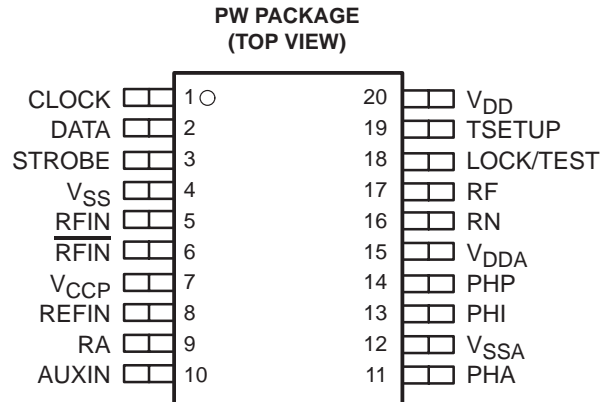


TRF2050 LOW-VOLTAGE 1.2-GHz FRACTIONAL-N/INTEGER-N SYNTHESIZER

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- **1.2-GHz Operation**
- **Two Operating Modes:**
 - Philips SA7025 Emulation Mode
Pin-for-Pin and Programming
Compatible
 - Extended Performance Mode (EPM)
- **Dual RF – IF Phase-Locked Loops**
- **Fractional-N or Integer-N Operation**
- **Programmable EPM Fractional Modulus of 1–16**
- **Normal, Speed-Up, and Fractional Compensation Charge Pumps**
- **Low-Power Consumption**



description

The TRF2050 is a low-voltage, low-power consumption 1.2-GHz fractional-N/integer-N frequency synthesizer component for wireless applications. Fractional-N division and an integral speed-up charge pump are used to achieve rapid channel switching. Two operating modes are available: 1) SA7025 emulation mode in which the part emulates the Philips SA7025 fractional-N synthesizer and 2) extended performance mode (EPM), which provides additional features including fractional accumulator modulus from 1 to 16 (compared to only 5 or 8 for the SA7025) and programmable control of the speed-up mode duration (compared to the SA7025 method of holding the strobe line high).

Along with external loop filters, the TRF2050 provides all functions necessary for voltage-controlled oscillator (VCO) control in a dual phase-locked loop (PLL) frequency synthesizer system. A main channel is provided for radio frequency (RF) channels and an auxiliary channel for intermediate frequency (IF) channels. The current-output charge pumps directly drive passive resistance-capacitance (RC) filter networks to generate VCO control voltages. Rapid main-channel frequency switching is achieved with a charge pump arrangement that increases the current drive and alters the loop-filter frequency response during the speed-up mode portion of the switching interval.



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

 **TEXAS
INSTRUMENTS**

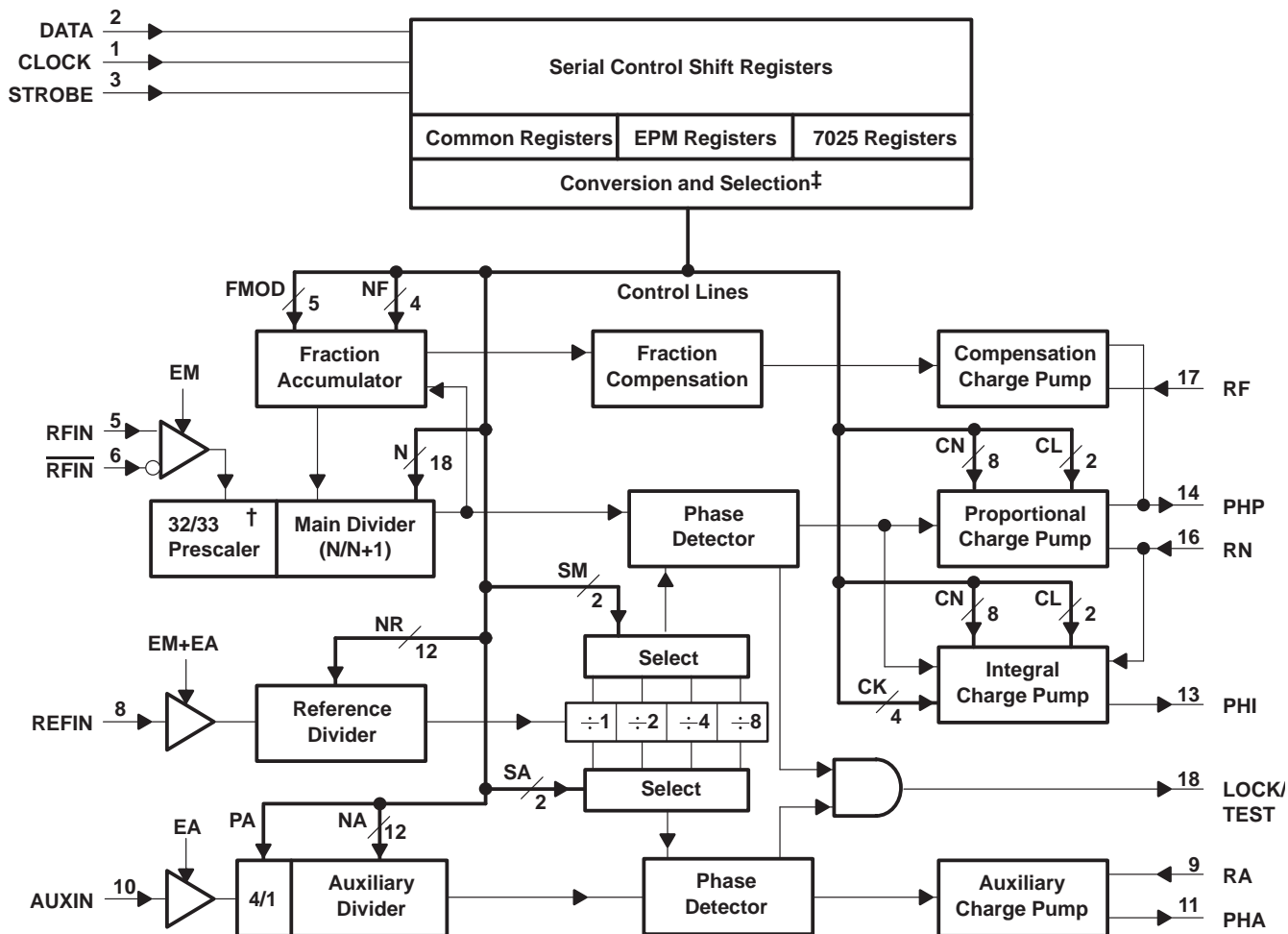
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functional block diagram†



† Terminals 4, 7, 12, 15, and 20 are for supply voltage. Terminal 19 is for testing. These terminals are not shown.

‡ Conversion and selection block provides emulation of SA7025 64/65/72 triple-modulus prescaler operation using the TRF2050 32/33 dual-modulus prescaler.

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Terminal Functions

| TERMINAL NAME | NO. | I/O | DESCRIPTION |
|--------------------------|-----|-----|--|
| AUXIN | 10 | I | Auxiliary channel RF input |
| CLOCK | 1 | I | Serial interface clock signal |
| DATA | 2 | I | Serial interface data signal |
| LOCK/ TEST | 18 | O | Lock detector/test mode output |
| PHA | 11 | O | Auxiliary charge pump output |
| PHI | 13 | O | Integral charge pump output |
| PHP | 14 | O | Proportional charge pump output |
| RFIN | 5 | I | Prescaler positive RF input |
| $\overline{\text{RFIN}}$ | 6 | I | Prescaler negative RF input |
| REFIN | 8 | I | Reference frequency input signal |
| RA | 9 | I | Resistor to V_{SSA} sets auxiliary charge pump reference current |
| RN | 16 | I | Resistor to V_{SSA} sets proportional and integral charge pump reference current |
| RF | 17 | I | Resistor to V_{SSA} sets compensation charge pump reference current |
| STROBE | 3 | I | Serial interface strobe signal |
| TSETUP | 19 | I | Test setup for pin 18. For lock detect output, pin 19 connects to V_{CC} through a pullup resistor; for test mode output, pin 19 terminates to ground. |
| V_{CCP} | 7 | | Prescaler positive supply voltage |
| V_{DD} | 20 | | Digital supply voltage |
| V_{DDA} | 15 | | Analog supply voltage |
| V_{SS} | 4 | | Digital ground |
| V_{SSA} | 12 | | Analog ground |

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

| | |
|---|-----------------|
| Supply voltage range, V_{CCP} , V_{DD} , V_{DDA} (see Note 1) | –0.6 V to 5.6 V |
| Input voltage range, logic signals | –0.6 V to 5.6 V |
| Operating ambient temperature range, T_A | –55°C to 85°C |
| Storage temperature range, T_{stg} | –65°C to 150°C |

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTE 1: Voltage values are with respect to V_{SSA} .



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recommended operating conditions

| | MIN | NOM | MAX | UNIT |
|--|---------------------|-----|---------------------|------|
| Supply voltage, V_{CCP} , V_{DD} , V_{DDA} | 3.6 | 4.8 | 5.1 | V |
| High-level input voltage, V_{IH} (CLOCK, DATA, STROBE) | $0.7 \times V_{DD}$ | | $V_{DD} + 0.3$ | V |
| Low-level input voltage, V_{IL} (CLOCK, DATA, STROBE) | -0.3 | | $0.3 \times V_{DD}$ | V |
| Operating free-air temperature, T_A | -40 | 25 | 85 | °C |

dc electrical characteristics $V_{DD} = V_{DDA} = V_{CCP} = 3.6$ V, over recommended operating free-air temperature range. internal registers: CN = 128, CL = 1, CK = 3, N = 3969, NF = 1, FMOD = 8, SM = 0, NA = 296, SA = 0, PA = 1. external components: RN = 18 k Ω , RF = 24 k Ω , RA = 100 k Ω (unless otherwise noted)

supply current: $I = I_{DD} + I_{CCP} + I_{DDA}$

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---------------------------------|-----|-----|-----|---------|
| $I_{STANDBY}$ Total standby supply currents | EM = EA = 0 (see Notes 2 and 3) | | | 200 | μ A |
| I_{MAIN} Operational supply currents | EM = 1, EA = 0 (see Note 3) | | 7.0 | | mA |
| I_{AUX} Operational supply currents | EM = 0, EA = 1 (see Note 3) | | 1.5 | | mA |
| I_{TOTAL} Operational supply currents | EM = EA = 1 (see Note 3) | | 7.5 | | mA |

NOTES: 2. $V_{RN} = V_{RA} = V_{RF} = V_{DDA}$

3. For optimum standby and operational current consumption, the following condition should be maintained:

$$V_{DD} \leq V_{DDA} < V_{DD} + 1.$$

digital interface

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|------------------------------------|---------------------|-----------------|----------------|-----|---------|
| V_{OH} High-level output voltage | LOCK/TEST | $I_{OH} = 2$ mA | $V_{DD} - 0.5$ | | V |
| V_{OL} Low-level output voltage | | | | | 0.5 |
| I_{IH} High-level input current | DATA, CLOCK, STROBE | | | 10 | μ A |
| I_{IL} Low-level input current | | | | 10 | μ A |

charge pump currents (see Figure 1)

auxiliary charge pump

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|-------------------------|-----|-----|----------|---------|
| $ I_{PHA} $ Output current PHA | $V_{PHA} = 0.5 V_{DDA}$ | 200 | 250 | 300 | μ A |
| $\frac{\Delta I_{PHA}}{ I_{PHA} }$ Relative output current variation PHA (see Figure 1) | | | 2% | 10% | |
| ΔI_{PHA} Output current matching PHA (see Figure 1) | $V_{PHA} = 0.5 V_{DDA}$ | | | ± 50 | μ A |

proportional charge pump, normal mode, $V_{RF} = V_{DDA}$

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|-------------------------|-----|-----|----------|---------|
| $ I_{PHP-NM} $ Output current PHP | $V_{PHP} = 0.5 V_{DDA}$ | 400 | 500 | 600 | μ A |
| $\frac{\Delta I_{PHP-NM}}{ I_{PHP-NM} }$ Relative output current variation PHP (see Figure 1) | | | 2% | 10% | |
| ΔI_{PHP-NM} Output current matching PHP (see Figure 1) | $V_{PHP} = 0.5 V_{DDA}$ | | | ± 50 | μ A |



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charge pump currents (see Figure 1) (continued)

proportional charge pump, speed-up mode, $V_{RF} = V_{DDA}$ (see the section on speed-up mode operation)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--|--|-------------------------|-----|-----|-----------|---------|
| $ I_{PHP-SM} $ | Output current PHP | $V_{PHP} = 0.5 V_{DDA}$ | 2 | 2.5 | 3 | mA |
| $\frac{\Delta I_{PHP-SM}}{ I_{PHP-SM} }$ | Relative output current variation PHP (see Figure 1) | | | 2% | 10% | |
| ΔI_{PHP-SM} | Output current matching PHP (see Figure 1) | $V_{PHP} = 0.5 V_{DDA}$ | | | ± 300 | μA |

integral charge pump, speed-up mode, $V_{RF} = V_{DDA}$ (see the section on speed-up mode operation)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--|--|-------------------------|-----|-----|-----------|---------|
| $ I_{PHI-SM} $ | Output current PHI | $V_{PHI} = 0.5 V_{DDA}$ | 4.8 | 6 | 7.2 | mA |
| $\frac{\Delta I_{PHI-SM}}{ I_{PHI-SM} }$ | Relative output current variation PHI (see Figure 1) | | | 2% | 8% | |
| ΔI_{PHI-SM} | Output current matching PHI (see Figure 1) | $V_{PHI} = 0.5 V_{DDA}$ | | | ± 600 | μA |

fractional compensation proportional charge pump, normal mode, $V_{RN} = V_{DDA}$

