GPD515/G5 Software Option (VSG114713E)
Part Number: CIMR-G5MXXXXXF-046 (1)

A Yaskawa GPD515/G5 flashed with this software has the ability to electronically emulate a lineshaft connection between 2 or more independently driven devices. In this system there will be a master device and one or more slave drives. The slaves will follow the master device and can be automatically aligned to it by using the alignment feature. Once aligned the relationship between the leading master device and the following slave drives will be maintained. The gearing feature allows the slaves drives to follow the master device at a definable ratio.

This system requires supplying the slave drive with a line driver quadrature feedback from the device to be followed. Any electronic device that is capable of supplying the following drive with the proper signal can be used as the master signal. The following drive will follow the master signal pulse for pulse after applying the ratio in either direction. The following drive must be operated using closed loop or flux vector control and therefore must have an encoder coupled to the motor.

The typical application will have a master drive and a slave drive. The equipment being driven requires two mechanically isolated and motor driven moving parts to maintain a constant position relationship to within a few encoder counts. The position of the moving part driven by the slave motor requires alignment to the position of the master device.

The master drive can be operated in any control mode but master device feedback connected to the slave drive is required. The feedback or master signal controls the follower drive. The follower drive monitors the master signal and compares it to the feedback from the slave motor's encoder. The follower will then compensate for any position errors resulting by adjusting the output frequency of the slave drive. This results in near perfect alignment between the master device and slave device. There is no accumulation of position error, so alignment will always be maintained within a few pulses.

The slave drive has an automatic alignment feature with this software. This feature provides a means of aligning the follower encoder to the master signal. This is accomplished by using two switches connected to the trigger inputs of the slave drive. One switch is used to indicate the position of the master. The other switch is used to indicate the position of the follower. When the alignment feature is active, advancing or retarding the slave motor corrects the difference between when these switches are activated. When both encoders are activated at the same time the master and follower are aligned. An offset feature is provided enabling fine adjustment for switch misalignment.

This software provides a trim advance and retard input to adjust the following drive in respect to the to the master. Adjustments can be made while running. This adjustment will change the position or phase relationship between the drives.

When the master signal is from another GPD515/G5 it is not necessary for it to be running lineshaft software. All follower or slave GPD515/G5 drives must be running lineshaft software.

Features:

Disable Lineshaft Input	– Disables the lineshaft software placing the drive back into standard control
Advance (Trim) Input	– Advances the alignment position of the slave drive at a settable rate
Retard (Trim) Input	– Retards the alignment position of the slave drive at a settable rate
Slave Trigger Input	– Indicates the position of the slave drive when activated
Master Trigger Input	– Indicates the position of the master drive when activated
Align Slave Input	– Enables the automatic alignment feature
Aligned Output	– Indicates the alignment procedure was performed and the following drive did align
Alignment Checking	– Monitors the difference between the trigger inputs with the result controlling an output
Alignment Fault	– Monitors the travel during alignment and faults the drive when the limit is exceeded
Following Alarm	– Monitors the following error and provides a selectable result when it exceeds the limit
Gear Ratio	– Adjust the ratio of the following drive in respect to the master
Monitors	– Displays useful information to indicate how close the follower is following

The disable lineshaft input provides a means to operate the drive independent from the master drive. This feature can be selected at any time and disables all lineshaft features when active. The position relationship between the master and the slave drive will be lost when this input is activated. The slave drive will maintain the current position with the master when the lineshaft disable input is deactivated.

The trim controls provide a means to adjust the position relationship between the master and the slave drives. The trim rate is settable. The slave position can be advanced or retarded in relation to the master drive when the slave's run input is on. The trim can function if the run input is on.

The align slave, master and slave trigger inputs are required to perform an alignment. The alignment procedure can be used to align the slave to the master using fixed trigger positions. This process does not control the master drive. All correction is made by the slave drive. The amount of the correction is controlled by the quadrature counts that are accumulated from the time when the first or leading trigger starts the process and continues until the trailing trigger stops it. The correction will be made as soon as the trailing trigger input becomes active. This process was intended to be performed at lower frequencies but will function if the triggers provide a minimum of a 5 millisecond signal.

