Commutator Port in the HCTL-1100/1000

Application Brief M-012

Introduction

This application brief describes the functioning of the commutator port in the HCTL-1100/1000 with examples. This application brief should be used in conjunction with the data sheet for the HCTL-1100/1000 for a description of actual register addresses, reading and writing to the HCTL-1100/1000, and "Align" mode operation.

The commutator port in the HCTL-1100 is used for closed loop control of stepper and brushless motors that have a 2 or 3 channel encoder attached to them. For programming purposes the commutator is a set of 6 registers that can be read or written to. The physical output interface provided by the commutator consists of 4 signals – PH A, PH B, PH C and PH D. These signals can be used to control motors with four phases or less.

The 6 registers are:

- Commutator Ring
- X Register
- Y Register
- Offset Register
- Maximum Phase Advance Register
- Velocity Timer Register

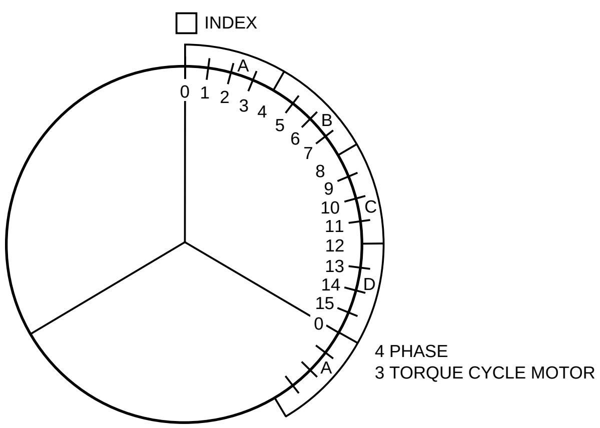
A Status Register is used to control whether the commutator works on the basis of quadrature counts or full cycles.

PHase A through PHase D signals are TTL logic compatible signals and they can be decoded to drive the power switches used to drive the phases of a brushless or stepper motor.

Programming the Commutator Registers

Example 1: For a 4 phase, 3 torque cycle motor with a 12 cycles per revolution (48 quadrature counts per revolution), 3 channel encoder, the diagram shown below illustrates how the 4 signals PH A, PH B, PH C and PH D are generated. The values programmed into the registers are:

Commutator Ring = 16
X Register = 4
Y Register = 0
Offset Register = 0
Maximum Phase Advance Register = 0
Velocity Timer Register = 0



- RING REGISTER DETERMINES THE NUMBER OF ENCODER COUNTS IN A TORQUE CYCLE
- RING REGISTER VALUE MAY BE IN FULL OR QUADRATURE COUNTS
- RING COUNTER CLEARED BY INDEX PULSE
- RING = 16

Figure 1. HCTL-1000 Ring Counter/Register

The Status Register is programmed to enable the commutator to work in quadrature.

In example 1, the basic configuration of the commutator is used and the advanced features that could reduce the torque ripple in the motor are not used. Example 2, given below, illustrates how the torque ripple in the motor can be reduced.

Example 2: For the same motor used in example 1, if the register values are programmed as:
Commutator Ring = 16
X Register = 2
Y Register = 2
Offset Register = 0
Maximum Phase Advance Register = 0
Velocity Timer Register = 0

Status Register programmed to enable the commutator to work in quadrature, the PH A, PH B, PH C and PH D signals are as shown in Figure 4, 5, and 6.

Example 2 shows how the torque ripple can be improved.

The two additional features that can be used are the phase offset and phase advance. Phase offset is used to control the beginning of the sequence of PH A, PH B, PH C and PH D signals with respect to the index signal, statically. Phase advance is used to further improve the torque ripple at different speeds. The start of the sequence of the four Phase signals can advanced, with respect to the index, proportionally with velocity of operation of the motor.