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|------------------|---|---|-----|------|-----|---------|
| $ I_{PHP-F-NM} $ | Output current PHP vs fractional numerator (see Note 4) | $V_{PHP} = 0.5 V_{DDA}$, $F_{NUM} = 1$ | | 1.25 | | μA |

NOTE: 4. Fractional compensation current is proportional to the numerator content of the fractional accumulator (FNUM).

charge pump leakage currents, $V_{RN} = V_{RA} = V_{RF} = V_{DDA}$

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|-----------|--------------------|-------------------------|-----|----------|-----|------|
| I_{PHP} | Output current PHP | $V_{PHP} = 0.5 V_{DDA}$ | | ± 10 | | nA |
| I_{PHI} | Output current PHI | $V_{PHI} = 0.5 V_{DDA}$ | | ± 10 | | |
| I_{PHA} | Output current PHA | $V_{PHA} = 0.5 V_{DDA}$ | | ± 10 | | |

ac electrical characteristics, $V_{DD} = V_{CCP} = V_{DDA} = 3.6 V$, $T_A = 25^\circ C$ (unless otherwise noted)

main divider

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|----------------|-----------------------------|--|-----|-----|-----|------|
| f_{RFIN} | RF input frequency | | | | 1.2 | GHz |
| V_{ID_RFIN} | Differential RF input power | 50- Ω single-ended characteristic impedance; ac-coupled | -20 | | 0 | dBm |



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ac electrical characteristics, $V_{DD} = V_{CCP} = V_{DDA} = 3.6\text{ V}$, $T_A = 25^\circ\text{C}$ (unless otherwise noted)
(continued)

auxiliary divider

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|-----|-----|-----------|------------|
| f _{AUXIN} Auxiliary input frequency (ac-coupled) | PA = 0: V _{DDA} = V _{DD} = 3.6 V V _{I_AUXIN} = 560 mVpp V _{I_AUXIN} = 200 mVpp | | | 125 70 | MHz MHz |
| | PA = 0: V _{DDA} = V _{DD} = 4.8 V V _{I_AUXIN} = 200 mVpp | | | 110 | MHz |
| | PA = 1: V _{DDA} = V _{DD} = 3.6 V V _{I_AUXIN} = 200 mVpp | | | 40 | MHz |
| | PA = 1: V _{DDA} = V _{DD} = 4.8 V V _{I_AUXIN} = 200 mVpp | | | 72 | MHz |
| Z _{AUXIN} Auxiliary input impedance | | 5 | 100 | | kΩ |
| | | | 3 | | pF |

reference divider

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--|-----------------|-----|-----|-----|------|
| f _{REFIN} Reference input frequency | | | | 40 | MHz |
| V _{I_REFIN} Reference input voltage | ac-coupled | 200 | | | mVpp |
| Z _{REFIN} Reference input impedance | | | 100 | | kΩ |
| | | | 3 | | pF |

timing requirements, serial data interface (see Figure 2)

| | | MIN | MAX | UNIT |
|------------------------|---|-----|-----|------|
| f _{CLOCK} | Clock frequency | | 10 | MHz |
| t _{w_CLKHI} | Clock high time pulse width, CLOCK high | 30 | | ns |
| t _{w_CLKLO} | Clock low time pulse width, CLOCK low | 30 | | ns |
| t _{su_Data} | Setup time, data valid before CLOCK↑ | 30 | | ns |
| t _{h_Data} | Hold time, data valid after CLOCK↑ | 30 | | ns |
| t _{h_Strobe} | Hold time, STROBE high before CLOCK↑ | 30 | | ns |
| t _{su_Strobe} | Setup time, STROBE low after CLOCK↑ | 30 | | ns |
| t _{w_STRBHI} | STROBE high time pulse width, STROBE high | 50 | | ns |



PARAMETER MEASUREMENT INFORMATION

charge-pump current output definitions

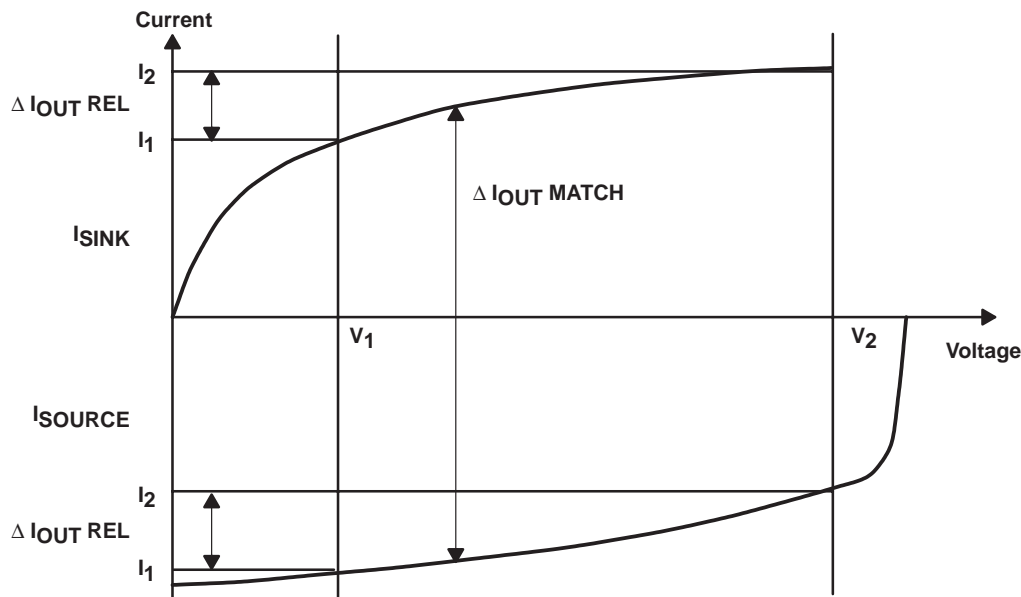


Figure 1. Charge-Pump Output Current Definitions

The relative output current variation is defined as the percent difference between charge-pump current output at two charge-pump output voltages and the mean charge-pump current output (see Figure 1):

$$\frac{\Delta I_{OUT REL}}{|I_{OUT MEAN}|} = 2 \times \frac{(I_2 - I_1)}{|(I_2 + I_1)|} \times 100\%; \text{ with } V_1 = 0.7 \text{ V}, V_2 = V_{DDA} - 0.8 \text{ V}.$$

Output current matching is defined as the difference between charge-pump sinking current output and charge-pump sourcing current output at a given charge-pump output (see Figure 1).

$$\Delta I_{OUT MATCH} = I_{SINK} - I_{SOURCE}; \text{ with } V_1 \leq \text{Voltage} \leq V_2.$$

serial-data interface timing

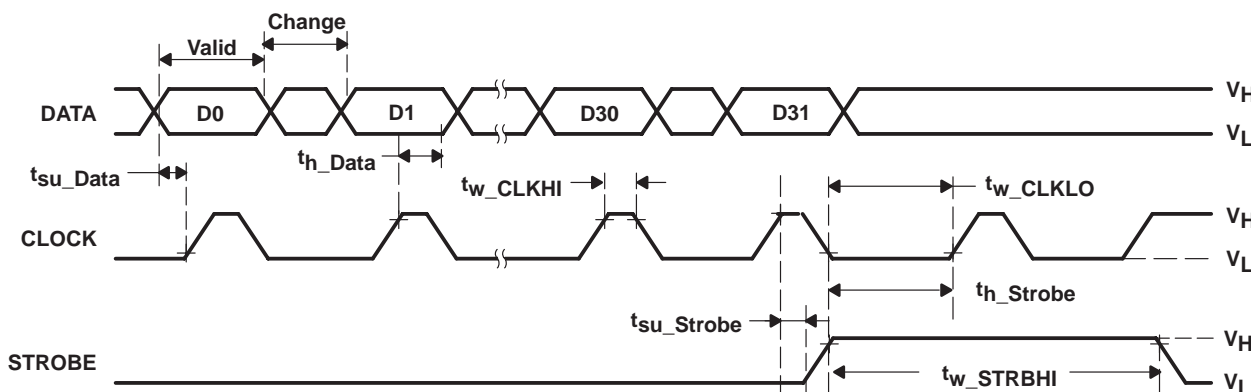
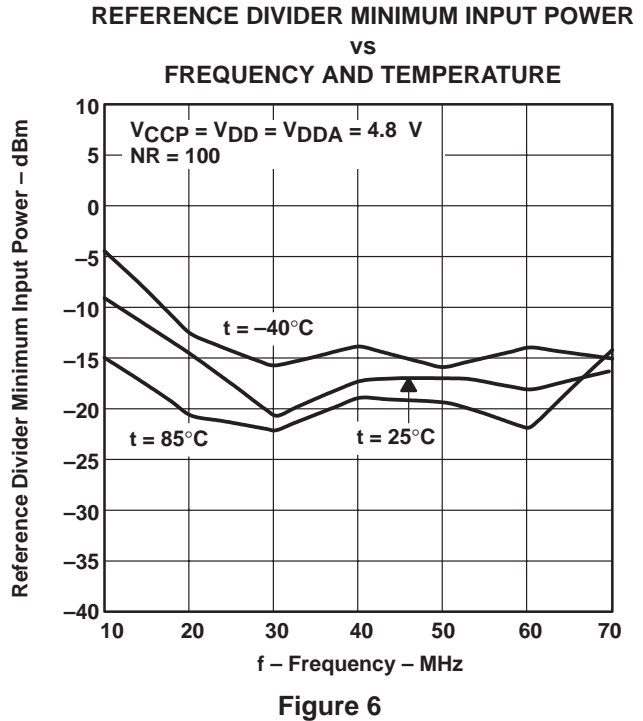
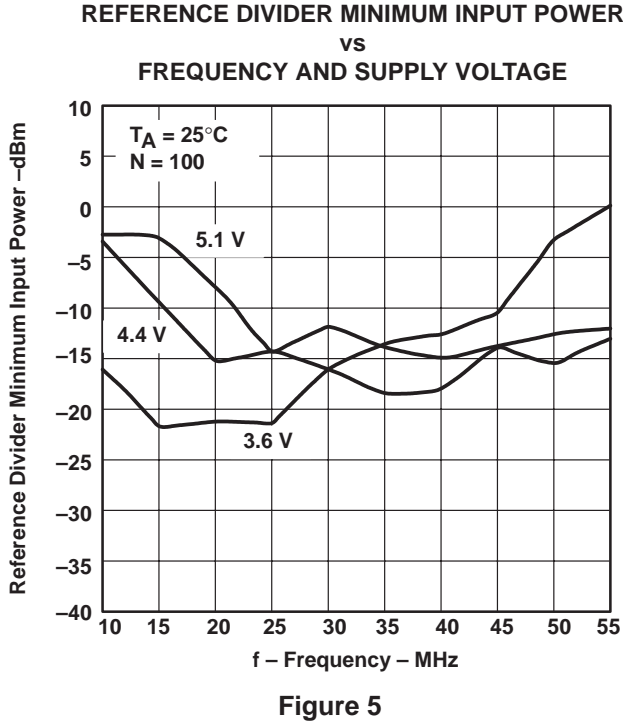
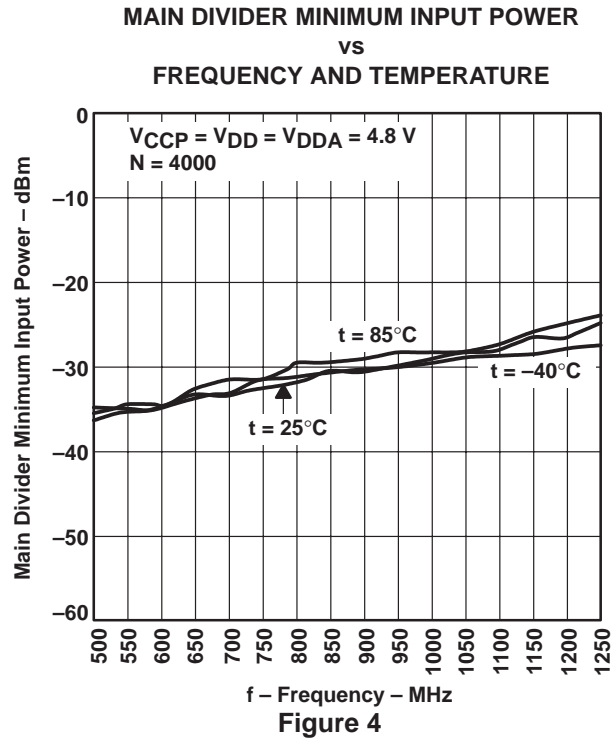
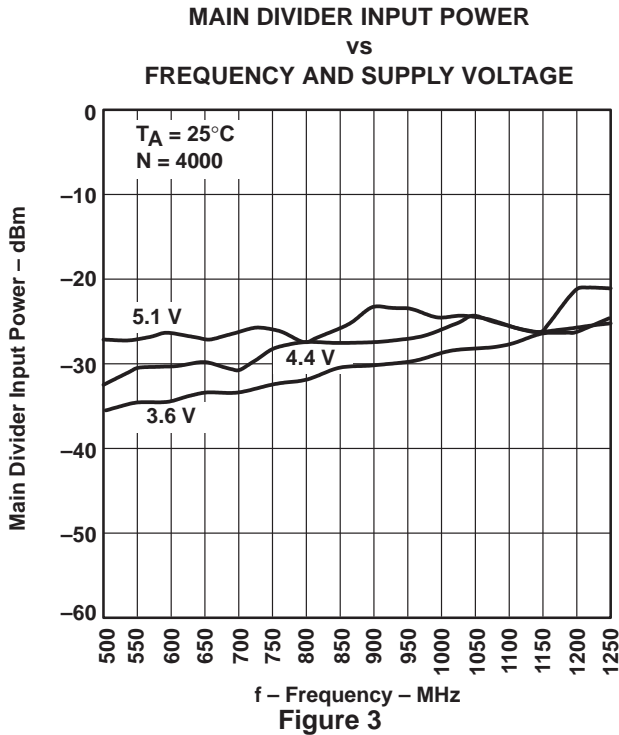