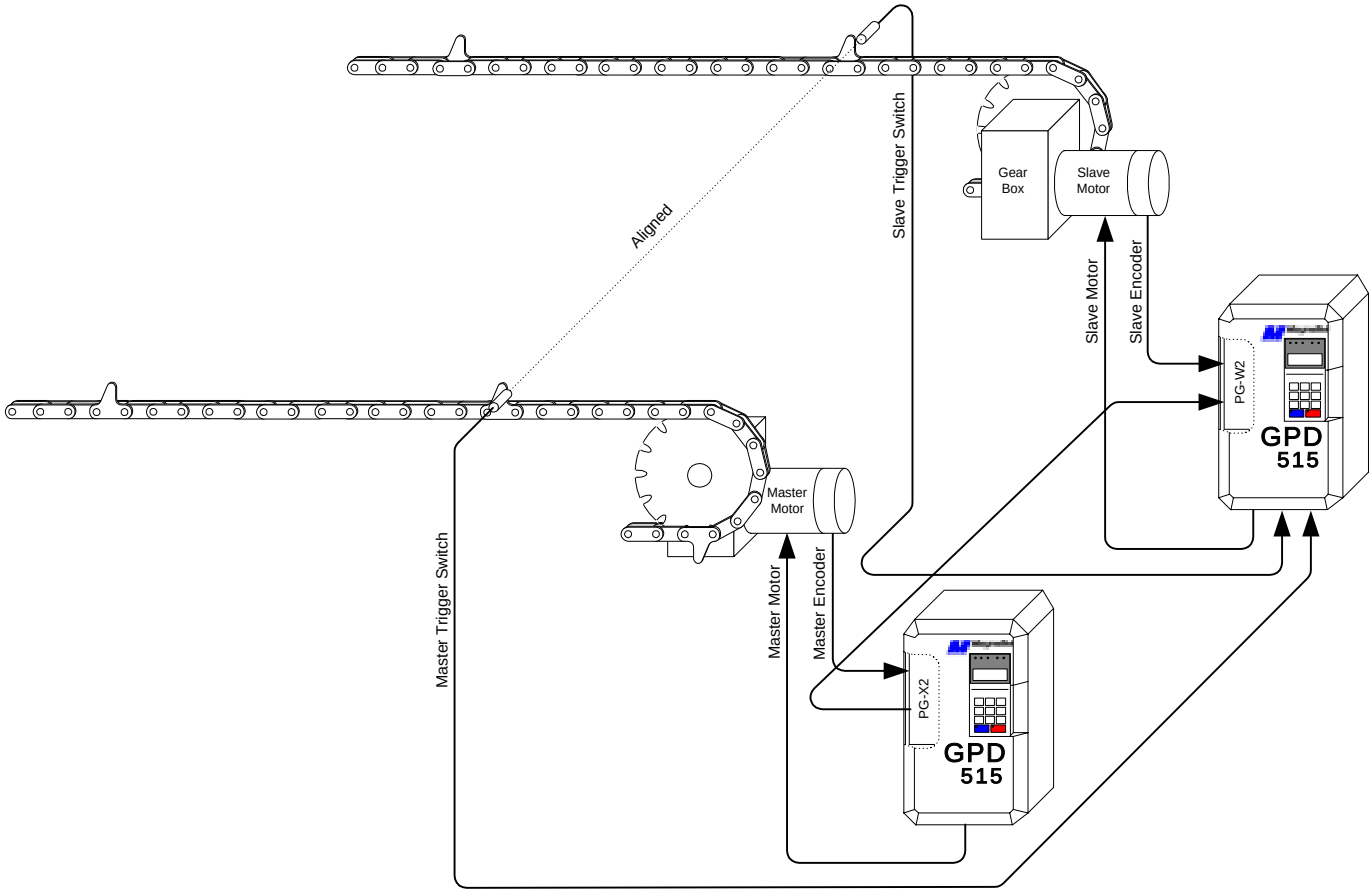
The alignment check is provided to indicate whether the trigger inputs are activated within a settable quadrature count range. An alignment check output will be on when the triggers are within the defined range and will go off when the range is exceeded. This output will only change after the trailing trigger has activated. This check is always active in lineshaft mode.

The following alarm monitors the quadrature error count that exists between the master and the slave drive. If the count exceeds the settable range a selectable action will occur.

