

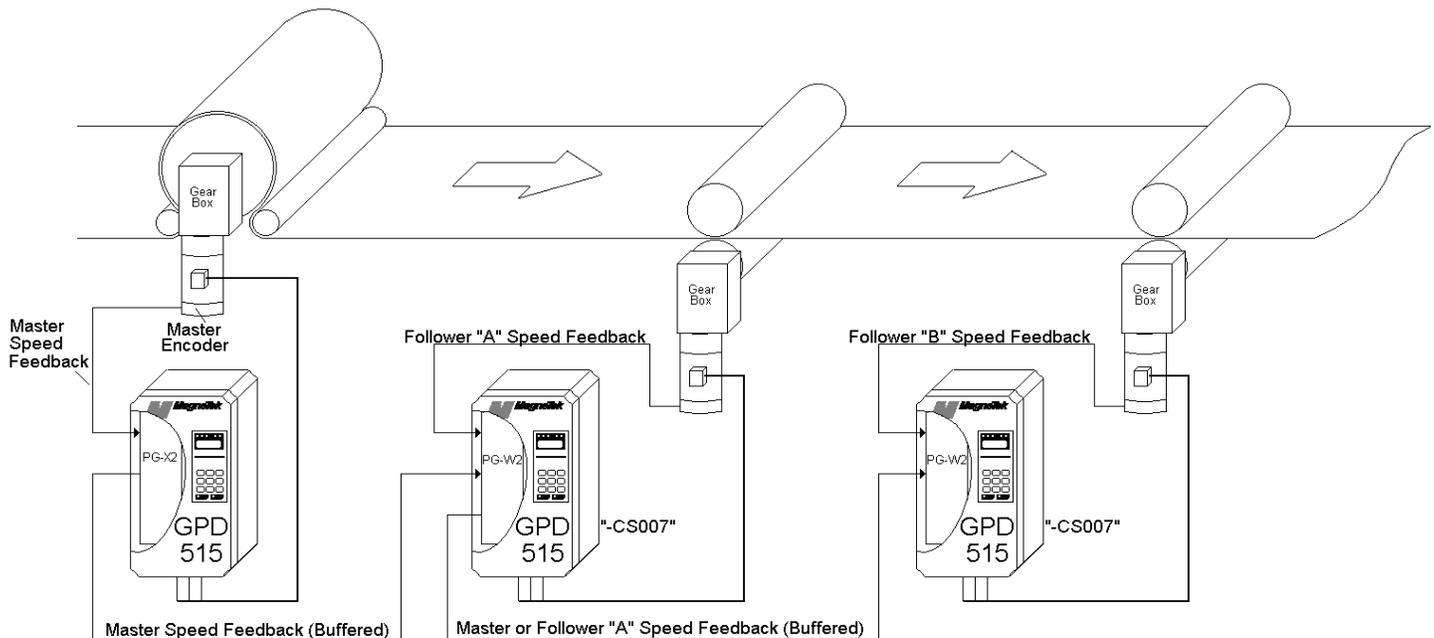
## Digital Follower (Velocity) FLASH Memory Software Option (S11103) Part Number: GPD515C-ZZZZ-CS007<sup>(1)</sup>

With this factory-installed FLASH software, the GPD515 has the ability to precisely follow the speed of a master encoder or drive. The speed / frequency ratio between the master and the follower are infinitely adjustable.

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.

### Specifications:

- Requires PG-W2 (DS014) card to function
- Available for all GPD515 drives
- 0.001 Hz Resolution
- Accepts Only Quadrature/Line Driver Signals
- Accepts virtually any encoder resolution
- Bi-directional (Selectable)
- “Draw” adjustable from –99.99% to +99.99%
- Ratio and “Draw” adjustable via:  
Digital Operator  
Serial Communications or  
Analog Signal (0 – 10V or 4 – 20 mA)
- Control Modes: Open Loop Vector, Flux Vector & V/f
- Serial Communications: Modbus RTU  
DeviceNet, Modbus Plus & Profibus



<sup>(1)</sup> ZZZZ refers to the base Model Number of the drive in which the software is installed.

---

## **1.0 Wiring**

Wire the incoming power, motor, accessories and control wiring as specified in the GPD515 Technical Manual TM4515.

If there is an encoder on the motor that this drive is running, wire that encoder to terminals 1 through 9 according to the PG-W2 instruction sheet (02Y025-0397).

