

Overvoltage Suppression F7 Drive Software Technical Manual



Software Number: VSF11015X, Drive Models: CIMR-F7UXXXXXX-062, CIMR-F7U40750F-145.
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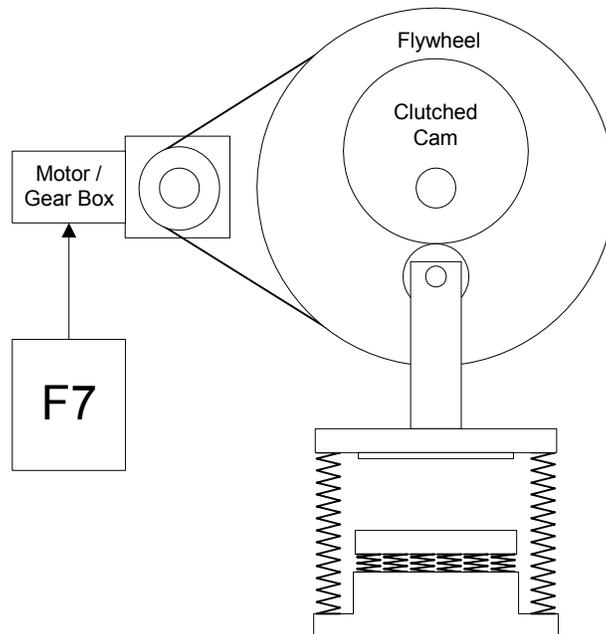
This document is intended to provide proper installation and use of the Yaskawa drive with custom software. This document is a supplement to the standard drive technical manual. It describes the effects on the drive parameters and functions with the software installed. Read and understand this document and the standard drive technical manuals before attempting to install, adjust, operate, inspect or maintain the drive. **Observe all cautions and warnings in this document and the standard drive technical manuals.** Custom software is written to add functionality to a standard AC drive to enhance or enable use in a specific application. The software is loaded to the flash ROM area of the control board, and replaces the standard drive software. Custom software can add new functions, modify standard functions, or even inhibit standard functions. It can be used to modify display text or parameter names. Custom software is usually loaded to the drive before delivery. The control board and drive nameplate are assigned unique part numbers and the software is registered, archived, and retrievable.

When seeking support for a drive with custom software, it is imperative to provide the unique part number shown on the drive nameplate. The software has been flashed to the control board memory and the operation of parameters, functions, and monitors are different than the standard drive software, as described herein.

1.0 Overview

This Overvoltage Suppression software allows an F7 drive to control rotating machinery where part of the machine's cycle creates a cyclic regenerative (over-hauling) load. The Pump Jack Oil Well and Stamping/Punch Press are two applications that this software was specifically created for. The benefit of this software is that dynamic braking resistors are not required for normal operation.

This software monitors the torque-producing current (I_q) in the motor, and regulates this against an I_q setpoint using a PI controller. If the torque producing current falls below the setpoint, the output frequency is increased to force a higher (positive) I_q and thus avoid a regenerative condition in the motor.



Stamping Press Application

2.0 Changes from Standard Product

- The "Ramp to Stop" stopping method (B1-03 = 0) is deleted.
- Several parameter defaults have changed. See section 4.5.
- The Stationary auto-tuning method (T1-01 = 1) will not set E2-02 (Rated Slip) and E2-03 (No-load Current). Therefore, these parameters must be manually set using the motor's nameplate data. See Section 5.2.

3.0 Limitations

- V/Hz and Open Loop Vector are the only control modes (A1-02 = 0 or 2) that support the Overvoltage Suppression function. Closed Loop V/F and Closed Loop Vector are available (A1-02 = 1 or 3) but the Overvoltage Suppression function is disabled.
- Bi-directional Speed Search. For some applications, when motor loading is extremely light at startup, it may be necessary to disable the bi-directional speed search feature by setting parameter B3-14 = 0.