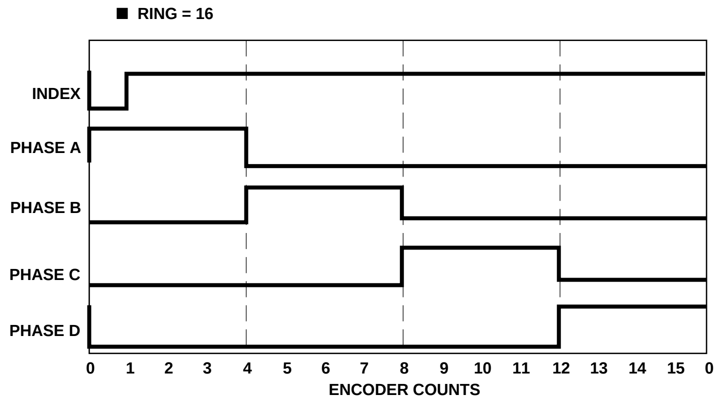


Figure 2. Basic Commutator Output

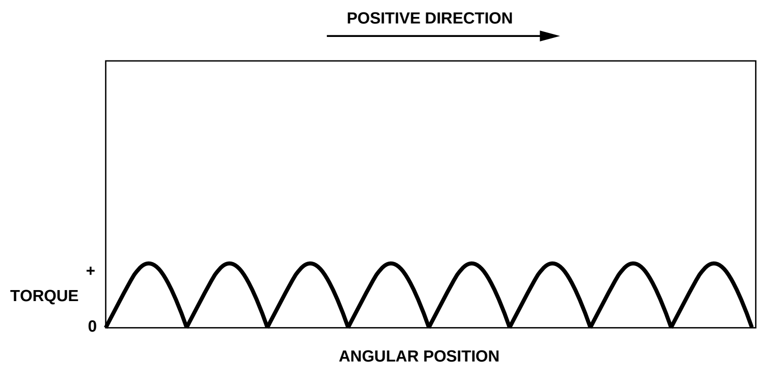


Figure 3. Torque Ripple of Step Motor with Basic Commutation

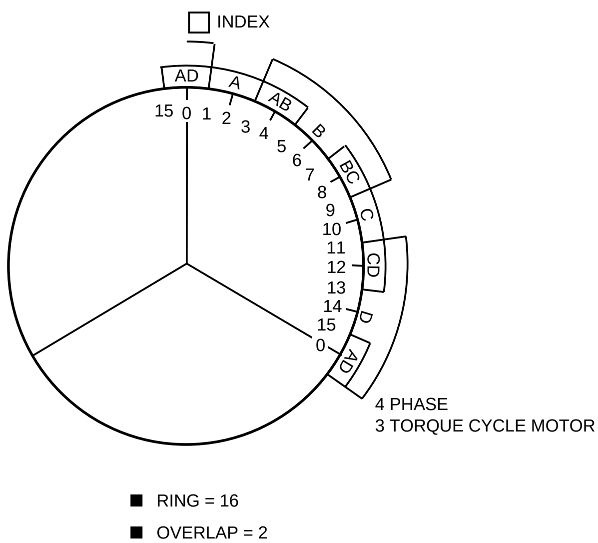


Figure 4. Phase Overlap Feature

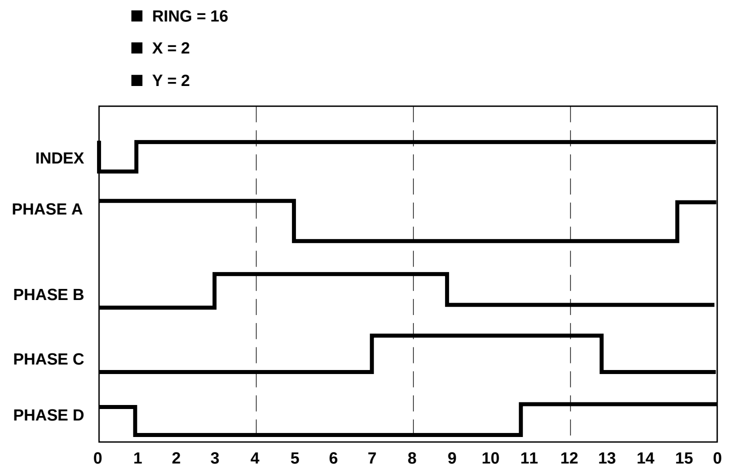


Figure 5. Commutator Output with Overlap

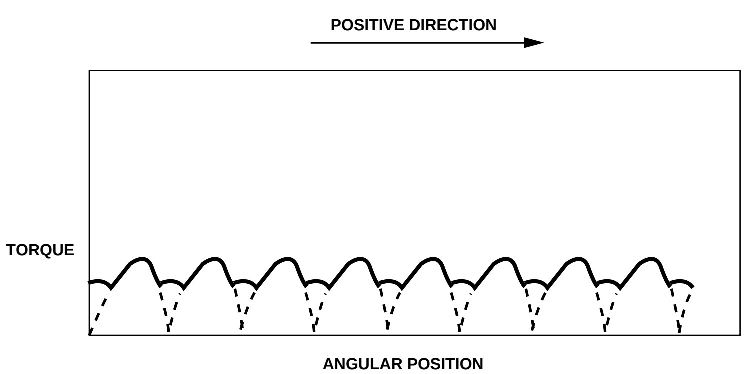


Figure 6. Torque Ripple with Phase Overlap Feature

Example 3: This example uses register settings used in example 1 and illustrates the effect of programming the Phase Offset register to -3. The value of -3 causes the four Phase signals to be generated in the fashion illustrated in Figures 7 and 8.

Example 4: For the same register settings as in example 1, if the Maximum Phase Advance register is programmed to 2 and the Velocity Timer register is programmed so as to give a given phase advance at a given velocity using the equation as shown in the Figure 9, the PH A through PH D signals are gener-

