

## General Description

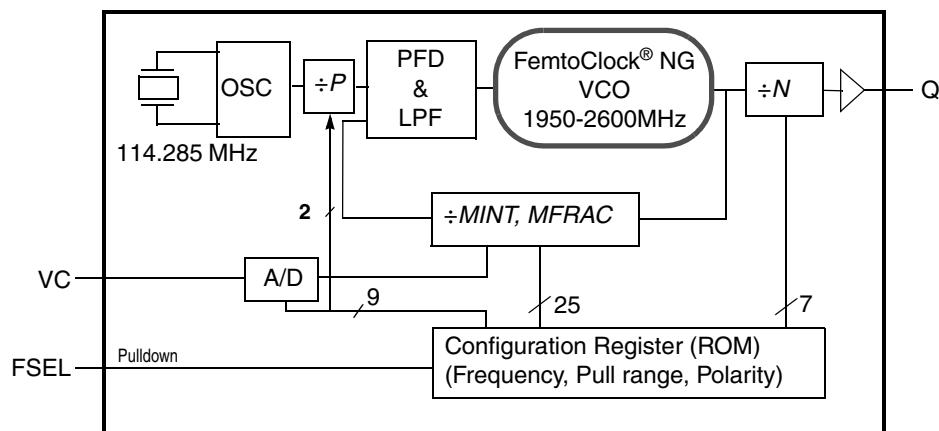
The IDT8N0DV85 is a LVCMS Dual-Frequency Programmable VCXO with very flexible frequency and pull-range programming capabilities. The device uses IDT's fourth generation FemtoClock® NG technology for an optimum of high clock frequency and low phase noise performance. The device accepts 2.5V or 3.3V supply and is packaged in a small, lead-free (RoHS 6) 6-lead ceramic 5mm x 7mm x 1.55mm package.

The device can be factory-programmed to any two frequencies in the range of 15.476MHz to 260MHz to the very high degree of frequency precision of 218Hz or better. The output frequency is selected by the FSEL pin. The extended temperature range supports wireless infrastructure, telecommunication and networking end equipment requirements.

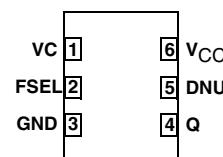
## Features

- Fourth generation FemtoClock® NG technology
- Programmable clock output frequency from 15.476MHz to 260MHz
- Two factory-programmed output frequencies
- Frequency programming resolution is 218Hz and better
- Absolute pull-range (APR) programmable from  $\pm 4.5$  to  $\pm 754.5$  ppm
- One 2.5V or 3.3V LVCMS clock output
- RMS phase jitter @ 156.25MHz (12kHz - 20MHz): 0.65ps (typical)
- RMS phase jitter @ 156.25MHz (1kHz - 40MHz): 0.94ps (typical)
- 2.5V or 3.3V supply voltage
- -40°C to 85°C ambient operating temperature
- Lead-free (RoHS 6) 6-lead ceramic 5mm x 7mm x 1.55mm package

## Block Diagram



## Pin Assignment



**IDT8N0DV85**  
6-lead ceramic 5mm x 7mm x 1.55mm  
package body  
CD Package  
Top View

## Pin Description and Characteristic Tables

**Table 1. Pin Descriptions**

Number	Name	Type	Description
1	VC	Input	VCXO Control Voltage input.
2	FSEL	Input	Pulldown <sup>NOTE1</sup>
3	GND	Power	Power supply pin.
4	Q	Output	Clock output. LVCMS interface levels.
5	DNU		Do not use.
6	V <sub>CC</sub>	Power	Power supply pin.

NOTE 1. *Pulldown* refers to internal input resistors. See Table 2, *Pin Characteristics*, for typical values

**Table 2. Pin Characteristics**

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
C <sub>IN</sub>	Input Capacitance	FSEL			5.5		pF
		VC			10		pF
C <sub>PD</sub>	Power Dissipation Capacitance		V <sub>CC</sub> = 3.465V or 2.625V		8		pF
R <sub>PULLDOWN</sub>	Input Pulldown Resistor				50		kΩ
R <sub>OUT</sub>	Output Impedance	Q	V <sub>CC</sub> = 3.3V		14		Ω
			V <sub>CC</sub> = 2.5V		17		Ω

## Function Tables

**Table 3A. Output Frequency**

15.476MHz to 260MHz

NOTE. Supported output frequency range. The output frequency can be programmed to any frequency in this range and to a precision of 218Hz.

## Principles of Operation

The block diagram consists of the internal 3<sup>RD</sup> overtone crystal and oscillator which provide the reference clock  $f_{XTAL}$  of 114.285MHz. The PLL includes the FemtoClock NG VCO along with the Pre-divider ( $P$ ), the feedback divider ( $M$ ) and the post divider ( $N$ ). The  $P$ ,  $M$ , and  $N$  dividers determine the output frequency based on the  $f_{XTAL}$  reference. The feedback divider is fractional supporting a huge number of output frequencies. Internal registers are used to hold up to two different factory pre-set configuration settings. The configuration is selected via the FSEL pin. Changing the FSEL control results in an immediate change of the output frequency to the selected register values. The  $P$ ,  $M$ , and  $N$  frequency configurations support an output frequency range 15.476MHz to 260MHz.

