NT2800
1 GHz FM Transmitter

Rev. 1
February 6, 2003

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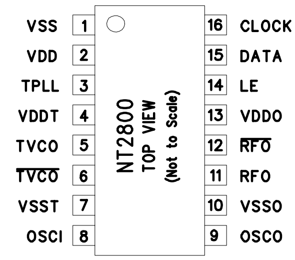
Features



- 100 - 1000 MHz Frequency Range
- Wide Bandwidth FM Transmitter
- Suitable for FM/FSK Modulation
- Direct-Modulation Scheme
- On-Chip PLL Synthesizer and VCO
- 3-wire serial interface
- 2.7 - 3.3V Operation / Standby Mode
- RF Output +1.5 dBm
- Low Cost, Quad Small Outline Package, (QSOP-16)
- BiCMOS Fabrication

Applications

- Analog/Digital 900 MHz Cordless Phones
- Telemetry/Data Radios
- Wireless Local Area Networks (WLAN)
- ISM Band (900 MHz) Wireless Products

Introduction

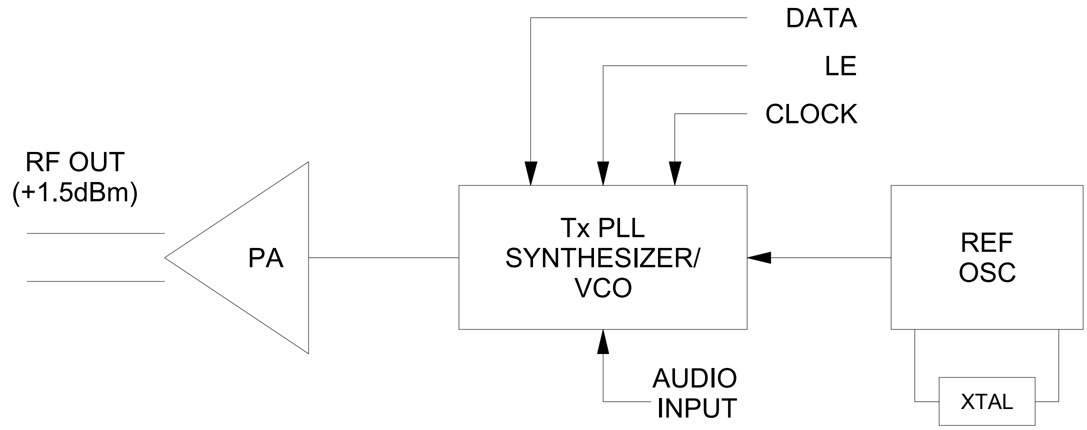
The NT2800 CHIP-MITTER^tm is a complete, single chip, FM Transmitter solution, which will operate in any 26 MHz band from 100-1000 MHz, including the Industrial Scientific Medical (ISM) band (902-928 MHz). Utilizing a direct-modulation approach, the NT2800 CHIP-MITTER^tm provides radio designers with a simple RF path design solution. The device is fabricated as a monolithic, BiCMOS, integrated circuit. It's transmitter section contains a directly modulated VCO and RF power amplifier (PA). An internal, high-performance phase locked loop (PLL) synthesizer with VCO allows transmitter operation over the entire RF tuning range. PLL programming, VCO trim, and power management, functions are accomplished via a 3-wire serial interface.

The BiCMOS construction of the NT2800 CHIP-MITTER^tm provides a high level of integration, with high performance operation and low power consumption. The CHIP-MITTER^tm operates over an industrial temperature range of -20C to +65C and over the supply voltage of +2.7 to +3.3 VDC. The device is available in an industry standard plastic package as a quad small outline package (QSOP-16).

Functional Description

A block diagram of the NT2800 CHIP-MITTER^tm is shown in Figure 1 on page 4. The transmit section of the device consists of a modulation input circuit, PLL synthesizer with directly modulated voltage controlled oscillator (VCO), and a RF power amplifier (PA). The PA is capable of providing +1.5 dBm into a 50 Ω load. Additionally, the device contains an on-chip crystal reference oscillator. A description of each of the major functional blocks follows.