The gear ratio provides a means to apply a ratio between the master device and the slave drive. This may be used to correct for errors in drivetrain ratios or to apply a required ratio between the drives.

The monitors provided allow monitoring of how well the slave drive is following the master signal. The master signal can also be monitored.

1.1 Sample Application

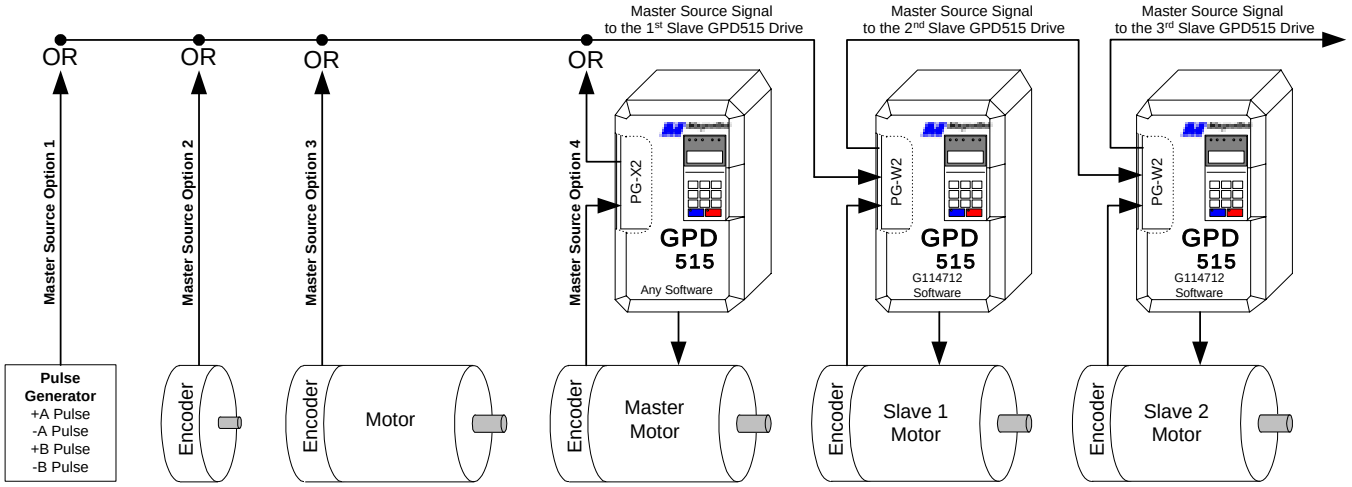


This example shows two pusher chains. Each chain is mechanically isolated from the other. The master and slave trigger switches are placed in line providing an alignment position for the pushers. The pusher's leading edge will activate the switches as they pass.