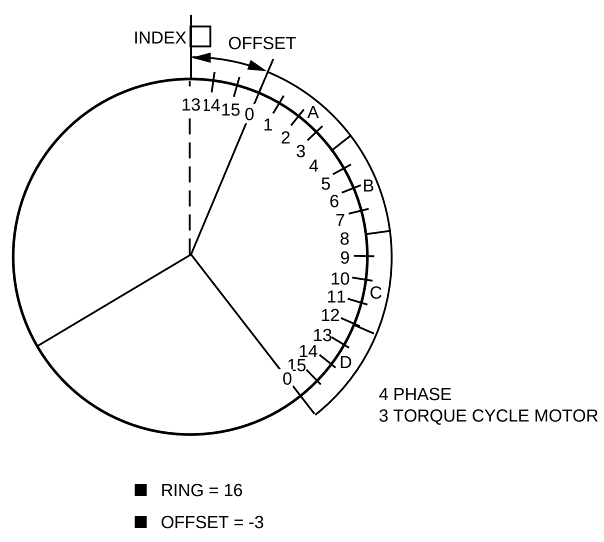


Figure 7. Phase Offset Feature

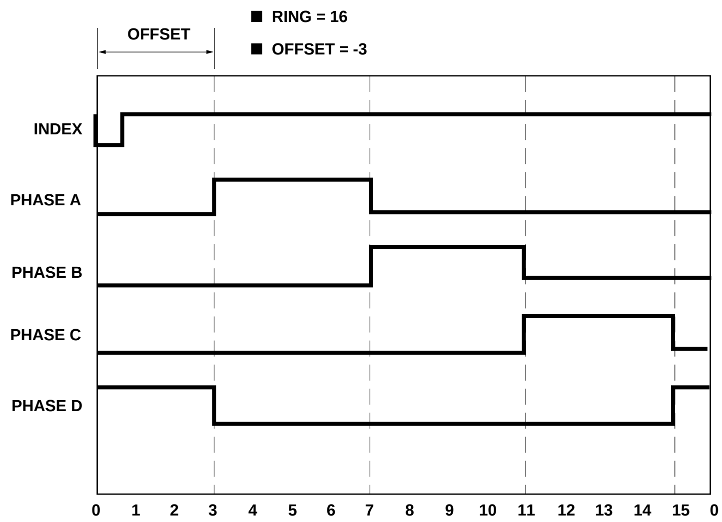


Figure 8. Commutator Output with Phase Offset

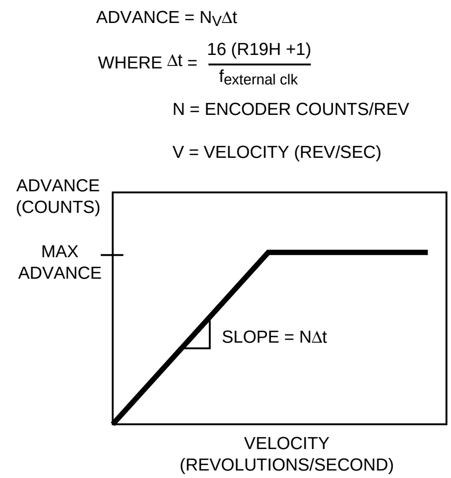


Figure 9. Phase Advance Equation and Graph

ated in the fashion indicated in Figure 10.

There are certain constraints on the values that can be written into the commutator registers. These constraints are:

- Full counts per revolution should be an integer multiple of the motor steps per revolution, or number of commutation steps per revolution.

$$-128 \le \left(\frac{3}{2}\right) \text{ring} + \text{offset} \pm \text{max. advance} \le +127$$

- X register cannot have a value of zero.

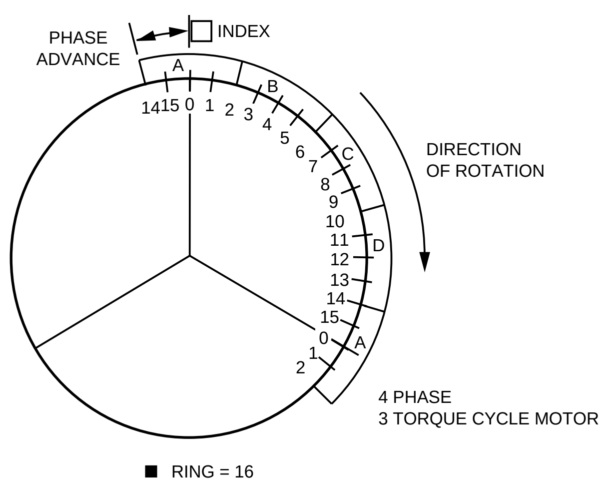


Figure 10. Phase Advance Feature

Summary

Choose an encoder that satisfies the counts per revolution requirements for the motor and align the index pulse physically to the last phase torque detent of the motor. This is done during assembly of the encoder on the motor shaft as shown in Figure 11.

With the last phase of the motor energized, and the encoder module powered, the code wheel is attached to the shaft in such a way that the index pulse is active. An oscilloscope can be used to determine if the index is active. Even if the index pulse is not exactly aligned with the last phase torque detent fine tuning can be done using the phase offset register at a later time. Figures 12 and 13 show the location of the index pulse for a 4 phase motor.

