NCO Core

Introduction

Numerically Controlled Oscillators (NCO) are found in many applications, such as demodulation, frequency synthesis, and up/down conversion. The NCO core is fully parameterized, allowing you to optimize the NCO for your system requirements. The NCO uses very few logic resources, and some number of memory blocks, depending on the parameters selected. Because the core uses memory, it is specific to the Altera FLEX® 10K family of devices.

The NCO is capable of high-speed operation–up to 100 MHz input frequency. It can support ROM depths of up to 2048 locations, with up to a 17-bit output amplitude. Any size of phase accumulator can be specified. A ¼ wave mode allows the NCO ROMs to represent a larger number of points than would typically be supported by memory found on board the PLDs.

NCO Ports

Table 1 and Table 2 describe the interface to the NCO.

Table 1. Input Signals

Signal	Description
SYSCLK	This is the main system clock. The phase accumulator is updated, and the signal samples output, on the rising edge of the SYSCLK.
ACLR	This active low signal resets the phase accumulator to zero. ACLR is asynchronous.
FREQCTL[]	This bus has the same precision as the phase accumulator. This value will control the output frequency of the NCO. The higher the input value, the faster the output frequency. This value is signed, so the highest output frequency possible is Nyquist (maximum ½ table increment).

Table 2.Output Signals

Signal	Description
REAL[]	This output bus contains the cosine, or real, component of the synthesized signal.
IMAG[]	This output bus contains the sine, or imaginary, component of the synthesized signal. When only a real output component is specified in the parameters, this bus contains zeros.

NCO Parameters

Table 3 shows NCO Parameters. There are six parameters, which define the size, performance, and behavior of the NCO.

Table 3.NCO Parameters

Parameter	Description
TYPE	There are two types of NCOs: Direct and NCO Calculated. Direct uses a full wave table stored in the EABs. Calculated uses a ¼ wave table that allows 4 times the input precision into the ROM, for the same number of EABs. The default is Direct.
OUTTYPE	There out two types of outputs: Real and Complex. Real only has a single component output. Complex has both cosine (real) and sine (imaginary) outputs. The default is Real.
PIPELINED	The internal processing of the NCO can be pipelined through the ROM access (2 stages of latency), or not. Pipelining is selected by Yes, deselected by No. The default is No.
ACCUMULATOR	The phase accumulator can be any precision, as long as it is 2-bits larger than the Phase parameter. The default is 16 (bits).
PHASE	This is the number of bits of precision into the ROM tables, which are addressed from the top of the phase accumulator. The range is 8 or 9 bits for Direct NCOs, and 10 or 11 bits for Calculated NCOs. The default is 8 (bits).
AMPLITUDE	This is the number of bits precision per output component. The range is 8 to 16 bits for Direct NCOs, and 9 to 17 bits for Calculated NCOs.The default is 8 (bits).

A Direct NCO will put out data in unsigned format. A Calculated NCO will output data in 2s complement format.

Using the NCO Core

Table 4 contains some examples of the NCO core size and performance, and their variance with different parameters.

Table 4.NCO Performance

Type	Output Type	Pipeline	Accum	Phase	Amplitude	Size (LCs)	Memory (EABs)	Speed (MHz)
Direct	Real	No	10 bits	8 bits	8 bits	10	1	87
Direct	Real	Yes	20 bits	9 bits	12 bits	20	3	70
Direct	Complex	No	16 bits	8 bits	8 bits	16	2	85
Direct	Complex	Yes	24 bits	9 bits	16 bits	24	8	105
Calculated	Real	No	24 bits	10 bits	9 bits	32	1	70
Calculated	Real	Yes	22 bits	11 bits	14 bits	33	4	108
Calculated	Complex	No	24 bits	10 bits	12 bits	32	4	69
Calculated	Complex	Yes	32 bits	11 bits	17 bits	44	8	78

All performance numbers are based on –1 speed grade devices. In an AHDL file, the NCO may be called in an inline instantiation. For example:

```
(realout[],imagout[]) = nco (sysclk, fc[],VCC)
                  WITH (type = “direct”, outtype = “complex”, pipeline =
“yes”,
                                  accum = 20, phase = 9, amplitude = 12);
```

Also the NCO may be called in a graphical file, once a symbol has been created for it.

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