The devices use the fractional feedback divider with a delta-sigma modulator for noise shaping and robust frequency synthesis capability. The relatively high reference frequency minimizes phase noise generated by frequency multiplication and allows more efficient shaping of noise by the delta-sigma modulator. The output frequency is determined by the 2-bit pre-divider ( $P$ ), the feedback divider ( $M$ ) and the 7-bit post divider ( $N$ ). The feedback divider ( $M$ ) consists of both a 7-bit integer portion ( $MINT$ ) and an 18-bit fractional portion ( $MFRAC$ ) and provides the means for high-resolution frequency generation. The output frequency  $f_{OUT}$  is calculated by:

$$f_{OUT} = f_{XTAL} \cdot \frac{1}{P \cdot N} \cdot \left[ MINT + \frac{MFRAC + 0.5}{2^{18}} \right] \quad (1)$$

## Frequency Configuration

An order code is assigned to each frequency configuration and the VCXO pull-range programmed by the factory (default frequencies). For more information on the available default frequencies and order codes, please see the Ordering Information Section in this document. For available order codes, see the *FemtoClock NG Ceramic-Package XO and VCXO Ordering Product Information* document.

For more information on programming capabilities of the device for custom frequency and pull-range configurations, see the *FemtoClock NG Ceramic 5x7 Module Programming Guide*.

**Table 3B. Frequency Selection**

Input	Selects
FSEL	
0 (default)	Frequency 0
1	Frequency 1

## Absolute Maximum Ratings

NOTE: Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These ratings are stress specifications only. Functional operation of product at these conditions or any conditions beyond those listed in the *DC Characteristics* or *AC Characteristics* is not implied. Exposure to absolute maximum rating conditions for extended periods may affect product reliability.

Item	Rating
Supply Voltage, $V_{CC}$	3.63V
Inputs, $V_I$	-0.5V to $V_{CC} + 0.5V$
Outputs, $V_O$	-0.5V to $V_{CC} + 0.5V$
Package Thermal Impedance, $\theta_{JA}$	49.4°C/W (0 mps)
Storage Temperature, $T_{STG}$	-65°C to 150°C

## DC Electrical Characteristics

**Table 4A. Power Supply DC Characteristics,  $V_{CC} = 3.3V \pm 5\%$ ,  $T_A = -40^\circ C$  to  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{CC}$	Power Supply Voltage		3.135	3.3	3.465	V
$I_{CC}$	Power Supply Current			135	163	mA

**Table 4B. Power Supply DC Characteristics,  $V_{CC} = 2.5V \pm 5\%$ ,  $T_A = -40^\circ C$  to  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{CC}$	Power Supply Voltage		2.375	2.5	2.625	V
$I_{CC}$	Power Supply Current			124	148	mA

**Table 4C. LVC MOS/LVTTL DC Characteristic,  $V_{CC} = 3.3V \pm 5\%$  or  $V_{CC} = 2.5V \pm 5\%$ ,  $T_A = -40^\circ C$  to  $85^\circ C$**

Symbol	Parameter	Test Conditions		Minimum	Typical	Maximum	Units
$V_{IH}$	Input High Voltage	$V_{CC} = 3.3V$		2		$V_{CC} + 0.3$	V
		$V_{CC} = 2.5V$		1.7		$V_{CC} + 0.3$	V
$V_{IL}$	Input Low Voltage	$V_{CC} = V_{IN} = 3.465V$		-0.3		0.8	V
		$V_{CC} = V_{IN} = 2.5V$		-0.3		0.7	V
$I_{IH}$	Input High Current	FSEL	$V_{CC} = V_{IN} = 3.465V$ or $2.625V$			150	$\mu A$
$I_{IL}$	Input Low Current		$V_{CC} = 3.465V$ or $2.625V$ , $V_{IN} = 0V$	-5			$\mu A$
$V_{OH}$	Output High Voltage	Q	$V_{CC} = 3.465V$	2.6			V
			$V_{CC} = 2.625V$	1.8			V
$V_{OL}$	Output Low Voltage	Q	$V_{CC} = 3.465V$ or $2.625V$			0.6	V

## AC Electrical Characteristics

**Table 5A. VCXO Control Voltage Input ( $V_C$ ) Characteristics,  $V_{CC} = 3.3V \pm 5\%$  or  $2.5V \pm 5\%$ ,  $T_A = -40^\circ C$  to  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$K_V$	Oscillator Gain, NOTE 1, 2, 3 $V_{CC} = 3.3V$	ADC_GAIN[5:0] = 000001		7.57		ppm/V
		ADC_GAIN[5:0] = 000010		15.15		ppm/V
		ADC_GAIN[5:0] = XXXXXX		$25 \cdot \text{ADC_GAIN} \div V_{CC}$		ppm/V
		ADC_GAIN[5:0] = 111110		469.69		ppm/V
		ADC_GAIN[5:0] = 111111		477.27		ppm/V
	Oscillator Gain, NOTE 1, 2, 3 $V_{CC} = 2.5V$	ADC_GAIN[5:0] = 000001		10		ppm/V
		ADC_GAIN[5:0] = 000010		20		ppm/V
		ADC_GAIN[5:0] = XXXXXX		$25 \cdot \text{ADC_GAIN} \div V_{CC}$		ppm/V
		ADC_GAIN[5:0] = 111110		620		ppm/V
		ADC_GAIN[5:0] = 111111		630		ppm/V
$L_{VC}$	Control Voltage Linearity	BSL Variation; NOTE 4	-1	$\pm 0.1$	+1	%
BW	Modulation Bandwidth			100		kHz
$R_{VC}$	VC Input Resistance		500			k $\Omega$
$V_{CNOM}$	Nominal Control Voltage			$V_{CC} \div 2$		V
$V_C$	Control Voltage Tuning Range; NOTE 4		0		$V_{CC}$	V

NOTE: Electrical parameters are guaranteed over the specified ambient operating temperature range, which is established when the device is mounted in a test socket with maintained transverse airflow greater than 500lfpm. The device will meet specifications after thermal equilibrium has been reached under these conditions.

NOTE 1:  $V_C = 10\%$  to  $90\%$  of  $V_{CC}$ .

NOTE 2: Nominal oscillator gain: Pull range divided by the control voltage tuning range of 3.3V.