The master encoder (or pulse reference source) should be wired to terminals 10 thru 16 according to the PG-W2 instruction sheet (02Y025-0397).

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

## **2.0 I/O Definitions**

### **2.1 New Multi-Function Digital Input Settings**

For Parameters H1-01 through H1-06.

Addition to Table 5-2 Multi-Function Input Terminal Data Settings (Section 5.32)<sup>(2)</sup>

Data	Function	Description	Availability			
			0	1	2	3
80	Pulse B w/ N.O.	Closed = Pulse monitor will output speed feedback (Terminals 3 thru 8) Open = Pulse monitor will output master reference pulses (Terminals 10 thru 15)	X	X	X	X
81	Pulse B w/ N.C.	Closed = Pulse monitor will output master reference pulses (Terminals 10 thru 15) Open = Pulse monitor will output speed feedback (Terminals 3 thru 8)	X	X	X	X

<sup>(2)</sup> GPD515 Technical Manual TM4515.

### **2.2 New Multi-Function Digital Output Settings**

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

None.

### **2.3 New Multi-Function Analog Input Settings**

For Parameters H3-05 and H3-09.

None.

### **2.4 New Multi-Function Analog Output Settings**

For Parameters H4-01 and H4-04.

None.

### 3.0 Startup Procedure

1. Perform the appropriate procedure for start-up using Section 2.2 of the GPD515 Technical manual. Most applications with this software utilize the flux-vector control method, which is highlighted in Section 2.2b.
2. Set the reference source to "Pulse Reference" (**b1-01** = 5).
3. Set the "Following Method" as desired (see Figure 1). With a setting of "1-direction" (**P2-01** = 0) and the master running forward, the follower motor will run forward. When the master runs in reverse, the follower will stay at zero speed. With a setting of "Bi-directional" (**P2-01** = 1) the follower will run whichever direction the master is running. A setting of "Absolute" (**P2-01** = 2) will result in the follower running forward regardless of the master's direction.

**Figure 1: Parameter P2-01 Description**

4. Parameters **P1-01**, **P1-02**, and **P1-03** can be calculated and set in many ways. Figure 2 illustrates the effect those parameters will have on the follower's frequency reference. When it is desired to have the follower motor shaft turn at exactly the same speed as the master encoder, use Table 1 below.

**Table 1: Common Settings for Parameters P1-01 thru P1-03**

Master Encoder PPR	Follower Motor Poles	P1-01 Setting	P1-02 Setting	P1-03 Setting
1024	2	125	128	0.00
2048	2	125	256	0.00
2500	2	2	5	0.00
<b>1024</b>	<b>4</b>	<b>125</b>	<b>64</b>	<b>0.00</b>
2048	4	125	128	0.00
2500	4	4	5	0.00
10000	4	1	5	0.00
1024	6	375	128	0.00
2048	6	375	256	0.00
2500	6	6	5	0.00
10000	6	3	10	0.00

- If the above table does not include your specific setup, use the following formula to determine the settings of **P1-01**, **P1-02** & **P1-03**.

**P1-01** = Number of Motor Poles (Follower Motor) \* 500

**P1-02** = Pulse Generator PPR (Master Encoder)

**P1-03** = 0

If a ratio different from 1 : 1 is needed, use the following equation:

X : Y - Where X = Master Encoder Revolutions and Y = Follower Motor Revolutions

**P1-01** = Number of Motor Poles (Follower Motor) \* 500 \* Y

**P1-02** = Pulse Generator PPR (Master Encoder) \* X

**P1-03** = 0

5. Verify that the master reference encoder is working. Bring up parameter **U1-01** on the digital operator by pressing MENU then DATA/ENTER. When the master reference encoder is moving, a non-zero frequency reference should show up here. If not, troubleshoot encoder wiring, or verify that **P2-01** is not set to 0 (One direction).

6. If the follower drive needs to run at a different speed, adjust one or more of the following parameters:  
 Follower is running too slow: Increase **P1-01**, or Decrease **P1-02**, or set **P1-03** to a positive number.  
 Follower is running too fast: Decrease **P1-01**, or Increase **P1-02**, or set **P1-03** to a Negative number.
7. **Optional Step:** If desired, the pulse output from the PG-W2 card can be switched between the master reference signal and the feedback signal by programming a Multi-Function Input Terminal (terminals 3 through 8, parameters **H1-01** through **H1-06**) to a value of 80 or 81. Then a contact closure can switch between a straight master/follower and a cascaded follower. Refer to the drawing on the page one of this instruction manual. If no further programming is done, Follower “B” will follow the master reference encoder. If a multi-function input is programmed and selected in Follower “A”, Follower “B” will follow Follower “A” instead of the master reference encoder.
8. Done.

