

Enhanced PID with Digital Velocity Follower F7 Drive Software Technical Manual



Software Number: VSF11004X, Drive Models: CIMR-F7UXXXXXX-058
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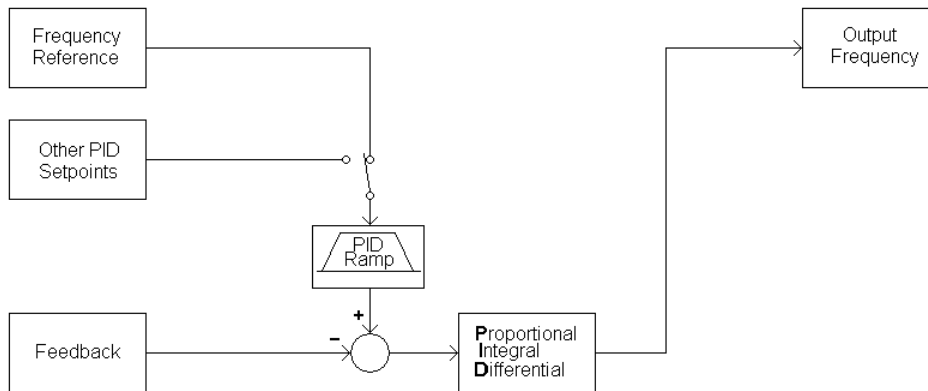
This document is intended to provide proper installation and use of the Yaskawa drive with custom software. This document is a supplement to the standard drive technical manual. It describes the effects on the drive parameters and functions with the software installed. Read and understand this document 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

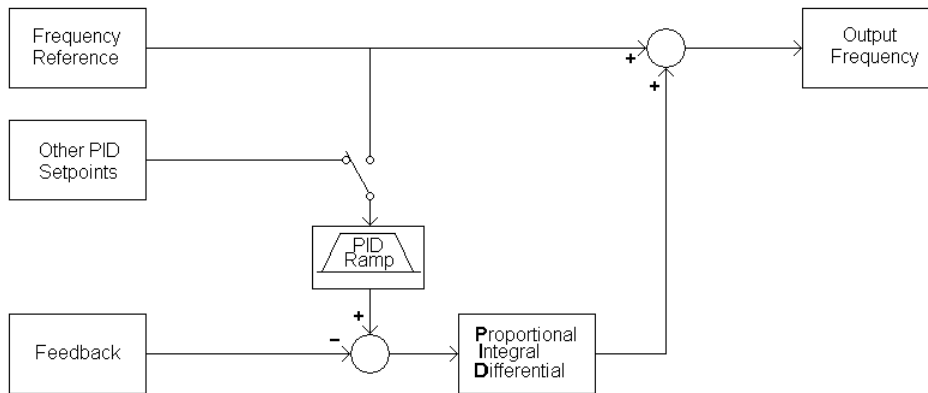
The enhanced PID features are designed to expand the functionality and correct some deficiencies of the drive's standard PID algorithm. The enhanced PID function utilizes the parameters of the standard software PID function (B5 group) as well as many new P group parameters. The digital velocity follower feature is designed to allow quadrature encoder feedback to be used as a precision bi-directional frequency reference.

1.1 Simplified Block Diagram of Enhanced PID: 2 Input (B5-01 = 1 or 2)



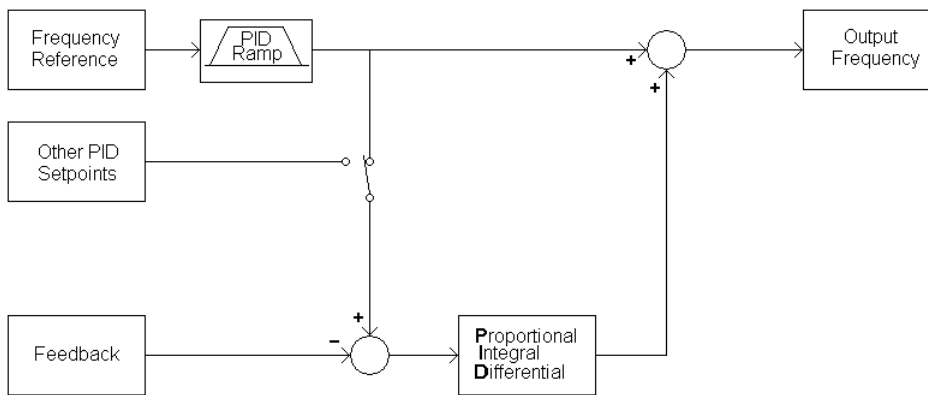
1.2 Simplified Block Diagram of Enhanced PID: 3 Input (B5-01 = 3 or 4)

(PID setpoint is independent of frequency reference)