E.g. for ADC\_GAIN[6:0] = 000001 the pull range is  $\pm 12.5$ ppm, resulting in an oscillator gain of  $25\text{ppm} \div 3.3V = 7.57\text{ppm/V}$ .

NOTE 3: For best phase noise performance, use the lowest  $K_V$  that meets the requirements of the application.

NOTE 4: BSL = Best Straight Line Fit: Variation of the output frequency vs. control voltage  $V_C$ , in percent.  $V_C$  ranges from 10% to 90%  $V_{CC}$ .

**Table 5B. AC Characteristics,  $V_{CC} = 3.3V \pm 5\%$  or  $2.5V \pm 5\%$ ,  $T_A = -40^\circ C$  to  $85^\circ C$** 

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$f_{OUT}$	Output Frequency Q		15.476		260	MHz
$f_I$	Initial Accuracy	Measured at $25^\circ C$			$\pm 10$	ppm
$f_S$	Temperature Stability	Option Code = A or B			$\pm 100$	ppm
		Option Code = E or F			$\pm 50$	ppm
		Option Code = K or L			$\pm 20$	ppm
$f_A$	Aging	Frequency drift over 10 year life			$\pm 3$	ppm
		Frequency drift over 15 year life			$\pm 5$	ppm
$f_T$	Total Stability	Option Code A or B (10 year life time)			$\pm 113$	ppm
		Option Code E or F (10 year life time)			$\pm 63$	ppm
		Option Code K or L (10 year life time)			$\pm 33$	ppm
$f_{JIT(cc)}$	Cycle-to-Cycle Jitter NOTE 1, 2, 3			20		ps
$f_{JIT(per)}$	Period Jitter, RMS; NOTE 1, 2, 3			3.3		ps
$f_{JIT(\emptyset)}$	RMS Phase Jitter (Random) NOTE 4	$f_{OUT} = 156.25MHz$ , Integration Range: 12kHz - 20MHz		0.65	0.90	ps
		$f_{OUT} = 156.25MHz$ , Integration Range: 1kHz - 40MHz		0.94		ps
$f_{JIT(\emptyset)}$	RMS Phase Jitter (Random) NOTE 4, 5	Integration Range: 12kHz - 20MHz		0.65	1.05	ps
$\Phi_N(100)$	Single-side Band Phase Noise	$f_{OUT} = 156.25MHz$ , 100Hz from Carrier		-65		dBc/Hz
$\Phi_N(1k)$	Single-side band phase noise	$f_{OUT} = 156.25MHz$ , 1kHz from Carrier		-96		dBc/Hz
$\Phi_N(10k)$	Single-side band phase noise	$f_{OUT} = 156.25MHz$ , 10kHz from Carrier		-117		dBc/Hz
$\Phi_N(100k)$	Single-side band phase noise	$f_{OUT} = 156.25MHz$ , 100kHz from Carrier		-126		dBc/Hz
$\Phi_N(1M)$	Single-side band phase noise,	$f_{OUT} = 156.25MHz$ , 1MHz from Carrier		-138		dBc/Hz
$\Phi_N(10M)$	Single-side band phase noise,	$f_{OUT} = 156.25MHz$ , 10MHz from Carrier		-144		dBc/Hz
$t_R / t_F$	Output Rise/Fall Time	20% to 80%	175		715	ps
$odc$	Output Duty Cycle		45		55	%
$t_{STARTUP}$	Device Start-up Time After Power-up				20	ms
$t_{SET}$	Output Frequency Settling Time After FSEL0 and FSEL1 Values are Changed				1	ms

NOTE: Characterized with VC in linear range.

NOTE: XTAL parameters (Initial Accuracy, temperature Stability, Aging and Total Stability) are guaranteed by manufacturing.

NOTE: Electrical parameters are guaranteed over the specified ambient operating temperature range, which is established when the device is mounted in a test socket with maintained transverse airflow greater than 500 l/fpm. The device will meet specifications after thermal equilibrium has been reached under these conditions.

NOTE 1: This parameter is defined in accordance with JEDEC standard 65.

