set to 1100, Register 12 is programmed. Figure 42 shows the input data format for programming this register.

Phase Resync Clock Divider Value

P16 to P1 (Bits[DB31:DB16]) set the timeout counter for activation of phase resync. This value must be set such that the resync happens immediately after (and not before) the PLL has achieved lock after reprogramming.

Calculate the timeout value using the following:

$$Time\ Out\ Value = Phase\ Resync\ Clock / PFD\ Frequency$$

Reserved

Bits[DB15:DB4] are reserved. Bit DB10 and Bit DB4 must be set to 1, but all other bits in this range must be set to 0.

REGISTER INITIALIZATION SEQUENCE

At initial power-up, after the correct application of voltages to the supply pins, registers must be programmed in sequence. For $f \leq 75$ MHz, use the following sequence:

1. Register 12
2. Register 11
3. Register 10
4. Register 9
5. Register 8
6. Register 7
7. Register 6
8. Register 5
9. Register 4
10. Register 3
11. Register 2
12. Register 1
13. Wait >16 ADC_CLK cycles. For example, if ADC_CLK = 99.417 kHz, wait 16/99,417 sec = 161 μs. See the Register 10 section for more information.
14. Register 0

For $f_{PFD} > 75$ MHz (initially lock with half f_{PFD}), use the following sequence:

1. Register 12.
2. Register 11.
3. Register 10.
4. Register 9.
5. Register 8.
6. Register 7.
7. Register 6.
8. Register 5.
9. Register 4 (with the R divider doubled to output half f_{PFD}).
10. Register 3.
11. Register 2 (for halved f_{PFD}).
12. Register 1 (for halved f_{PFD}).
13. Wait >16 ADC_CLK cycles. For example, if ADC_CLK = 99.417 kHz, wait 16/99417 sec = 161 μs. See the Register 10 section for more information.
14. Register 0 (for halved f_{PFD} ; autocalibration enabled).
15. Register 4 (with the R divider set for desired f_{PFD}).
16. Register 2 (for desired f_{PFD}).
17. Register 1 (for desired f_{PFD}).
18. Register 0 (for desired f_{PFD} ; autocalibration disabled).

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FREQUENCY UPDATE SEQUENCE

Frequency updates require updating the auxiliary modulator (MOD2) in Register 2, the fractional value (FRAC1) in Register 1, and the integer value (INT) in Register 0. It is recommended to perform a temperature dependent V_{TUNE} calibration by updating Register 10 first. A counter reset (Bit DB4) is also required in the frequency update sequence. Therefore, for $f_{PPD} \leq 75$ MHz, the sequence must be as follows:

1. Register 10.
2. Register 4 (counter reset enabled [DB4 = 1])
3. Register 2
4. Register 1
5. Register 0 (autocalibration disabled [DB21 = 0])
6. Register 4 (counter reset disabled [DB4 = 0])
7. Wait > 16 ADC_CLK_DIV cycles. For example, if ADC_CLK_DIV = 99.417 kHz, wait 16/99417 sec = 161 μ s. See the Register 10 section.
8. Register 0 (autocalibration enabled [DB21 = 1])

For $f_{PPD} > 75$ MHz (initially lock with half f_{PPD}), the sequence must be as follows:

1. Register 10.
2. Register 4 (counter reset enabled [DB4 = 1])
3. Register 2 (for halved f_{PPD}).
4. Register 1 (for halved f_{PPD}).
5. Register 0 (for halved f_{PPD} ; autocalibration disabled).
6. Register 4 (counter reset disabled [DB4 = 0]), with the R divider doubled to output half f_{PPD} .
7. Wait >16 ADC_CLK cycles. For example, if ADC_CLK = 99.417 kHz, wait 16/99417 sec = 161 μ s. See the Register 10 section for more information.
8. Register 0 (for halved f_{PPD} ; autocalibration enabled).
9. Register 4 (with the R divider set for desired f_{PPD}).
10. Register 2 (for desired f_{PPD}).
11. Register 1 (for desired f_{PPD}).
12. Register 0 (for desired f_{PPD} ; autocalibration disabled).