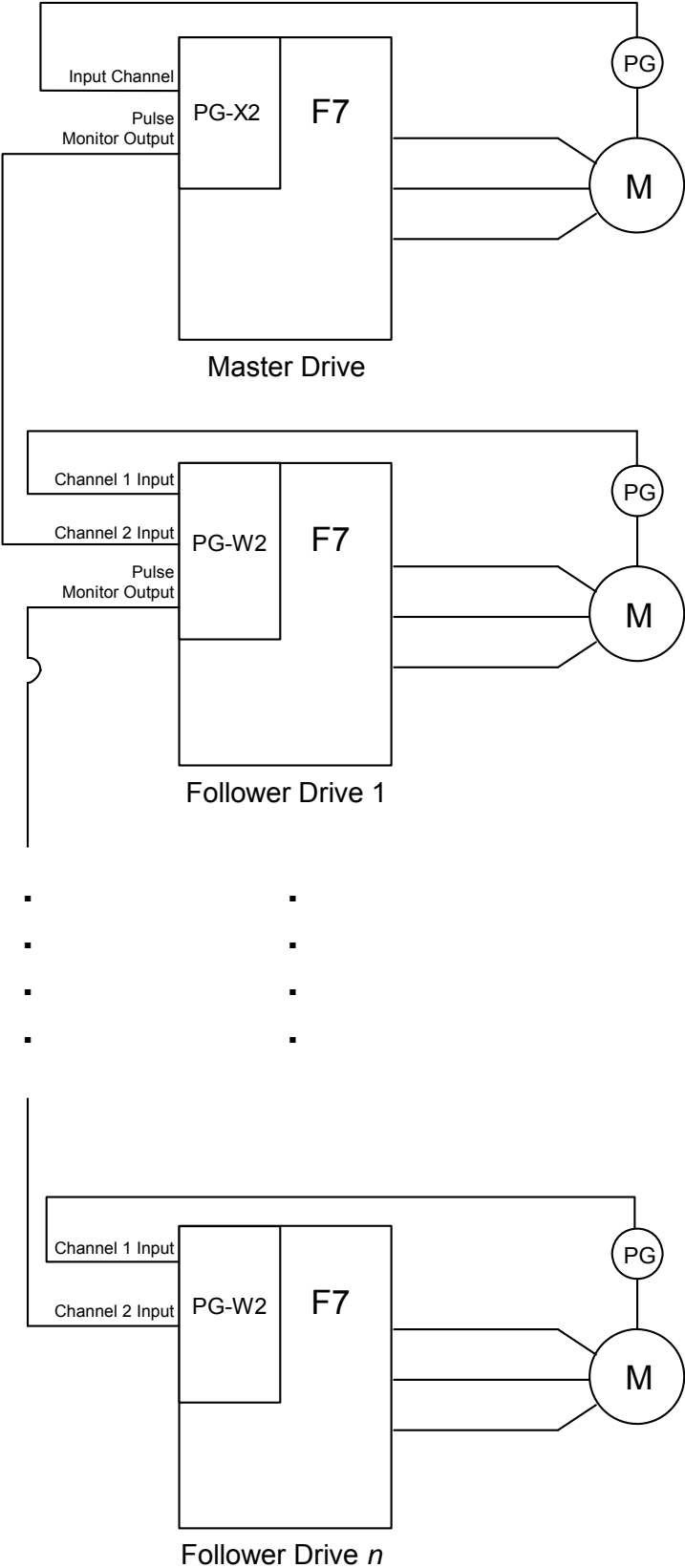


1.3 Simplified Block Diagram of Enhanced PID: 2 Input (B5-01 = 3 or 4)

(PID setpoint is same as the frequency reference)



1.4 Typical Connection Configuration for Digital Velocity Follower Function



2.0 Changes from Standard Product

2.1 Enhanced PID / Digital Velocity Follower versus Standard Software

Feature	Enhanced PID / Digital Velocity Follower	Standard Software
PID Process Controller	√	√
Full Range PID (2-input)	√	√
PID + Frequency Reference Capable (3-input)	√	√
PID x Frequency Reference Capable (3-input)	√	
PID Setpoint Offset Parameter Added	√	
Bi-Directional PID Output	√	√
PID + Trim is Accomplished Algebraically, Regardless of Commanded Direction	√	
Frequency Reference as PID Setpoint	√	√
Parameter B5-19 "PID Setpoint" can be changed during running	√	
Independent Digital PID Setpoint	√	√
Independent Digital PID Setpoint (changeable during run)	√	
Multiple PID Setpoint Sources (digital preset, analog, pulse input, Modbus RTU, option card)	√	√
Setpoint Ramp (when PID setpoint is from frequency reference)	√	√
Setpoint Ramp (all PID setpoints, regardless of source)	√	
Multiple PID Feedback Sources (analog, pulse input)	√	√
Feedback Detection (high, low, on-delay, off-delay, digital output, alarm, fault, during run, always detected)	√	
PID Monitors with User Units (scaled using parameter O1-03)	√	
Detailed PID Monitors (proportional, integral, derivative)	√	
Integral Hold Digital Input	√	√
Positive Integral Hold Digital Input (integrator can only decrease)	√	
Negative Integral Hold Digital Input (integrator can only increase)	√	
PID Output Limit	√	√
Independent + / - PID Output Limits (B5-06 PID limit now functions only as a PID upper limit)	√	
PID Output Gain can be proportional to the frequency reference	√	
PID Output Gain (0.1 Resolution)	√	√
PID Output Gain (0.01 Resolution)	√	
Digital Velocity Follower Functionality Added for Use with a PG-W2, PG-X2, or PG-B2 Option Card	√	
Directional Precision Encoder Frequency Reference (requires PG-W2 or PG-X2)	√	
Parameter E2-04 (Motor Poles) is Available in All Control Modes (advanced access level only for V/f and Open Loop Vector)	√	