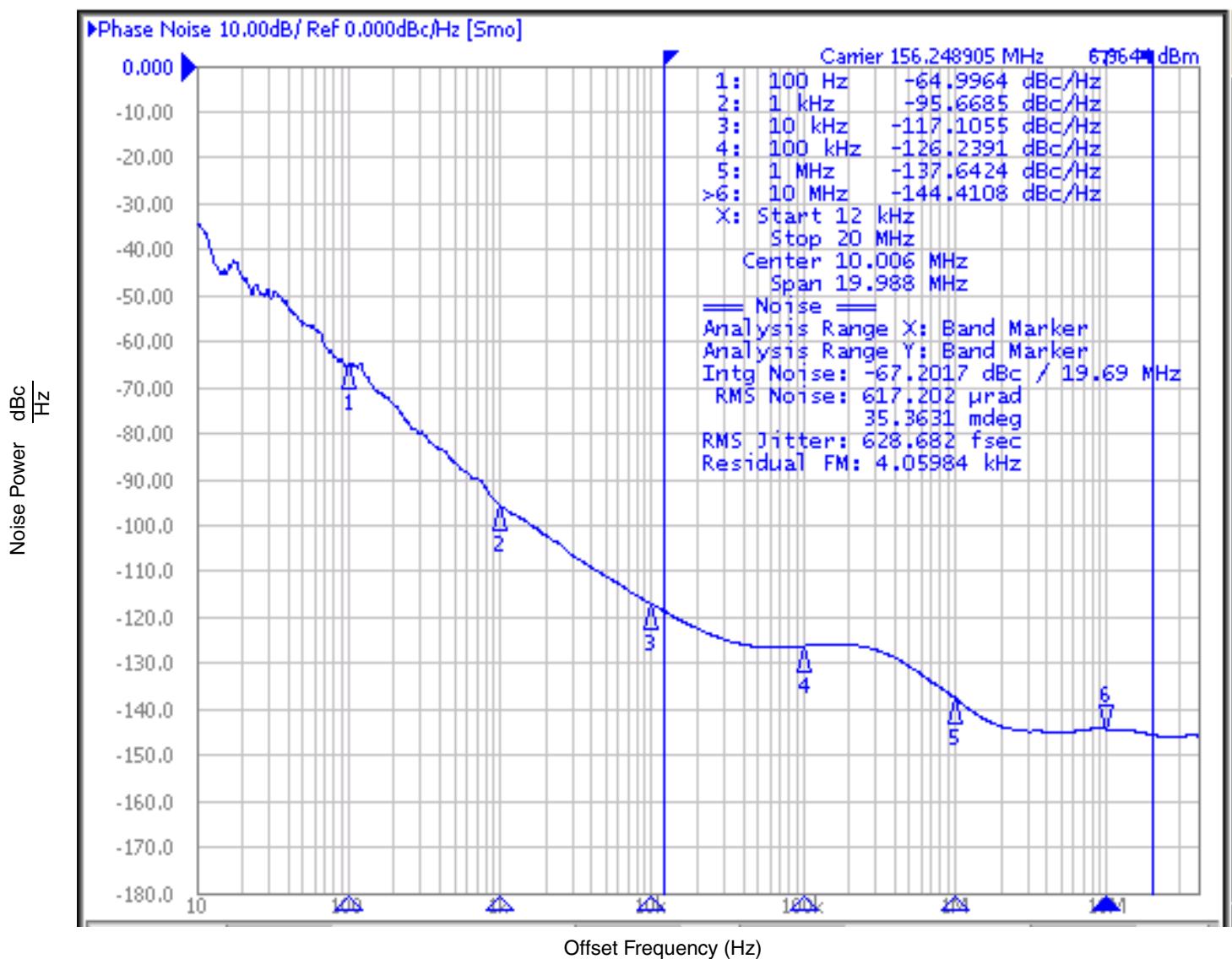
NOTE 2: Tested at supply voltage  $V_{CC} = 3.3V \pm 5\%$ .

NOTE 3: Applies to output frequencies: 15.476, 19.44, 25, 33.33, 74.174, 74.25, 100, 106.25, 122.88, 125, 150, 155.52, 156.25, 161.132, 176.8328, 187.5, 200, 212.5, 250 and 260MHz.

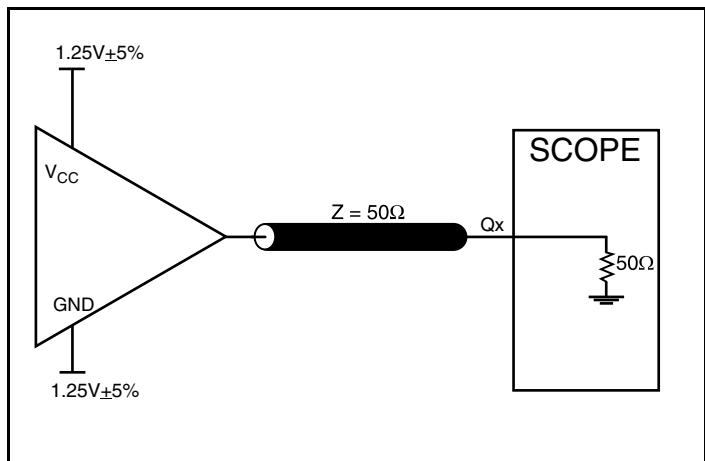
NOTE 4: Refer to phase noise plot.

NOTE 5: Applies to output frequencies: 25, 33.33, 100, 106.25, 122.88, 125, 148.5, 150, 155.52, 156.25, 161.132, 164.3555, 166.62875, 176.8328, 187.5, 212.5 and 250MHz.

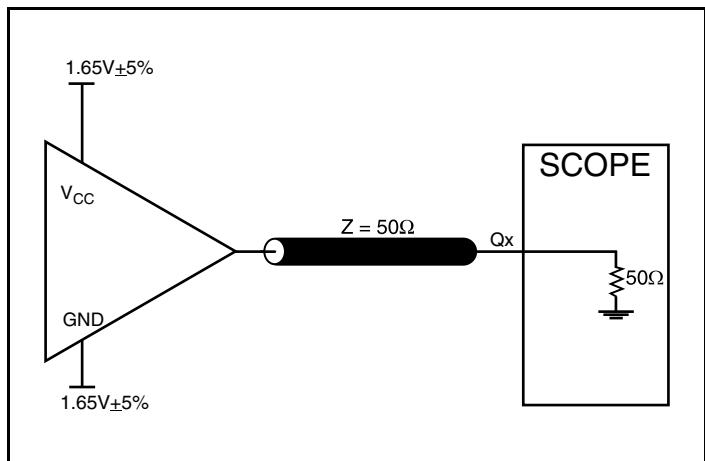
## Typical Phase Noise at 156.25MHz (12kHz - 20MHz)