Figure 2. Serial-Data Interface Timing

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TYPICAL CHARACTERISTICS



TYPICAL CHARACTERISTICS

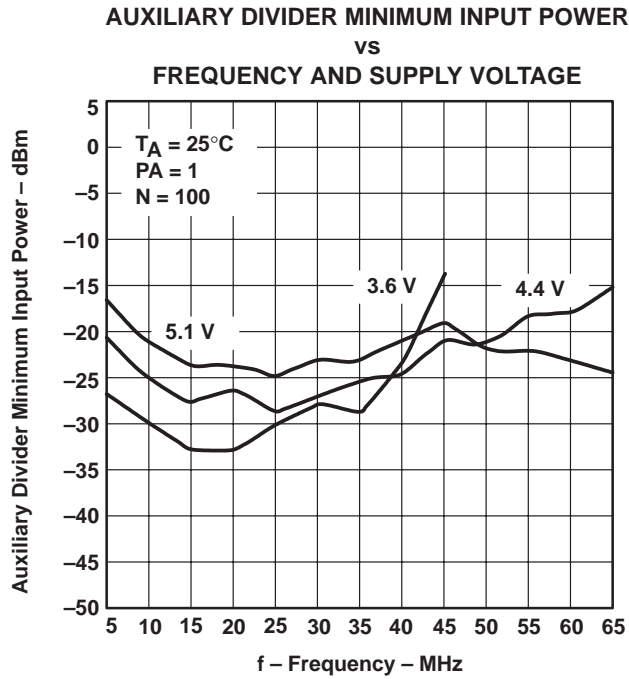


Figure 7

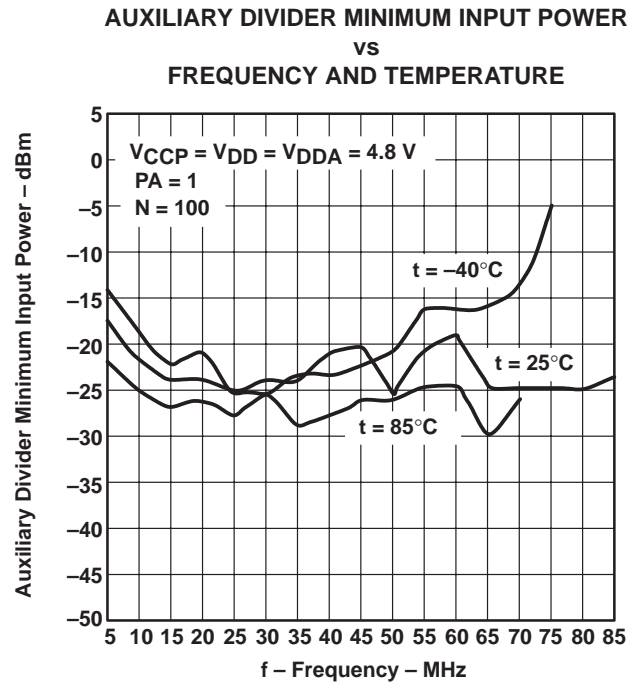


Figure 8

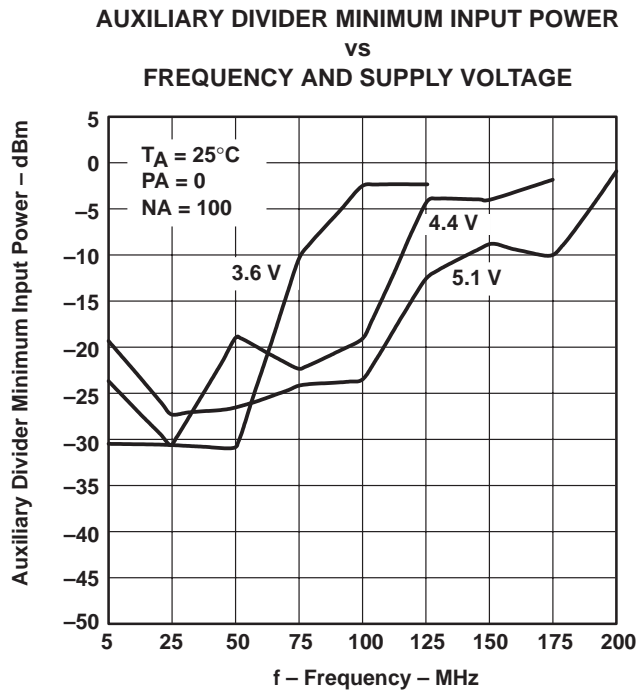


Figure 9

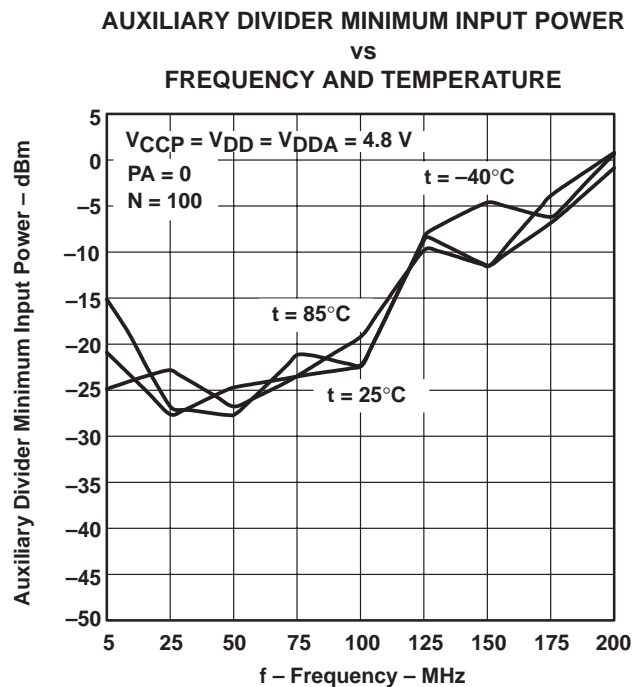


Figure 10

TRF2050
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TYPICAL CHARACTERISTICS

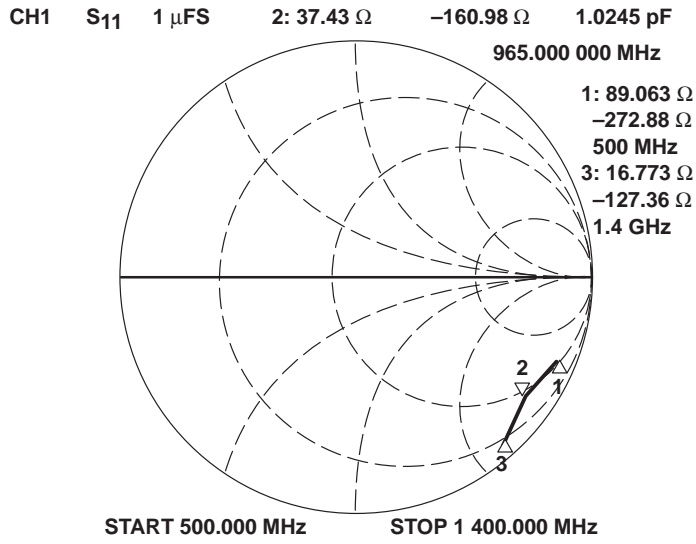


Figure 11. Typical RFIN Impedance (S₁₁)

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APPLICATION INFORMATION

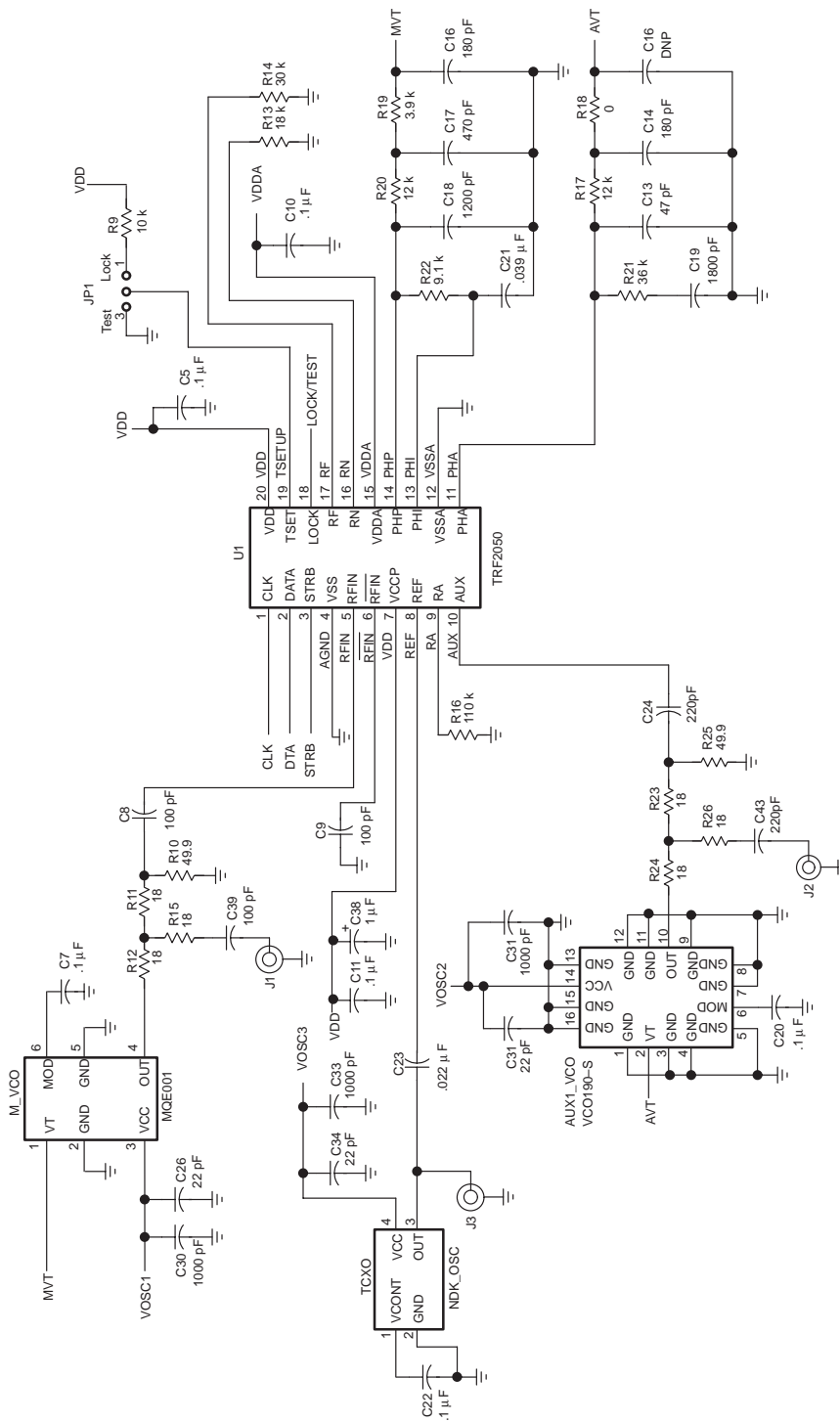
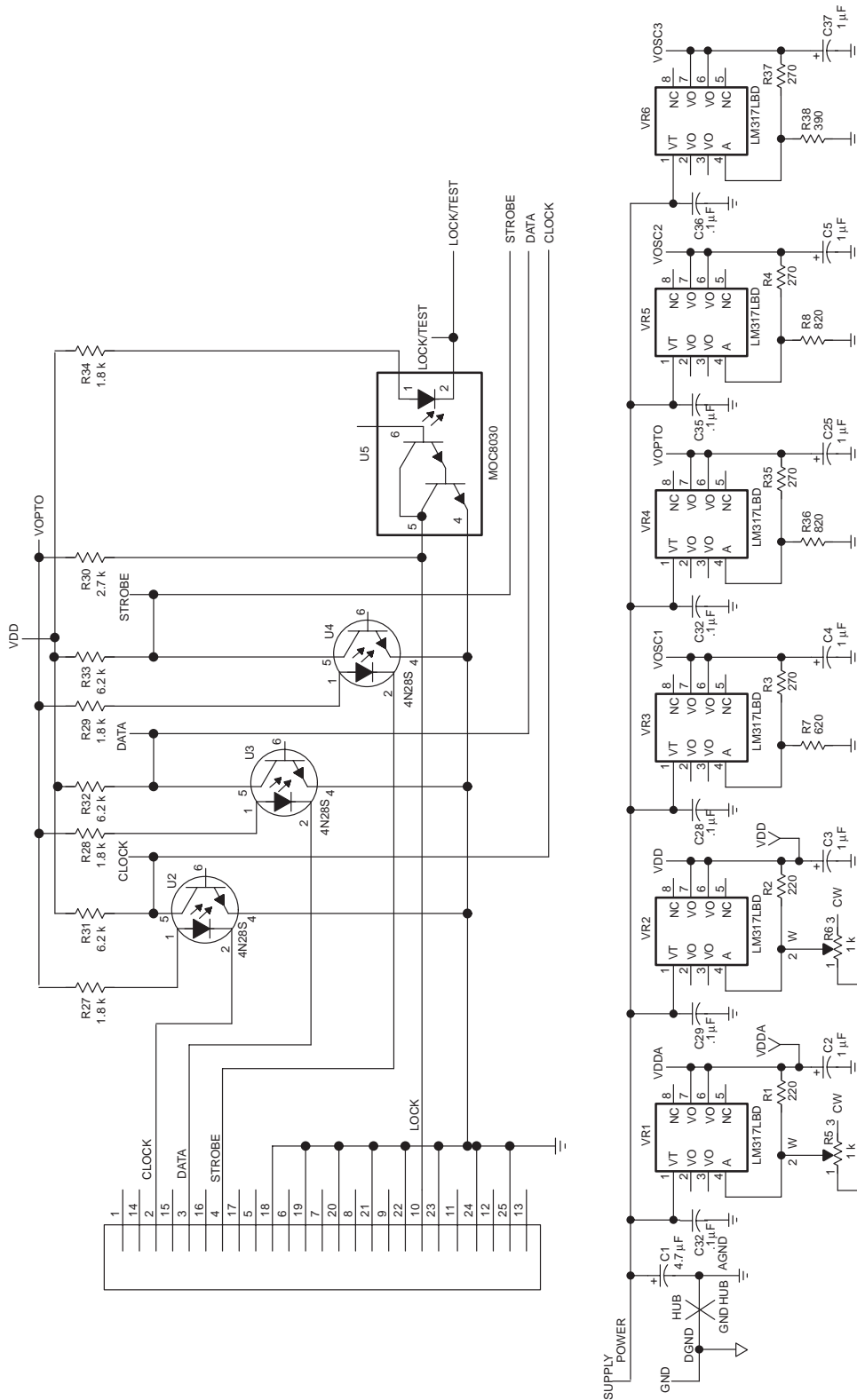