## 4.0 Custom Software Parameters

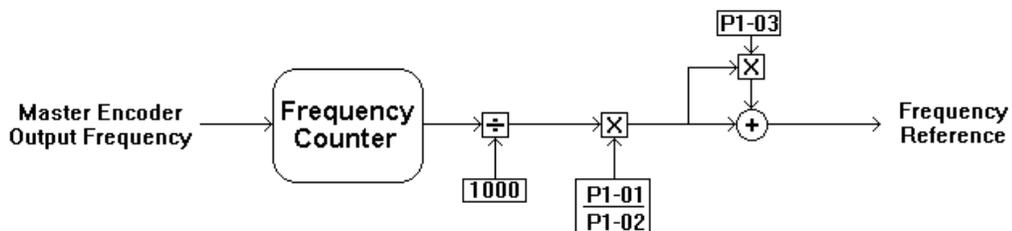
### 4.1 New Program Group



### 4.2 New Program Function



### 4.3 New Program Parameters



**Figure 2: Block Diagram – Frequency Reference**

---

<b>Gear Tooth 1</b> <b>P1-01= 1</b>
----------------------------------------

**P1-01 Gear Tooth 1**

Setting Range: 0 to 10000  
Factory Default: 1  
Modbus Address: 0580H

A	A	A	A
---	---	---	---

This is the "Numerator" portion of the pulse ratio. (See Figure 2)

<b>Gear Tooth 2</b> <b>P1-02= 1</b>
----------------------------------------

**P1-03 Gear Tooth 1**

Setting Range: 0 to 10000  
Factory Default: 1  
Modbus Address: 0581H

A	A	A	A
---	---	---	---

This is the "Denominator" portion of the pulse ratio. (See Figure 2)

<b>Ratio Setting</b> <b>P1-03= 0.00</b>
--------------------------------------------

**P1-03 Ratio Setting**

Setting Range: -99.99 to +99.99  
Factory Default: 0.00  
Modbus Address: 0582H

A	A	A	A
---	---	---	---

Sets the amount of frequency reference increase or decrease (draw) as a percentage of the incoming reference. (See Figure 2)