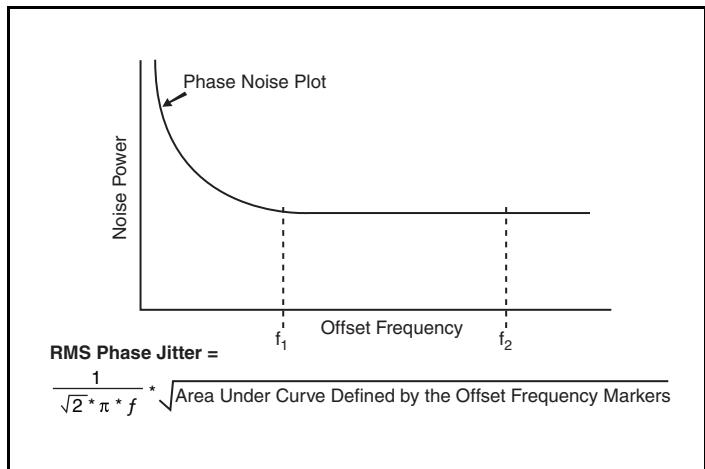
## Parameter Measurement Information



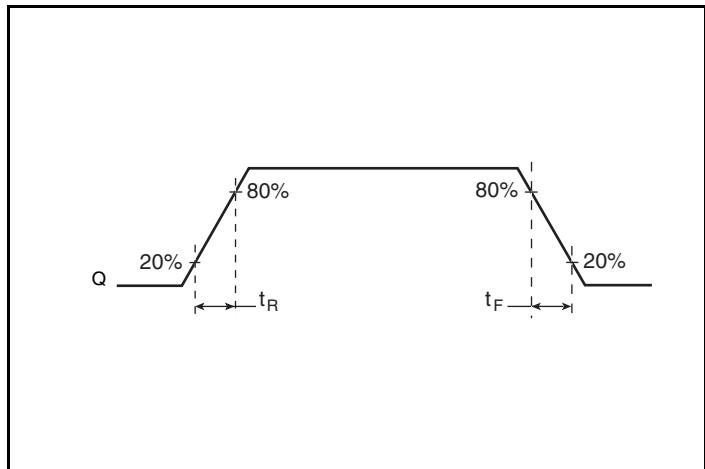
2.5V LVCMS/LVTTL Output Load AC Test Circuit



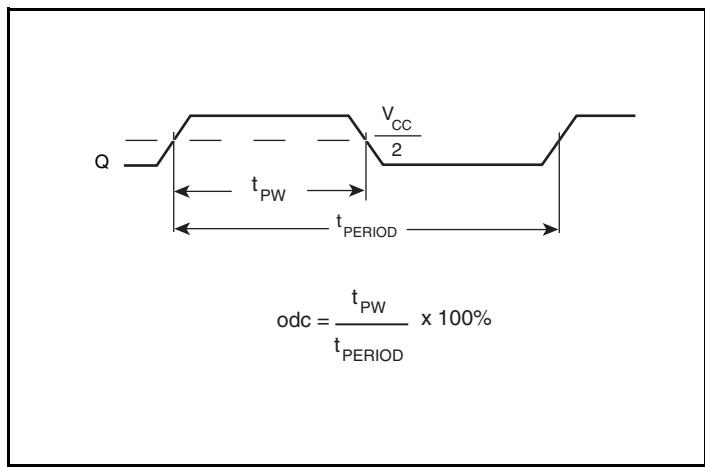
3.3V LVCMS/LVTTL Output Load AC Test Circuit



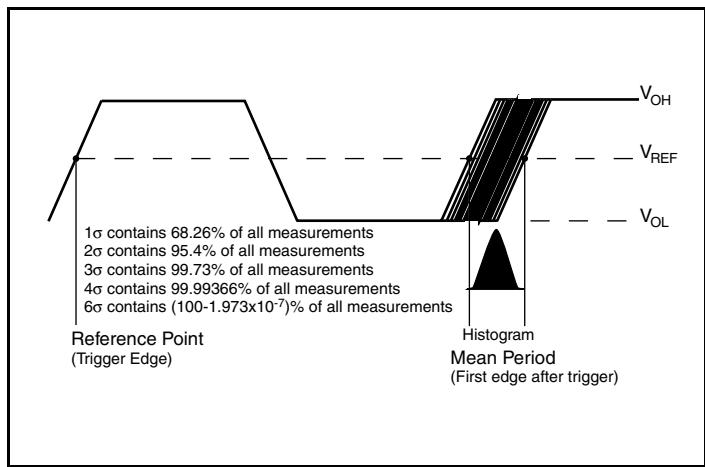
RMS Phase Jitter



Output Rise and Fall Time



Output Duty Cycle/Pulse Width/Period



RMS Period Jitter

## Applications Information

### Recommendations for Unused Input Pins

#### Inputs:

##### LVC MOS Pins

The control pin has an internal pulldown; additional resistance is not required but can be added for additional protection. A  $1\text{k}\Omega$  resistor can be used.

## Schematic Layout

Figure 1 shows an example of IDT8N0DV85 application schematic. In this example, the device is operated at  $V_{CC} = 3.3V$ . The schematic example focuses on functional connections and is intended as an example only and may not represent the exact user configuration. Refer to the pin description and functional tables in the datasheet to ensure the logic control inputs are properly set. For example FSEL can be configured from an FPGA instead of set with pull up and pull down resistors as shown.

The typical application of the IDT8N0DV85 is a voltage-controlled oscillator as part of a PLL. The two connections necessary to be made to the PLL are VC, the analog control voltage that sets the center frequency of the VCXO, and Q, which is the oscillator output. VC is the analog output of the PLL low pass loop filter that serves to remove noise from the phase detector error output.

In order to achieve the best possible filtering, it is recommended that the placement of the filter components be on the device side of the PCB as close to the power pins as possible. If space is limited, the  $0.1\mu F$  capacitor in each power pin filter should be placed on the device side of the PCB and the other components can be placed on the opposite side.

As with any high speed analog circuitry, the power supply pins are vulnerable to random noise, so to achieve optimum jitter performance isolation of the  $V_{CC}$  pin from the power supply is required. In order to achieve the best possible filtering, it is recommended that the placement of the filter components be on the device side of the PCB as close to the power pins as possible. If space is limited, the  $0.1\mu F$  capacitor on the  $V_{CC}$  pin must be placed on the device side with direct return to the ground plane though vias. The remaining filter components can be on the opposite side of the PCB.