Figure 12. Evaluation Board Schematic (Part 1 of 2)

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APPLICATION INFORMATION



Note: Evaluation board dc supply circuitry and PC interface only

Figure 12. Evaluation Board Schematic (Part 2 of 2)



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APPLICATION INFORMATION

Table 1. TRF2050 Evaluation Board Parts List

| DESIGNATORS | DESCRIPTION | VALUE | QTY | SIZE (mm) | MANUFACTURER | MANUFACTURER P/N |
|---|--------------------|----------|-----|--------------|--------------|------------------|
| C1 | Capacitor | 4.7 uF | 1 | "A" 3.2x1.6 | Venkel | TA010TCM475KAR |
| C2, 3, 4, 5, 25, 37, 38 | Capacitor | 1.0 uF | 7 | "A" 3.2x1.6 | Venkel | TA025TCM105KAR |
| C6, 7, 10, 11, 20, 22, 27, 28, 29, 32, 35, 36 | Capacitor | 0.1 uF | 12 | 0603 1.6x.08 | Murata | GRM39Y5V104Z016 |
| C8, 9, 39 | Capacitor | 100 pF | 3 | 0603 1.6x.08 | Murata | GRM39COG series |
| C13 | Capacitor | 47 pF | 1 | 0603 1.6x.08 | Murata | GRM39COG series |
| C14, 16 | Capacitor | 180 pF | 2 | 0603 1.6x.08 | Venkel | C0603COG series |
| C15 | Capacitor | Not Used | | 0603 1.6x.08 | | Not Used |
| C17 | Capacitor | 470 pF | 1 | 0603 1.6x.08 | Murata | GRM39X7R series |
| C18 | Capacitor | 1200 pF | 1 | 0603 1.6x.08 | Murata | GRM39X7R series |
| C12, 30, 33 | Capacitor | 1000 pF | 3 | 0603 1.6x.08 | Murata | GRM39X7R series |
| C19 | Capacitor | 1800 pF | 1 | 0603 1.6x.08 | Venkel | C0603X7R series |
| C21 | Capacitor | .039 pF | 1 | 1210 3.2x2.5 | Panasonic | ECH–U1H393JB |
| C23 | Capacitor | .022 uF | 1 | 0603 1.6x.08 | Murata | GRM39X7R series |
| C24, 40 | Capacitor | 220 pF | 2 | 0603 1.6x.08 | Murata | GRM39X7R series |
| C26, 31, 34 | Capacitor | 22 pF | 3 | 0603 1.6x.08 | Murata | GRM39COG series |
| R1, 2 | Resistor | 220 Ω | 2 | 0603 1.6x.08 | Panasonic | ERJ–3GSYJ221 |
| R3, 4, 35, 37 | Resistor | 270 Ω | 4 | 0603 1.6x.08 | Panasonic | ERJ–3GSYJ271 |
| R5, 6 | Resistor | 1 kΩ | 2 | .25" square | Bourns | 3269W001102 |
| R7 | Resistor | 620 Ω | 1 | 0603 1.6x.08 | Panasonic | ERJ–3GSYJ series |
| R8, 36 | Resistor | 820 Ω | 2 | 0603 1.6x.08 | Panasonic | ERJ–3GSYJ series |
| R9 | Resistor | 10 kΩ | 1 | 0603 1.6x.08 | Panasonic | ERJ–3GSYJ series |
| R10, 25 | Resistor | 49.9 Ω | 2 | 0603 1.6x.08 | Panasonic | ERJ–3EKF49R9 |
| R11, 12, 15, 23, 24, 26 | Resistor | 18 Ω | 6 | 0603 1.6x.08 | Panasonic | ERJ–3GSYJ series |
| R13 | Resistor | 18 kΩ | 1 | 0603 1.6x.08 | Panasonic | ERJ–3GSYJ series |
| R14 | Resistor | 30 kΩ | 1 | 0603 1.6x.08 | Panasonic | ERJ–3GSYJ series |
| R16 | Resistor | 110 kΩ | 1 | 0603 1.6x.08 | Panasonic | ERJ–3GSYJ series |
| R17, 20 | Resistor | 12 kΩ | 2 | 0603 1.6x.08 | Panasonic | ERJ–3GSYJ series |
| R18 | Resistor | 0 Ω | 1 | 0603 1.6x.08 | Venkel | CR0603–16W–000J1 |
| R19 | Resistor | 3.9 kΩ | 1 | 0603 1.6x.08 | Panasonic | ERJ–3GSYJ series |
| R21 | Resistor | 36 kΩ | 1 | 0603 1.6x.08 | Panasonic | ERJ–3GSYJ series |
| R22 | Resistor | 9.1 kΩ | 1 | 0603 1.6x.08 | Panasonic | ERJ–3GSYJ series |
| R27, 28, 29, 34 | Resistor | 1.8 kΩ | 4 | 0603 1.6x.08 | Panasonic | ERJ–3GSYJ series |
| R30 | Resistor | 2.7 kΩ | 1 | 0603 1.6x.08 | Panasonic | ERJ–3GSYJ series |
| R31, 32, 33 | Resistor | 6.2 kΩ | 3 | 0603 1.6x.08 | Panasonic | ERJ–3GSYJ series |
| R38 | Resistor | 390 Ω | 1 | 0603 1.6x.08 | Panasonic | ERJ–3GSYJ series |
| U1 | Integrated circuit | | 1 | | TI | TRF2050 |
| U2, 3, 4 | Optoelectronics | | 3 | 730C–04 | Motorola | 4N28S |



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APPLICATION INFORMATION

Table 1. TRF2050 Evaluation Board Parts List (Continued)

| DESIGNATORS | DESCRIPTION | VALUE | QTY | SIZE (mm) | MANUFACTURER | MANUFACTURER P/N |
|--------------------|--------------------------------------|----------|-----|-----------|------------------------|------------------|
| U5 | Optoelectronics | | 1 | 730C–04 | Motorola | MOC8030S |
| VR1, 2, 3, 4, 5, 6 | Voltage regulator | | 6 | SO–8 | National Semiconductor | LM317LM |
| P1 | Para. connector | | 1 | | AMP | 747238–4 |
| J1, 2, 3 | SMA connector | | 3 | | EF Johnson | 142–0701–831 |
| TP1 to TP8 | Test point | Assorted | 8 | | Components Corp. | TP–105–01 series |
| Main VCO | Voltage-controlled oscillator | | 1 | | Murata | MQE001 |
| TCXO | Temp.-compensated crystal oscillator | | 1 | | Toyocom | TCO–980 |
| AUX VCO | Voltage-controlled oscillator | | 1 | | Vari-L Comp. | VCO190–S |