# Follow Method P2-01 = 0

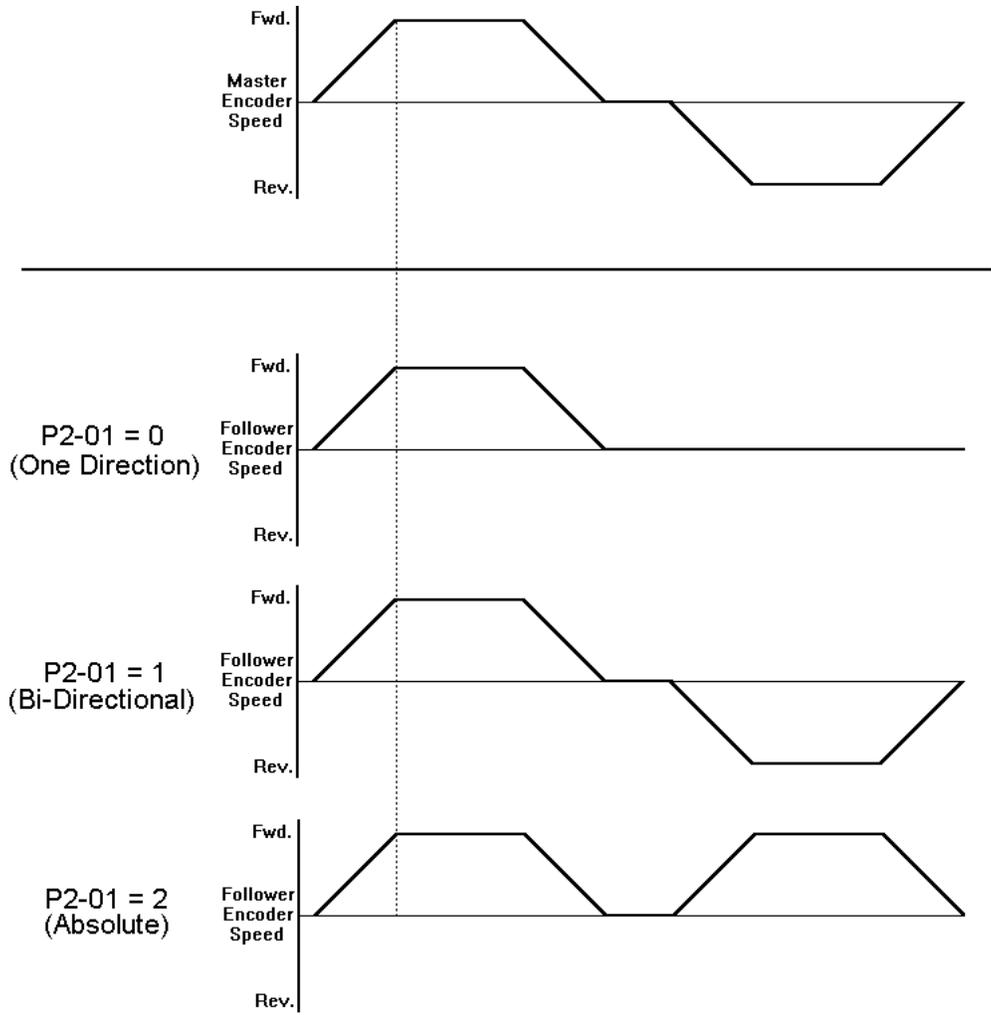
## P2-01 Follow Method

A	A	A	A
---	---	---	---

Setting Range: 0 to 2  
 Factory Default: 0  
 Modbus Address: 0590H

This parameter effects how the drive will react when the master pulse reference source or encoder changes directions (fwd or rev).

Setting	Description
0	One Direction
1	Bi-directional
2	Absolute Value



---

#### 4.4 Modified Parameter(s)

Reference Source b1-01 = 1
-------------------------------

#### **b1-01 Reference Source**

A	A	A	A
---	---	---	---

Setting Range: 0 to 5  
Factory Default: 1  
Modbus Address: 0180H

This parameter determines from what source the frequency reference will come from. Added was a setting of "5 – Pulse Reference"..

Setting	Description
0	Operator
1	Terminals
2	Serial Com
3	Option PCB
4	EWS
<b>5</b>	<b>Pulse Reference</b>

