

## GPD515/G5 Software Option (VSG114815) Part Number: CIMR-G5MXXXXXF-047 <sup>(1)</sup>

<2> New to software version VSG114815

Electronic Line shaft Software allows one or more GPD515/G5 driven motors to be synchronized to a master encoder signal. The master encoder provides a pulse reference to the follower that results in the follower commanding its motor to maintain a specific shaft position. The follower drive monitors the pulse feedback from the master encoder and its own encoder. The follower will then compensate for any position errors by adjusting its motor's output speed, resulting in near perfect alignment between the system master and the follower motor. There is no accumulation of position error, so alignment will always be maintained.

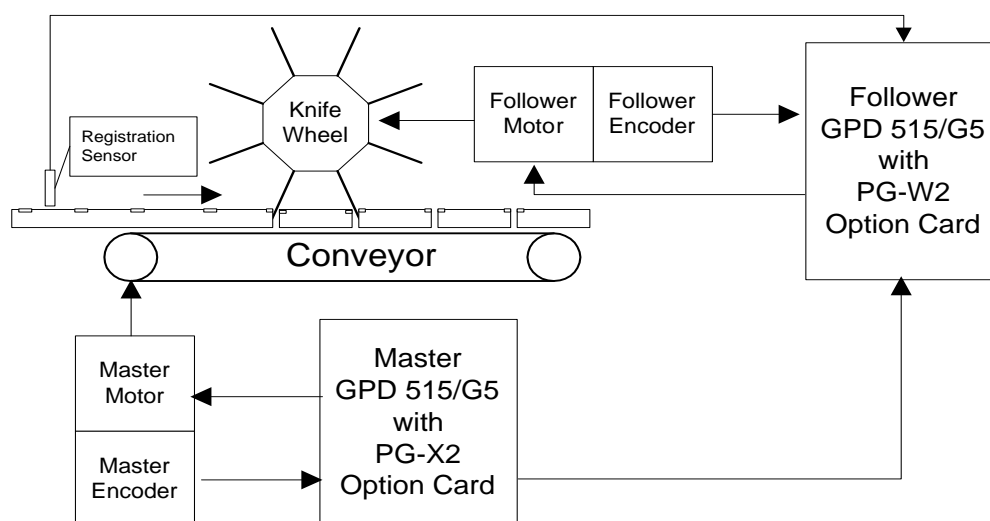
The follower also possesses an electronic gearing feature. This allows the follower to operate at a ratio of the master as though the two were mechanically coupled through belts or gearing. This software includes "Enhanced" Modbus communications.

The registration control feature allows the follower drive to accept a registration mark from the moving product and regulate its angular position. This is used for special applications such as packaging machines, flying cutoffs, label applicators, etc.

**Note:** This software can be enabled and disabled using parameter **P2-07**. <2>

**Note:** Reference source when electronic line shaft is disabled is determined by parameter **b1-01**. <2>

**Note:** This software requires that the PG-W2 Dual Encoder Feedback Option Board (CDR001040) be installed on the follower. Both the master reference encoder and the follower encoder need to be of the *line driver* and *quadrature* type. The registration sensor, if used, must be *line driver type also*. **Hardware jumper HDR1 on the PG-W2 board must be set to "up" position for this software to work properly.**



(1) XXXX refers to the base Model Number of the drive in which the software is installed.

This document is an addendum to Technical Manual TM4515, listing the effect of this software on the parameters in the drive and function descriptions in the manual.