Figure 1. NT2800 Block Diagram



Transmit PLL Synthesizer

The transmit (Tx) on-chip PLL synthesizer with an on-chip, voltage controlled oscillator (VCO), contains a dual-modulus prescaler (32/33) and employs a digital phase locked loop architecture. The transmit VCO can operate in any 24 MHz band from 100-1000 MHz. The transmit PLL accepts audio modulation to provide a frequency modulated (FM) RF carrier. Utilizing a direct modulation approach, the modulation voltage is directly applied to the PLL loop filter. The VCO center frequency is determined by an external tank circuit comprised of two inductors connected to the TVCO (pin 5) and $\overline{\text{TVCO}}$ (pin 6). An external PLL loop filter network, connected to TPLL (pin 3), filters the VCO control voltage. This control voltage (K_{VCO} = 26 MHz/V) is used to tune the tank frequency of the VCO via an internal, common-anode, varactor pair. The transmit frequency is programmed via a three wire serial interface (Data, Clock, and Load Enable).

Reference Oscillator

The on-chip crystal reference oscillator is a CMOS colpitts oscillator. The reference oscillator provides the reference frequency for the Tx PLL.

Power Amplifier

The on-chip RF power amplifier is a differential gain stage. The power amplifier requires a combiner network as shown in the application circuit (Figure 4 on page 12). The combiner network converts the amplifier's differential output (balanced 700Ω) to a single-ended output, capable of delivering +1.5 dBm into a 50Ω load.

Pin Description

This section summarizes the pin descriptions of the NT2800 by pin name.

Figure 2. Pin Configuration for QSOP-16 Package

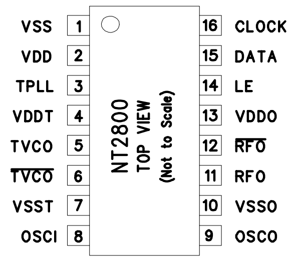


Table 1. Pin Descriptions

Pin Name	Pin Number	Description
VSS	1	Digital ground: This is the ground pin for the internal CMOS digital circuitry.
VDD	2	Digital power supply: This is the power supply pin for the internal CMOS digital circuitry for the synthesizer, reference synthesizer dividers, PLL charge-pump, PLL phase / frequency detector and crystal oscillator. This pin should be de-coupled to ground, as close to the pin as possible, with a high quality 0.1 µF ceramic capacitor.
TPLL	3	Transmit Voltage Controlled Oscillator: This pin connects to an external PLL loop filter, which provides the tuning voltage for the internal varactor tuning diodes. The PLL loop dynamics are controlled by the loop filter component values. Transmitter modulation is accomplished by directly applying the modulating signal (Audio/Data) to the PLL loop, via an external AC coupled, pre-filter network.
VDDT	4	Transmit VCO supply: This is the power supply pin for the internal voltage controlled oscillator (VCO) and buffer. This pin should be de-coupled to ground, as close to the pin as possible, with RF quality 100 pF and 1.0 nF ceramic capacitors.
TVCO $\overline{TVCO}$	5, 6	Transmit VCO Tank: These single-end outputs drive the external, balanced, VCO resonant tank circuit. The tank circuit generates the overall oscillation frequency for the TxVCO. Since the VCO is directly modulated, the resultant carrier frequency is that of the VCO frequency.
VSST	7	Transmit VCO ground: This is the ground pin for the internal VCO and buffer circuits.
OSCI	8	Oscillator Input: This CMOS input is the reference frequency input for both the Tx and Rx PLLs. When used with an external reference oscillator, the signal level should be within the range of 200-400 mV peak. Additionally, this input can be used with the OSCO pin to form a Colpitts crystal oscillator.
OSCO	9	Oscillator Output: This CMOS compatible output is used in conjunction with OSCIN to form a Colpitts oscillator using an external, low cost, crystal (parallel-resonant).

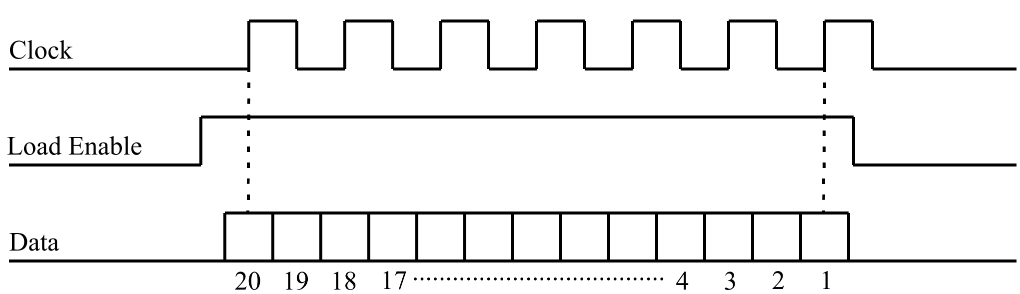
Table 1. Pin Descriptions (Continued)

