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MV-PLC SAMPLE :

Basic Positioning template program

The PLC option board for 3G3MV inverters provides the needed hardware to perform a basic position control software. We can read an encoder with A and B phase signals, digital inputs and have complete control on the inverter speed and Run commands. We have additional I/O and fully programmable PLC. That's all needed for a position controller application.

The control loop is performed by the ladder program. The selected control loop performs a very simple P controller on the position error between demanded and real positions.. Then it limits and applies a frequency reference proportional to it. With this setup, without profile generator (acceleration, deceleration generated by position reference calculations), we have a compact position controller software, that will solve a lot of simple point to point applications.

METHOD :

- We apply directly the position difference as speed reference , we have programmed some acceleration on the inverter (so it will ramp up at that defined rate). The inverter has zero deceleration, so when the position is reaching the point automatically the speed is reduced gradually, generating some non-linear ramp, but stopping in the correct position.
- As the PLC can not handle big negative numbers we have to apply an offset position and work around an intermediate point, scaling for the user.

FEATURES :

- Easy to use
- Continuous loop
- Scaled setpoint by N1/N2 factor.
- 2 InPosition windows. The second one can be defined bigger for faster sequence control.
- Variable P Gain
- Position_Reset available
- Home(origin) search sequence, with fast forward and slow backwards seek. Definable speeds
- Home(origin) timeout control

LIMITATIONS :

- As the 3G3MV is an open loop inverter, with only P type of controller, inertial loads might not be well handled by the software, leading to oscillation. Lowering P gain can help, but lowers dynamics. It is preferred some kind of frictional load. Most applications that use a high gear-ratio gear-motor will be mostly controlled. To control inertial loads a more sophisticated control loop should be programmed. Using a free motor can lead to unstability.
- Deceleration profile will be exponential due to the method of using the position diference to generate speed reference.
- We are limited to two word position references. So 80000000 quadrature pulses aprox.
- The values allowed for the fractional factor limit the reference position range. Scaling intermediate results can only be two word values. The bigger the factor, the shortest the position reference allowed. It is recommended to use values from 1 to 10 in N1 and N2.
- We don't have the real concept of following error as the program does not perform a real positioning profile. We only have the "demanded-real position" error.

INVERTER/PLC SETUP :

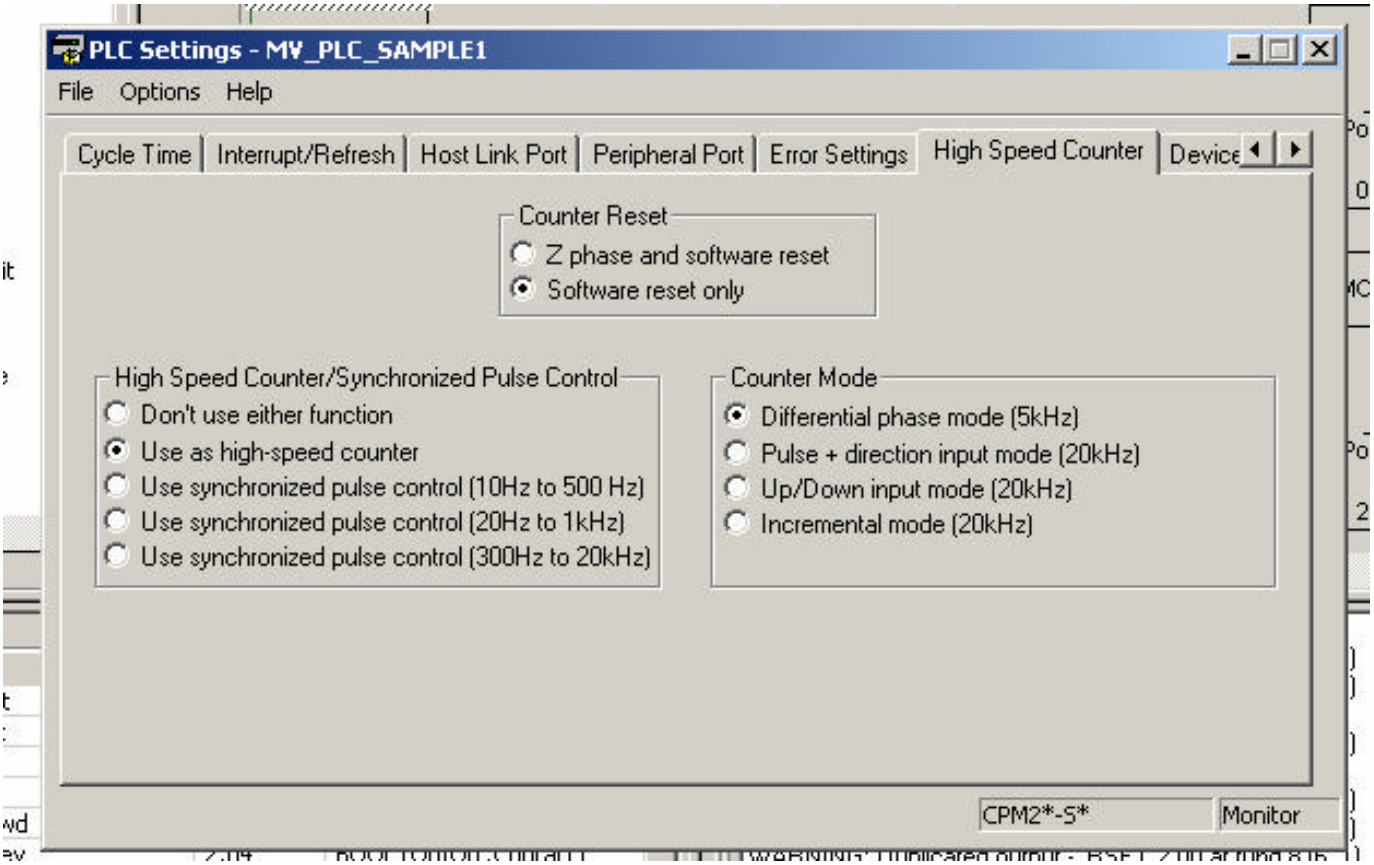
We need some specific settings in the inverter for a correct positioner work :