3. Limitations

The digital velocity follower feature (B1-01 = 5) cannot be used under either of the following conditions:

- a. If a PG-W2 is installed, and "Motor 2" uses the V/Hz w/PG or Flux Vector control method (E3-01 = 1 or 3).
- b. If a PG-X2 / PG-B2 is installed and control method is V/Hz w/PG or Flux Vector (A1-02 = 1 or 3).

Note: If the PG-W2 option is used, jumper HDR1 must be set to the "top" position (using the 2 pins closest to the 4CN connector).

4. Related Parameters and Functions

4.1 Parameters

Parameter Number	Modbus Address	Parameter Name <i>Digital Operator Display</i>	Description	Range	Default	Change During Run	Access Level For All Control Modes *1
B1-01	180H	Frequency Reference Selection <i>Reference Source</i>	Sets the frequency reference source. 0: Operator 1: Control Terminal Strip 2: Modbus RTU (Terminals R+, R-, S+, S-) 3: Option Card 4: Pulse Input (Terminal RP) 5: PG Option Card (PG-W2, PG-X2, PG-B2 as the frequency reference)	0 ~ 5	1	No	Q
P1-01	600H	Feedback Detection Mode Selection <i>Fb Det Mode Sel</i>	This parameter selects the characteristics of the PID feedback detection function. 0: Output/AlwaysDet Feedback high & low multi-function digital outputs are enabled (if programmed); detection is always active. 1: Output/DuringRUN Feedback high & low multi-function digital outputs are enabled (if programmed); detection is active only during run. 2: Alarm/AlwaysDet Feedback range alarms (FRH, FRL) and feedback high & low multi-function digital outputs are enabled (if programmed); detection is always active 3: Alarm/DuringRUN Feedback range alarms (FRH, FRL) and feedback high & low multi-function digital outputs are enabled (if programmed); detection is active only during run 4: Fault/AlwaysDet Feedback range faults (FRH, FRL) and feedback high & low multi-function digital outputs are enabled (if programmed); detection is always active. Drive coasts to a stop and activates the fault contacts. 5: Fault/DuringRUN Feedback range faults (FRH, FRL) and feedback high & low multi-function digital outputs are enabled (if programmed); detection is active only during run. Drive coasts to a stop and activates the fault contacts.	0 ~ 5	0	No	A

*1: Access Level (A1-01): Q = "Quick Start", A = "Advanced", F = "Factory".

4.1 Parameters (continued)

Parameter Number	Modbus Address	Parameter Name <i>Digital Operator Display</i>	Description	Range	Default	Change During Run	Access Level For All Control Modes *1
P1-02	601H	Feedback Detection Level (High) Fb Det Lvl High	This parameter sets the detection level for PID feedback (high) detection function.	-100.0 ~ +100.0 %	100.0	No	A
P1-03	602H	Feedback On-Delay Time (High) Fb High On-Delay	This parameter sets the on-delay time for the PID feedback detection (high) function.	0.0 ~ 100.0 sec	0.0	No	A
P1-04	603H	Feedback Off-Delay Time (High) Fb HighOff-Delay	This parameter sets the off-delay time for the PID feedback (high) detection function.	0.0 ~ 100.0 sec	0.0	No	A
P1-05	604H	Feedback Detection Level (Low) Fb Det Lvl Low	This parameter sets the detection level for PID feedback (low) detection function.	-100.0 ~ +100.0 %	0.0	No	A
P1-06	605H	Feedback On-Delay Time (Low) Fb Low On-Delay	This parameter sets the on-delay time for the PID feedback detection (low) function.	0.0 ~ 100.0 sec	0.0	No	A
P1-07	606H	Feedback Off-Delay Time (Low) Fb Low Off-Delay	This parameter sets the off-delay time for the PID feedback (low) detection function.	0.0 ~ 100.0 sec	0.0	No	A
P1-08	607H	Feedback Detection Hysteresis FbDet Hysteresis	This parameter sets the hysteresis level for the PID feedback detection function (high & low).	0.0 ~ 10.0 %	10.0	No	A
P2-01	60AH	PID Lower Limit PID Lower Limit	This parameter sets the PID lower limit as a percentage of the maximum output frequency (E1-04). Works in conjunction with the PID Limit (B5-06), which sets the upper limit. <i>Note: If P2-01 is set greater than B5-06, an OPE12 error will be displayed.</i>	-100.0 ~ 100.0 %	-100.0	Yes	A

*1: Access Level (A1-01): Q = "Quick Start", A = "Advanced", F = "Factory".