# Electronic Lineshaft with Registration

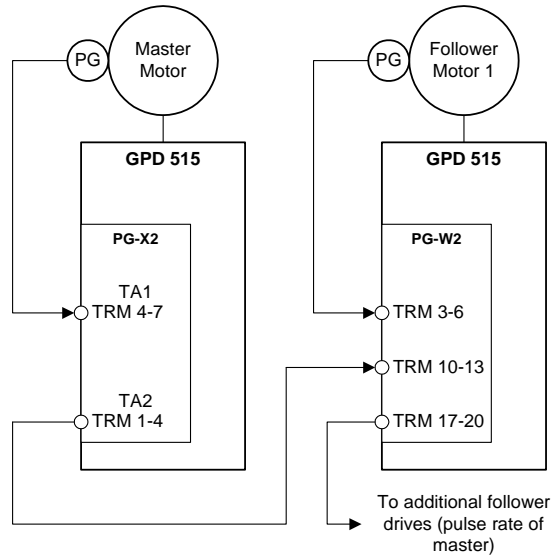
## 1.0 Wiring

Wire the incoming power, motor, accessories and control wiring as specified in the GPD515/G5 Technical Manual TM4515. The master encoder (or pulse reference source) should be wired to terminals 10 through 16 according to the PG-W2 instruction sheet. The registration sensor, if used, must be wired to terminal 7 & 8 of the PG-W2 card. **Do not use parameter F1-05 to change encoder phasing in this software. Please swap encoder signals A+ and A- instead.**

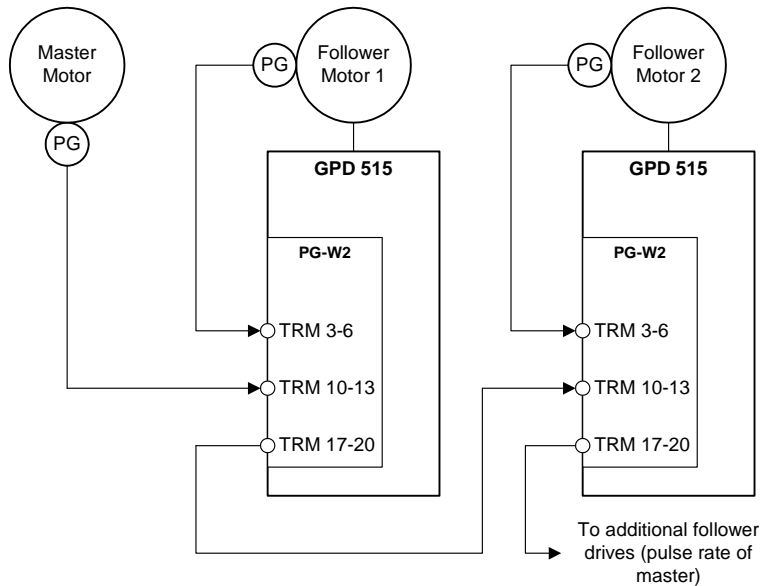
**Note:** The +12V supply on the PG-W2 card is capable of only 200mA, be sure not to overload it.

## 1.1 Encoder Wiring Examples

Example of a Multiple Follower System with a VFD Driven Master



Example of a Multiple Follower System (non-VFD Driven Master)



# Electronic Lineshaft with Registration

## 2.0 I/O Definitions

### 2.1 New Multi-Function Digital Input Settings

For constants H1-01 through H1-06.

Setting	Display	Description
80	Disable LineShft	Closed: Line Shaft Mode is disabled. When disabled, parameter <b>b1-01</b> determines frequency reference. <2>
81	Gear Ratio 2	Closed: Gear Ratio #2 is selected (P2-01, P2-02)
82	Reset Follow Err	Closed: Following error is reset to zero. <2>
83	Advance Follower	Closed: Follower drive will increase speed without accumulating error
84	Retard Follower	Closed: Follower drive will decrease speed without accumulating error
85	Raise Gear Ratio	Closed: The MOP function raises the gear ratio of the follower
86	Lower Gear Ratio	Closed: The MOP function lowers the gear ratio of the follower
87	Reset Gear Ratio	Closed: The MOP function resets the gear ratio of the follower

<2> New to software version VSG114815.

### 2.2 New Multi-Function Digital Output Settings

For constants F5-01 and F5-02, and H2-01 through H2-03.

**None**

### 2.3 New Multi-Function Analog Input Settings

For constants H3-05 and H3-09.

**None**

### 2.4 New Multi-Function Analog Output Settings

For constants F4-01, F4-03, H4-01, and H4-04.