- We will use two sets of ramps… one is for the positioning with acceleration defined and deceleration set to zero…
- n021=1 sec n022=0 sec for position control (n022 must be always zero).
- The other will be used in speed control mode, where we require both accel and deceleration to be active…
- n019=2 sec n020=2 sec for speed control or any desired.
- n54=11 (accel/deccel change by S5 or internally controlled by PLC) To allow the program to do the changeover automatically. The PLC will simulate that input by 207.04 control bit
- It is recommended a modified VF curve for better response in the lower frequency range … Typically for Vector values like following are good initial values :
- n015=30V, n016 = 0.1Hz , n017=15Hz
- Keep n35=0 (0.01Hz resolution of speed references) for better resolution in speed control.

We also need particular settings in the PLC side :

In the PLC, following bits have to be cleared : IR209.0=0 and IR209.1=0. In this way we provide full Speed reference and Run command control from the PLC regardless the inverter settings.
And the configuration for the input encoder (24Vdc type).

For the counter to work with the encoder we need following settings :



I/O CONNECTIONS :

In the template following basic inputs are predefined :
PLC Input 0 : A Channel encoder
PLC Input 1 : B Channel encoder
PLC Input 2 : Home/Origin sensor

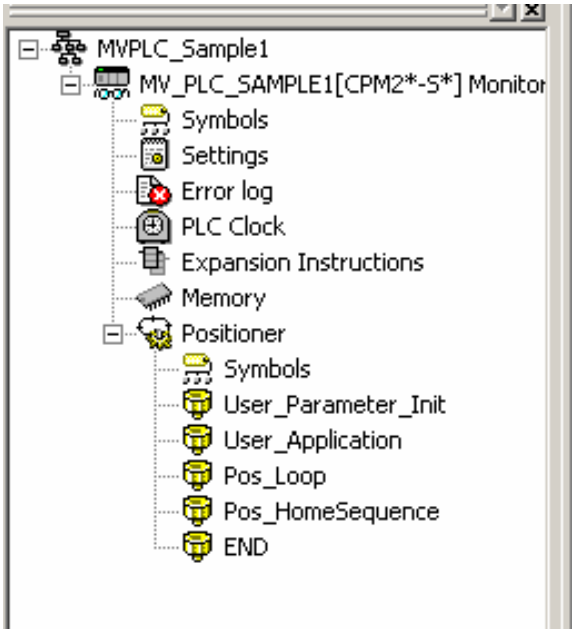
Then the user program can use the rest of PLC and inverter inputs …
In our Application example we use :
PLC Input 3 for Home/Origin request and
PLC Input 4 for positioning

DEFINING THE APPLICATION :

- When counting for the required accuracy a safe rule is to count on 20-30 quad edge pulse error directly on the motor. Depends mostly on the mechanical system design.
- The encoder can be either in the motor or after gearbox. For higher accuracy in the motor is good, but then we have to be careful with the frequency limits of the input.
- In any case take into account the 5KHz maximum input rate for the maximum motor speed. Depends on the encoder resolution, where it is placed and encoder max rpm. Typical figure is for a 1500rpm motor, with encoder directly coupled to motor that we can use a 200ppr encoder if we require full speed range : This is 5KHz at top speed.

PROGRAM STRUCTURE :

Two main sections have to be added to the end of the PLC program ..
Pos_Loop provides the position/speed control capabilities
and **Pos_HomeSequence** provides the home sequence facilities.



User_Parameter_Init will be used by the customer to initialize Position program parameters and application own parameters
User_Application will make use of the control bits and parameters of the Positioning template to do the machine sequence. If the user program has more sections all have to be in front of the Pos_??? sections.