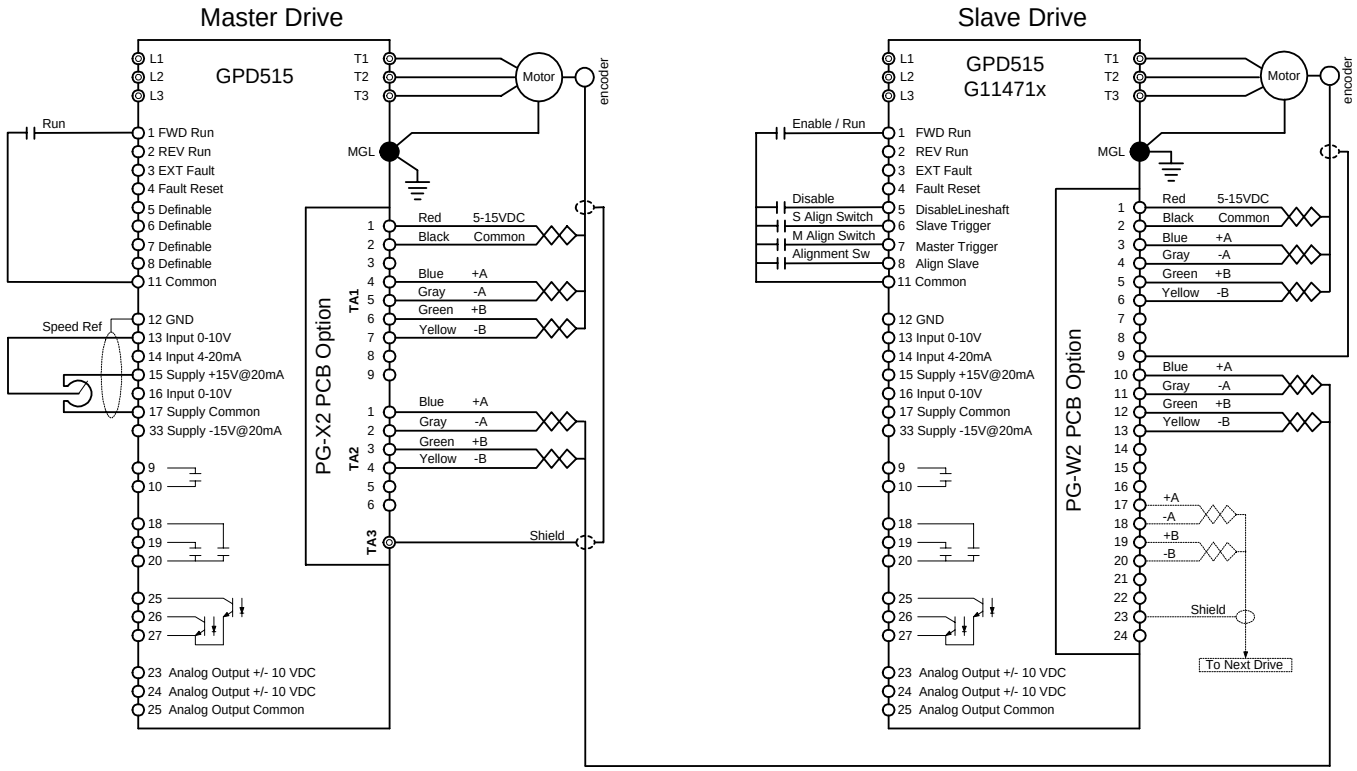
When this line starts alignment is necessary. The "Align Slave" input must be activated and maintained to cause the alignment feature to operate. The slave drive will align itself after the trailing pusher has triggered. The "Aligned" output indicates that the alignment procedure was successful and that the "Align Slave" input may be removed. If this input is not removed alignment will occur each time a pusher passes a trigger switch. The pushers will be aligned to the associated trigger switch position.

The lineshaft software will maintain the follower's position in respect to the master. The follower position is monitored and if it exceeds the users set value a following fault or alarm will result. The alignment check will also monitor the quadrature counts between the triggers. An "Alignment Check" output will remain on if the check was within the set range.

1.2 Example Configuration Diagram



1.2 Example Wiring Diagram



1.3 PG-W2 Terminal Description and Wiring Notes

Refer to the GPD515/G5 User's Manual for additional information regarding encoder feedback option cards.

PG-W2 Terminal #	Designation	Function	Remarks
1	IP12	Power Supply	+12V supply to power encoder
2	IG12		0V, Common for 12V power supply
3	+A	Follower Motor Feedback	Channel 1, Pulse Input A
4	-A		
5	+B		Channel 1, Pulse Input B
6	-B		
10	+A	Master Device Signal	Channel 2, Pulse Input A
11	-A		
12	+B		Channel 2, Pulse Input B
13	-B		
17	+A	Pulse Output (Mirrors Channel 2)	Encoder 2, Pulse Output, Channel A (5V pk)
18	-A		
19	+B		Encoder 2, Pulse Output, Channel B (5V pk)
20	-B		

For proper lineshaft operation the following conditions must be met:

1) A PG-W2 encoder feedback card must be installed in the follower VFD(s).
2) The pulse reference from the master device must be quadrature, differential line driver type.
3) Encoder feedback from the follower motor must be quadrature, differential line driver type.
4) When the master operates in its normal, forward direction, monitor U1-50 of the follower should display a positive value. If it does not, it may be necessary to reverse the channel 2 pulse input A wires at terminals 10 and 11 of the follower's PG-W2.
5) If the follower's U1-50 display is positive, when the drive is commanded to run via input to terminal #1, the motor should rotate in the proper direction and the follower's U1-05 monitor should display a positive value. If the motor direction is incorrect, it may be necessary to reverse any two of the motor leads on the VFD output. If the motor fails to rotate, or is unstable, it may be necessary to reverse the channel 1 pulse input A wires at terminals 3 and 4 of the PG-W2.
6) **Do not use parameter F1-05 to change encoder phasing in this software. Please swap encoder signals A+ and A- instead.**

1.4 Alignment Operation Description

The alignment operation performed by the follower drive requires three external inputs. The "Align Slave" input enables and disables the alignment feature. The "Master Trigger" input indicates the master drive is at the aligned position. The "Slave Trigger" input indicates that the slave drive is at the aligned position. The aligned position is where both trigger switches are activated at the same time.