**None**

## 3.0 Startup Procedure

1. Perform the flux vector start-up procedure in Section 2.2b of the GPD515 Technical manual. Set the follower encoder's Pulses Per Revolution (PPR) into parameter **F1-01**. If the encoder phasing is backwards, swap wires 3 & 4 on the PG-W2 card. **Parameter F1-05 must be set to "CCW" (0) (factory default) when using this software.**
2. Set the reference source to "Line Shaft" (**b1-01** = 5).
3. Verify that the master reference encoder is working. Bring up parameter **U1-50** on the follower digital operator by pressing MENU then DATA/ENTER, DOWN, DATA/ENTER, and DOWN (several times). Turn the master reference encoder. Parameter **U1-50** should display a positive value when the encoder is turned forward, and a negative value when it is turned in reverse. If a negative value is displayed when the master encoder is turned forward, swap wires 10 & 11 on the PG-W2 card. Do not change any other wires.
4. Set the master encoder's Pulses Per Revolution (PPR) into parameter **P1-01**.

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5. With no other adjustments, the follower motor's shaft will track the master encoder's position & velocity. *If a different ratio is desired*, enter that ratio into parameters **P1-02** and **P1-03**. Parameter **P1-02** is the numerator and parameter **P1-03** is the denominator as shown in the following equation. The ratio between the master and follower must be able to be exactly expressed in the following equation to avoid position drift. The MOP gear ratio function is multiplied to the **P1-02/P1-03** ratio to form the final follower gear ratio.

$$\text{Motor Speed} = \frac{\text{P1-02}}{\text{P1-03}} \times \text{Master Encoder Speed}$$

(Position) (Position)

6. Press MENU then DATA/ENTER to return to drive ready mode. If the SEQ and REF lights are *not* on, press the LOCAL/REMOTE button to turn them on.
7. Command a forward run by closing terminal 1 to terminal 11 on the follower drive. The follower motor should remain stationary as long as the master encoder remains stationary. Rotate the master and check parameter **U1-53** – Position Error. If everything is working properly, this parameter should show a reasonably low number (<20). It is normal for this number to change very rapidly from positive to negative.
8. If the position error (**U1-53**) is too high, adjusting the speed regulator and the position regulator can help lower it by improving the response. Response can be improved by first increasing the ASR gain (**C5-01**). Next, if more responsiveness is required, increase parameter **P1-04** and decrease parameter **P1-05**. All of these parameters will interact with each other and with the motor/load so multiple adjustments may be necessary. Going too high with parameters **C5-01** and **P1-04**, or too low with parameter **P1-05** will cause instability.
9. Assign digital inputs for advance / retard, M.O.P., and Ratio 2 as needed.

## 4.0 Custom Software Parameters

### 4.1 New Program Group

Group P  
Elect Line Shaft

### 4.2 New Program Function

Function P1  
Line Shaft Data

Function P2  
Line Shaft Data

Function P3  
Registration

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## 4.3 New Program Parameters

Master PPR  
P1-01 = 1024

Setting Range: 0 to 10,000  
Factory Default: 1024 (adjustable while running)  
Modbus Address: 0580H

### P1-01 Master PPR

Q	Q	Q	Q
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The number of output pulses per revolution (PPR) from the master encoder.

Ratio Numerator  
P1-02 = 1000

Setting Range: 1 to 10,000  
Factory Default: 1000 (adjustable while running)  
Modbus Address: 0581H (Serially adjustable while running without enter command)

### P1-02 Ratio Numerator

Q	Q	Q	Q
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Used in conjunction with **P1-03** to set up the ratio of the follower. The MOP gear ratio function is multiplied to the **P1-02/P1-03** ratio to form the final follower gear ratio.

Example: With **P1-02** = 4, and **P1-03** = 1, the ratio will be 4/1, or 4. With this ratio, for every revolution of the master, the follower will make four revolutions.

Ratio Denominator  
P1-03 = 1000

Setting Range: 1 to 10,000  
Factory Default: 1000 (adjustable while running)  
Modbus Address: 0582H (Serially adjustable while running without enter command)

### P1-03 Ratio Denominator

Q	Q	Q	Q
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See **P1-02** for description.