The frequency change only occurs when writing to Register 0.

RF SYNTHESIZER—A WORKED EXAMPLE

Use the following equations to program the ADF4355-2 synthesizer:

$$RF_{OUT} = INT + \frac{FRAC1 + \frac{FRAC2}{MOD2}}{MOD1} \times (f_{PPD}) / RF \text{ Divider} \quad (7)$$

where:

- RF_{OUT} is the RF frequency output.
- INT is the integer division factor.
- $FRAC1$ is the fractionality.
- $FRAC2$ is the auxiliary fractionality.
- $MOD2$ is the auxiliary modulus.
- $MOD1$ is the fixed 24-bit modulus.
- $RF \text{ Divider}$ is the output divider that divides down the VCO frequency.

$$f_{PPD} = REF_{IN} \times ((1 + D) / (R \times (1 + T))) \quad (8)$$

where:

- REF_{IN} is the reference frequency input.
- D is the RF REF_{IN} doubler bit.
- R is the RF reference division factor.
- T is the reference divide by 2 bit (0 or 1).

For example, in a universal mobile telecommunication system (UMTS) where 2112.8 MHz RF frequency output (RF_{OUT}) is required, a 122.88 MHz reference frequency input (REF_{IN}) is available. Note that the ADF4355-2 VCO operates in the frequency range of 3.4 GHz to 6.8 GHz. Therefore, an RF divider of 2 must be used ($VCO \text{ frequency} = 4225.6 \text{ MHz}$, $RF_{OUT} = VCO \text{ frequency} / RF \text{ divider} = 4225.6 \text{ MHz} / 2 = 2112.8 \text{ MHz}$).

The feedback path is also important. In this example, the VCO output is fed back before the output divider (see Figure 43).

In this example, divide the 122.88 MHz signal by 2 to generate a f_{PPD} of 61.44 MHz. The desired channel spacing is 200 kHz.

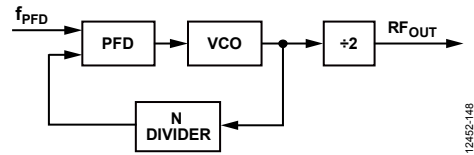


Figure 43. Loop Closed Before Output Divider

The worked example is as follows:

- $N = VCO_{OUT} / f_{PPD} = 4225.6 \text{ MHz} / 61.44 \text{ MHz} = 68.7760416666666667$
- $INT = \text{int}(VCO \text{ frequency} / f_{PPD}) = 68$
- $FRAC = 0.7760416666666667$
- $MOD1 = 16,777,216$
- $FRAC1 = \text{int}(MOD1 \times FRAC) = 13019817$
- $\text{Remainder} = 0.6666666667 \text{ or } 2/3$
- $MOD2 = f_{PPD} / \text{GCD}(f_{PPD} / f_{CHSP}) = 61.44 \text{ MHz} / \text{GCD}(61.44 \text{ MHz} / 200 \text{ kHz}) = 1536$
- $FRAC2 = \text{remainder} \times 1536 = 1024$

From Equation 8, where the RF Divider = 2,

$$f_{PPD} = (122.88 \text{ MHz} \times (1 + 0) / 2) = 61.44 \text{ MHz} \quad (9)$$

$$2112.8 \text{ MHz} = 61.44 \text{ MHz} \times ((INT + (FRAC1 + FRAC2 / MOD2) / 2^{24}) / 2) \quad (10)$$

where:

- $INT = 68$
- $FRAC1 = 13,019,817$
- $MOD2 = 1536$
- $FRAC2 = 1024$

REFERENCE DOUBLER AND REFERENCE DIVIDER

The on-chip reference doubler allows the input reference signal to be doubled. The doubler is useful for increasing the PFD comparison frequency. To improve the noise performance of the system increase the PFD frequency. Doubling the PFD frequency usually improves noise performance by 3 dB.