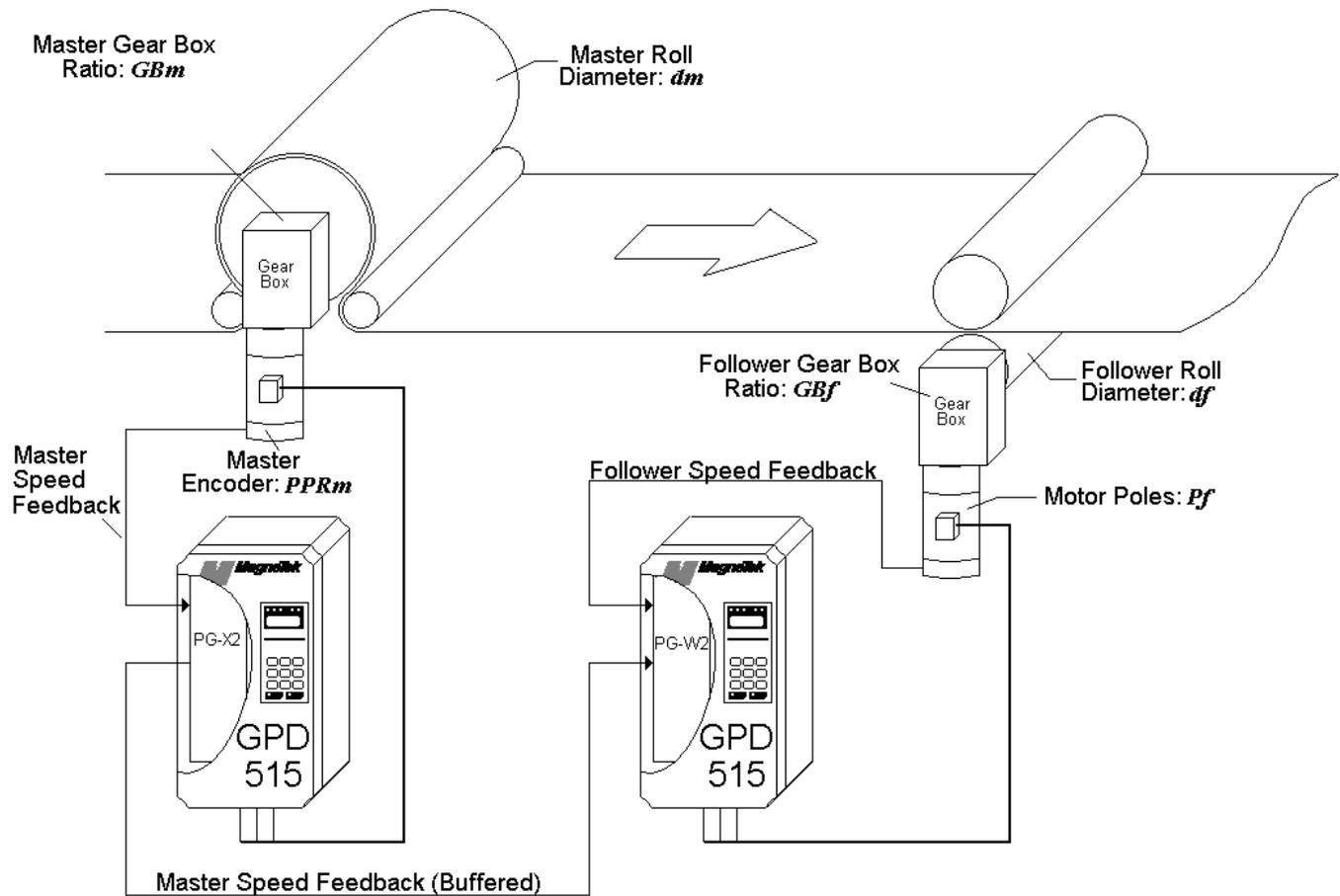
#### 5.0 New Monitors

None.

#### 6.0 New Alarm and Fault Codes

None.

**Appendix 1: Advanced Application Notes**  
**Part 1: Web Process Line - 1 : 1 follower with a 5% draw**



Step 1: Calculate the Frequency Ratio

$$FrequencyRatio = \frac{500(GBf)(Pf)(dm)}{(PPRm)(df)(GBm)}$$

- Where:
- dm = diameter of master roll
  - df = diameter of follower roll
  - PPRm = Master Reference Encoder pulses per revolution
  - GBf = Follower Gear Box ratio (motor RPM / roll RPM)
  - Pf = Motor poles, follower motor
  - GBm = Master Gear Box Ratio (motor RPM / roll RPM)

Note: If no gearbox is present, the gear box ratio is 1.

---

Step 2: Determine drive parameters **P1-01** & **P1-02**

If Frequency Ratio $\geq 1$  <b>P1-01</b> = 10000 <b>P1-02</b> = 10000 / Freq. Ratio	If Frequency Ratio $< 1$  <b>P1-01</b> = Freq. Ratio * 10000 <b>P1-02</b> = 10000
-----------------------------------------------------------------------------------------------	--------------------------------------------------------------------------------------------

**EXAMPLE:**

On a paper machine, a nip roll (follower roll) has to follow master roll with a 5% fixed draw.

Nip (follower) roll diameter = **df** = 16.0"

Master roll diameter = **dm** = 34.078"

Master encoder pulses per revolution = **PPRm** = 1024

Gearbox between the follower motor and the follower will cause the motor shaft to turn 4.048 turns for one turn on the follower roll.

**GBf** = motor / roll = 4.048 / 1 = 4.048

Follower motor has 4 poles = **Pf** = 4

Gearbox between master motor and the master roll will cause the motor shaft to turn 7.5 turns for one turn of the master roll.