4.0 Related Parameters and Functions

4.1 Overvoltage Suppression PI Controller Parameters

Parameter Number	Modbus Address	Parameter Name <i>Digital Operator Display</i>	Description	Range	Default	Change During Run	Access Level *1
P1-01	0600H	OV Suppression PI Setpoint OV Reg Setpoint *2	This parameter sets the OV Suppression PI setpoint in percent of motor torque-producing current (Iq). <i>Note: 100% Iq = 100% motor rated torque.</i>	-100.0 ~ 100.0 %	12.0	Yes	A
P1-02	0601H	OV Suppression Proportional Gain OV Reg Gain *2	This parameter sets the gain of the OV Suppression PI controller. This determines the responsiveness of the Iq regulator. A larger setting equals more responsiveness.	0.00 ~ 25.00	2.20	Yes	A
P1-03	0602H	OV Suppression Integral Time OV Reg I Time *2	This parameter sets the integral time of the OV Suppression PI controller. This determines the responsiveness of the Iq regulator. A smaller setting equals more responsiveness.	0.00 ~ 160.00 sec	0.10	Yes	A
P1-04	0603H	OV Suppression Positive Integral Limit OV Reg I Limit	This parameter sets the positive limit of the integrator in the OV Suppression PI controller. <i>Note: 100% = Fmax (E1-04).</i>	0.0 ~ 100.0 %	100.0	No	A
P1-05	0604H	OV Suppression Positive Overall Limit OV Reg Limit	This parameter sets the positive limit of the OV Suppression PI controller (P+I). <i>Note: 100% = Fmax (E1-04).</i> <i>Note: A setting of 0.0% disables the OV Suppression PI controller.</i>	0.0 ~ 100.0 %	100.0	No	A
P1-06	0605H	Motor Torque Producing Current (Iq) Feedback Filter Time Feedback Filter *2	This parameter sets the 1 st order filter time of the motor torque-producing current feedback. A larger setting equals a more filtered feedback but less responsiveness.	5 ~ 10000 msec	100	Yes	A

*1: Access Level (A1-01): Q = "Quick Start", A = "Advanced", F = "Factory". V/F and Open Loop Vector only.

4.2 Pumpjack Application Specific Parameters

Parameter Number	Modbus Address	Parameter Name <i>Digital Operator Display</i>	Description	Range	Default	Change During Run	Access Level *1
P1-07	0606H	OV Regulator Gain Frequency Gain Frequency *2	This parameter sets the OV regulator gain change endpoint. See section 5.3 for details on this function.	0.00 ~ 400.00 Hz	90.00	Yes	A
P1-08	0607H	OV Regulator Gain Multiplier Gain Multiplier *2	This parameter sets gain multiplier for the OV regulator gain (P1-02) based on output frequency. See section 5.3 for details on this function.	1.000 ~ 10.000	1.300	Yes	A
P2-01	060AH	Heatsink Overheat Off -Delay Time OH Off Delay	This parameter sets the amount of time that the drive will revert to a reduced speed after an Overheat Pre-alarm occurs. See section 5.5 for details.	0.0 ~ 30.0 min	0.0	No	A
P2-02	060BH	Heatsink Overheat Speed Reduction OH Spd Reduce	This parameter sets the multiplier used to reduce the frequency reference after an Overheat Pre-alarm occurs. See section 5.5 for details. <i>Note: 100% = Fmax (E1-04)</i>	0.0 ~ 100.0 %	100.0	No	A
P2-03	060CH	Belt Break Detection Belt Break Det.	This parameter configures the Belt Break Detection function. If the drive's soft starter is at maximum output frequency (E1-04) for more than 30 seconds, a belt-break fault (B-BRK) will occur. See section 5.4 for details. 0: Disabled 1: Enabled	0 ~ 1	1	No	A
P3-01	0614H	Torque Limit During Start Start Torque	This parameter determines the forward and reverse motoring torque limits after a run command is received, but before the torque start timer (P3-02) expires. Overwrites L7-01 and L7-02.	0 ~ 300 %	200 %	No	A
P3-02	0615H	Torque Limit During Start Timer Start Torq Time	This parameter sets the time that parameter P3-01 will overwrite L7-01 and L7-02 after a run command is received.	0.0 ~ 10.0 sec	0.0	No	A
P3-03	0616H	Torque Limit During Start Ramp Time Torq Lim Ramp Tm	This parameter sets the time required to ramp the torque limit 100%. This determines the rate at which the torque limits will return to the L7-01 and L7-02 values at the end of the starting torque time (P3-02).	0.1 ~ 10.0 sec	1.0	No	A

*1: Access Level (A1-01): Q = "Quick Start", A = "Advanced", F = "Factory". V/F and Open Loop Vector only.