Pin Name	Pin Number	Description
VSSO	10	Transmit RF ground: This is the ground pin for the internal power-amplifier (PA) and bipolar sections of the synthesizer divider. This pin should be connected directly to an RF ground plane using through-hole vias.
RFO $\overline{\text{RFO}}$	11, 12	RF Amplifier Outputs: These are the differential outputs of the power amplifier which require a combiner network as shown in the application circuit (Figure 4 on page 12). The output impedance of the power amplifier (PA) is ≈700Ω (differential). The combiner circuit, (Figure 4 on page 12) allows the delivery of 1.5 dBm into a 50Ω load.
VDDO	13	Transmit PA supply: This is the power supply pin for the internal power-amplifier (PA) and bipolar sections of the synthesizer divider. This pin should be de-coupled to ground, as close to the pin as possible, with RF quality 100 pF and 1.0 nF ceramic capacitors.
LE	14	Load Enable: This CMOS compatible input when HIGH allows data to be shifted into the internal shift register.
DATA	15	Serial Data Input: This CMOS compatible input accepts data MSB first. Refer to the Serial Programming Interface section on page 6 for additional information on the programming format.
CLK	16	Serial Clock: This CMOS compatible input shifts serial data into the internal 20-bit serial shift register, upon the rising edge of the clock signal.

Serial Programming Interface

Transmit VCO divide ratios are controlled by a standard 3-wire bus comprised of Clock, Load Enable, and Data inputs (Figure 3 on page 6). The programming word contains 20 bits, the first two bits select the programming of the transmit VCO frequency, reference frequency or device operational modes. The remaining bits contain data to be programmed.

Figure 3. Serial Bus Logic



Serial bus data is applied to DATA (pin 15) and clocked into the internal shift registers on the positive edge of CLOCK (pin 16), while Load Enable (pin 14) is held at logic[1]. Data is loaded from the shift registers into the data registers on the negative edge of the Load Enable (LE). This load is NOT synchronized with the programmable divider, i.e. the load is controlled directly by the negative falling edge of the Load Enable.

Reference Frequency Register

Table 2. Reference Frequency Register

Register Bit Number	Data Bit Number and Function	Description
Bit 1 (last bit loaded)	Load control bit 1	Set to logic (0).
Bit 2	Load control bit 2	Set to logic (0).
Bit 3	Ref(1) LSB	External reference frequency divide value. Division is allowed in the range 1 to 1024 with the number entered in binary form. This sets the internal reference frequency for the phase detector. Internal Reference Frequency = Reference Oscillator Frequency / Reference divide value
Bit 4	Ref(2)	
Bit 5	Ref(3)	
Bit 6	Ref(4)	
Bit 7	Ref(5)	
Bit 8	Ref(6)	
Bit 9	Ref(7)	
Bit 10	Ref(8)	
Bit 11	Ref(9)	
Bit 12 (first bit loaded)	Ref(10) MSB	

Transmit Frequency Register

Table 3. Transmit Frequency Register

Register Bit Number	Data Bit Number and Function	Description
Bit 1 (last bit loaded)	Load control bit 1	Set to logic (0)
Bit 2	Load control bit 2	Set to logic (1)
Bit 3 LSB	Ta(1)	VCO frequency A register
Bit 4	Ta(2)	
Bit 5	Ta(3)	
Bit 6	Ta(4)	
Bit 7 MSB	Ta(5)	

Table 3. Transmit Frequency Register (Continued)

Register Bit Number	Data Bit Number and Function	Description
Bit 8 LSB	Tm(1)	VCO frequency M register $\text{Divide Ratio} = (32 \cdot M) + A$ $\text{TxVCO} = \text{Internal Reference} \times \text{Divide Ratio}$
Bit 9	Tm(2)	
Bit 10	Tm(3)	
Bit 11	Tm(4)	
Bit 12	Tm(5)	
Bit 13	Tm(6)	
Bit 14	Tm(7)	
Bit 15	Tm(8)	
Bit 16	Tm(9)	
Bit 17 MSB	Tm(10)	
Bit 18	Tx VCO Trim bit 1	See Table 4 on page 8 for trim bit values.
Bit 19	Tx VCO Trim bit 2	
Bit 20 (first bit loaded)	Tx VCO Trim bit 3	