The reference divide by 2 divides the reference signal by 2, resulting in a 50% duty cycle PFD frequency.

SPURIOUS OPTIMIZATION AND FAST LOCK

Narrow loop bandwidths can filter unwanted spurious signals, but these bandwidths usually have a long lock time. A wider loop bandwidth achieves faster lock times but may lead to increased spurious signals inside the loop bandwidth.

OPTIMIZING JITTER

For lowest jitter applications, use the highest possible PFD frequency to minimize the contribution of in-band noise from the PLL. Set the PLL filter bandwidth such that the in-band noise of the PLL intersects with the open-loop noise of the VCO, minimizing the contribution of both to the overall noise.

Use the [ADIsimPLL](#) design tool for this task.

SPUR MECHANISMS

This section describes the two different spur mechanisms that arise with a fractional-N synthesizer and how to minimize them in the [ADF4355-2](#).

Integer Boundary Spurs

One mechanism for fractional spur creation is the interactions between the RF VCO frequency and the reference frequency. When these frequencies are not integer related (the purpose of a fractional-N synthesizer), spur sidebands appear on the VCO output spectrum at an offset frequency that corresponds to the beat note or the difference in frequency between an integer multiple of the reference and the VCO frequency. These spurs are attenuated by the loop filter and are more noticeable on channels close to integer multiples of the reference where the difference frequency can be inside the loop bandwidth (thus the name, integer boundary spurs).

Reference Spurs

Reference spurs are generally not a problem in fractional-N synthesizers because the reference offset is far outside the loop bandwidth. However, any reference feedthrough mechanism that bypasses the loop may cause a problem. Feedthrough of low levels of on-chip reference switching noise, through the prescaler back to the VCO, can result in reference spur levels as high as -80 dBc.

LOCK TIME

The PLL lock time divides into a number of settings. All of these are modeled in the [ADIsimPLL](#) design tool. Faster lock times than those detailed in this data sheet are possible. Contact your local Analog Devices, Inc., sales representative for more information.

Lock Time—A Worked Example

Assuming $f_{\text{PFD}} = 61.44 \text{ MHz}$,

$$\text{VCO Band Div} = \text{Ceiling}(f_{\text{PFD}}/2,400,000) = 26$$

where $\text{Ceiling}()$ rounds up to the nearest integer.

By combining the following two equations:

$$\text{ALC Wait} > (50 \mu\text{s} \times f_{\text{PFD}})/\text{Timeout}$$

$$\text{Synthesizer Lock Timeout} > (20 \mu\text{s} \times f_{\text{PFD}})/\text{Timeout}$$

The following is found:

$$\text{ALC Wait} = 2.5 \times \text{Synthesizer Lock Timeout}$$

Maximize ALC Wait (to reduce Timeout to minimize time) so that $\text{ALC Wait} = 30$ and $\text{Synthesizer Lock Timeout} = 12$.

Finally, $\text{ALC Wait} > (50 \mu\text{s} \times f_{\text{PFD}})/\text{Timeout}$, is rearranged as

$$\text{Timeout} = \text{Ceiling}((f_{\text{PFD}} \times 50 \mu\text{s})/\text{ALC Wait})$$

$$\text{Timeout} = \text{Ceiling}((61.44 \text{ MHz} \times 50 \mu\text{s})/30) = 103$$

Synthesizer Lock Timeout

The synthesizer lock timeout ensures that the VCO calibration DAC, which forces V_{TUNE} , has settled to a steady value for the band select circuitry.

The timeout and synthesizer lock timeout variables programmed in Register 9 select the length of time the DAC is allowed to settle to the final voltage, before the VCO calibration process continues to the next phase, which is VCO band selection. The PFD frequency is used as the clock for this logic, and the duration is set by

$$\frac{\text{Timeout} \times \text{Synthesizer Lock Timeout}}{\text{PFD Frequency}}$$

The calculated time must be equal to or greater than 20 μs .