*2: Making large changes in these settings while the drive is running can result in large and very rapid changes in the output frequency. Change these parameters in small increments only.

4.3 Monitors (U1-XX)

Monitor Number	Modbus Address	Monitor Name <i>Digital Operator Display</i>	Description	Scaling for Multi-function Analog Output (H4-01/H4-04)	Unit	Access Level *1
U1-90	0720H	Soft Start Frequency Reference Soft Start Freq	Displays the frequency reference after the soft starter, but before the OV Regulator PI controller output.	100% = Fmax (E1-04)	0.01 Hz	Q
U1-91	0721H	Overvoltage Frequency Reference OV Reg Total Ref	Displays the frequency reference after the output of the OV Regulator PI controller.	100% = Fmax (E1-04)	0.01 Hz	Q
U1-92	0722H	Overvoltage Suppression Regulator Error Signal OV Reg Error	Displays the error (setpoint - feedback) of the OV Regulator PI controller.	100% = Motor Rated Torque (Iq)	0.1 %	Q
U1-93	0723H	Overvoltage Suppression Regulator Output OV Reg Output	Displays the output of the OV Regulator PI controller.	100% = Fmax (E1-04)	0.1 %	Q

*1: Access Level (A1-01): Q = "Quick Start", A = "Advanced", F = "Factory". V/F and Open Loop Vector only.

4.4 Faults

Fault Display	Description	Cause	Countermeasures
B-BRK	Belt Break	The drive's output frequency was at the maximum output frequency (E1-04) for more than 30 seconds. See section 6.3 for details.	Fix belt / coupling.

4.5 Alarms

Alarm Display	Description	Cause	Countermeasures
OTDLY Overtemp Delay	Over-temperature Delay	The drive's heat sink temperature exceeded parameter L8-02 (Overheat Pre-alarm Level) and then fell below the L8-02 level within the P2-01 time. This alarm will flash until the P2-01 timer has expired. See section 6.4 for details.	Decrease the drive heat sink temperature. Check the drive's cooling fans. Check the sizing of the drive's enclosure.

4.6 Parameter Default Changes

Parameter	Name	Description	Units	Range	Default
A1-02	Control Method	0: V/F 1: V/F w/PG 2: Open Loop Vector 3: Flux Vector <i>Note: The OV Suppression function is only available in V/F and Open Loop Vector (A1-02 = 0 or 2).</i>	-	0 ~ 3	0
B1-03	Stopping Method	0: Ramp to Stop 1: Coast to Stop 2: DC Injection to Stop 3: Coast to Stop With Timer	-	1 ~ 3	1
E1-04	Maximum Output Frequency	Maximum frequency that the drive will output.	0.1 Hz	50.0 ~ 400.0	90.0 *3

*3: The 90.0 Hz default setting only applies when E1-03 = F (Custom V/f Pattern).

NOTE: The Overvoltage Suppression feature works best in Open Loop Vector (A1-02 = 2), only AFTER a full Rotational auto-tune is performed (T1-01 = 0). If a Rotational auto-tune cannot be performed, a Stationary auto-tune can be performed (T1-01 = 1). You must manually set E2-02 (Rated Slip) and E2-03 (No-load Current) from the motor's nameplate data before running the auto-tune as the Stationary auto-tuning method will not tune these parameters in this software. If performance is not achieved after the Stationary auto-tune, use the V/F control mode (A1-02 = 0) instead. See Section 5.2 for further details.

CAUTION: The Overvoltage Suppression function is NOT active when the output frequency is at the maximum output frequency (E1-04). This is because the function needs frequency headroom to work.

CAUTION: The motor / machinery connected to an F7 drive with this software needs to be mechanically capable of operation at the maximum output frequency (E1-04).

CAUTION: Bi-directional Speed Search. If motor loading is extremely light at startup, it may be necessary to disable the bi-directional speed search feature by setting parameter B3-14 = 0. Not doing so may result in the motor accelerating in the wrong direction.