# Electronic Lineshaft with Registration

Position P gain  
P1-04 = 10.00

Setting Range: 0.00 to 100.00  
Factory Default: 10.00 (adjustable while running)  
Modbus Address: 0583H

## P1-04 Position Error Proportional Gain

Q	Q	Q	Q
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The 'proportional gain' adjusts the follower's speed reference to compensate for any position error between the master and follower. The proportional function increases speed compensation based on the magnitude of the position error. Increasing the proportional gain makes the follower more responsive to position errors.

The maximum correction factor added by **P1-04** is 5 Hertz.

Position I time  
P1-05 = 0.10 Sec

Setting Range: 0.00 to 100.00  
Factory Default: 0.10 Sec (adjustable while running)  
Modbus Address: 0584H

## P1-05 Position Error Integral Time

Q	Q	Q	Q
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The 'integral time' adjusts the follower's speed reference to compensate for any position error between the master and follower. The integral function increases speed compensation based on the amount of time a given error exists. Decreasing the integral time makes the follower more responsive to position errors.

The maximum correction factor added by P1-05 is 5 Hertz.

TrimRate ct/10ms  
P1-06 = 20

Setting Range: 0 to 1000  
Factory Default: 20 (adjustable while running)  
Modbus Address: 0585H

## P1-06 Rate Of Advance/Retard At Digital Input

Q	Q	Q	Q
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The follower can be advanced or retarded at the rate of **P1-06** counts every 10 mSec, whenever a multifunction digital input programmed to 83 (advance) or 84 (retard) is closed. When the digital input is removed, the follower will maintain synchronization with the master, at the follower's advanced (retarded) position.

Follw.trip cnts  
P1-07 = 4096

Setting Range: 0 to 32,767  
Factory Default: 4096 (adjustable while running)  
Modbus Address: 0586H

## P1-07 Follower Trip Counts

Q	Q	Q	Q
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If the position error between the master and the follower exceeds the **P1-07** setting, the follower will respond based on the **P1-08** setting.

# Electronic Lineshaft with Registration

## Trip Reaction P1-08 = 2

Setting Range: 0 to 2  
Factory Default: 2 (adjustable while running)  
Modbus Address: 0587H

### P1-08 Trip Reaction

Q	Q	Q	Q
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If the position error between the master and the follower exceeds the **P1-07** setting, the follower responds as selected below.

Setting	Description
0	The follower continues operation without trip annunciation.
1	The follower continues operation while displaying FOL_ALM.
2	The follower faults, coasting to a stop, and displays FOL_FLT.

## Resync Property P1-09 = 1

Setting Range: 0 to 1  
Factory Default: 1 (adjustable while running)  
Modbus Address: 0588H

### P1-09 Resynchronization Property

Q	Q	Q	Q
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The follower can be configured to respond to, or ignore, position errors when it is under power, but not running. With a setting of 0, the follower will monitor the position of both the master and the follower. If a position error develops, via movement of the master or follower shaft, at the initiation of a run command, the follower will advance or retard accordingly, to cancel the position error. With a setting of 1, the follower sets the position error to zero, ignoring any movement of the master or follower that occurred while the follower was stopped.

Setting	Description
0	Accumulates position error when not running. Corrects error at 'run'.
1	Ignores position error when not running. Does not correct at 'run'.

## MOP Rate of Chng P1-10 = 0.0020

Setting Range: 0 to 1.0000  
Factory Default: 0.0020 (adjustable while running)  
Modbus Address: 0589H

### P1-10 MOP Rate of Change per 100ms

Q	Q	Q	Q
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A closed digital input to a terminal selected for Raise/Lower Gear Ratio (set value 85/86) will increase or decrease the gear ratio by **P1-10** every 100ms between the master encoder and the follower drive. A digital input to a terminal set to Reset Gear Ratio (set value 87) will reset the MOP gear ratio back to 1.0000. See **P2-01** and **P1-02**. The MOP function is multiplied by the preset gear ratio to form the final gear ratio.