VCO Band Selection

Use the PFD frequency again as the clock for the band selection process. Calculate this value by

$$\text{PFD}/(\text{VCO Band Selection} \times 16) < 150 \text{ kHz}$$

The band selection takes 11 cycles of the previously calculated value. Calculate the duration by

$$11 \times (\text{VCO Band Selection} \times 16)/\text{PFD Frequency}$$

Automatic Level Calibration Timeout

Use the automatic level calibration (ALC) function to choose the correct bias current in the [ADF4355-2](#) VCO core. Calculate the time taken by

$$5 \times 11 \times \text{ALC Timeout} \times \text{Timeout}/\text{PFD Frequency}$$

PLL Low-Pass Filter Settling Time

The time taken for the loop to settle is inversely proportional to the low-pass filter bandwidth. The settling time is also modeled in the [ADIsimPLL](#) design tool.

The total lock time for changing frequencies is the sum of the four separate times (synthesizer lock, VCO band selection, ALC timeout, and PLL settling time) and is all modeled in the [ADIsimPLL](#) design tool.

APPLICATIONS INFORMATION

DIRECT CONVERSION MODULATOR

Direct conversion architectures are increasingly used to implement base station transmitters. Figure 44 shows how to use Analog Devices, Inc., devices to implement such a system.

The circuit block diagram shows the AD9761 TxDAC[®] used with the ADL5375. The use of a dual integrated DAC, such as the AD9761, ensures minimum error contribution (over temperature) from this portion of the signal chain.

The local oscillator (LO) is implemented using the ADF4355-2. The low-pass filter was designed using the ADIsimPLL design tool for a PFD of 61.44 MHz and a closed-loop bandwidth of 20 kHz.

The LO ports of the ADL5375 can be driven differentially from the complementary RF_{OUTA+}/RF_{OUTA-} outputs of the ADF4355-2. Differential drive gives better second-order distortion performance than a single-ended LO input and eliminates the use of a balun to convert from a single-ended LO input to the more desirable differential LO input for the ADL5375.

The ADL5375 accepts LO drive levels from -6 dBm to +6 dBm. The optimum LO power can be software programmed on the ADF4355-2, which allows levels from -4 dBm to +5 dBm from each output.

The RF output is designed to drive a 50 Ω load; however, it must be ac-coupled, as shown in Figure 44. If the I and Q inputs are driven in quadrature by 2 V p-p signals, the resulting output power from the ADL5375 modulator is approximately 2 dBm.