**GBm** = motor / roll = 7.5 / 1 = 7.5

$$FrequencyRatio = \frac{500(4.048)(4)(34.078)}{(1024)(16.0)(7.5)} = 2.245$$

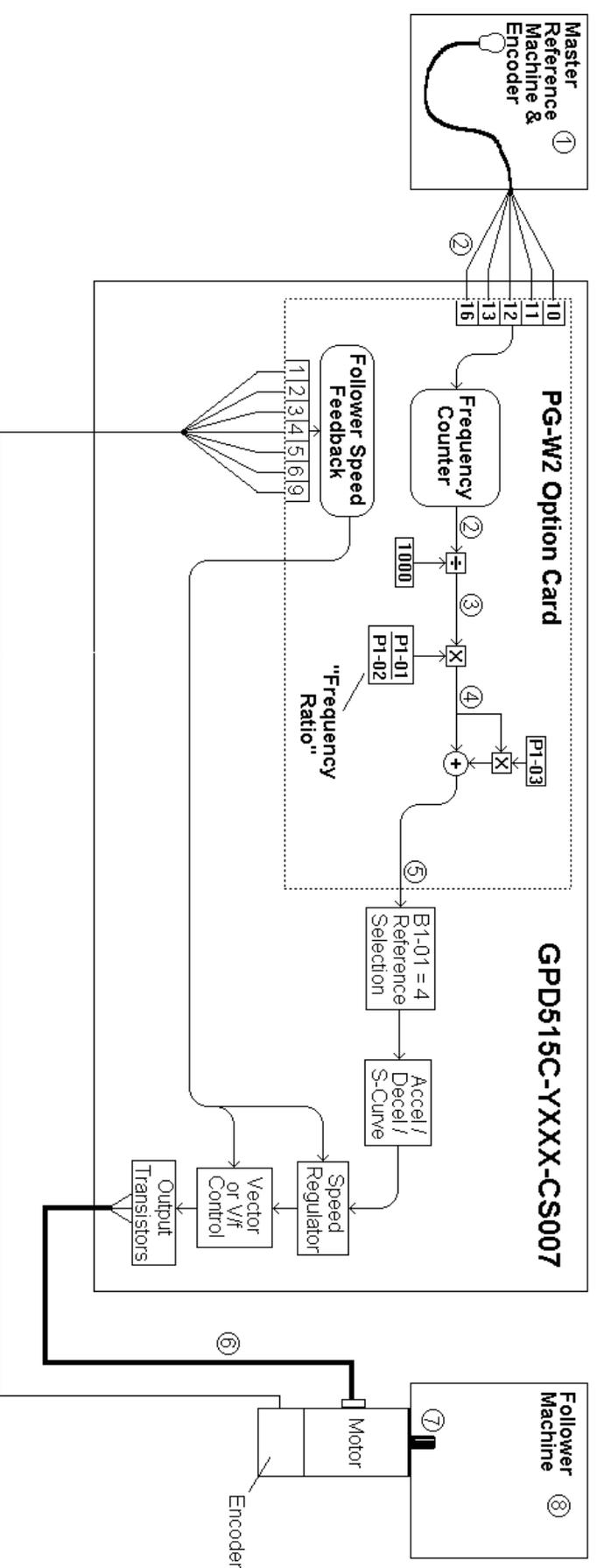
Frequency Ratio is greater than 1, so:

**P1-01** = 10000

**P1-02** = 10000 / 2.245 = 4454 (rounded to nearest whole number)

**P1-03** = 5.0% (to achieve the 5% fixed draw)

## Part 2: Widget machine - 1 : 1 follower (detailed explanation)



### Overview:

In the above drawing there is a machine where one section has to follow another with an exact **speed** match. The portion of the machine that is the "master" has an encoder mounted to a portion of the machine that is moving at line speed, such as a line shaft. The follower is connected to a GPD515 with the CS007 software option (which includes the PG-W2 option card).

### Machine Description:

The line shaft of the machine will produce 1 widget per revolution. There is an encoder attached to this line shaft which is the quadrature / line driver type with a separate power supply. It will produce 360 PPR (pulses per revolution). This encoder is attached to the follower drive's PG-W2 card on terminals 10-13 with the shield on terminal 16.

The follower machine has a standard 4-pole motor on it. This motor is connected to a GPD515 with the CS007 software option (includes the PG-W2 option card). The follower machine has a 25:1 gear reduction connected to the motor. One turn of the output of the gear reduction corresponds to 1 widget.

---

## PG-W2 Theory Of Operation

The PG-W2 card is a dual input encoder card. One input into the PG-W2 card can be used as a frequency reference (terminals 10 - 13). The other input can be used as a speed feedback (terminals 3 - 6). There is one +12V power supply (terminals 1 and 2) capable of 200mA. Typically this power supply can only provide enough current to power one encoder.

The frequency coming into the PG-W2 on terminals 10 - 13 is processed internally to come up with a frequency reference. First, the incoming frequency is divided by 1000. Then it is multiplied by parameter **P1-01** then divided by parameter **P1-02**. The ratio of **P1-01** over **P1-02** is called the frequency ratio. It allows the incoming frequency to be scaled to any application. Parameter **P1-03** will increase or decrease the frequency reference by a set percentage.