# Electronic Lineshaft with Registration

Ratio 2 Numer.  
P2-01 = 1000

Setting Range: 1 to 10,000  
Factory Default: 1000 (adjustable while running)  
Modbus Address: 0590H

## P2-01 Ratio 2 Numerator

Q	Q	Q	Q
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A digital input to a terminal selected for Gear Ratio 2 (set value 81) will select parameters **P2-01** and **P2-02** as the follower's ratio of the master encoder signal. When this input is made, parameters **P1-02** and **P1-03** will be ignored.

See **P1-02** for further information and an example.

Ratio 2 Denom.  
P2-02 = 1000

Setting Range: 1 to 10,000  
Factory Default: 1000 (adjustable while running)  
Modbus Address: 0591H

## P2-02 Ratio 2 Denominator

Q	Q	Q	Q
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See **P2-01**.

Ratio Chg/Scan  
P2-03 = 0.0010

Setting Range: 0.0001 to 1.0000  
Factory Default: 0.0010 (adjustable while running)  
Modbus Address: 0592H

## P2-03 Ratio Change Per Scan

Q	Q	Q	Q
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This parameter adjusts how quickly the gear ratio changes between ratio 1 and ratio 2.

Example: Assume that the ratio is being changed from 3/2 (ratio of 1.5:1) to 62/9 (ratio of 6.89:1). The ratio increases by  $6.89 - 1.5$ , which is 5.39. There are 200 scans per second. If P2-03 is set to 0.0010, then this would account for a ratio increase of  $0.0010 \times 200$ , or 0.2 per second. The required correction is 5.39 at a rate of 0.2/second would mean that the final ratio would be reached in  $5.39 / 0.2$ , or 26.95 seconds.

Pgain Reduc cts  
P2-04 = 1

Setting Range: 0 to 2000  
Factory Default: 1 (adjustable while running)  
Modbus Address: 0593H

## P2-04 Proportional Gain Reduction Counts

Q	Q	Q	Q
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This parameter reduces the proportional gain of **P1-04** when the position error counts **U1-53** is less than the **P2-04** value. This parameter adds stability when the error count is low without hurting response when error count is high.

Example: **P2-04** = 10 and **P1-04** = 7. If error count **U1-53** = 3, then position error gain =  $(7 \times 3) / 10 = 2.1$  instead of 21.



# Electronic Lineshaft with Registration

## Encdr.Monitor PG Channel 1

Setting Range: 0 to 1  
Factory Default: 0 (adjustable while running)  
Modbus Address: 0594H

### P2-05 Encoder Monitor Port Selection

Q	Q	Q	Q
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This parameter determines which encoder signal is used for the PG monitor port of the PG-W2 card (terminals 17-22).

Setting	Description
0	PG Channel 1 (terminals 3-8) is used for the PG monitor.
1	PG Channel 2 (terminals 10-15) is used for the PG monitor.

## Elec Lnshft Mode<2> 1: Enabled

Setting Range: 0 to 3  
Factory Default: 1  
Modbus Address: 0595H

### P2-07 Electronic Line Shaft Enable / Disable <2>

Q	Q	Q	Q
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This parameter enables and disables the electronic line shaft function. Note: Electronic line shaft is disabled either by this parameter, a multi-function input (data = 80), or if the drive is in "Local" mode.

Setting	Description
0	Electronic Line Shaft Is Disabled, drive runs as a standard G5.
1	Electronic Line Shaft is Enabled

## Registration Disable

Setting Range: 0 to 2  
Factory Default: 0 (adjustable while running)  
Modbus Address: 05a0H

### P3-01 Registration Control

Q	Q	Q	Q
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This parameter selects the functionality of the registration control.

Setting	Description
0	Disabled. No registration control.
1	Enabled. Corrects position of follower after each registration mark. This would be used when a product is moved an exact distance relative to the master encoder. Example: tractor feed paper.
2	Enabled w/ MOP. Corrects position of follower after each registration mark and adjusts the overall lineshaft ratio. This would be used when a product is moved an almost fixed distance relative to the master encoder. Example: nip roll feed paper.