When the "Align Slave" input is activated the slave drive will monitor the trigger inputs. The slave drive will accumulate the error count that separates the leading edges of the trigger inputs. When aligned both triggers are simultaneous. When not aligned the leading trigger will start an error count. The following trigger will stop the error count and the error will be corrected by advancing or retarding the slave drive at a maximum frequency of 4 Hz. The correction will occur when the leading edge of the following trigger is activated.

The recommended speed range for alignment is between 6 to 12Hz. Alignment can be performed at higher speeds. The trigger inputs require a minimum signal of 5 milliseconds. If the alignment speed is below 4 Hz the slave drive may run in the reverse direction to retard.

Parameter P1-02: "Align Offset" has been provided to adjust for misalignment of the trigger switches. The adjustment allows for + / - 9999 quadrature encoder counts or approximately 2.5 motor revolutions when using a

1024 pulse encoder with a 4096 quadrature encoder count. The sign is determined in respect to the master trigger switch.

Alignment is when both master and slave triggers are activated simultaneously. If the trigger switches are not aligned properly the align offset can be used to correct the error. A negative offset indicates the slave drive needs to retard. A positive offset indicates the slave drive needs to advance.

A minus offset value is indicative of the slave trigger occurring before the master resulting in the need to retard the drive by the negative offset count set in P1-02. A positive value indicates the slave trigger occurs after the master resulting in the need to advance the drive.