In order to figure out the correct settings of **P1-01** and **P1-02**, the frequency ratio needs to be determined. When determining the frequency ratio, several pieces of information are required: reference encoder speed (at a particular line speed), encoder output frequency, follower motor speed (at a particular line speed), number of motor poles for the follower and follower motor frequency.

Determining Frequency Ratio For The Above Example (circled numbers correspond to areas in the above drawing)

① Encoder Speed:

The encoder attached to the line shaft turns one revolution for every widget produced. Therefore if the line is running at 65 widgets / minute, the encoder is turning at 65 RPM.

② Encoder output frequency ( $f_e$ ):

The encoder produces 360 pulses per revolution. The encoder is turning at 65 RPM.

$$f_e = \frac{360 \text{ pulses}}{\text{revolution}} * \frac{65 \text{ revolution}}{\text{min}} * \frac{1 \text{ min}}{60 \text{ sec}} = 390 \frac{\text{pulses}}{\text{sec}} = 390 \text{ Hz}$$

⑦ ⑧ Motor Speed:

With a line speed of 65 widgets / minute, the output of the gear reduction will be 65 RPM. The gear reduction is 25:1.

$$\text{Motor Speed} = 65 \text{ RPM} * \frac{25}{1} = 1625 \text{ RPM}$$

⑥ Motor Frequency:

Motor speed is 1625 RPM and there are four motor poles

$$f_m = \frac{\text{motor poles} * \text{motor RPM}}{120} = \frac{4 * 1625}{120} = 54.17 \text{ Hz}$$

⑤ Frequency Reference:

If the GPD515 is in Flux Vector mode, Open Loop Vector Mode, or V/f with PG mode, or V/f mode with slip comp enabled, the drive will automatically compensate for slip in the follower motor. Therefore, calculated motor frequency should equal frequency reference.

③ Frequency Reference after encoder output frequency has been divided by 1000. Encoder frequency = 390Hz

$$f_3 = \frac{390 \text{ Hz}}{1000} = 0.39 \text{ Hz}$$

④ For the sake of determining the frequency ratio, assume that parameter **P1-03** is set to 0.00%. This would make the frequency at ④ the same as at ⑤.

#### Frequency Ratio:

With all of the above equations solved, the frequency ratio can now be determined. Ideally, **P1-01** would equal the frequency at ④, and **P1-02** would equal the frequency at ③, however, only whole numbers can be entered into **P1-01** and **P1-02**.

In order to solve this problem, multiply both frequencies by 10, 100, 1000, or 10000. Seek the highest numbers possible without exceeding 10000.

Frequency at ③ = 0.39Hz

Frequency at ④ = 54.17Hz

Therefore:

$$\mathbf{P1-01} = 54.17\text{Hz} * 100 = 5417$$

Because the frequency at ④ was multiplied by 100, the frequency at ③ needs to be multiplied by 100 also.

$$\mathbf{P1-02} = 0.39\text{Hz} * 100 = 39$$

Enter these values into the drive.

#### Other Programming Considerations:

There are many parameters in the drive which will effect how closely the follower will track the master. Below is a list of the most commonly used parameters with the PG-W2 option card.

Parameter	Description
b1-01	Reference Source - This parameter should be set to a value of 5, which will force the drive's frequency reference to come from the PG-W2 option card. Other reference sources can be used. See the GPD515 Technical manual TM4515.
C1-01	Acceleration Rate - To achieve maximum response from the follower, this parameter needs to be set to a value lower (faster) than the maximum expected rate of speed change. This parameter can be set all the way down to zero. For more information, consult the GPD515 Technical manual TM4515.
C1-02	Deceleration Rate - Same considerations as Acceleration Rate.
C5-01	ASR Gain - The higher this number is set, the closer the follower will track, but if this number is set too high, the follower will become unstable. This parameter will only be available when in the Flux Vector or V/f w/PG feedback modes.
C5-02	Integral Time - The lower this number is set, the closer the follower will track, but if this number is set too low, the follower can become unstable. This parameter will only be available when in the Flux Vector or V/f w/PG feedback modes.
E1-04	Maximum Output Frequency - This parameter needs to be set to a high enough value. Be careful not to exceed the motor manufacturer's speed rating.

