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RSS-NIR
Phase Initialization for the PMD Ion 500 Motor Drive and Brushless Servo Motor with Encoder Feedback

When powered up, the rotational position of the motor shaft relative to the motor housing is unknown. This means the position angle of the rotor magnets in relation to the stator coils is unknown. Without this information, the motor drive does not know which coils to excite to produce torque.

There is a shaft position angle, that I'll call the "zero phase angle", that is just defined as a specific orientation of the magnets relative to the coils. If the rotor is known to be at the zero phase angle then it is also known exactly how to excite the motor coils to produce torque. If the rotor is a known distance from the zero phase angle then it is also known exactly how to excite the coils to produce torque.

The rotary incremental encoder mounted on the motor shaft has a single index mark that produces a pulse signal for each rotation of the rotor at a specific shaft position angle. The angle of the index mark is a fixed number of encoder counts from the zero phase angle of the rotor. This number of encoder counts is the Index Offset referred to in the *Magellan Motion Processor Programmer's Command Reference* under the "GetIndexOffset" and "SetIndexOffset" commands.

Each motor/encoder combination has a different index offset that is set when the encoder is installed on the motor shaft. The index offset of each can be determined experimentally and will not change for as long as the motor and encoder remain mated. The index offsets are then constants that can be loaded into the motor drives during their initialization at power up.

Another set of commands, "GetPhaseAngle" and "SetPhaseAngle" read and write a register that holds current distance of the rotor shaft from the zero phase angle. At power up this distance is unknown and reading the register will always return '0'. If the motor can be turned until the encoder index mark is detected, the phase angle will be known to be exactly the index offset - the distance between the index mark and the zero phase angle.

Phase initialization is the process of rotating the motor, at most a single rotation, to detect an index pulse and record the phase angle. From then until the motor drive is powered off, the phase angle can be tracked by adding and subtracting encoder counts from the initial phase angle. Each time an index pulse is detected, the phase angle is reinitialized to clear any error produced by missed encoder counts.

The challenge with phase initialization is to get the motor to rotate without any knowledge of the initial phase angle. And, if this is accomplished, to rotate the motor

without it running away. Also, to rotate the motor the brake must be released. Without knowledge of the phase angle the motor drive cannot maintain a position and the load could freefall. The following algorithm should meet these challenges and safely accomplish phase initialization.

1. The brake is controlled by the Axis Out signal. Use the "SetAxisOutMask" to keep the brake engaged for the next several steps. Selection Mask - Source register is Disabled (0), Source axis is this axis, Axis 1 (0), Source register mask is (0x02) , Sense Mask – No inputs inverted (0x0000). This will keep the brake engaged.
2. Use the "SetSignalSense" command to invert the Negative Limit, Positive Limit, and the Encoder Index signals(0x0034).
3. Disable the drive output using the "SetOperating Mode" command – Disable Drive (0)
4. Set the motor limit to zero with the "SetMotorLimit" command.
5. Eliminate any chance of the drive trying to close a position error by setting the error to zero with the command "ClearPositionError".
6. Remove any emergency stop signals by turning the E-stop slap switch and allowing the spring loaded button to pop up.
7. Reset the event status using the "ResetEventStatus" command – ResetEventStatus 0x0000.
8. Verify the drive event status is reset using the command "GetEventStatus" and checking that the all the bits except Motion Complete (bit 0) and Capture Received (bit 3) are cleared. If not, go back to step 1 of the phase initialization procedure.
9. Set the Index Offset with the "SetIndexOffset" command to the predetermined index offset. Inserter = 660, Latch Rotator = 76
10. The "SetPhaseCorrectionMode" command should be set to Enabled. This will force the Phase Angle to the Index Offset value every time the encoder index pulse is detected.
11. Send the "GetSignalStatus" command. Mask the returned value for the encoder index signal. If not set, we need to move the motor until the index is detected. Go to step 7.
12. If resting on the index mark, the phase is initialized. Verify this by using the "GetPhaseAngle" command and seeing that it is non-zero. If so, go to Axis initialization. If not, go to step 1 and repeat phase initialization procedure.
13. Set breakpoint 1 using the "SetBreakpoint" and "SetBreakpointValue" commands. For the "SetBreakpoint" command, set the trigger source to be the Signal Status register. Set the breakpoint action to be Disable Motor Output and higher control modules. For the "SetBreakpointValue" command, set the trigger action to be the Encoder Index by entering the mask value for the encoder index bit of the signal status register (0x0004).
14. Now we can release the brake, but we must set the mask such that it will reengage if the index pulse is detected. Send the "SetAxisOutMask" with the Selection Mask - Source register set to the Signal Status register (3), Source axis is this axis, Axis 1 (0), Selection mask is the encoder index (0x0004) , Sense Mask – Inverts

the encoder index (0x0004). This will keep release the brake. If the load moves due to gravity or the commands that follow, no more than one revolution will occur before the index mark is crossed. When this happens the phase angle will be initialized by the enabled Phase Correction Mode, the motor output will be disabled by Breakpoint 1, and the brake will be engaged by the Axis Out Mask.

15. Check to see if the load fell one rotation and initialized the phase angle. Wait thee seconds and then use the "GetEventStatus" command and check the Breakpoint 1 bit (bit 2) to see if it has been latched. If not, go to step 17.
16. Verify the phase angle was initialized by using the "GetPhaseAngle" command and seeing that it is non-zero. If so, go to Axis initialization. If not, go to step 1 and repeat phase initialization procedure.
17. The axis did not fall so we must get the motor to move "open loop" without knowing the proper phase. First use the "SetOperatingMode" command to enable only the axis and the motor output control module (0x0003). In this mode the command motion command bypasses the trajectory generator, position control loop, and current control loop, and is passed directly to the motor output.
18. Check to see if we are against a positive limit by checking bits 11 of the Activity Status register using the "GetActivityStatus" register. Save this data for the next step.
19. Set the motor command limit to 3 Amps = 14.2% of peak drive capacity. (14.2% /100%) * 32767 = 4637 = 0x121C.
20. If the axis was found to be in positive limit back in step 17, set the motor command to -3 Amps with the "SetMotorCommand" command (0xEDE4). If the axis was not in positive limit, set the motor command to +3 Amps with the "SetMotorCommand" command (0x121C). If the phase angle is accidentally close to the correct phase angle, the motor will move up to one rotation.
21. Wait 3 seconds and set the motor command to 0 Amps using the "SetMotorCommand" command.
22. Check to see if the motor moved to the index mark by using the "GetEventStatus" command and checking the Breakpoint 1 bit to see if it is latched. Also use the "GetPhaseAngle" command to see if the phase angle has been updated with a value different than the last known value. If these events can be verified the phase initialization is complete and you can proceed to Axis initialization.
23. If the motor did not move because the phase angle was not close to the correct angle, use the command "SetPhaseAngle" to increase the angle by 60º. If this results in a phase angle of 360º, phase initialization failed – go to step 1 of the phase initialization procedure. If the phase angle is less than 360º, go to step 20.