Table 4. Transmit VCO Trim Bits

Transmit VCO trim bits are programmed in the Transmit Frequency Register (Table 3 on page 7).			
Register Bit 20	**Register Bit 19**	**Register Bit 18**	**Trim Number**
Trim Bit 3	**Trim Bit 2**	**Trim Bit 1**	
0	0	0	0 – Minimum Capacitance
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7 – Maximum Capacitance

Mode Register

Table 5. Mode Register

Register Bit Number	Data Bit Number and Function	Logic [0] Setting	Logic [1] Setting
Bit 1 (Last bit loaded)	Load Control Bit 1		Required
Bit 2	Load Control Bit 2		Required
Bit 3	Not Used		
Bit 4	Not Used		
Bit 5	Transmit Section	Off	On
Bit 6	Not Used		
Bit 7	Transmit Charge Pump Current	0.2 mA	1.0 mA
Bit 8	Not Used		
Bit 9 (First bit loaded)	Tx Charge Pump Polarity	Normal	Invert

Electrical Specifications

Table 6. Electrical Characteristics

Parameter	Symbol	Minimum	Typical	Maximum	Units
Overall Device:					
Power Supply Voltage	Vdd	2.7	3	3.3	V
Operating Temperature	Topr	-20		65	C
Tx Current Consumption (w/RF VCO)	Tx Idd		25		mA
Standby Current	Istb		5		mA
Frequency of Operation	Fopr	100		1000	MHz
System Level Specifications: Apply to application circuit (Figure 4 on page 12).					
Channel Spacing			150		KHz
Channel Step Size		50			KHz
L.O. Spurious Output			-60	-57	dBc
Tx Output Power (At Antenna Output)	Po	-3	-0.5	1	dBm
Tx Tuning Range		100		1000	MHz
Device Level Specifications:					
PLL (Tx)					
Phase Noise (10 KHz Offset)			-85		dBc/Hz
Phase Noise (100 KHz Offset)			-105		dBc/Hz
Phase Noise (1.0 MHz Offset)			-125		dBc/Hz

Table 6. Electrical Characteristics (Continued)

Parameter	Symbol	Minimum	Typical	Maximum	Units
Phase Noise (22.75 MHz Offset)			-150		dBc/Hz
Spurious Products (Unwanted)		-60			dBc
Step Size		50			KHz
Reference Oscillator (Internal)		5		20	MHz
Power Amplifier (PA)					
Power Output		0	1.5	3	dBm
Output Impedance (Differential)		500	600	700	
Harmonic Level (2nd) - 909 MHz			-54.2		dBc
Harmonic Level (3rd)			-44.2		dBc
Harmonic Level (4th)			-70.9		dBc
Transmit Audio Response					
Input Level (Standard Test Conditions)			200		mVrms
Input Sensitivity	Kvco		26 MHz/V		V
Bandwidth (-3 dB)		0.3		70	KHz

Design Information

Board Layout

Design of ultra-high frequency (UHF) circuits requires careful attention to detail and layout. Careful attention to layout should be observed to minimize stray inductance and capacitance effects. This attention to detail will preserve RF sensitivity of the NT2800 CHIP-MITTER^{tm}. At high frequencies, microstrip or strip-line transmission line techniques must be employed. Using state-of-the-art CAD techniques for PCB layout, standard FR-4 fiberglass PCB material (1.6-mm thickness) may be employed. For maximum performance, however, RF quality substrate material should be used.

Supply Decoupling

The NT2800 is nominally powered with 2.7 to 3.3 VDC. All supply pins must be bypassed to a RF, analog, or digital ground plane depending on the type of supply pin. For RF supply pins, a 100 pF ceramic capacitor in parallel with a 1.0 nF ceramic capacitor, both RF quality, should provide adequate decoupling. For analog and digital supply pins, 0.01 - 0.1 µF RF quality capacitors should be used. The bypass capacitors should be placed as close to all power supply pins as possible. An effort should be made to minimize the trace length between the capacitor leads and the respective NT2800 power supply and common pins.