4.1 Parameters (continued)

Parameter Number	Modbus Address	Parameter Name <i>Digital Operator Display</i>	Description	Range	Default	Change During Run	Access Level For All Control Modes *1
P2-02	60BH	PID Output Gain 2 Output Gain 2	This parameter sets the gain at the output of the PID. Functions the same as PID Output Gain (B5-10), but with finer resolution (0.01 versus 0.1). The total output gain is determined by B5-10 x P2-02.	0.00 ~ 25.00	1.00	No	A
P2-03	60CH	PID Setpoint Offset Setpoint Offset	This parameter sums with the PID setpoint (analog input, pulse input, network communication, or parameter) to provide an offset.	-100.0 ~ +100.0 %	0.0	No	A
P2-04	60DH	PID Trim Mode Selection PID Trm Mode Sel	This parameter selects how the PID output will trim the frequency reference. Active only when b5-01 = 3 or 4. 0: Constant The PID output trim is independent of the frequency reference. 1: Freq Ref Prop The PID output trim is proportional to the frequency reference.	0 ~ 1	0	No	A
P2-05	60EH	Frequency Reference Proportional Trim Lower Limit FrefProp Low Lim	This parameter sets the lower limit of the PID output trim of the frequency reference when P2-01 = 1 (trim is proportional to the frequency reference). Active only when b5-01 = 3 or 4 and P2-04 = 1.	0.00 ~ 100.00 %	10.00	Yes	A
P3-01	614H	Master Encoder Pulses per Revolution Master PG PPR	This parameter sets the resolution, in pulses per revolution, of the encoder used in the digital velocity follower function. This applies to the PG-W2, PG-X2, and PG-B2 cards. Parameter E2-04 (Motor Poles) must also be correctly set. The PG-W2 and PG-X2 have a maximum input frequency of 300 kHz. The PG-B2 has maximum input frequency of 32 kHz.	1 ~ 60,000	1024	No	A
P3-02	615H	Ratio Numerator Ratio Numerator	This parameter sets the numerator of the gear ratio in the digital velocity follower function.	1 ~ 65,535	10000	Yes	A
P3-03	616H	Ratio Denominator Ratio Denominator	This parameter sets the denominator of the gear ratio in the digital velocity follower function.	1 ~ 65,535	10000	Yes	A

*1: Access Level (A1-01): Q = "Quick Start", A = "Advanced", F = "Factory".

4.1 Parameters (continued)

Parameter Number	Modbus Address	Parameter Name <i>Digital Operator Display</i>	Description	Range	Default	Change During Run	Access Level For All Control Modes *1
P3-04	617H	Ratio Adjustment Ratio Adj	This parameter will add or subtract a percentage of the incoming frequency reference in the digital velocity follower function. This is often used to achieve a slight draw or tension.	-99.99 ~ +99.99 %	0.00	Yes	A
P3-05	618H	Following Method Follow Method	This parameter determines the relationship between the direction (phasing) of the incoming encoder signal and the resultant frequency reference in the digital velocity follower function. 0: One Direction Positive pulses = Positive reference Negative pulses = Zero reference 1: Bi-Directional Positive pulses = Positive reference Negative pulses = Neg. reference 2: Absolute Value Positive pulses = Positive reference Negative pulses = Positive reference 3: Inv. One Dir Positive pulses = Zero reference Negative pulses = Positive reference 4: Inv. Bi-Dir. Positive pulses = Negative reference Negative pulses = Positive reference 5: Inv. Abs. Value Positive pulses = Negative reference Negative pulses = Negative reference	0 ~ 5	1	No	A
P3-06	619H	PG-W2 Pulse Monitor Output Channel Select PG Mon Ch Sel	This parameter selects which input channel of the PG-W2 card is sent to the pulse monitor terminals 17-22. See section 4.7 for details. 0: Channel 1 Input terminals 3-8 are output to pulse monitor terminals. 1: Channel 2 Input terminals 10-15 are output to pulse monitor terminals.	0 ~ 1	1	No	A

*1: Access Level (A1-01): Q = "Quick Start", A = "Advanced", F = "Factory".

4.2 Monitors (U1-XX)

Monitor Number	Modbus Address	Monitor Name <i>Digital Operator Display</i>	Description	Scaling for Multi-function Analog Outputs Terminals FM and AM (H4-01, H4-04)	Unit	Access Level For All Control Modes *1
U1-90	720H	PID Feedback <i>PID Feedback</i>	Displays the PID feedback as a percentage of the maximum output frequency.	100%: Maximum Output Frequency (E1-04)	0.1 %*2	A
U1-91	721H	PID Input <i>PID Input</i>	Displays the PID input value as a percentage of the maximum output frequency.	100%: Maximum Output Frequency (E1-04)	0.1 %*2	A
U1-92	722H	PID Output <i>PID Output</i>	Displays the PID output value as a percentage of the maximum output frequency.	100%: Maximum Output Frequency (E1-04)	0.1 %*2	A
U1-93	723H	PID Proportional Output <i>PID P Output</i>	Displays the PID proportional value as a percentage of the maximum frequency.	100%: Maximum Output Frequency (E1-04)	0.1 %*2	A
U1-94	724H	PID Integral Output <i>PID I Output</i>	Displays the PID integral value as a percentage of maximum output frequency.	100%: Maximum Output Frequency (E1-04)	0.1 %*2	A
U1-95	725H	PID Derivative Output <i>PID D Output</i>	Displays the PID derivative value as a percentage of the maximum output frequency.	100%: Maximum Output Frequency (E1-04)	0.1 %*2	A
U1-96	726H	PID Setpoint <i>PID Setpoint</i>	Displays the PID setpoint as a percentage of the maximum output frequency.	100%: Maximum Output Frequency (E1-04)	0.1 %*2	A
U1-97	727H	Encoder Input <i>Encoder Input</i>	Displays the frequency of the raw encoder input of the digital velocity follower function.	N/A	0.1 kHz	A
U1-98	728H	Encoder Reference <i>Encoder Ref.</i>	Displays the frequency reference generated by the encoder input of the digital velocity follower function.	100%: Maximum Output Frequency (E1-04)	0.1 Hz	A