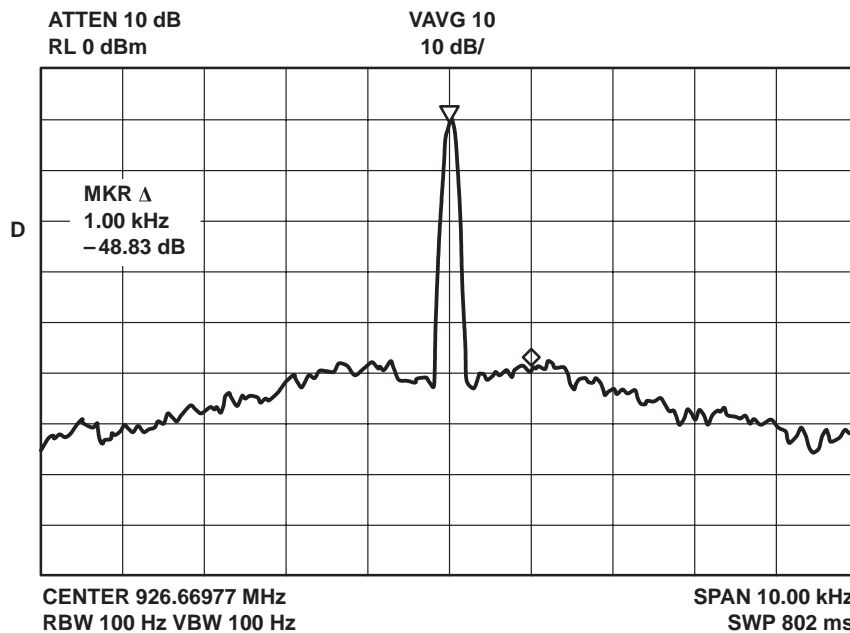


Figure 13. Close-in Noise at 926.67 MHz; MODULO – 8; NF = 1; CN = 64

APPLICATION INFORMATION

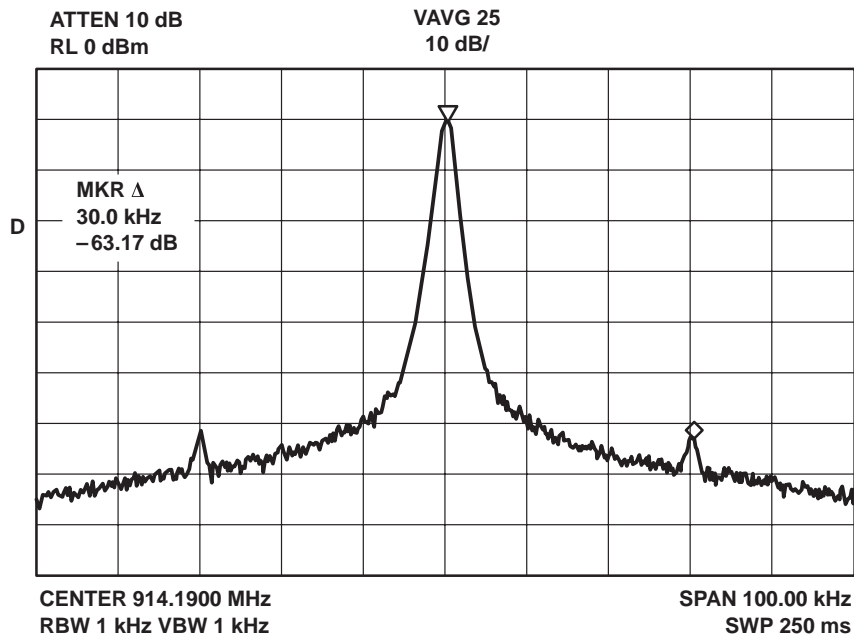


Figure 14. Fractional Spurs, $f_{VCO} = 914.19$ MHz; MODULO – 8; NF = 1; CN = 64

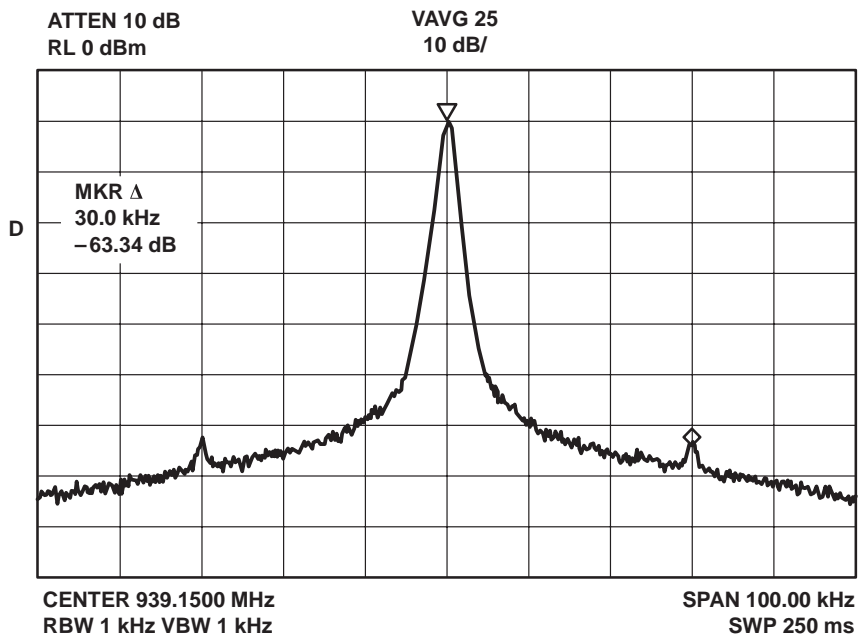


Figure 15. Fractional Spurs, $f_{VCO} = 939.15$ MHz; MODULO – 8; NF = 1; CN = 64

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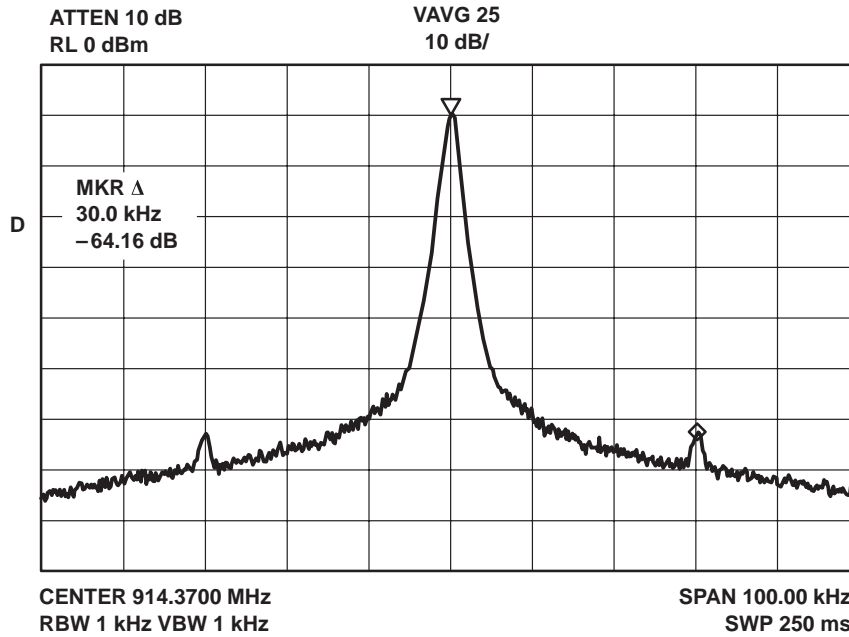


Figure 16. Fractional Spurs, $f_{VCO} = 914.37$ MHz; MODULO – 8; NF = 7; CN = 64

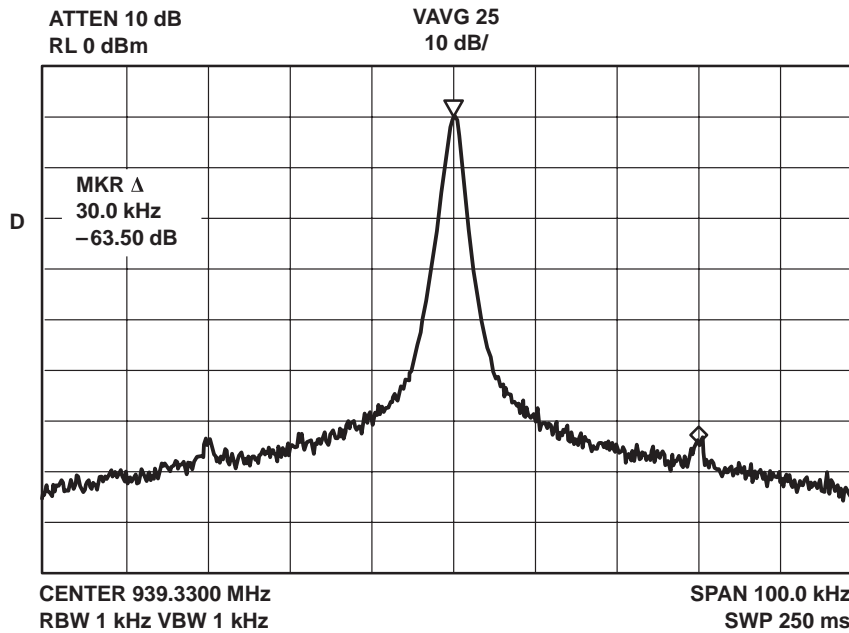


Figure 17. Fractional Spurs, $f_{VCO} = 939.33$ MHz; MODULO – 8; NF = 7; CN = 64

PRINCIPLES OF OPERATION

serial programming input

The TRF2050 internal registers are programmed using a three-wire (CLOCK, DATA, STROBE) serial interface. The serial data is structured into 24-bit standard-length or 32-bit long-length words of which one or four bits are dedicated address bits. The flag LONG in the D-Word determines whether the A0 (LONG = 0) or A1 (LONG = 1) format is applicable. Figures 18 and 19 show the format of the serial data for two modes of TRF2050 operation: SA7025 and EPM, respectively. The least significant bit (LSB) of the C-Word determines the operational mode of the TRF2050: 0 = SA7025, 1 = EPM.

In SA7025 mode, the TRF2050 emulates the Philips SA7025 with respect to serial programming. Microcontroller software written for the SA7025 works transparently when the TRF2050 is operated in SA7025 emulation mode.

Figure 2 shows the timing diagram of the serial input. When the STROBE signal is low, the signal on the DATA input is clocked into a shift register on the positive edges of the CLOCK. When the STROBE signal is high, depending on the 1 or 4 address bit(s), the data is latched into different working registers or temporary registers. In order to fully program the synthesizer, four words must be sent: D, C, B, and A. The E-Word is for testing purposes only.

The A-Word contains new data for the main divider. The A-Word is loaded only when a main divider synchronization signal is also active. This is done to avoid phase jumps during reprogramming the main divider. The synchronization signal is generated by the main divider.

When the TRF2050 is operated in SA7025 emulation mode, programming the A-Word sets the main charge pumps, which are located on outputs PHP and PHI, into speed-up mode, as long as the STROBE is high. When the TRF2050 is operated in EPM mode, speed-up mode duration is determined by field G in the B-Word.

NOTE:

The C-Word must be sent during the first programming cycle after power-up in order to set the mode of operation (7025 or EPM).

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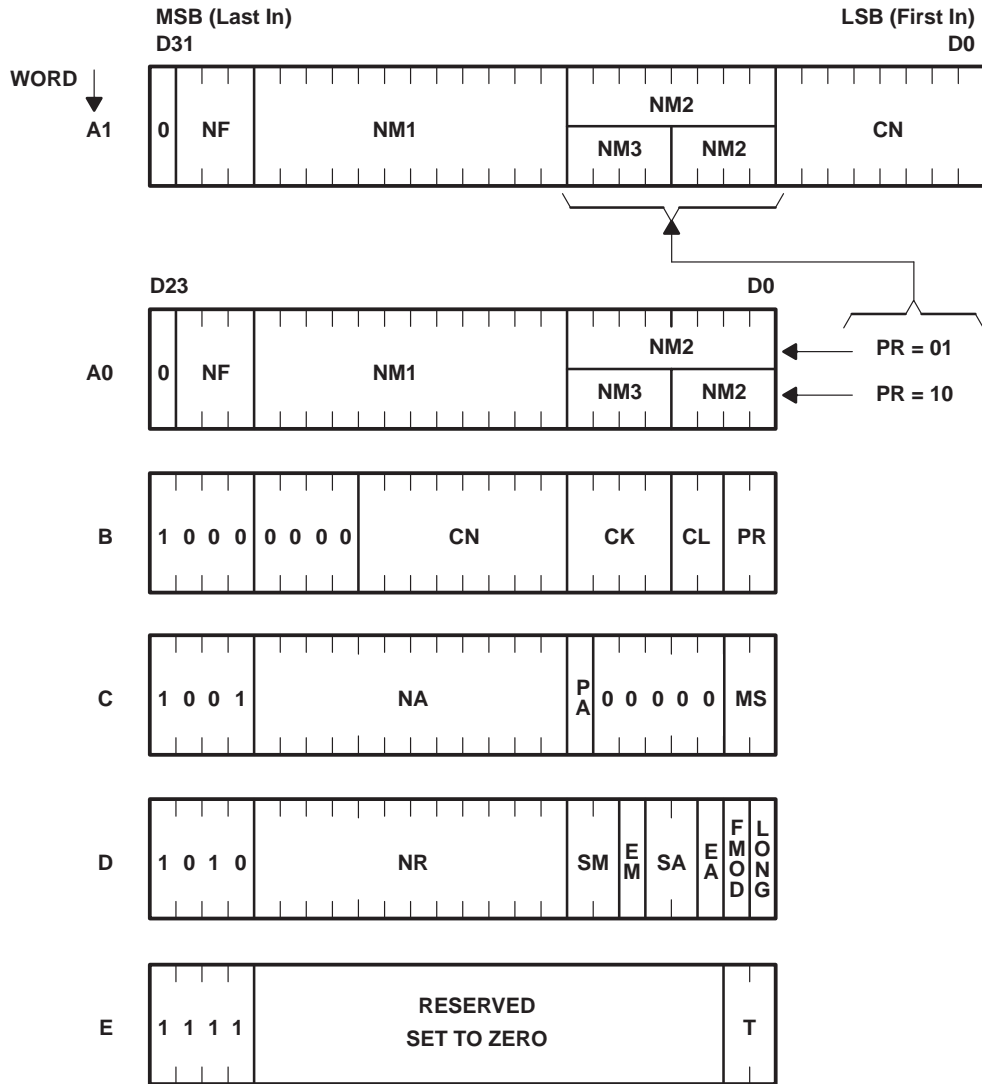


Figure 18. Serial Word Format for SA7025 Emulation Mode

PRINCIPLES OF OPERATION

Table 2. SA7025 Emulation Serial-Word-Format Function Listing

| SYMBOL | BITS | FUNCTION |
|---------------|------------------------------|---|
| CK | 4 | Binary acceleration factor for integral charge pump current |
| CL | 2 | Binary acceleration factor for proportional charge pump current |
| CN | 8 | Binary current-setting factor for main charge pumps |
| EA | 1 | Auxiliary divider enable flag: 0 = disabled 1 = enabled |
| EM | 1 | Main divider enable flag: 0 = disabled 1 = enabled |
| FMOD | 1 | Fractional-N modulus selection: 0 = modulo 5 1 = modulo 8 |
| LONG | 1 | A word format selection: 0 = 24-bit A0 format 1 = 32-bit A1 format |
| MS | 2 | Mode select 00 = 7025 Emulation Mode |
| NA | 12 | Auxiliary divider ratio |
| NF | 3 | Fractional-N increment |
| NM1 | 12 | Number of main divider cycles when prescaler modulus = 64 |
| NM2 | 8 if PR = 01 4 if PR = 10 | Number of main divider cycles when prescaler modulus = 65 |
| NM3 | 4 if PR = 10 | Number of main divider cycles when prescaler modulus = 72 |
| NR | 12 | Reference divider ratio |
| PA | 1 | Auxiliary prescaler select: 0 = divide by 4 1 = divide by 1 |
| PR | 2 | Prescaler type: PR = 01; modulus 2 prescaler (64/65) PR = 10; modulus 3 prescaler (64/65/72) |
| SA | 2 | Reference select for auxiliary phase detector |
| SM | 2 | Reference select for main phase detector |
| T | 2 | Test mode connection of internal signals to the LOCK terminal: 00 = ACCU overflow 01 = Auxiliary divider 10 = Main divider 11 = Reference divider |

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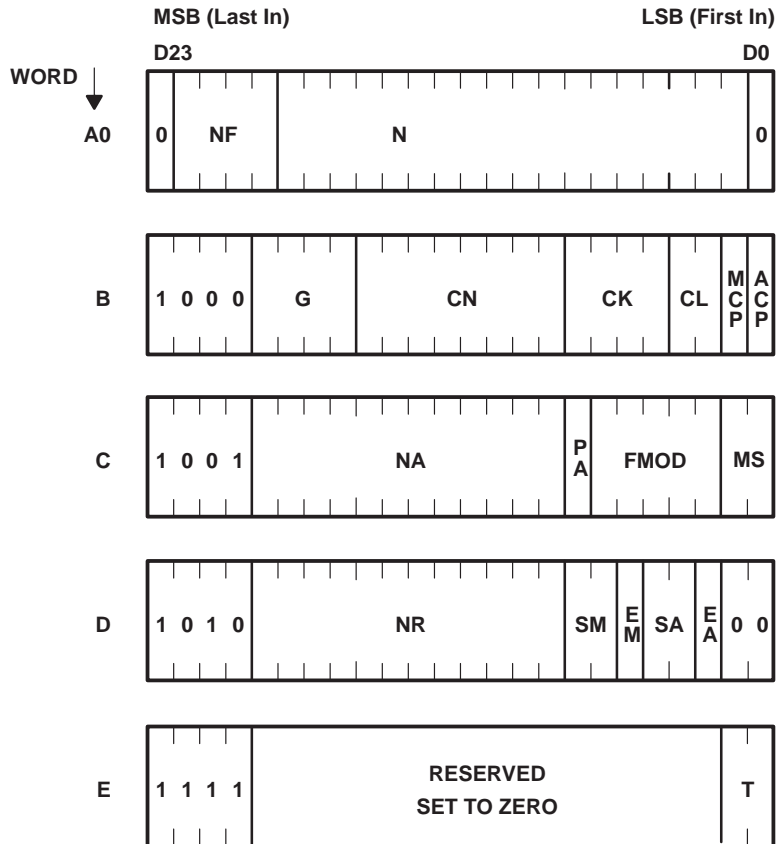