5.0 Function Description

5.1 Overvoltage Regulator

The motor torque-producing current is detected and subtracted from the OV Regulator setpoint (P1-01). The result (error) is run through the OV Regulator PI controller. The PI controller will add frequency to the frequency reference in order to maintain a constant I_q setpoint. The PI controller will NOT subtract frequency from the frequency reference. This is done to keep the torque producing current positive (motoring) thus preventing regeneration and subsequent overvoltage faults (OV). This eliminates the need for a dynamic braking resistor package.

5.2 Open Loop Vector Control

In order to obtain optimal performance when using the Open Loop Vector control method (A1-02 = 2), a motor auto-tune should be performed. Ideally, the motor should be uncoupled from the load, and a Rotational auto-tune (T1-01 = 0) should be performed.

If the motor cannot be uncoupled from the load, then a Stationary auto-tune (T1-01 = 1) should be performed. In this software, Motor Rated Slip and Motor No-Load Current are not calculated in the Stationary auto-tuning method. Therefore, these need to be calculated and manually entered prior to running the Stationary auto-tune. After entering the E2-02 and E2-03 values, perform the auto-tune.

Motor Rated Slip (E2-02) should be calculated as follows:

Example: 4-pole, 60 Hz motor, Motor Rated Speed = 1730 RPM

$E2-02 = (\text{Motor Synchronous Speed} - \text{Motor Rated Speed}) * \text{Motor Poles} / 120$

$E2-02 = (1800\text{RPM} - 1730\text{RPM}) * 4 / 120$

$E2-02 = 2.33 \text{ Hz}$

Motor No-Load Current (E2-03) can sometimes be read directly off of the motor nameplate; it is often listed as NLA (no-load amps). If there is no listing on the nameplate, motor no-load current can be estimated as follows: Motor full load current (FLA) * 35%.

Example: 4-pole, 60 Hz motor, Motor FLA = 60 Amps.

$E2-03 = 60 \text{ Amps} * 35\%$

$E2-03 = 21 \text{ Amps}$.

5.3 OV Regulator Gain Increase

Parameters P1-07 (OV Regulator Gain Frequency) and P1-08 (OV Regulator Gain Multiplier) automatically increase the overvoltage suppression regulator gain (P1-02) when the drive's output is above the motor base frequency (E1-06). This is sometimes necessary to compensate for the motor's reduced torque characteristics above its base speed (otherwise known as the constant horsepower or field weakening area). Shown below is an example when E1-04 = 150Hz, E1-06 = 60Hz, P1-02 = 1.00, P1-07 = 90.00 Hz, and P1-08 = 2.000.

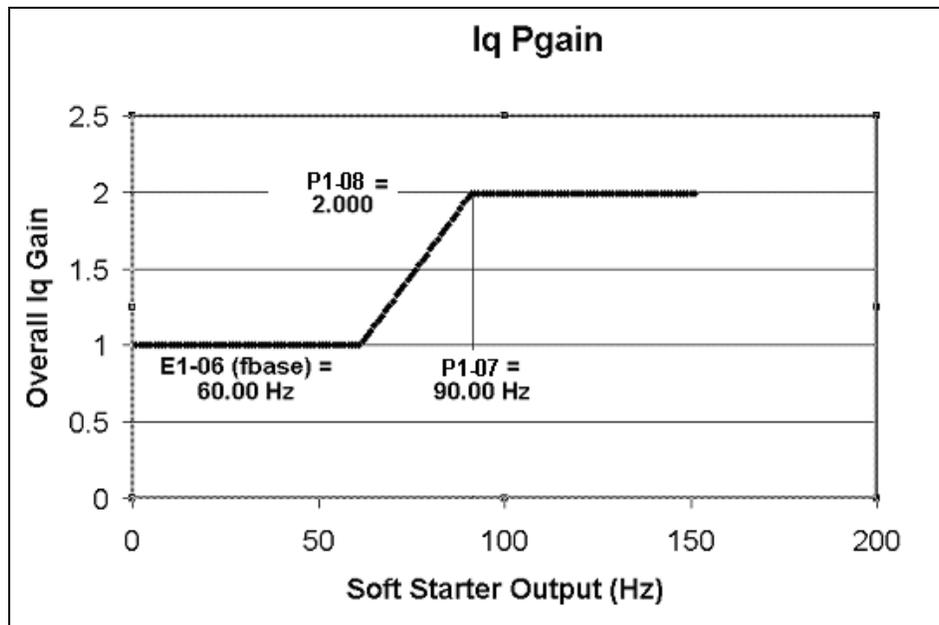


Figure 2: OV Regulator Gain Multiplier Above Motor Base Speed

5.4 Belt Break Detection

If the drive's output frequency is at maximum frequency for more than 30 continuous seconds, the drive will assume that the belt or coupling between the motor and the machinery has become disconnected. The drive will fault on a belt-break fault (B-BRK), energize the fault contacts (MA, MB, and MC), and coast to stop.