Power supply filter component recommendations are a general guideline to be used for reducing external noise from coupling into the devices. The filter performance is designed for a wide range of noise frequencies. This low-pass filter starts to attenuate noise at approximately 10kHz. If a specific frequency noise component is known, such as switching power supplies frequencies, it is recommended that component values be adjusted and if required, additional filtering be added. Additionally, good general design practices for power plane voltage stability suggests adding bulk capacitance in the local area of all devices.

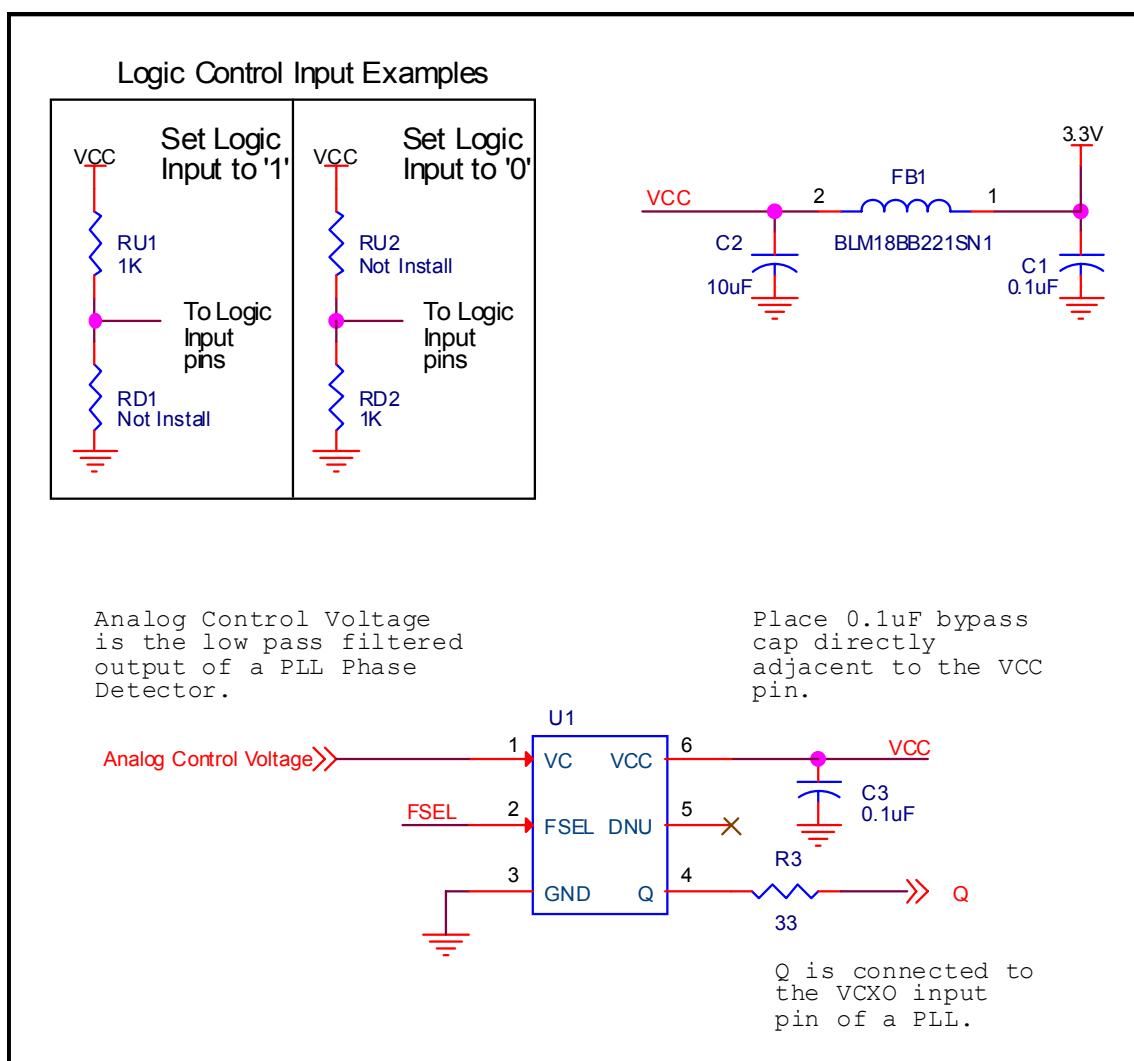


Figure 1. IDT8N0DV85 Application Schematic

## Power Considerations

This section provides information on power dissipation and junction temperature for the IDT8N0DV85. Equations and example calculations are also provided.

### 1. Power Dissipation.

The total power dissipation for the IDT8N0DV85 is the sum of the core power plus the power dissipation in the load(s). The following is the power dissipation for  $V_{CC} = 3.3V + 5\% = 3.465V$ , which gives worst case results.

- Power (core)<sub>MAX</sub> =  $V_{CC\_MAX} * I_{CC} = 3.465V * 163mA = 564.8mW$

#### Total Static Power:

$$= \text{Power (core)}_{MAX} = 564.8mW$$

#### Dynamic Power Dissipation at $F_{OUT}$ (max)

$$\text{Total Power } (F_{OUT\_MAX}) = [(C_{PD} * N) * \text{Frequency} * (V_{CC})^2] = [(8pF * 1) * 260MHz * (3.465V)^2] = 25mW$$

#### Total Power

##### Total Power

$$\begin{aligned} &= \text{Static Power} + \text{Dynamic Power Dissipation} \\ &= 564.8mW + 25mW \\ &= 589.8mW \end{aligned}$$

### 2. Junction Temperature.

Junction temperature,  $T_j$ , is the temperature at the junction of the bond wire and bond pad, and directly affects the reliability of the device. The maximum recommended junction temperature is 125°C. Limiting the internal transistor junction temperature,  $T_j$ , to 125°C ensures that the bond wire and bond pad temperature remains below 125°C.