Figure 19. Serial Word Format for Extended Performance Mode (EPM)

PRINCIPLES OF OPERATION

Table 3. Extended Performance Mode Function Table

| SYMBOL | BITS | SAME AS SA7025 MODE | FUNCTION |
|--------|------|---------------------|---|
| ACP | 1 | No | Auxiliary charge polarity: 0 = positive 1 = negative |
| CK | 4 | Yes | Binary acceleration factor for integral charge pump current |
| CL | 2 | Yes | Binary acceleration factor for proportional charge pump current |
| CN | 8 | Yes | Binary current setting factor for main charge pumps |
| EA | 1 | | Auxiliary divider enable flag: 0 = disabled 1 = enabled |
| EM | 1 | Yes | Main divider enable flag: 0 = disabled 1 = enabled |
| FMOD | 5 | No | Fraction accumulator modulus |
| G | 4 | No | Speed-up mode duration (See Table 9) |
| MCP | 1 | No | Main charge pump polarity: 0 = positive 1 = negative |
| MS | 2 | No | Mode select 01 = Extended Performance Mode |
| N | 18 | No | Overall main divider integer division ratio (NM) |
| NA | 12 | Yes | Auxiliary divider ratio |
| NF | 4 | No | Fractional-N increment |
| NR | 12 | Yes | Reference divider ratio |
| PA | 1 | Yes | Auxiliary prescaler select: 0 = divide by 4 1 = divide by 1 |
| SA | 2 | Yes | Reference select for auxiliary phase detector |
| SM | 2 | Yes | Reference select for main phase detector |
| T | 2 | Yes | Test mode connection of internal signals to the LOCK terminal: 00 = ACCU overflow 01 = Auxiliary divider 10 = Main divider 11 = Reference divider |

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main divider – general (see Figure 20)

The differential RFIN inputs are amplified to internal ECL logic levels and provide excellent sensitivity (better than –20 dBm at 1 GHz), making the prescaler ideally suited for direct interface with a VCO. The internal dual-modulus (32/33) prescaler and counter sections divide the VCO frequency down to the reference phase detector frequency. The prescaler division ratio (+32 or +33) is controlled by a feedback signal that is a function of the 18-bit N-field counters. The N-field counter section is composed of two separate counters: a 5-bit A-Counter and a 13-bit B-Counter. The prescaler divides by 33 until the A-Counter reaches terminal count and then divides by 32 until the B-Counter reaches terminal count, whereupon both counters reset and the cycle repeats. The following equation relates the total N division as a function of the 32/33 prescaler:

$$N_{\text{Total}} = 32 (B - A) + 33(A), \text{ where } 0 \leq A \leq 31, \text{ and } 31 \leq B \leq 8191.$$

It is not necessary to determine the values of A and B in the equation above; simply program the N field with the total division ratio desired (fractional effects ignored).

The N-division ratio has a range of $992 \leq N_{\text{Total}} \leq 262143$.

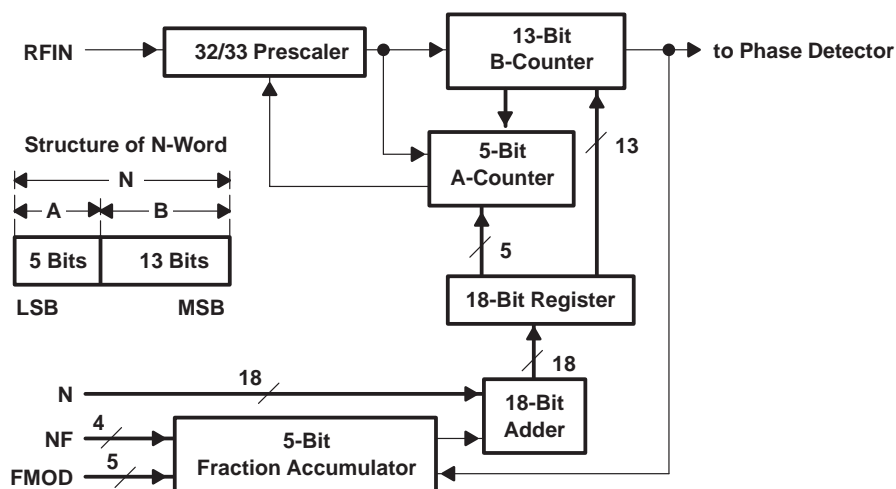


Figure 20. Main Divider Organization

main divider – SA7025 emulation

The internal triple modulus prescaler configuration of the SA7025 provides for prescaler division ratios of 64/65/72. The TRF2050 has internal conversion logic that allows the TRF2050 to emulate the SA7025 main divider operation. When operated in SA7025 emulation mode, the TRF2050 is programmed using the SA7025 serial interface format shown in Figure 18. The TRF2050 internal conversion is transparent and need not be considered under normal use, thereby allowing use of existing SA7025 programming codes without change.

The following equations relate the total N-division as a function of the emulated 64/65 dual-modulus and 64/65/72 triple-modulus prescalers:

$$N_{\text{Total}} = 64 (NM1 + 2) + 65 (NM2), \text{ where } PR = 01 \text{ and}$$

$$N_{\text{Total}} = 64 (NM1 + 2) + 65 (NM2) + 72 (NM3 + 1), \text{ where } PR = 10.$$

PRINCIPLES OF OPERATION

main divider – SA7025 emulation (continued)

For contiguous channels, the following rules must be observed:

For PR = 01: $61 \leq NM1 \leq 4095$ and $0 \leq NM2 \leq 63$, which yields minimum and maximum divide ratios of 4032 and 266303, respectively.

For PR = 10: $14 \leq NM1 \leq 4095$ and $0 \leq NM2 \leq 15$, and $0 \leq NM3 \leq 15$, which yields minimum and maximum divide ratios of 1096 and 264335, respectively.

main divider – synchronization

The A-Word is loaded only when a main divider synchronization signal is active. This prevents phase jumps when reprogramming the main divider. The synchronization signal is generated by the main divider, and it is active while the main divider is counting down from the programmed value. When the main divider reaches its terminal count, a main divider output pulse is sent to the main phase detector. Also at this time, the loading of the A-Word is disabled. Therefore, to correctly load the new A-Word, the STROBE signal must be active high for at least a minimum number of VCO input cycles at RFIN.

main divider – fractional accumulator

The TRF2050 main synthesizer loop can operate as a traditional integer-N feedback PLL or as a fractional-N feedback PLL. The integer-N feedback loop divides the VCO frequency by integer values of N, which results in phase detector reference comparisons at the desired channel spacing. A fractional-N feedback loop divides the VCO frequency by an integer term plus a fractional term, which results in phase detector reference comparisons at integer multiples of the desired system channel spacing.

Integer-N division: $VCO \text{ frequency} \div N = \text{phase detector reference frequency}$
 = channel spacing

Fractional-N division: $VCO \text{ Frequency} \div (N + NF/FMOD) = \text{phase detector reference frequency}$
 = $FMOD \times \text{channel spacing}$

where $0 \leq NF < FMOD$ and $1 \leq FMOD \leq 16$.

Because the main counter and prescaler sections cannot divide by a fraction of an integer, the fractional-N division is accomplished by averaging main divider cycles by N and N+1. A fractional accumulator is programmed with values of NF and FMOD to control the main counter and prescaler sections to divide by N or N+1.

The fractional accumulator operates modulo FMOD and is incremented by NF at the completion of each main divider cycle. When the fractional accumulator overflows, division by N+1 occurs. Otherwise, the main counters and prescaler divide by N; division by N+1 is transparent to the user. Table 4 shows the contents of the fractional accumulator and the resulting N or N+1 division for two fractional division ratios.

PRINCIPLES OF OPERATION

main divider – fractional accumulator (continued)

Table 4. Fractional Accumulator Operation

| NF = 3, FMOD = 8 | | NF = 6, FMOD = 8 | |
|-----------------------|-------------------|-----------------------|-------------------|
| ACCUMULATOR NUMERATOR | STATE | ACCUMULATOR NUMERATOR | STATE |
| 3 | ÷ N | 6 | ÷ N |
| 6 | ÷ N | 4 | ÷ N + 1, overflow |
| 1 | ÷ N + 1, overflow | 2 | ÷ N + 1, overflow |
| 4 | ÷ N | 0 | ÷ N + 1, overflow |
| 7 | ÷ N | 6 | ÷ N |
| 2 | ÷ N + 1, overflow | 4 | ÷ N + 1, overflow |
| 5 | ÷ N | 2 | ÷ N + 1, overflow |
| 0 | ÷ N + 1, overflow | 0 | ÷ N + 1, overflow |

For example, suppose that a typical AMPS channel of 953.25 MHz is desired. Because AMPS channel spacing is 30 kHz, for fractional-N operation the main phase detector reference frequency must be a multiple of 30 kHz; 240 kHz is typical. A value of FMOD = 8 is selected because 240 kHz / 30 kHz = 8. Dividing the channel frequency by the reference frequency results in $953.13 \div 240 \text{ kHz} = 3971.375 = 3971 + 3/8$. This example is shown in Table 4 where NF = 3 and FMOD = 8. The table shows that over the period of a complete fractional accumulator cycle, the fractional accumulator overflows three times for every eight main divider cycles. Figure 21 illustrates the division by N or N+1 for this 3/8 fractional channel example.

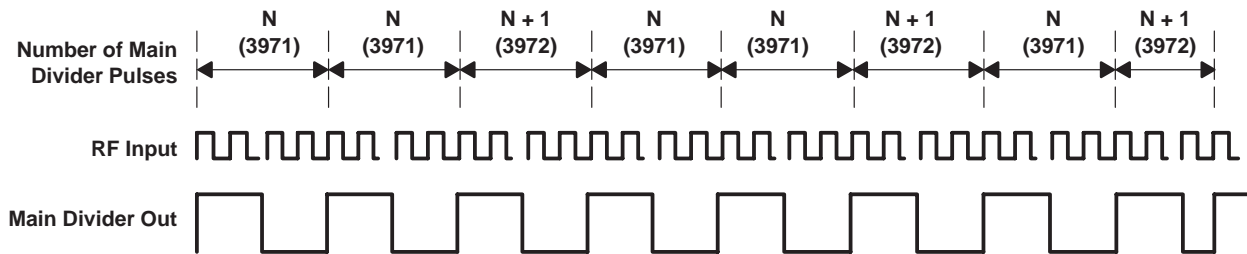


Figure 21. 3/8 Fractional Channel Main Divider Operation

The mean division over the complete fractional accumulator cycle as shown in Figure 21 is:

$$N_{\text{MEAN}} = \frac{3971 + 3971 + 3972 + 3971 + 3971 + 3972 + 3971 + 3972}{8} = 3971.375$$

$$= 3971 + 3/8$$

Therefore, fractional channels are available every 30 kHz or 240 kHz $\frac{1}{\text{FMOD}} = \frac{240 \text{ kHz}}{8}$.

main divider – integer channels

In the case where NF = 0, only division by N occurs, and the fractional accumulator is essentially in a steady state with a numerator of 0. It never increments or overflows. A channel that requires NF = 0 is a pure integer channel because the fractional term of $\frac{\text{NF}}{\text{FMOD}}$ is zero.

PRINCIPLES OF OPERATION

main divider – fractional-N sidebands and compensation

Programming a fractional-N channel means the main divider and prescaler divide by N or $N + 1$ as dictated by the operation of the fractional accumulator. Because the main divider operation is integer in nature and the desired VCO frequency is not, the output of the main phase detector is modulated with a resultant fractional-N phase ripple that produces sideband energy if left uncompensated. This phase ripple is proportional and synchronized to the contents of the fractional accumulator that is used to control fractional-N sideband compensation. Only channels that require a nonzero value of NF have the fractional-N sideband energy. The fractional-N sidebands, which appear at offset frequencies from the VCO fundamental tone, are multiples of $NF/FMOD$. Figure 22 shows the fractional-N phase detector ripple for a $3/8$ fractional channel.