*1: Access Level (A1-01): Q = "Quick Start", A = "Advanced", F = "Factory".

*2: Unit based on O1-03 (Display Scaling) setting. Refer to O1-03 parameter description the F7 programming manual TM.F7.02 for further information.

4.3 Multi-function Digital Input Settings (H1-0X)

Setting	Display	Description	Available For All Control Modes
80	Positive Integral Hold	Closed: Integral is permitted to decrease, but not increase.	√
81	Negative Integral Hold	Closed: Integral is permitted to increase, but not decrease.	√

√: Available.

4.4 Multi-function Digital Output Settings (H2-0X)

Setting	Display	Description	Available For All Control Modes
40	Feedback High	Closed: PID feedback has exceeded P1-02 level for the time set in P1-03.	√
41	Feedback Low	Closed: PID feedback has fallen below the P1-05 level for the time set in P1-06.	√

√: Available.

4.5 Faults

Fault Display	Description	Cause	Countermeasures
FRH Feedback Range High	PID feedback out of range (high). Motor will coast to a stop.	P1-01 = 4 or 5 and the PID feedback has exceeded the P1-02 level for the time set in P1-03.	Correct the cause of the high feedback signal.
FRL Feedback Range Low	PID feedback out of range (low). Motor will coast to a stop.	P1-01 = 4 or 5 and the PID feedback has fallen below the P1-05 level for the time set in P1-06.	Correct the cause of the low feedback signal.
OPE12 PID / DVF Err	<p>1. PID limit setting error</p> <p>2. Motor 2 control method is Flux Vector or V/Hz w/PG and the frequency reference source is PG Option Card</p> <p>3. PG-X2 or PG-B2 card installed, control method is Flux Vector or V/Hz w/PG, and the frequency reference source is PG option card</p>	<p>1. P2-01 is set greater than B5-06</p> <p>2. B1-01 = 5, E3-01 = 1 or 3, and H1-XX = 16</p> <p>3. PG-X2 / PG-B2 installed, A1-02 = 1 or 3, and B1-01 = 5</p>	Correct the parameter settings.

4.6 Alarms

Alarm Display	Description	Cause	Countermeasures
FRH Feedback Range High	PID feedback out of range (high)	P1-01 = 2 or 3 and the PID feedback has exceeded the P1-02 level for the time set in P1-03.	Correct the cause of the high feedback signal.
FRL Feedback Range Low	PID feedback out of range (low)	P1-01 = 2 or 3 and the PID feedback has fallen below the P1-05 level for the time set in P1-06.	Correct the cause of the low feedback signal.

4.7 Pulse Output Monitor Configuration

Option Card	P3-06 Setting	Input Terminals: Signal Name	Output Terminals: Signal Name
PG-W2	0: Channel 1	3: A + 4: A - 5: B + 6: B - 7: Z + 8: Z -	17: A + 18: A - 19: B + 20: B - 21: Z + 22: Z -
	1: Channel 2	10: A + 11: A - 12: B + 13: B - 14: Z + 15: Z -	

5.0 Function Description

5.1 Enhanced PID

The Enhanced PID feature includes many enhancements over the drive's standard PID function. The PID algorithm is programmed using the existing b5 group of parameters as well as the P group of parameters. Enhanced features include:

- The value of the PID feedback is monitored, and can trigger digital outputs, alarms, and faults based upon preset high and low levels.
- The ramp in the PID setpoint behaves differently depending upon the PID mode and the reference source. In most cases, the PID setpoint ramp affects only the PID setpoint. When the PID + Trim feature is enabled (B5-01 = 3 or 4) and there is no independent PID setpoint, the PID ramp affects both the PID setpoint and the frequency reference.
- The PID output is now algebraically summed with the frequency reference. Motor rotation will be forward if: a forward run is commanded and there is a positive PID + trim, or if a reverse run is commanded and there is a negative PID + trim. Motor rotation will be reverse if: a reverse run is commanded and there is a positive PID + trim, or if a forward run is commanded and there is a negative PID + trim.
- Some further functionality has been added to the PID algorithm:
 - a. Increased resolution of the PID Output Gain
 - b. Independent positive and negative integral holds
 - c. Independent positive and negative PID output limits
 - d. Added setpoint offset parameter
 - e. The PID output can be added directly to, or multiplied by, the frequency reference.
 - f. The output of the PID can be proportional to the frequency reference.