The equation for  $T_j$  is as follows:  $T_j = \theta_{JA} * P_{d\_total} + T_A$

$T_j$  = Junction Temperature

$\theta_{JA}$  = Junction-to-Ambient Thermal Resistance

$P_{d\_total}$  = Total Device Power Dissipation (example calculation is in section 1 above)

$T_A$  = Ambient Temperature

In order to calculate junction temperature, the appropriate junction-to-ambient thermal resistance  $\theta_{JA}$  must be used. Assuming no air flow and a multi-layer board, the appropriate value is 49.4°C/W per Table 6 below.

Therefore,  $T_j$  for an ambient temperature of 85°C with all outputs switching is:

$$85^\circ C + 0.590W * 49.4^\circ C/W = 114.1^\circ C. \text{ This is below the limit of } 125^\circ C.$$

This calculation is only an example.  $T_j$  will obviously vary depending on the number of loaded outputs, supply voltage, air flow and the type of board (multi-layer).

**Table 6. Thermal Resistance  $\theta_{JA}$  for a 6-lead Ceramic 5mm x 7mm Package, Forced Convection**

$\theta_{JA}$ by Velocity			
Meters per Second	0	1	2
Multi-Layer PCB, JEDEC Standard Test Boards	49.4°C/W	44.2°C/W	42.1°C/W

## Reliability Information

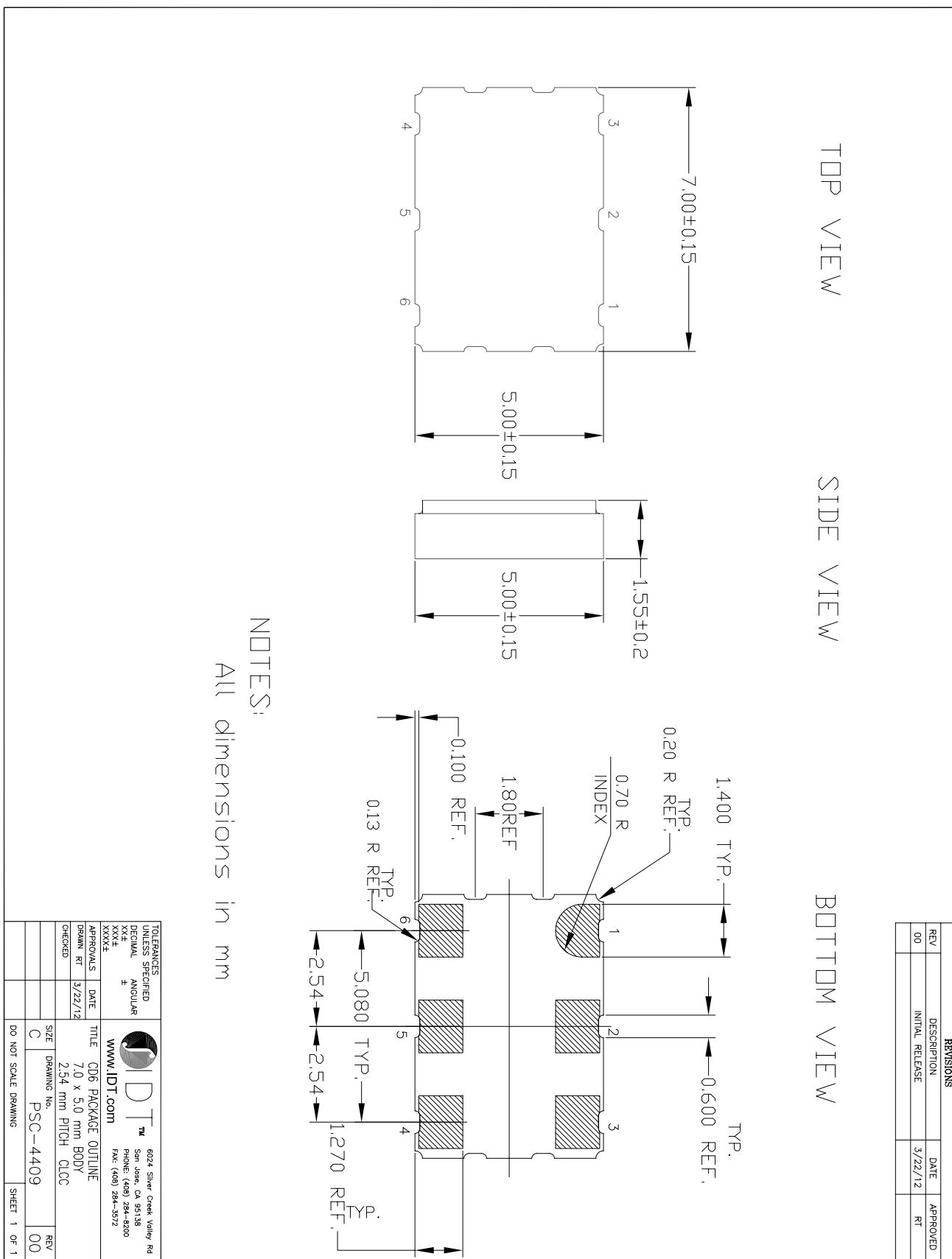
**Table 7.  $\theta_{JA}$  vs. Air Flow Table for a 6-lead Ceramic 5mm x 7mm Package**

$\theta_{JA}$ vs. Air Flow			
Meters per Second	0	1	2
Multi-Layer PCB, JEDEC Standard Test Boards	49.4°C/W	44.2°C/W	42.1°C/W