Alignment Timing Chart

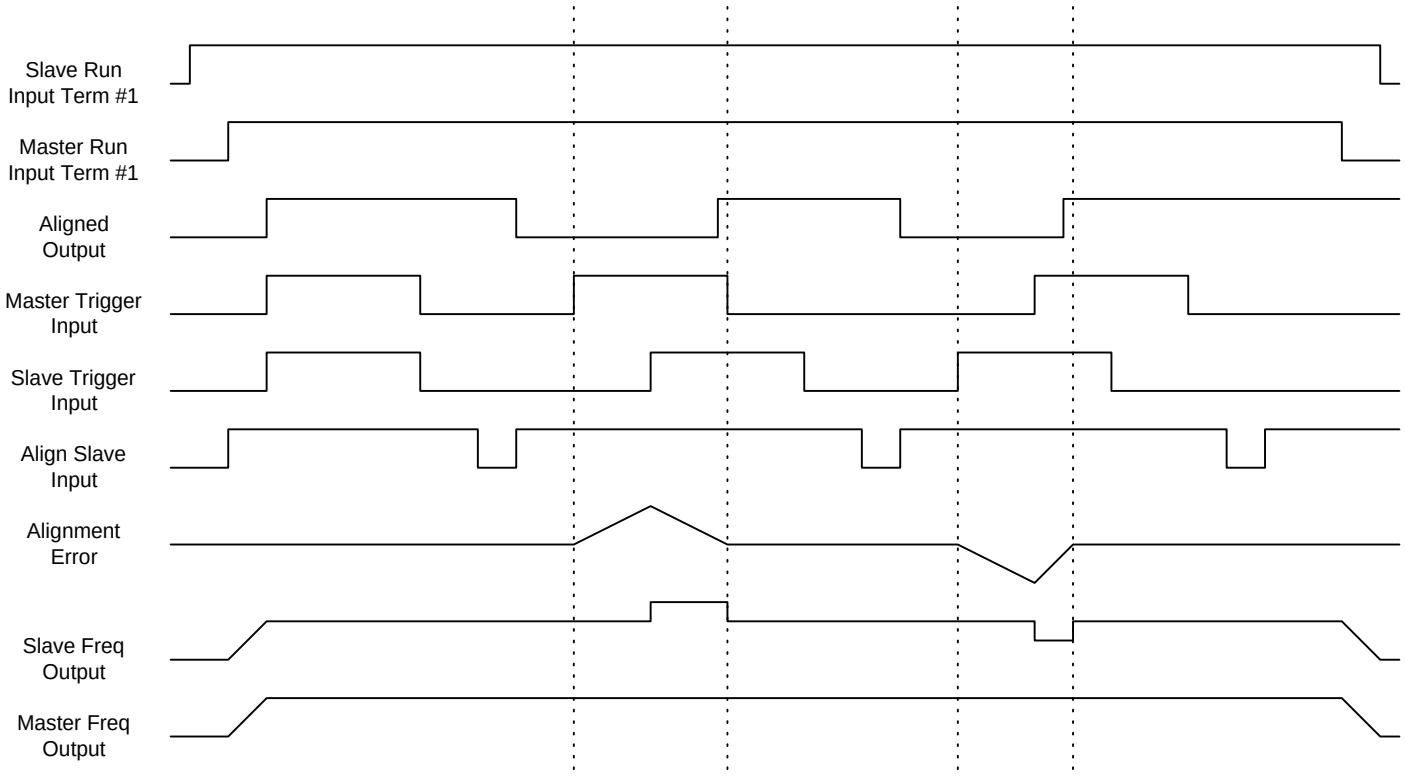


Chart Explanation:

The slave drive is set to run. The master driver is set to run. The slave follows the master drive. The align slave input is activated and maintained. Both master and slave triggers are activated simultaneously. No alignment error is accumulated and no correction in alignment is made.

The master trigger is activated. The alignment error begins to accumulate. The slave trigger is activated. The alignment error accumulation stops. The alignment error is corrected by accelerating the slave drive because the master was leading the slave. Both triggers are deactivated.

The slave trigger is activated. The alignment error begins to accumulate. The master trigger is activated. The alignment error accumulation stops. The alignment error is corrected by decelerating the slave drive because the slave was leading the master. Both triggers are deactivated.

The “Aligned Output” will activate when the slave drive has corrected the position error to within 50 encoder counts. It will not reset until the “Slave Run” input has been removed or the “Align Slave” input has been removed and reactivated.

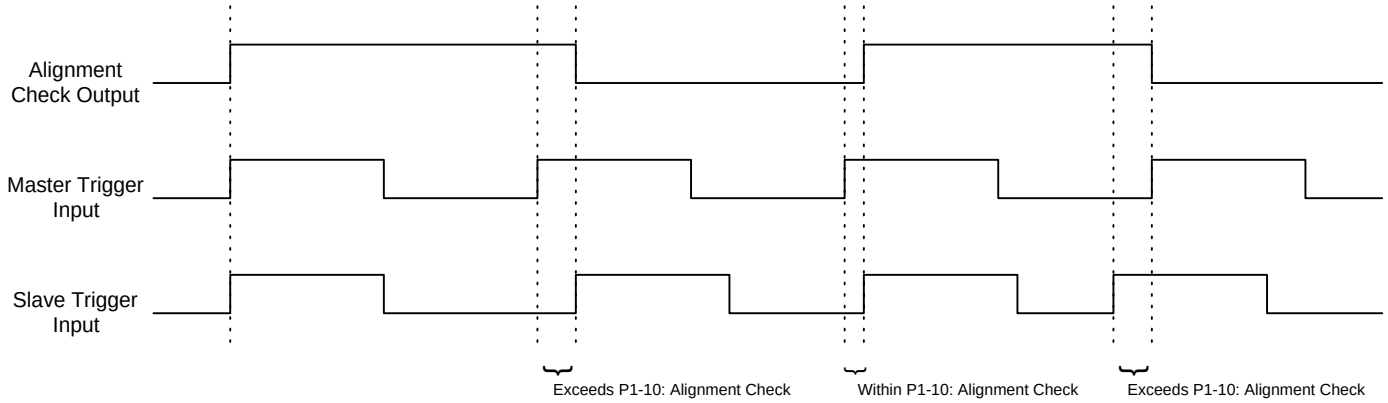
When the run signal is removed from the master drive the slave drive will follow the master to a stop.

When the alignment process has completed the “Align Slave” input may be removed to prevent continuous alignment. The “Aligned Output” will not reset until the “Align Slave” input has been removed and reactivated.