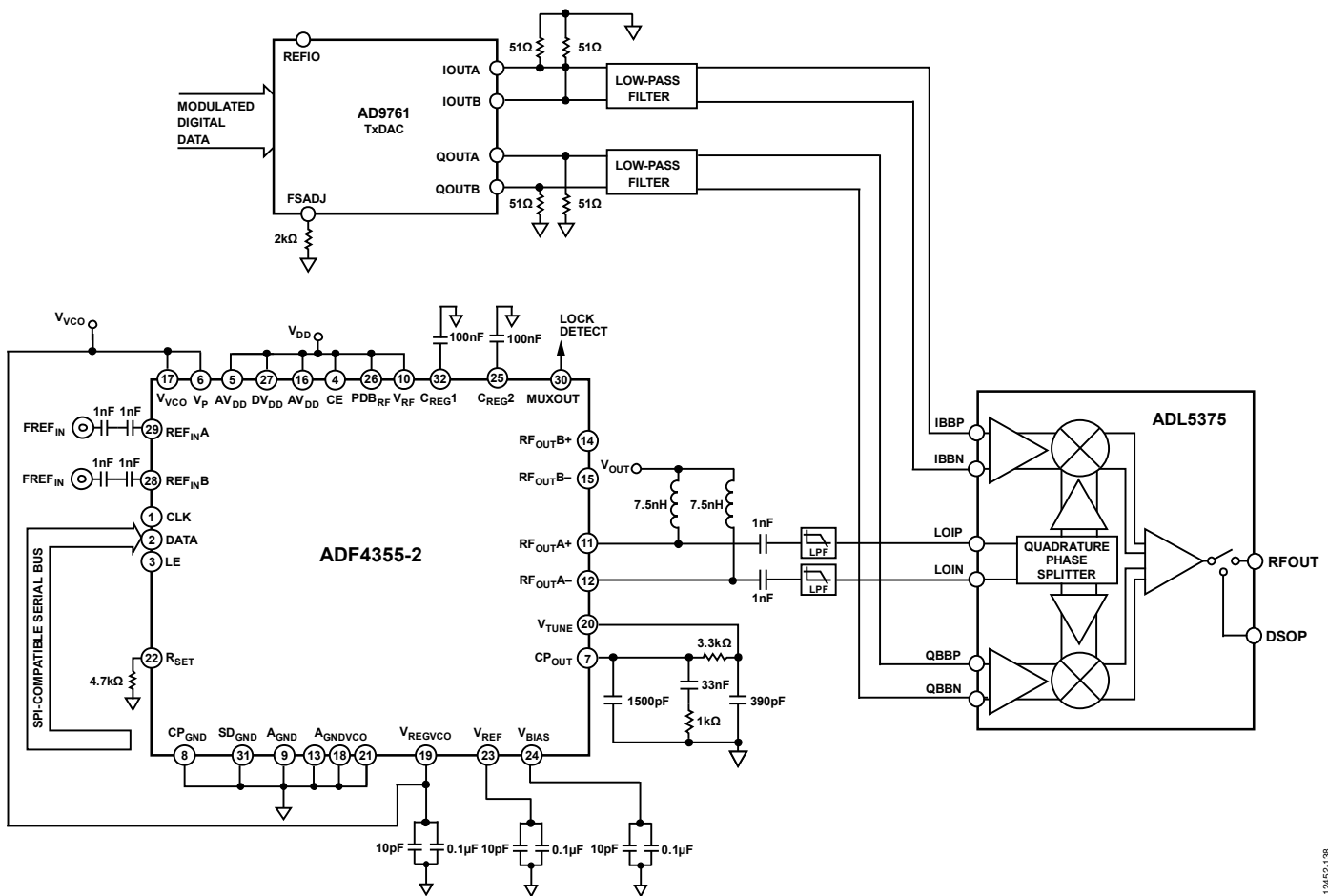


Figure 44. Direct Conversion Modulator

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Power Supplies

The ADF4355-2 contains four multiband VCOs that together cover an octave range of frequencies. To ensure best performance, it is vital to connect a low noise regulator, such as the ADM7170, to the V_{VCO} pin. Connect the same regulator to V_{VCO}, V_{REGVCO}, and V_P.

For the 3.3 V supply pins, use two ADM7170 regulators, one for the DV_{DD} and AV_{DD} supplies and one for V_{RF}. Figure 45 shows the recommended connections.

PRINTED CIRCUIT BOARD (PCB) DESIGN GUIDELINES FOR A CHIP-SCALE PACKAGE

The lands on the 32-lead lead frame chip-scale package are rectangular. The PCB pad for these lands must be 0.1 mm longer than the package land length and 0.05 mm wider than the package land width. Center each land on the pad to maximize the solder joint size.

The bottom of the chip-scale package has a central exposed thermal pad. The thermal pad on the PCB must be at least as large as the exposed pad. On the PCB, there must be a minimum clearance of 0.25 mm between the thermal pad and the inner edges of the pad pattern. This clearance ensures the avoidance of shorting.

To improve the thermal performance of the package, use thermal vias on the PCB thermal pad. If vias are used, incorporate them into the thermal pad at the 1.2 mm pitch grid. The via diameter must measure between 0.3 mm and 0.33 mm and the via barrel must be plated with 1 oz. of copper to plug the via.