5.5 Heatsink Over-temperature Speed Reduction

If the heatsink temperature exceeds L8-02 (Overheat Pre-alarm Level), the drive's frequency reference will automatically be reduced by the percentage set in parameter P2-02. This is done to prevent an Overheat Fault (OH) by reducing the machine speed and thus it's loading on the drive. The drive will remain at this frequency for the time set in parameter P2-01.

While the heatsink temperature is above L8-02, an "OH - Heatsnk Overtemp" alarm will flash. If the temperature drops below the L8-02 level and before the P2-01 timer expires, "OTDLY - Overtemp Delay" will flash on the keypad. When the P2-01 timer expires, the drive will accelerate back to its normal frequency reference.

If the temperature increases back above the L8-02 setting before P2-01 has expired, the timer will be reset.

5.6 Motoring Torque Limits at Start

When a run command is first issued, the drive will internally use parameter P3-01 as both the forward and the reverse motoring torque limit, for the time specified in parameter P3-02. When the P3-02 time expires, the torque limit ramps back to the L7-01 & L7-02 values, at a rate determined by parameter P3-03. The time set into parameter P3-03 represents a torque limit change of 100%. P3-02 can be more than, less than, or the same as L7-01 or L7-02.

Example: If P3-01 = 200%, L7-01 = 50%, and P3-03 = 2.0 seconds, the torque limit ramp time would be calculated as follows:

$$\begin{aligned}\Delta\text{Torque Limit} &= P3-01 - L7-01 = 200\% - 50\% = 150\% \\ \text{Ramp Time} &= \Delta\text{Torque Limit} * P3-03 / 100\% = (150\% * 2.0) / 100\% = 3.0 \text{ seconds} \\ \text{Ramp Time} &= 3.0 \text{ seconds.}\end{aligned}$$

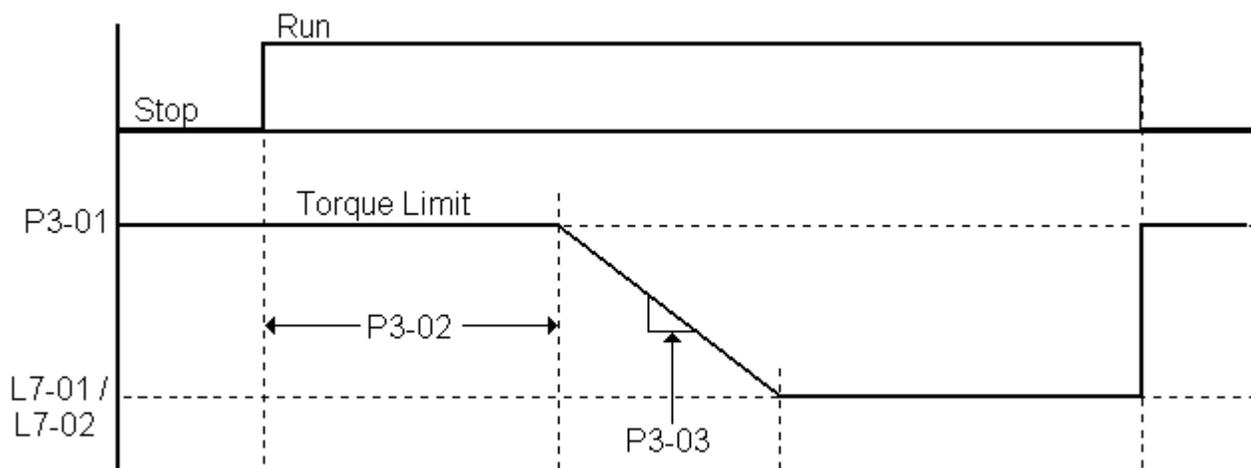


Figure 3: Motoring Torque Limit at Start

6.0 Block Diagram