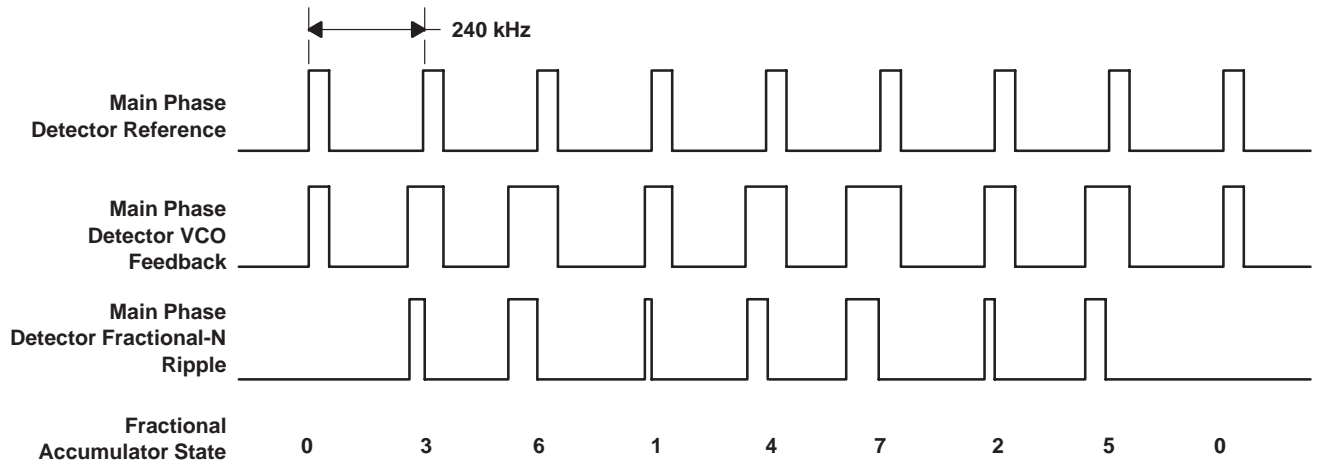


Figure 22. Fractional-N Phase Detector Ripple for $3/8$ Channel

The TRF2050 has internal circuitry that provides a means to compensate for the phase detector fractional-N phase ripple, thereby significantly reducing the magnitude of the fractional-N sidebands. Because the current waveform output of the main PLL proportional charge pumps is modulated with the phase detector fractional-N phase ripple, a fractional-N compensation charge-pump output is summed with the main PLL proportional charge pump.

Figure 23 shows the fractional-N ripple magnitude on the main PHP charge-pump output. The magnitude is essentially constant, and the pulse width is modulated with the contents of the fractional accumulator. The area under the main PHP charge-pump curve represents the amount of charge delivered to the loop filter network. In order to minimize fractional-N sidebands in the VCO spectrum, the compensation current waveform is generated to have *equal* and *opposite* sign magnitude *area* to the main PHP charge pump.

PRINCIPLES OF OPERATION

main divider – fractional-N sidebands and compensation (continued)

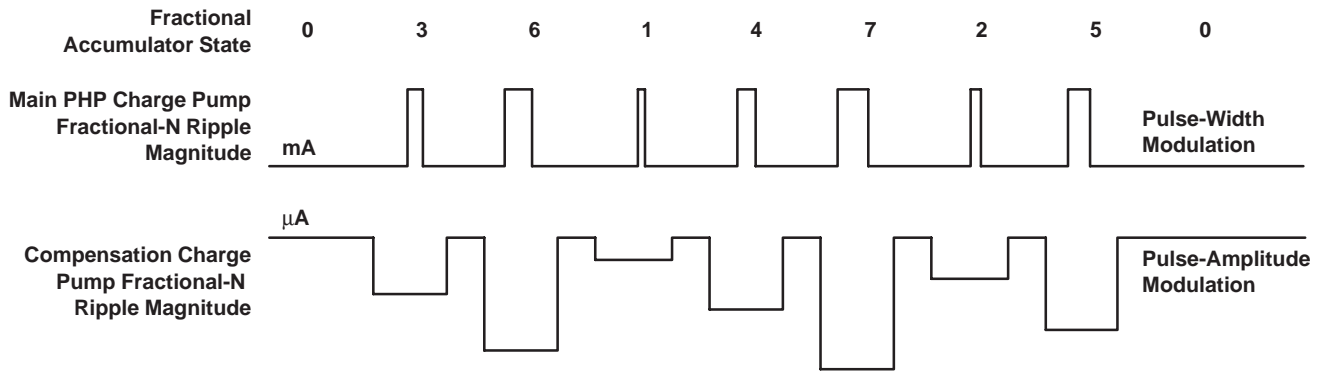


Figure 23. Main PHP and Compensation Charge Pump Fractional-N Waveforms for 3/8 Channel

The compensation waveform is pulse-amplitude modulated with the contents of the fractional accumulator. The main PHP pulse magnitude is much larger than the compensation pulse magnitude but the compensation pulse has a much longer duration than that of the main PHP pulse. The compensation pulse is optimally centered about the main PHP charge pump pulse in order to avoid additional sideband energy due to the phase offset between the main and compensation pulses.

The following example illustrates a method for determining correct values for RN, RF, and CN for minimal fractional-N sidebands based on VCO frequency and reference frequency.

Assumptions:

- The main VCO is locked on channel
 - 953-MHz ±10-MHz main VCO operation, 942.99–962.91 MHz
 - 19.44-MHz reference frequency
 - 240-kHz phase detector reference frequency
 - 500-μA peak main PHP current

- Determine the fundamental fractional-N pulse width portion of the main PHP charge-pump output waveform for the lower, upper, and mean frequencies.

$$\text{Frac}_{\text{PW-LWR}} = \frac{1}{f_{\text{PD}}} - \frac{N}{f_{\text{VCO}}} = \frac{1}{240 \text{ kHz}} - \frac{3929}{942.99 \text{ MHz}} = 132.557 \text{ ps},$$

$$\text{Frac}_{\text{PW-UPR}} = \frac{1}{f_{\text{PD}}} - \frac{N}{f_{\text{VCO}}} = \frac{1}{240 \text{ kHz}} - \frac{4012}{962.91 \text{ MHz}} = 129.815 \text{ ps},$$

$$\text{Frac}_{\text{PW-MEAN}} = \frac{\text{Frac}_{\text{PW-LWR}} + \text{Frac}_{\text{PW-UPR}}}{2} = \frac{132.557 \text{ ps} + 129.815 \text{ ps}}{2} = 131.186 \text{ ps}.$$

The mean-unit pulse width of the fractional-N portion of the main PHP charge-pump output waveform over the VCO frequencies of interest is 131.186 ps. This fundamental pulse width is modulated by the contents of the fractional accumulator. For the 3/8 fractional-N channel example, the pulse width varies as shown in Table 5.

PRINCIPLES OF OPERATION

main divider – fractional-N sidebands and compensation (continued)

Table 5. Main PHP Fractional-N Pulse-Widths and Areas for 3/8 Channel

| NF = 3, FMOD = 8 | | |
|-------------------|--------------------------------------|--------------------------------------|
| ACCUMULATOR STATE | MAIN PHP FRACTIONAL PULSE WIDTH (ps) | MAIN PHP FRACTIONAL AREA (ps X AMPS) |
| 3 | 3 x <i>PW-Mean</i> = 393.558 | 393.558 ps x 500 μA = .196779 |
| 6 | 6 x <i>PW-Mean</i> = 787.116 | 787.116 ps x 500 μA = .393558 |
| 1 | 1 x <i>PW-Mean</i> = 131.186 | 131.186 ps x 500 μA = .065593 |
| 4 | 4 x <i>PW-Mean</i> = 524.744 | 524.744 ps x 500 μA = .262372 |
| 7 | 7 x <i>PW-Mean</i> = 918.302 | 918.302 ps x 500 μA = .459151 |
| 2 | 2 x <i>PW-Mean</i> = 262.372 | 262.372 ps x 500 μA = .131186 |
| 5 | 5 x <i>PW-Mean</i> = 655.930 | 655.930 ps x 500 μA = .327965 |
| 0 | 0 x <i>PW-Mean</i> = 0 | 0 ps x 500 μA = 0 |

Table 5 also shows the area of the fractional-N portion of the main PHP charge-pump waveform.

- Determine the pulse width of the compensation charge-pump output waveform.

$$\text{Comp}_{PW} = \frac{1}{f_{Ref}} = \frac{1}{19.44 \text{ MHz}} = 51.440 \text{ ns}$$

- Determine the fundamental compensation charge-pump current magnitude using the fundamental main PHP fractional area.

$$\text{Comp}_{Mag} = \frac{\text{Frac}_{Area}}{\text{Comp}_{PW}} = \frac{0.065593 \text{ psA}}{51.440 \text{ ns}} = 1.275 \text{ μA}$$

Table 6 shows the magnitude of the compensation pulse as a function of the fractional accumulator.

Table 6. Compensation Pulse Magnitudes for 3/8 Channel

| NF = 3, FMOD = 8 | |
|-----------------------|-----------------------------------|
| Accumulator Numerator | Compensation Pulse Magnitude (μA) |
| 3 | 3 x 1.275 = 3.825 |
| 6 | 6 x 1.275 = 7.651 |
| 1 | 1 x 1.275 = 1.275 |
| 4 | 4 x 1.275 = 5.101 |
| 7 | 7 x 1.275 = 8.926 |
| 2 | 2 x 1.275 = 2.550 |
| 5 | 5 x 1.275 = 6.376 |
| 0 | 0 x 1.275 = 0 |

- Using the result of step 3, determine the value of RF to give the fundamental compensation pulse magnitude.

$$\text{RF (k}\Omega) = \frac{25}{\text{Comp}_{Mag}(\mu\text{A})} = \frac{25}{1.275} = 19.6 \text{ k}\Omega.$$

PRINCIPLES OF OPERATION

main divider – fractional-N sidebands and compensation (continued)

- Determine the values of CN and RN for the main PHP charge-pump peak current of 500 μA. Assume that a midrange value of CN equals 128.

$$RN(k\Omega) = \left(18.75 \times \frac{CN}{256} \times \frac{1}{I(mA)} \right) - 0.75 = \left(18.75 \times \frac{128}{256} \times \frac{1}{0.5 \text{ mA}} \right) - 0.75 = 18 \text{ k}\Omega$$

- The value of the fundamental compensation pulse magnitude calculated in step 3 is fixed and the compensation pulse width calculated in step 2 is also fixed. However, because the VCO can tune over a significant range of frequencies, the pulse width of the fractional-N portion of the main PHP charge-pump waveform varies; thus, the area of the same waveform varies. In order to maintain equal areas under the fractional-N portion of the main PHP charge-pump and compensation waveforms, CN must vary with the VCO frequency. As the VCO frequency increases, the fractional-N portion of the main PHP charge-pump waveform pulse width decreases proportionally, thereby decreasing the area under the same waveform. Therefore, CN is adjusted to equalize the main PHP and compensation waveform areas, as follows:

$$\begin{aligned} \text{Frac}_{PW-LWR} &= 132.557 \text{ ps for } f_{VCO} = 942.99 \text{ MHz} \\ \text{Frac}_{PW-UPR} &= 129.815 \text{ ps for } f_{VCO} = 962.91 \text{ MHz} \end{aligned}$$

The fundamental area of the fractional-N portion of the main PHP charge-pump waveform (step 1) is calculated as 0.065593 picosecond x amperes. If you calculate the fundamental area of the fractional-N portion of the main PHP charge-pump waveform using the actual pulse widths above in place of the average pulse width calculated in step 1, the fractional-N main PHP areas is obtained as follows:

$$\begin{aligned} \text{Frac}_{Area-LWR} &= 132.557 \text{ ps} - 0.500 \text{ mA} = 0.066279 \text{ (ps} \times \text{amps)} \\ \text{Frac}_{Area-UPR} &= 129.815 \text{ ps} - 0.500 \text{ mA} = 0.064691 \text{ (ps} \times \text{amps)} \end{aligned}$$

The actual areas under the fractional-N portion of the main PHP waveform require slight modification in the charge-pump current. The variation of CN required for area equalization is determined using a simple ratio form:

$$\begin{aligned} CN_{LWR} &= \frac{\text{Frac}_{Area-AVG}}{\text{Frac}_{Area-UPR}} \times CN_{AVG} = \frac{0.065593}{0.066279} \times 128 = 126 \\ CN_{UPR} &= \frac{\text{Frac}_{Area-AVG}}{\text{Frac}_{Area-LWR}} \times CN_{AVG} = \frac{0.065593}{0.064691} \times 128 = 130 \end{aligned}$$

Therefore, for this example, CN can vary from 126-130 over the VCO frequency range of 942.99 – 962.91 MHz for optimum fractional-N sideband suppression. Due to component and circuit tolerances, additional deviations in CN may be appropriate.

auxiliary divider

The input signal on AUXIN is amplified by a single-ended, ac-coupled input buffer/amplifier that has sufficient sensitivity (200 mVpp at 200 MHz) for direct connection to a typical VCO. The 12-bit (NA) auxiliary divider incorporates a divide by 1 (PA = 1) or divide by 4 (PA = 0) prescaler. The total division ratio can be expressed as:

$$\begin{aligned} N_{Total} &= 4 \times NA \text{ where } PA = 0 \\ N_{Total} &= NA, \text{ where } PA = 1 \text{ and } NA = 4 \text{ to } 4095 \end{aligned}$$



PRINCIPLES OF OPERATION

reference divider

The input signal on REFIN is amplified by a single-ended, ac-coupled input buffer/amplifier that has sufficient sensitivity for direct connection to a typical TCXO. The 12-bit (NR) reference divider total division ratio can be expressed as:

$$N_{\text{Total}} = NR, \text{ where } NR = 4 \text{ to } 4095$$

A four-section postscaler is connected to the output of the reference divider section. The main and auxiliary synthesizer sections can individually select a reference postscaler division of 1, 2, 4, or 8 by programming fields SM and SA, respectively (see Figure 24).