5.2 Digital Velocity Follower

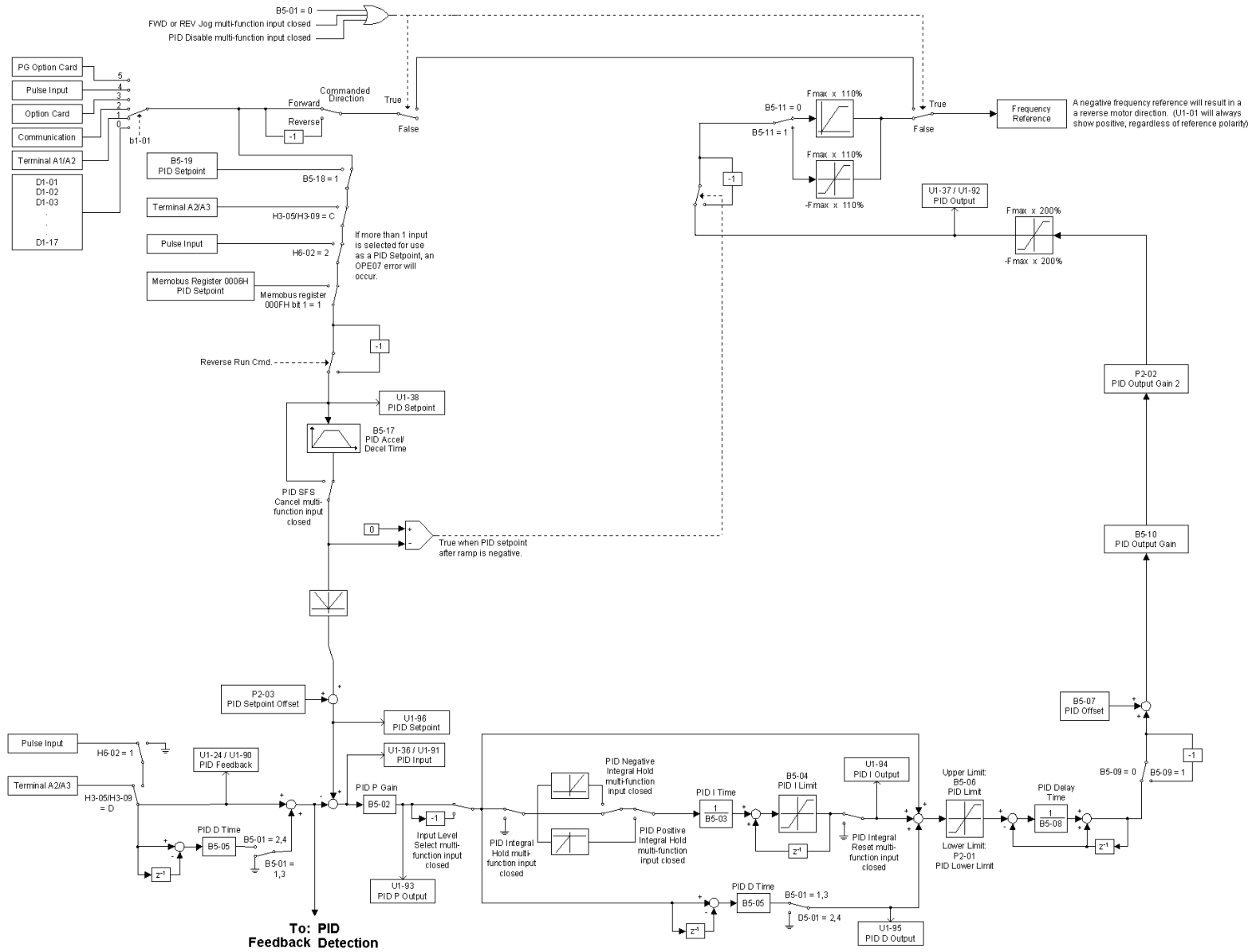
When the Digital Velocity Follower is enabled (B1-01 = 5), the drive will follow the speed of the encoder signal (Channel 1 of the PG-X2 or PG-B2, channel 2 of the PG-W2). Using the gear ratio parameters P3-02 and P3-03, the drive can be made to run at a ratio of the master speed. Further adjustment of the ratio can be obtained using parameter P3-04. Parameter P1-05 determines how the drive reacts when the encoder reference changes directions. This reference can be used alone or in the enhanced PID function.