SETTING POSITION PARAMETERS :

The software provides the following BIT/WORD interface area and default values ….
NOTE : as the reading of the encoder signal comes from quadrature signals, the name quads refers to four counts for each encoder pulse…. It means a 200ppr encoder will provide a real resolution of 800 quads per revolution….
The frequency limit is defined by the real pulse limit, not quads.
Default values are the default values in the examples provided. Customer can fill its own values.
It is recommended to first do a trial run in speed with small reference and check that the counting of the encoder corresponds to speed reference given. If not some wiring might be wrong. Once positive sense corresponds to positive count, then we can go for the positioner settings.

PARAMETER	Type	Description	Default Value
2.0	BIT R/W	Control_Mode : 0=Speed, 1=Position	0
2.1	BIT R/W	Position_Reset : 1=reset . Use with SET. Resets to zero when done	0
2.2	BIT R/W	Home_Request : 1=Home is requested. The sequence begins. Once finished we can have either 3.0=1 (Home_OK) or 3.1=1 (Home_Error). The maximum time to perform home is defined in DM32	0
2.3	BIT R/W	Speed_Run_Fwd : In Speed mode (2.0=0), it generates Run forward of the inverter with 2.3=1. The speed reference from DM2036. 209.0=0 and 209.1=0 for full PLC control.	0
2.4	BIT R/W	Speed_Run_Rev : Like 2.3, but in reverse direction	0
3.0	BIT R	Home_OK : When home is finished and OK, this bit is activated	--
3.1	BIT R	Home_Error : If home is not finished in the defined timeout DM32, then Home_Error appears and the sequence is cancelled.	--
3.2	BIT R	In_Position1 : The finest in position. Defined window in DM16. Used for the positioner work itself.	--
3.3	BIT R	In_Position2 : Available for fastest sequence work. We define in DM18. Typically used to start processes slightly before the final position is reached (activate a valve, move other axis, etc….).	--
DM10	DWORD R/W BCD	SP : BCD. SetPoint of position (in units) DM10 and DM11	0
DM12	DWORD R/W BCD	SP_PV_Scale_N1 : Numerator of SP&PV scaling	1
DM14	DWORD R/W BCD	SP_PV_Scale_N2 : Denominator of SP&PV scaling **N1** **Scaling is..units * ---------- = quads** **N2** Default values correspond to direct quad control	1
DM16	DWORD R/W BCD	In_Position1_Window : Defines the width of the In_Position output 1. This has to be the most accurate positioning window. Usually just some units.In units	2
DM18	DWORD R/W BCD	In_Position2_Window : Defines a wider window for use in the software sequence (start some actions just while the movement is being finished). In quads	20
DM20	DWORD R/W BCD	Home_Initial_Pos : In units. Defines the initial movement to an initial position <>0 after the homing process has been defined.	0
DM22	DWORD R/W Decimal	Max_Frequency : Value in speed units from the inverter (depends on n035). We recommend n035 to leave standard (0) so we have the best resolution (0.01Hz).	2000
DM24	DWORD R/W	P_Gain : This is the factor that will generate the final speed reference from the position error quads. If it is too big we will have overshoot. If	10

PARAMETER	Type	Description	Default Value
	BCD	too low, positioning will be slow. If we have big inertia it might happen that even with small gain we have unstability.	
DM26	DWORD R/W BCD	Max_Pos_Error : This limits the error output. This is necessary mainly for calculation limit issues.	10000
DM28	DWORD R/W BCD	PV_Rotary_Scale : This is an additional “Present Value” readout that shows in DM44 (Dword) Whole DM28 groups of counts and in DM46 (Dword) the remaining in one “wrap around count”. If we use a scaling for degrees and DM28 is 360, then is just turns/degrees idea.	360
DM30	WORD R/W Decimal	Home_Fast_Speed : This is the first speed used to find the home/origin sensor in reverse sense. Decimal value in units defined by n035. By default 0.01Hz	50
DM31	WORD R/W Decimal	Home_Seek_Speed : Once found the sensor, forward seek at this speed is performed until the sensor disappears. This ensure accurate homing. Decimal value in units defined by n035. By default 0.01Hz	20
DM32	WORD R/W BCD	Home_Process_MaxTime : Timeout value in 0.1 sec unit. This is the allowed time for the homing process to finish.	150
DM2036	WORD R/W Decimal	MV_Freq_Ref_Set : This is the speed reference when the PLC is controlling the inverter. In position mode (2.0=1) The program generates automatically this reference. In speed mode (2.0=0) the user has to set the value to control the speed.	100
DM40	DWORD R BCD	PV_Final : Scaled Present Value. Real position read from the encoder. Scaling factors to/from quads in DM12 / DM14	--
DM44	DWORD R BCD	PV_Whole_Turns : Scaled PV with “wrap around” function from DM28	--
DM46	DWORD R BCD	PV_Angular_Position : Scaled PV with “wrap around” function from DM28	--

Have a look to the simple User_Application section to check how simple it is to use the positioner program.