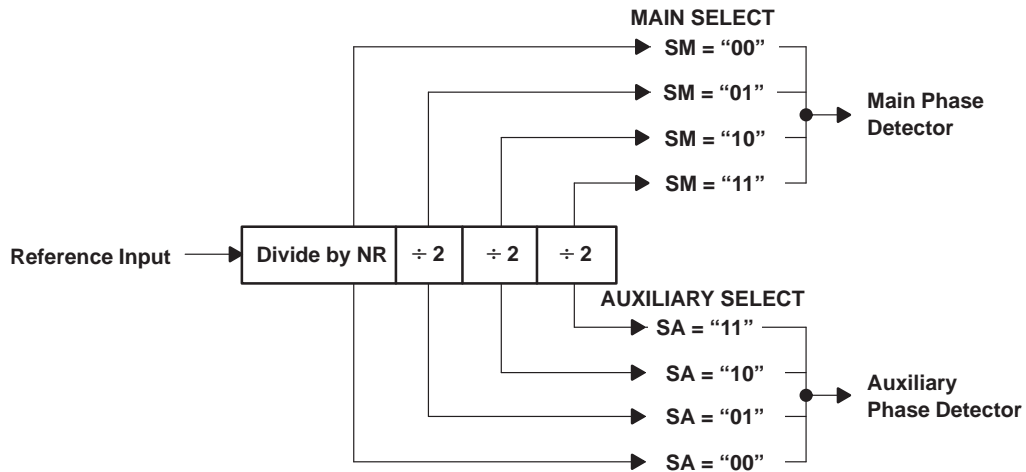


Figure 24. Reference Divider

phase detectors

The main and auxiliary synthesizer sections (see Figure 25) incorporate dual D-type flip-flop phase-frequency detectors (PFD). A PFD has gain with a phase error over a range of $\pm 2\pi$ and exhibits an infinite pull-in range. Dead-band compensation about zero-phase error is provided by forcing the sourcing and sinking charge pumps to have a minimum on-time of $1/f_{\text{Ref}}$ when the loop is operating in a locked condition.

The phase detectors can be programmed for polarity sense. Normally, external system VCOs have a positive slope control-voltage frequency characteristic. Some VCOs have a negative slope characteristic. The TRF2050 main and auxiliary phase detectors can be programmed for use with positive or negative slope VCOs using the *MCP* and *ACP* fields, respectively, in the B-Word (EPM mode).

For positive slope VCOs: $MCP = ACP = 0$

For negative slope VCOs: $MCP = ACP = 1$

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PRINCIPLES OF OPERATION

phase detectors (continued)

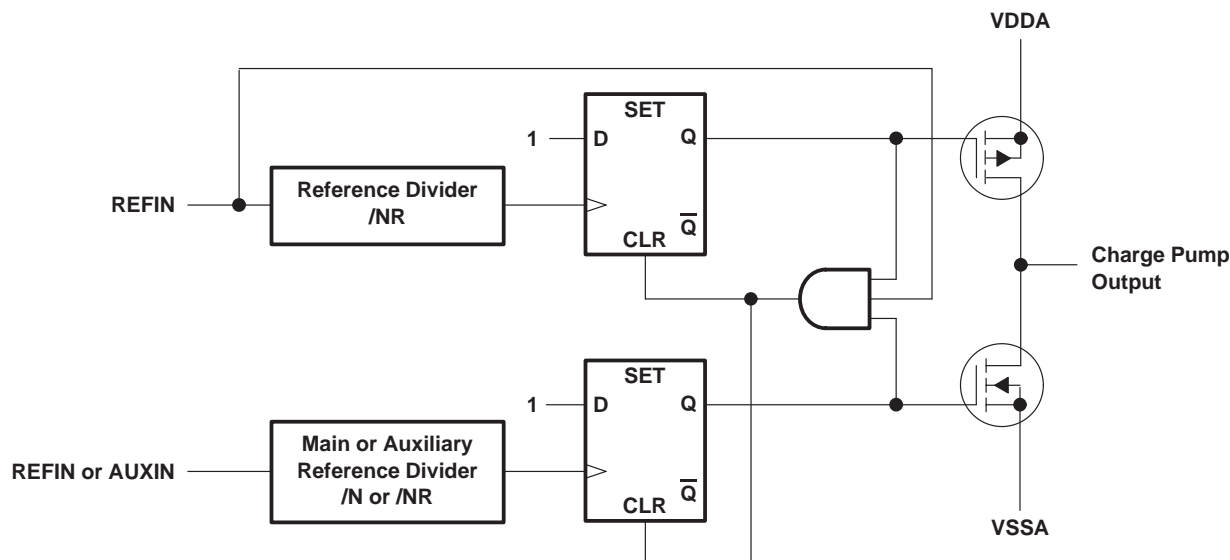


Figure 25. Main and Auxiliary Phase Detector Circuit

charge-pump current plans

The TRF2050 uses internal band-gap references and external resistors to develop biasing reference currents for the various charge pumps sections. Three terminals are designated for the external resistors: RN, RF, and RA. Internal, programmable coefficients CN, CL, and CK are also used. Table 7 shows how the external resistors are used to achieve desired charge-pump peak currents.

Table 7. Charge Pump Current Plans

| PARAMETER | MODE | CONDITION | UNIT |
|--|----------|-----------|------|
| Peak proportional, normal mode current $PHP_{PK-NM} = \left(\frac{18.75}{RN + 0.75} \times \frac{CN}{256} \right)$ | Normal | RN in kΩ | mA |
| Peak proportional, speed-up mode current $PHP_{PK-SM} = \left(\frac{18.75}{RN + 0.75} \times \frac{CN}{256} \right) + \left(\frac{18.75}{RN + 0.75} \times \frac{CN}{256} \times 2^{CL+1} \right)$ | Speed-up | RN in kΩ | mA |
| Peak integral, speed-up mode current $PHI_{PK-SM} = \left(\frac{18.75}{RN + 0.75} \times \frac{CN}{256} \times CK \times 2^{CL+1} \right)$ | Speed-up | RN in kΩ | mA |
| †Peak compensation, normal mode current $Comp_{PK} = \frac{30}{RF}$ | Normal | RF in kΩ | μA |
| Peak auxiliary current $PHA_{PK} = \left(\frac{1.25}{RA} \times 20 \right)$ | Normal | RA in kΩ | mA |

† The compensation charge-pump current is a pulse-amplitude modulated with the contents of the fractional accumulator. See the section on Main Divider – Fractional-N Sidebands and Compensation.

The average charge-pump current for the PHP, PHI, and PHA terminals is defined by:

$$I_{AVG} = \frac{\theta_{error}}{2\pi} \times I_{PK}$$

PRINCIPLES OF OPERATION

loop enable/disable

The main and auxiliary loops can be enabled and disabled by the contents of the enable bits EM and EA, respectively. When disabled, all currents in the RF input stages are switched off; the bias currents for the respective charge-pump circuits are switched off as well. When both loops are disabled (EM = EA = 0), the reference input stage currents are switched off. The reference chain can be turned off because the serial interface operates independent of the reference input for the loading of serial words.

Table 8. Loop Enable/Disable

| EM | EA | ENABLED | DISABLED |
|----|----|----------------------------|----------------------------|
| 0 | 0 | | Main, Auxiliary, Reference |
| 0 | 1 | Auxiliary, Reference | Main, |
| 1 | 0 | Main, Reference | Auxiliary |
| 1 | 1 | Main, Auxiliary, Reference | |

speed-up mode

When the main synthesizer frequency is changed, it may be desirable to increase the loop bandwidth for a short time in order to achieve a faster lock time. The proportional charge-pump current is increased and the integral charge-pump current is switched on for the duration of speed-up mode. The section, *charge-pump current plans*, illustrates how the charge-pump currents are a function of the external resistor RN and the programmable coefficients CN, CL, and CK.

The duration of the speed-up mode is determined by the operational mode of the TRF2050 device: enhanced performance mode (EPM) or SA7025 emulation mode. In EPM mode, the speed-up mode duration is controlled as a function of the G field in the B-Word and the reference frequency divider period.

Table 9. Speed-Up Mode

| G VALUE | DURATION _{EPM} |
|---------|---|
| 0–14 | $[(G+1) \times NR \times SM \times 16]/f_{REFIN}$ |
| 15 | $< (NR \times SM)/(f_{REFIN} \times 2)$; which is less than 1/2 a phase detector cycle |

When the TRF2050 is operated in SA7025 emulation mode, the speed-up mode duration is a function of the STROBE signal associated with the A-Word. When the STROBE signal followed by an A-Word write transaction goes active, the speed-up mode currents begin and persist until the STROBE signal is returned to an inactive state.

lock detect

The lock condition of the PLL is defined as a phase difference of less than a ± 1 cycle on the reference input REFIN. The LOCK terminal can be polled to determine the synthesizer lock condition of either or both loops. The lock detect function is described by the Boolean expression:

$$LOCK = (LD_{Main} + \overline{EM}) \cdot (LD_{Aux} + \overline{EA})$$

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PRINCIPLES OF OPERATION

test modes

The LOCK terminal may be used for test operations by terminating pin 19 to ground. When test modes are enabled, the LOCK terminal is connected to internal nodes of the TRF2050. Test modes are enabled by writing ones to the two LSBs of the E-Word. Test modes are disabled by terminating pin 19 to V_{CC} through a pull-up resistor of 10 k Ω .

Table 10. Test Modes

| T1 | T0 | MODE |
|----|----|---|
| 0 | 0 | Buffered output of the fractional accumulator |
| 0 | 1 | Buffered output of the auxiliary divider |
| 1 | 0 | Buffered output of the main divider |
| 1 | 1 | Buffered output of the reference divider |

The test mode can be used to verify the division ratio of the reference divider, the auxiliary divider, and the main divider and prescaler.

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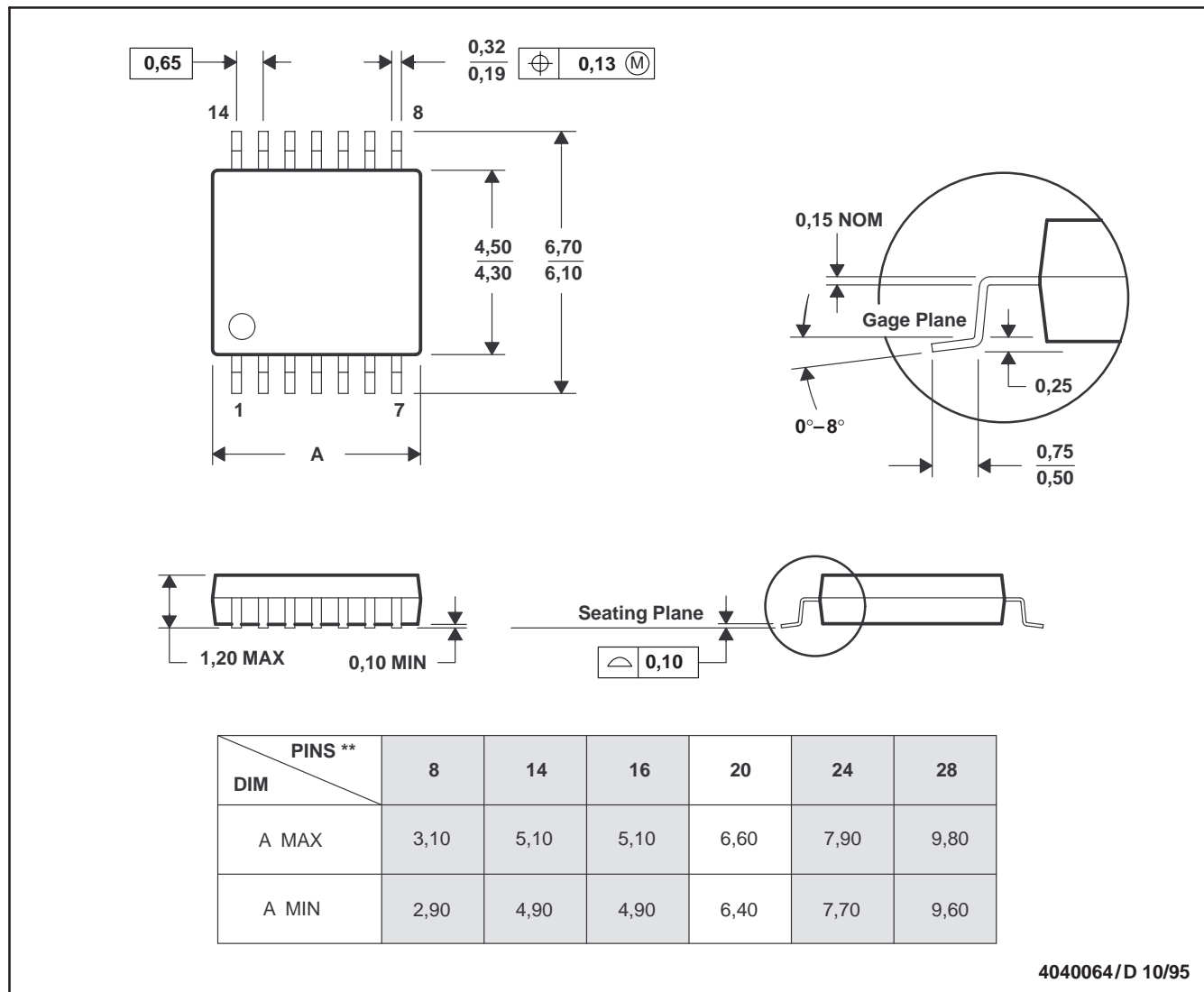
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MECHANICAL DATA

PW (R-PDSO-G)**

PLASTIC SMALL-OUTLINE PACKAGE

14 PIN SHOWN



- NOTES: A. All linear dimensions are in millimeters.
 B. This drawing is subject to change without notice.
 C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
 D. Falls within JEDEC MO-153

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