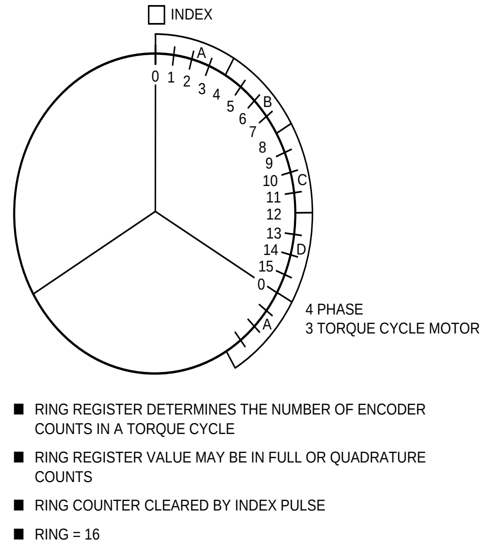


Figure 11. Index Channel Alignment

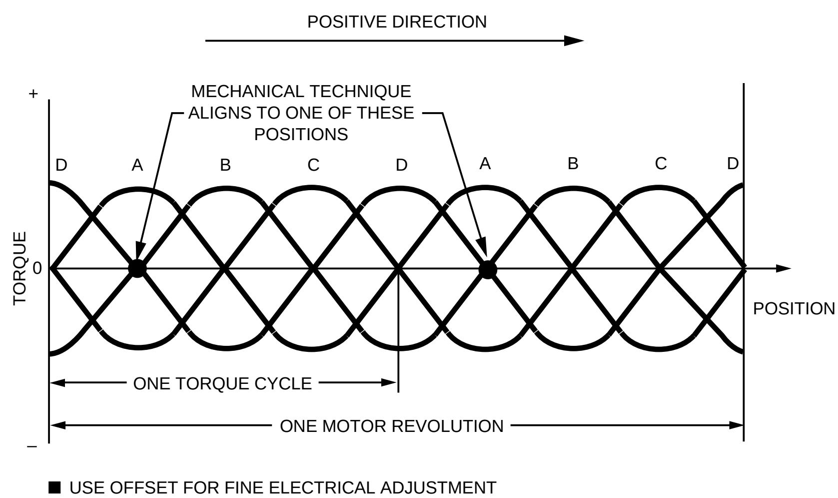


Figure 12. Index Channel Alignment — Motor Torque Cycle

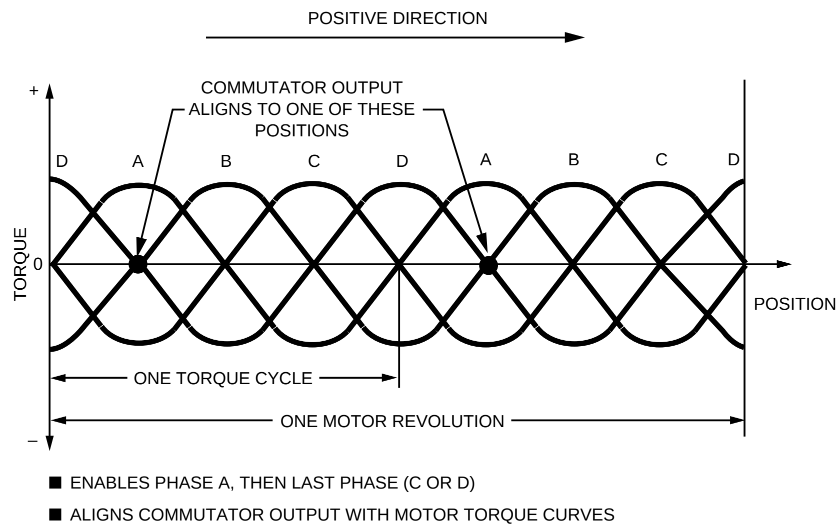


Figure 13. HCTL-1000 Align Mode

To program the commutator follow these steps:

- Choose commutation based on full counts or quadrature counts and set the Status register.
- Choose Ring Register value to correspond to number of counts in one commutation cycle; full counts or quadrature counts depending on the status register.
- Choose X and Y register values to satisfy the firing sequence of the motor phases and such that,

  X+Y = Ring/(number of phases)

- "Align" the motor and adjust the Offset Register for optimum performance in both directions. Please refer to the data sheet for the HCTL-1100 for explanation of the "Align" mode.
- Check commutator constraints equation and correct the register programmed values if the constraints equation is not satisfied.

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Data subject to change.

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