For a microwave PLL and VCO synthesizer, such as the ADF4355-2, take care with the board stack up and layout. Do not consider using FR4 material because it is too lossy above 3 GHz. Instead, Rogers 4350, Rogers 4003, or Rogers 3003 dielectric material is suitable.

Take care with the RF output traces to minimize discontinuities and ensure the best signal integrity. Via placement and grounding are critical.

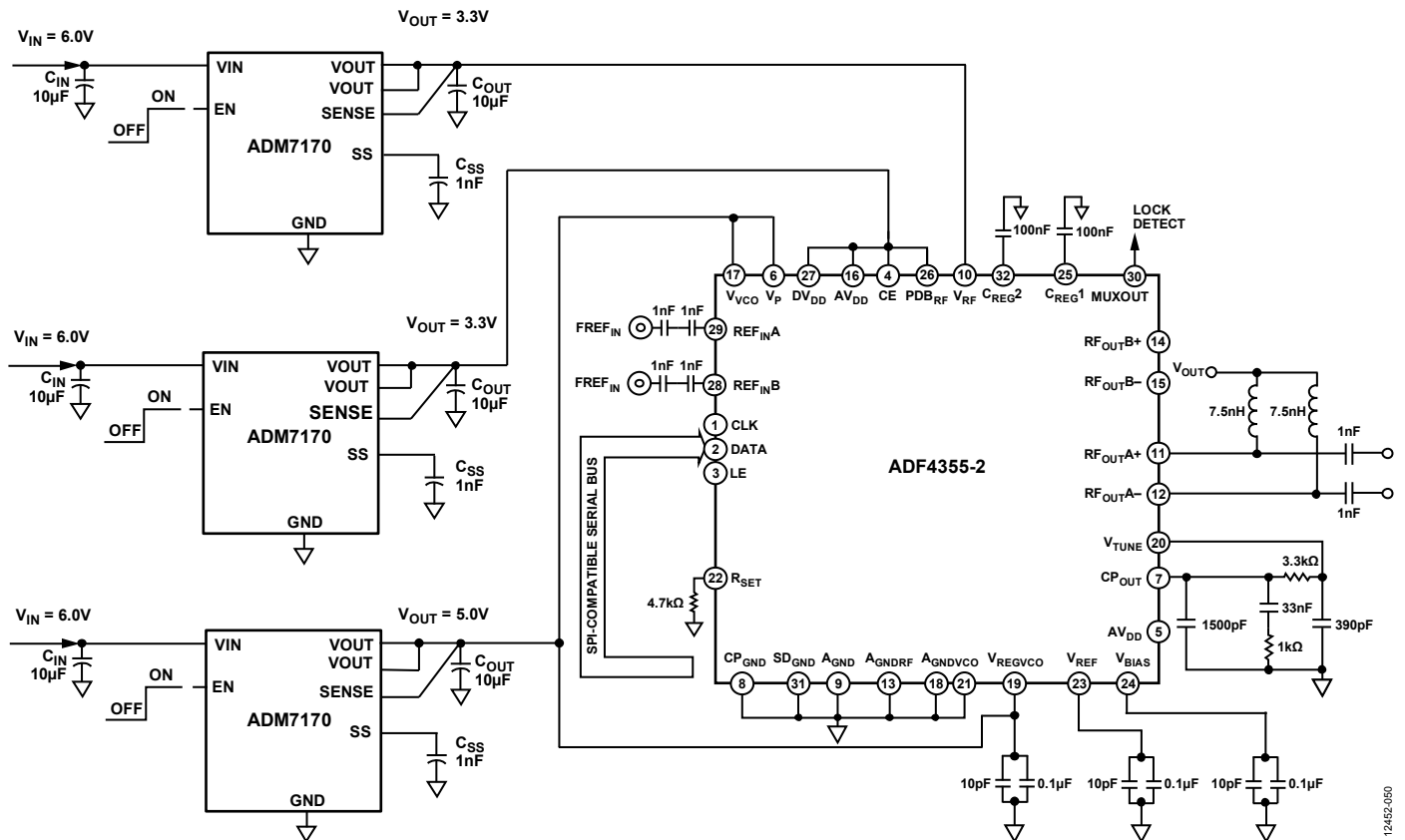


Figure 45. ADF4355-2 Power Supplies

OUTPUT MATCHING

The low frequency output can simply be ac-coupled to the next circuit, if desired; however, if higher output power is required, use a pull-up inductor to increase the output power level.

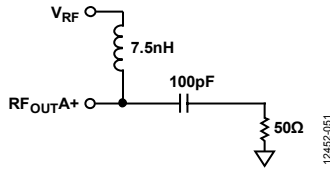


Figure 46. Optimum Output Stage

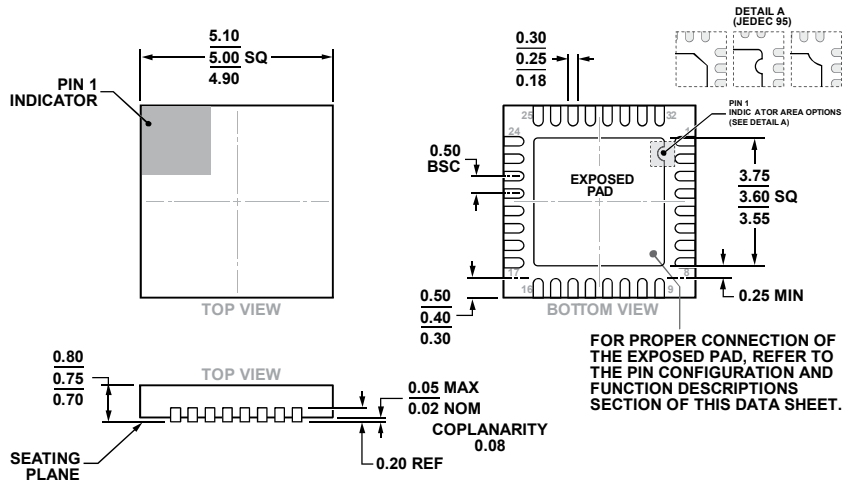
When differential outputs are not needed, terminate the unused output or combine it with both outputs using a balun.

For lower frequencies below 2 GHz, it is recommended to use a 100 nH inductor on the RF_{OUTA+}/RF_{OUTA-} pins.