6.0 Block Diagrams

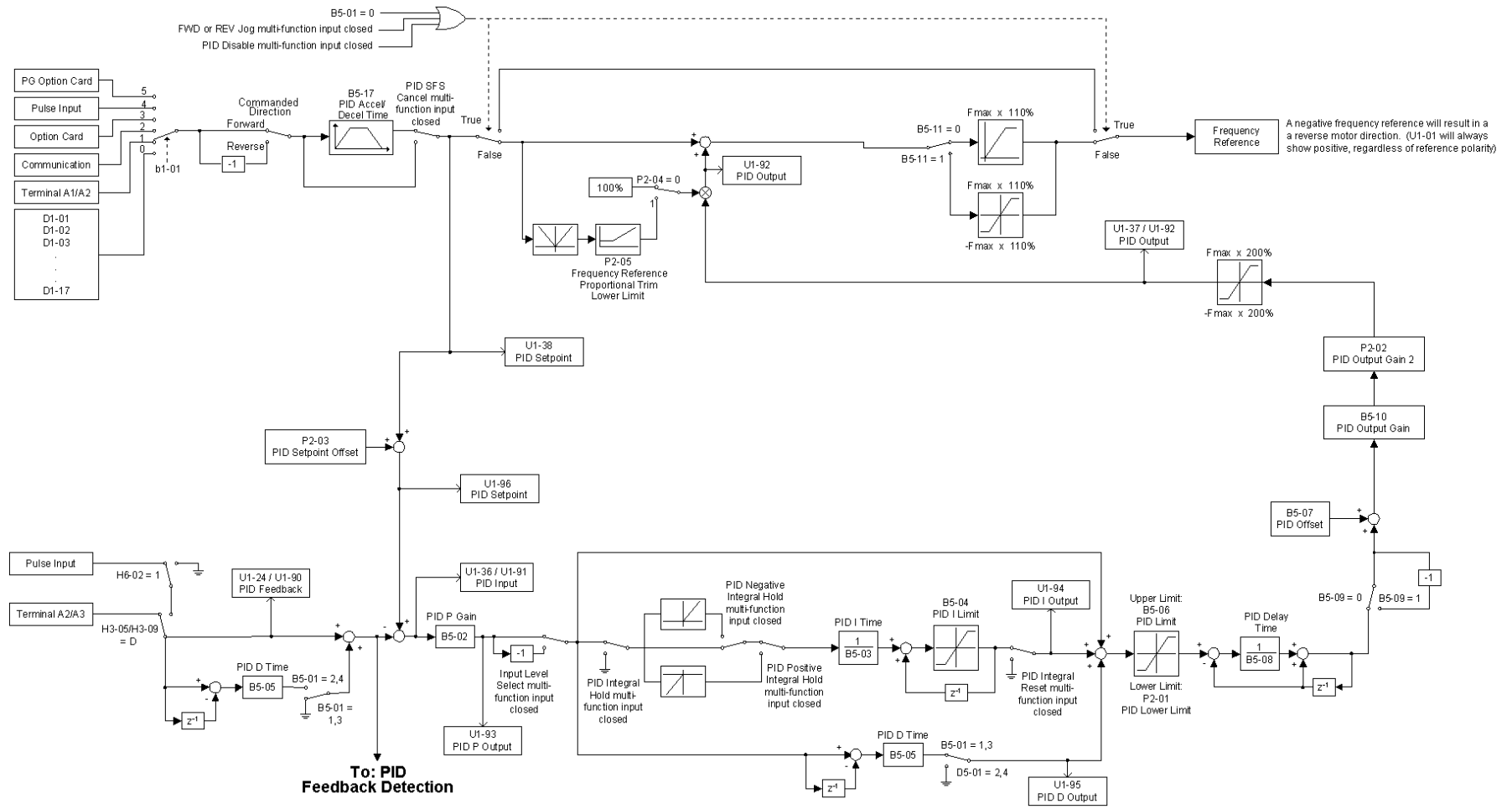
The following pages give detailed flowcharts of the following software functions:

- 6.1 Enhanced PID with 2 Inputs (B5-01 = 1 or 2)
- 6.2 Enhanced PID with 2 Inputs (B5-01 = 3 or 4)
- 6.3 Enhanced PID with 3 Inputs (B5-01 = 3 or 4)
- 6.4 Enhanced PID Feedback Detection
- 6.5 Digital Velocity Follower