1.4 Alignment Check Description

When operating in lineshaft mode an alignment check is performed. This check monitors the difference in quadrature counts that separates the trigger inputs. The alignment offset is factored into the calculation. If the error count exceeds the value set in P1-10 the alignment check output will be off. This output will only change states after an alignment check. When the alignment check output is on it indicates that the error count between the master and slave trigger inputs was less than the value set in P1-10 when last checked.

Alignment Checking Chart



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
83	Advance Slave	Closed: Slave drive will increase speed without accumulating error
84	Retard Slave	Closed: Slave drive will decrease speed without accumulating error
85	Slave Trigger	Closed: The slave encoder has achieved the alignment position
86	Master Trigger	Closed: The master encoder has achieved the alignment position
87	Align Slave	Closed: The error count between the triggers will be corrected

2.2 New Multi-Function Digital Output Settings

For constants H2-01 through H2-03.

Setting	Display	Description
40	Alignment Check	On = The alignment has check was within the set range
42	Aligned	On = The alignment function was performed successfully

3.0 Configuration Notes

This software document is only a supplement to the GPD515/G5 Series instruction manual. All parameters and features not mentioned in this document have not changed.

3.1 Changed Factory Defaults of Standard Parameters

None

3.2 Minimum Programming Requirements for “Line Shaft” Operation

1. The follower VFD must be programmed for the Flux Vector control method, A1-02 = 3.
2. The follower’s run and reference sources, B1-01 and B1-02, must be set to 5:Line Shaft.

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

4.3 New Program Parameters

Master PPR P1-01= 1024

Setting Range: 0 to 10000
Factory Default: 1024
MODBUS Address: 0580H

P1-01	Master PPR	B	B	B	B

The number of output pulses per revolution from the master encoder. (not quadrature)

Align Offset P1-02= 0

Setting Range: + / - 9999
Factory Default: 0
MODBUS Address: 0581H

P1-02	Align Offset	B	B	B	B

The “Aligned Offset” is provided to correct for the misalignment of the trigger inputs preventing the need to do fine mechanical adjustments. This value may be used as a fine tuning feature to align the slave to the master making setup much easier. The range provides for approximately 2.5 motor revolution.

Over Travel Lmt P1-03= 0	Setting Range: 1 to 99999 Factory Default: 0 MODBUS Address: 0582H

P1-03	Over Travel Lmt	B	B	B	B

The “Over Travel Limit” is used during the alignment procedure and is the maximum error count permitted. The error count is the number of encoder pulses that occurs between trigger inputs. When master and slave are aligned the error count will be 0. If this value is exceeded an “Align_Flt” will occur and stop the drive.

Position P gain P1-04= 10.00	Setting Range: 0.00 to 100.00 Factory Default: 10.00 MODBUS Address: 0583H

P1-04	Position Error Proportional Gain	B	B	B	B

The ‘proportional gain’ adjusts the follower’s speed reference to compensate for any position error between the master and slave. 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 defaults at +/- 2.000 Hz. This limit can be adjusted using P2-04 P Limit.

Position I time P1-05= 0.10 Sec	Setting Range: 0.00 to 100.00 Sec Factory Default: 0.10 Sec MODBUS Address: 0584H

P1-05	Position Error Integral Time	B	B	B	B

The ‘integral time’ adjusts the follower’s speed reference to compensate for any position error between the master and slave. 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 defaults at +/- 2.000 Hz. This limit can be adjusted using P2-05 I Limit.

TrimRate ct/10ms P1-06= 20	Setting Range: 0 to 1000 Factory Default: 20 MODBUS Address: 0585H

P1-06	Rate of Advance/Retard at Digital Input	B	B	B	B

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. This feature also functions when a gear ratio is used.

Follw.trip cnts	Setting Range: 0 to 32767 Factory Default: 4096 MODBUS Address: 0586H

P1-07= 4096

P1-07	Follower Trip Counts	B	B	B	B

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.

Trip Reaction
P1-08= 2

Setting Range: 0 to 2
Factory Default: 2
MODBUS Address: 0587H

P1-08	Trip Reaction	B	B	B	B

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
MODBUS Address: 0588H

P1-09	Resync Property	B	B	B	B

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 until a 'run' command is initiated.

Setting	Description
0	Accumulates position error when not running. Corrects error at 'run'
1	Holds position error at zero when not running.