The RF_{OUTA+}/RF_{OUTA-} pins are a differential circuit. Provide each output with the same (or similar) components where possible, such as the same shunt inductor value, bypass capacitor, and termination.

The auxiliary frequency output, RF_{OUTB+}/RF_{OUTB-}, can be treated the same as the RF_{OUTA+}/RF_{OUTA-} output. If unused, leave both RF_{OUTB+}/RF_{OUTB-} pins open.

OUTLINE DIMENSIONS



COMPLIANT TO JEDEC STANDARDS MO-220-WHHD-5.

Figure 47. 32-Lead Lead Frame Chip Scale Package [LFCSP]
 5 mm × 5 mm Body and 0.75 mm Package Height
 (CP-32-12)

Dimensions shown in millimeters

ORDERING GUIDE

| Model ¹ | Temperature Range | Package Description | Package Option |
|--------------------|-------------------|---|----------------|
| ADF4355-2BCPZ | −40°C to +85°C | 32-Lead Lead Frame Chip Scale Package [LFCSP] | CP-32-12 |
| ADF4355-2BCPZ-RL7 | −40°C to +85°C | 32-Lead Lead Frame Chip Scale Package [LFCSP] | CP-32-12 |
| EV-ADF4355-2SD1Z | | Evaluation Board | |

¹ Z = RoHS Compliant Part.