When registration control is enabled, the phase angle between the registration mark and the follower drive can be adjusted by advance or retard digital input commands or by writing the counts you want it to change to Modbus address 05a9H.

<2> New to software version VSG114815.

# Electronic Lineshaft with Registration

**Reg. Response**  
**1/2 correction**

Setting Range: 0 to 7  
Factory Default: 2 (adjustable while running)  
Modbus Address: 05a1H

## P3-02 Registration Response Control

Q Q Q Q

This parameter selects the amount of position correction that occurs after each registration mark.

Setting	Description
0	No Correction
1	Full correction. The controller will try and fully correct a registration error before the next registration mark.
2	1/2 correction. The controller will try and correct 1/2 the registration error before the next registration mark.
3	1/3 correction. The controller will try and correct 1/3 the registration error before the next registration mark.
4	1/4 correction. The controller will try and correct 1/4 the registration error before the next registration mark.
5	1/5 correction. The controller will try and correct 1/5 the registration error before the next registration mark.
6	1/6 correction. The controller will try and correct 1/6 the registration error before the next registration mark.
7	1/7 correction. The controller will try and correct 1/7 the registration error before the next registration mark.

**Mtr Rev per Cut**  
**P3-03 = 1**

Setting Range: 1 to 8  
Factory Default: 1  
Modbus Address: 05a2H

## P3-03 Motor Revolutions Per Cut

Q Q Q Q

This is the number of revolutions that the motor will make per registration mark. The machine must be geared to so that an even number of motor revolutions occurs between registration marks.

**P3-01** = (motor revolutions) / (registration marks)

Example: 2 knife cut of wheel, it would be acceptable to use a 2:1, 4:1, 6:1, 8:1, 10:1, 12:1, 14:1 or 16:1 ratio between the motor and gear box.

# Electronic Lineshaft with Registration

Err Cts for MOP  
P3-04 = 100

Setting Range: 0 to 32,767  
Factory Default: 100 (adjustable while running)  
Modbus Address: 05a3H

## P3-04 Error Counts for MOP Adjustment

Q	Q	Q	Q
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When **P3-01** is set to **Enable w/ MOP**, this function watches how much error is occurring in the registration. Consistent registration error would indicate that the gear ratio setting **P1-02** and **P1-03** are not set perfect. The registration count error is summed up in monitor **U1-59**. When the total is greater than the **P3-04** setting, the MOP ratio **U1-57** gets incremented by 0.0001 each time.

Max Correct/scan  
P3-05 = 10

Setting Range: 0 to 10,000  
Factory Default: 10 (adjustable while running)  
Modbus Address: 05a4H

## P3-05 Maximum Registration Correction Per Scan

Q	Q	Q	Q
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When starting a new product batch or starting the machine, there may be a lot of registration error on the first couple of registration marks. This parameter limits the rate of correction. The default setting of 10 will allow 10 counts of correction every 5 ms scan. On a 1024 PPR encoder this is 30 rpm. Setting this number too high will allow the registration control to make abrupt corrections when the error is large.

Serial MOP Cntl  
Disable

Setting Range: 0 to 1  
Factory Default: 0  
Modbus Address: 05a7H

## P3-08 Serial MOP Ratio Control

Q	Q	Q	Q
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Setting	Description
0	Disabled. Serial control of Modbus ratio is disabled.
1	Enabled. Allows serial communication to set the value of the MOP ratio using Modbus address 05a8H. The value sent to address 05a8H is divided by 10,000 to determine the final ratio. No enter command is required after writing the information to address 05a8H.

## 5.0 New Monitors

Master Encoder  
U1-50 = 0.00 kHz

Range: 0.00 to 327.67 kHz  
Modbus Address: 00D0H

### U1-50 Master Encoder

Displays the pulse frequency of the master encoder.