Alignment Check
P1-10 = 100

Setting Range: 0 to 32767
Factory Default: 100
MODBUS Address: 0589H

P1-10	Alignment Check Counts	B	B	B	B

The alignment check counts is the number of error counts that are acceptable between the position trigger inputs. When the error count is within this range the alignment checked output will activate. The output will only change states after a check has been performed.

Ratio Numerator P2-01=1000	Setting Range: Factory Default: MODBUS Address:	0 to 9999 1000 0590H

P2-01	Ratio Numerator	Q	Q	Q	Q

The ratio numerator is multiplied by the encoder feedback from the master and then is divided by the ratio denominator. This provides the ability to use a gear ratio between the master and the slave. See P2-02.

Ratio Demomin P2-02=1000	Setting Range: Factory Default: MODBUS Address:	0 to 9999 1000 0591H

P2-02	Ratio Denominator	Q	Q	Q	Q

The ratio denominator is divided into the product of the ratio numerator and the encoder feedback from the master.

Example:

Slave Speed = (Master Encoder Feedback x P2-01) / P1-02

Feedback = 10 Hz , P1-01 = 1000, P2-02 = 250
Slave Speed = (10 Hz x 1000) / 250 or 40 Hz

Feedback = 10 Hz , P1-01 = 250, P2-02 = 1000
Slave Speed = (10 Hz x 250) / 1000 or 2.5 Hz

The position relationship between the master and the slave is maintained just as if a lineshaft went through a gearbox with the same ratio. If the ratio is unknown it may be determined by counting the motor revolutions required to make a complete machine cycle of both the master and slave. Convert the counts into a four digit number by multiplying or dividing both by the same number. Set P1-01 to the slave count and set P1-02 to the master count.

Example:

Master = 10 revs., Slave = 2.5 revs., Multiply both by 100
Master = 1000, Slave = 250
P1-01 = 250, P1-02 = 1000

P Limit P2-04=2.000 HZ	Setting Range: Factory Default: MODBUS Address:	0.000 to 20.000 2000 0593H

P2-04	Proportional Limit	Q	Q	Q	Q

This parameter limits the proportional part of the position regulator.

I Limit P2-05=2.000 HZ

Setting Range: 0.000 to 20.000
Factory Default: 2000
MODBUS Address: 0594H

P2-05	Integral Limit	Q	Q	Q	Q

This parameter limits the integral part of the position regulator. This parameter should be increased when the drive will not stay shaft-locked under heavy loads or at high speeds (above base speed). Too high of a setting will result in instability or overshoot.

D Time P2-06 = 0.00 sec

Setting Range: 0.00 to 100.00
Factory Default: 0.00
MODBUS Address: 0595H

P2-06	Derivative Time	Q	Q	Q	Q

This parameter provides control of the derivative function of the PID speed control loop. Setting this value to zero will remove any affect that it may have. The derivative provides a means to stabilize the position error if it is oscillating between plus and minus. Setting this value to high will cause instability.

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	Q	Q	Q	Q

Displays the pulse frequency of the master encoder.

Slave Reference U1-51= 0.0 HZ

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

U1-51	Slave Reference	Q	Q	Q	Q

Displays the frequency reference of the follower drive prior to 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	Q	Q	Q	Q

Displays the error, in 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	P-Gain Correction of Position Error	Q	Q	Q	Q

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

Posit.I Gain U1-55= 0.000 HZ	Range: -2.000 to 2.000 Hz MODBUS Address: 00D5H

U1-55	I-Gain Correction of Position Error	Q	Q	Q	Q

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

LineShaft Speed U1-56= 0.00 HZ	Range: -99.99 to 327.67 Hz MODBUS Address: 00D6H

U1-56	Line Shaft Speed Reference Output	Q	Q	Q	Q

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

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 slave exceeded the allowable amount. (P1-07 – P1-08)	Check for physical obstruction of slave motion.

Fault Display	Name	Description	Corrective Action
FOL_FLT Following Fault	Following Error	The position error between the master and slave exceeded the allowable amount. (P1-07 – P1-08)	Check for physical obstruction of slave motion.

Fault Display	Name	Description	Corrective Action
ALIGN_FLT Align Fault	Alignment Error	The error count between the master and slave exceeded the allowable amount. (P1-03)	Check the trigger input switches.