Grounding

The circuit designer should attempt to locate the NT2800 CHIP-MITTER^{tm}, associated analog input circuitry and interconnections as far as possible from logic circuitry. A solid RF analog ground should be placed around the LNA and associated RF filter circuitry, while a solid digital ground should be placed around the reference oscillator. Analog signals should be routed as far as possible from digital signals and should cross them at right angles. Ground connections for the NT2800. Connect all ground pins together to a low impedance ground plane, as close to the device as possible. Observe proper RF grounding and shielding techniques. The NT2800 should be used with separate analog and digital ground planes. The digital and analog ground planes should be "summed" at one point, typically at the power supply filter capacitor.

Operating Precautions

NUMA Technologies' plastic molded BiCMOS LSI devices are designed and manufactured for trouble-free operation when used under normal operating conditions. Our products are subjected to stringent electrostatic, mechanical strength, and environmental tests for assured reliability. When working with our products the user should observe the following precautions:

1. Use the product in the range of the rated operating voltage, operating temperature, operating input/output voltage and input/output current. If the product is used outside these operating parameters, the user may experience high failure rates.
2. Do not expose the product to excessive mechanical vibration, repetitive shock, or rapid or cyclic temperature changes. These factors can cause the bond wires in the plastic package to break.
3. Although all terminals have electrostatic protection, damage may still occur if very high electrostatic potentials are applied. Use of a conductive container or aluminum foil for packaging and transportation is recommended. (Untreated plastic containers are NOT recommended.) Use grounded soldering tools and test equipment.
4. The NT2800 employs Electrostatic Discharge (ESD) protection. CMOS inputs are rated to 2 KV using the human body model or 1 KV with the charge contact model. Bipolar RF inputs are protected to the greatest extent possible and consistent with industry standards, while meeting RF performance parameters.

Transmit VCO

The Tx VCO operates over a frequency range of 100 - 1000 MHz within the temperature range –20 to 65 °C. Amplitude variation over the tuning range is less than 1dB (±0.5 dB). The maximum change of VCO frequency in the locked state due to a variable load between short and open or when an antenna is touched or brought near a metal object is less than ±2.5 KHz.

Transmit Amplifier

Power level at the amplifier output is +1.5 dBm with a variation less than ±1.5 dB. This includes changes in amplitude from the VCO.

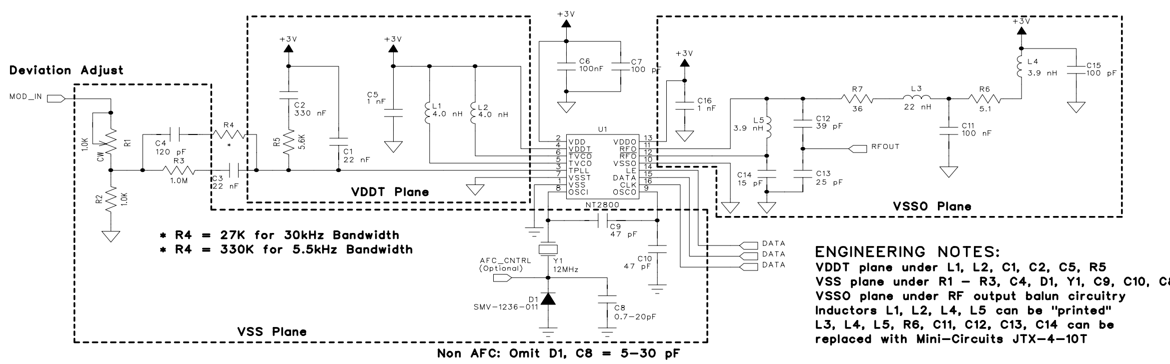
Load Pull

The transmit amplifier is stable (in-band) over a VSWR of 10:1; frequency shift is less than ±2.5 KHz over the 10:1 range.

900 MHz Transmitter Application Circuit

A circuit diagram for a high performance wireless transmitter is shown in Figure 4 on page 12. This circuit can be used for wireless audio, data or telemetry links. It is compliant in the USA for operation in the 902 - 928 MHz ISM band. The circuit will operate with a supply voltage of 2.7 to 3.3 VDC. Tuning and power management functions for the NT2800 (U1) are accessed via an industry standard 3-wire compatible serial interface. The printed VCO inductors (L1 and L2) provide the reactive elements for the on-chip VCO. The transmitter can be tuned over a range of 902 to 928 MHz via the 3-wire interface. The modulation input accepts either data or analog signals depending on the application, i.e. audio (FM) or data (FSK).

Figure 4. 900 MHz ISM Band Transmitter Application Circuit



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