Follower Reference  
U1-51 = 0.0 Hz

Range: -999.9 to 3276.7 Hz  
Modbus Address: 00D1H

### U1-51 Follower Reference

Displays the frequency reference of the follower drive prior to gear ratio adjustments. The follower will not exceed its maximum output frequency based on **E1-04** and **D2-01**.

Ref.After Gear  
U1-52 = 0.0 Hz

Range: -999.9 to 3276.7 Hz  
Modbus Address: 00D2H

### U1-52 Follower Reference After Gear Ratio

Displays the frequency reference of the follower drive after ratio adjustments. The follower will not exceed its maximum output frequency based on **E1-04** and **D2-01**.

Position err cts  
U1-53 = 0

Range: -9999 to 32767  
Modbus Address: 00D3H

### U1-53 Position Error In Counts

Displays the error, in quadrature encoder counts, between the master and follower.

Posit.P Gain  
U1-54 = 0.000 Hz

Range: -2.000 to 2.000 Hz  
Modbus Address: 00D4H

### U1-54 Proportional Gain Correction of Position Error

Displays the frequency adjustment to the follower's speed reference, based on the proportional gain setting.

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Posit.I Gain  
U1-55 = 0.000 Hz

Range: -2.000 to 2.000 Hz  
Modbus Address: 00D5H

## U1-55 Integral Time Correction of Position Error

Displays the frequency adjustment to the follower's speed reference, based on the integral time setting.

Line Shaft Speed  
U1-56 = 0.00 Hz

Range: -99.99 to 327.67 Hz  
Modbus Address: 00D6H

## U1-56 Line Shaft Speed Reference Output

The follower's final speed reference derived from the Lineshaft algorithm. Includes the initial reference from the master plus compensation due to gearing and proportion/integral adjustments.

MOP Ratio  
U1-57 = 1.0000

Range: 0 to 2.0000  
Modbus Address: 00D7H

## U1-57 MOP Ratio

Displays the value of the MOP gear ratio. See **P1-10** and section 2.1: New Digital Inputs.

Registration Err  
U1-58 = 0

Range: -32767 to 32767  
Modbus Address: 00D8H

## U1-58 Registration Error

With registration control enabled in **P3-01**, this monitor displays the difference between the registration mark and the desired position. The value is updated after each registration mark.

Reg.Error Total  
U1-59 = 0

Range: -32767 to 32767  
Modbus Address: 00D9H

## U1-59 Registration Error Total Counter

This monitor is a running sum of the registration error that has occurred at each registration mark. When this value exceeds the value of **P3-04**, the MOP ratio value is incremented by 0.0001 and the value of this counter is reset to 0. This function is only active when **P3-01** = 2 (registration w/ MOP).

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## 6.0 New Alarm and Fault Codes

Alarm Display	Name	Description	Corrective Action
FOL_ALM Following Alarm	Following Alarm	The position error between the master and follower exceeded the allowable amount. (See <b>P1-07</b> , <b>P1-08</b> )	Check for physical obstruction of the follower motion.

Fault Display	Name	Description	Corrective Action
FOL_FLT Following Fault	Following Error	The position error between the master and follower exceeded the allowable amount. (See <b>P1-07</b> , <b>P1-08</b> )	Check for physical obstruction of the follower motion.
Encr. Fault CCW only in ELS	Encoder Direction Fault	When in Lineshaft mode, parameter <b>F1-05</b> must be set to 0 (CCW direction).	Set <b>F1-05</b> to 0 (CCW) and swap wires on the PG-W2 card, terminals 3 and 4.
OPE12 Carrier 2.5, 5, 10	Carrier Frequency Setting Fault	This software requires the carrier frequency to be set at 2.5, 5.0, or 10 kHz.	Set <b>C6-01</b> to 2.5, 5.0, or 10 kHz.

## 7.0 Changed Defaults of Parameters

Parameter	Original	VSG114814	Function
<b>A1-01</b>	Quick	Advanced	Access Level
<b>A1-02</b>	Open Loop Vector	Flux Vector	Control Mode
<b>C6-01</b>	15.0 kHz	10.0 kHz	Max Carrier Frequency