## Transistor Count

The transistor count for IDT8N0DV85 is: 47,414

## Package Outline and Package Dimensions

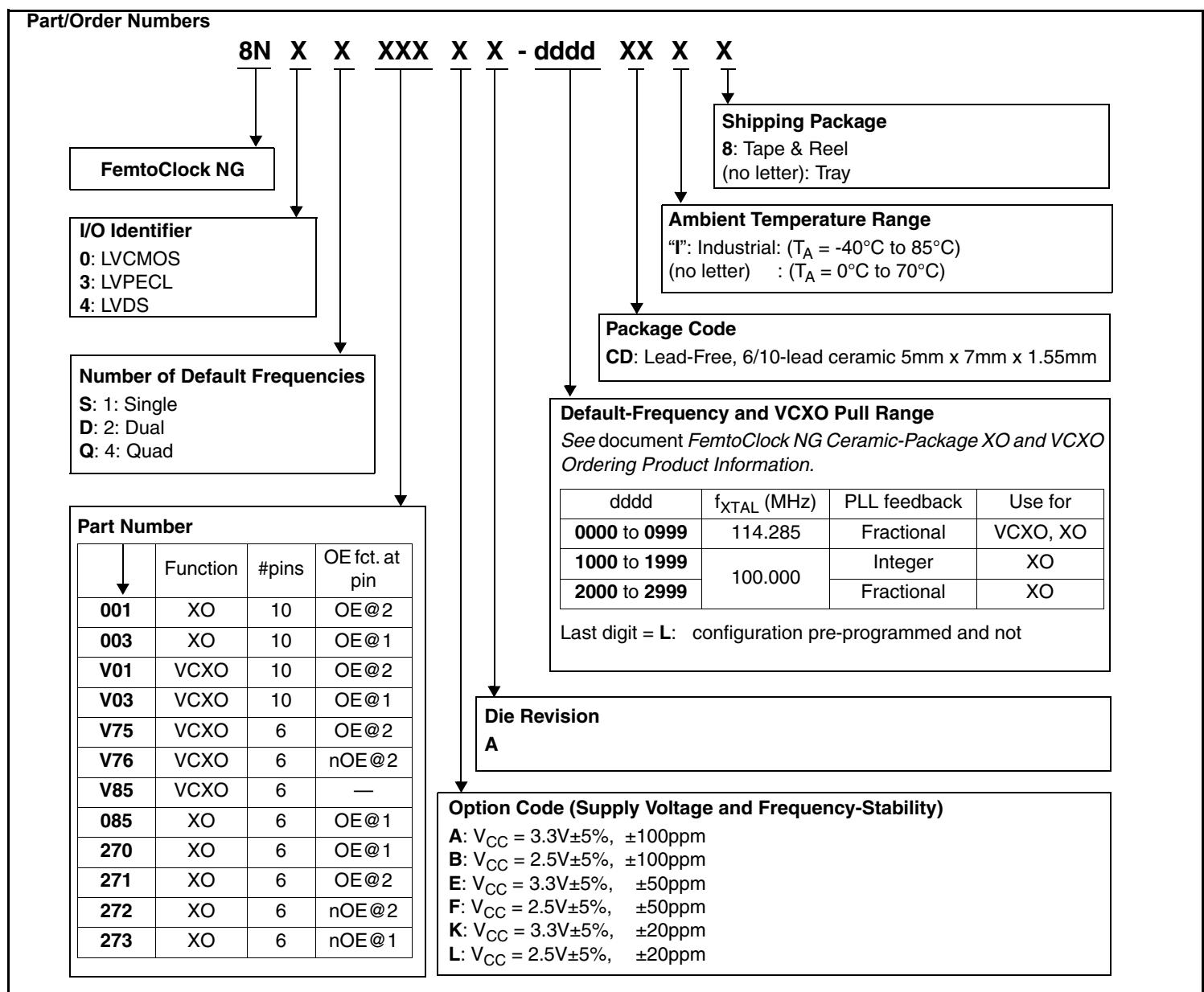


## Ordering Information for FemtoClock NG Ceramic-Package XO and VCXO Products

The programmable VCXO and XO devices support a variety of device options such as the output type, number of default frequencies, internal crystal frequency, power supply voltage, ambient temperature range and the frequency accuracy. The device options, default frequencies and default VCXO pull range must be specified at the time of order and are programmed by IDT before the shipment. The table below specifies the available order codes, including the device options and default frequency configurations. Example part number: the order code 8N3QV01FG-0001CDI specifies a programmable, quad default-frequency VCXO with a voltage supply of 2.5V, a LVPECL output, a  $\pm 50$ ppm crystal frequency accuracy,

contains a 114.285MHz internal crystal as frequency source, industrial temperature range, a lead-free (6/6 RoHS) 6-lead ceramic 5mm x 7mm x 1.55mm package and is factory-programmed to the default frequencies of 100MHz, 122.88MHz, 125MHz and 156.25MHz and to the VCXO pull range of min.  $\pm 100$ ppm.

Other default frequencies and order codes are available from IDT on request. For more information on available default frequencies, see the *FemtoClock NG Ceramic-Package XO and VCXO Ordering Product Information* document.



NOTE: For order information, also see the *FemtoClock NG Ceramic-Package XO and VCXO Ordering Product Information* document.

**Table 8. Device Marking**

Marking	Industrial Temperature Range ( $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$ )	Commercial Temperature Range ( $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$ )
	IDT8N0DV85yA- <b>ddddCDI</b>	IDT8N0DV85yA- <b>ddddCD</b>
<b>y</b> = Option Code, <b>dddd</b> =Default-Frequency and VCXO Pull Range		

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