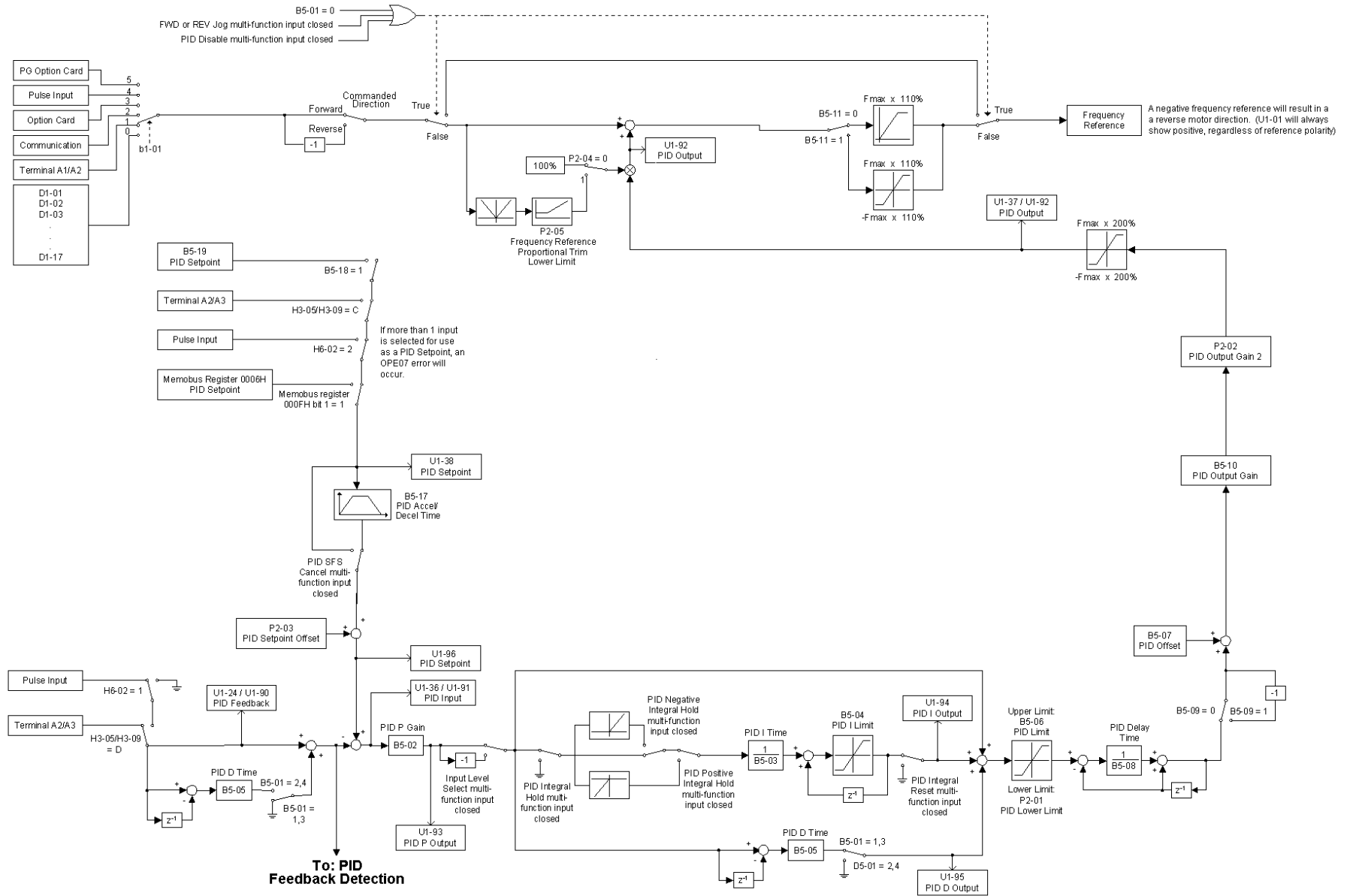
6.1 Enhanced PID with 2 Inputs (b5-01 = 1 or 2)



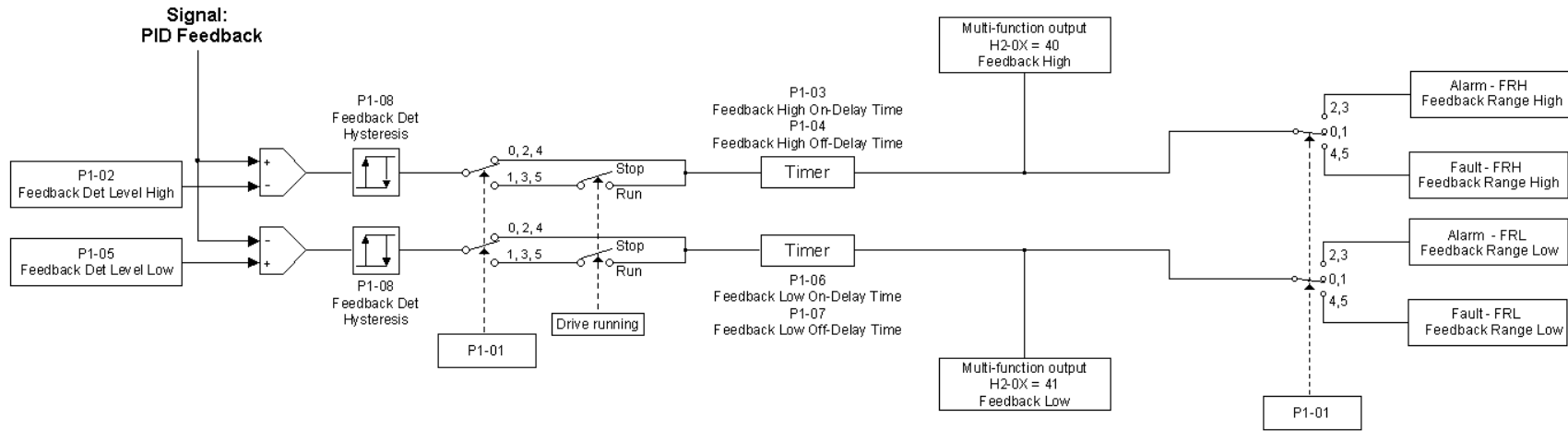
6.2 Enhanced PID with 2 Inputs (b5-01 = 3 or 4)



6.3 Enhanced PID with 3 Inputs (b5-01 = 3 or 4)



6.4 Enhanced PID Feedback Detection



6.5 Digital Velocity Follower