## Part 3: Variable Ratio Using A Potentiometer & The PG-W2 card

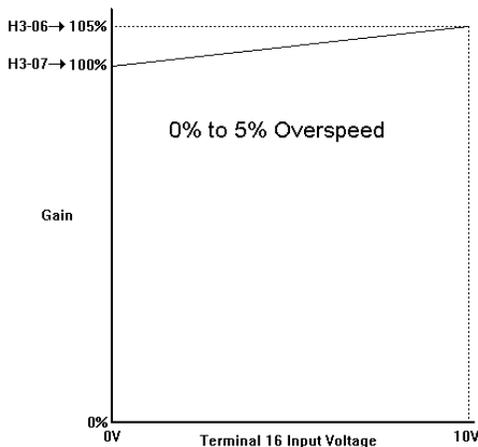
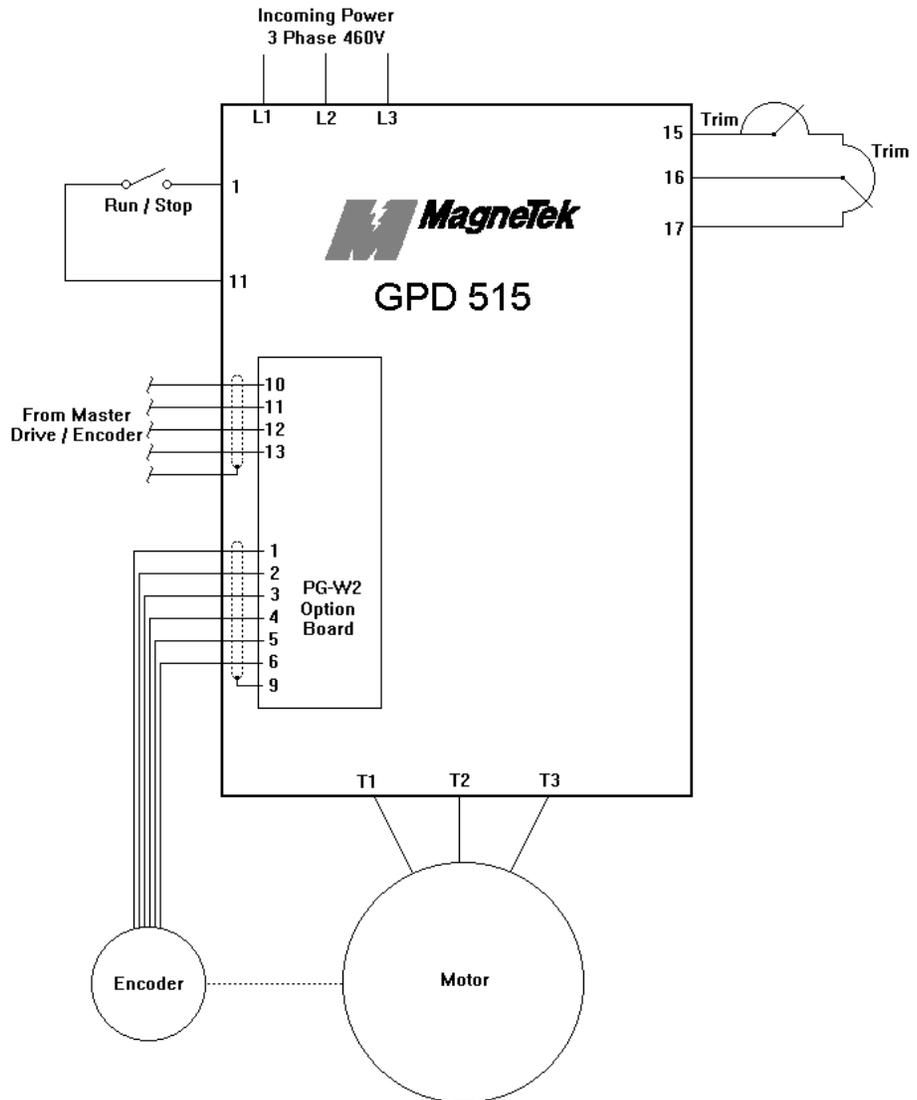
Sometimes an application will call for a variable ratio or “draw” while using the PG-W2 card. For example: A follower drive needs to have an exact speed match plus an adjustable 0 - 5% overspeed.

Parameters **P1-01** & **P1-02** should be calculated as described in Part 2 of this document. Parameter **P1-03** should be left at 0.0%.

An 0 - 10V analog signal, brought in on terminal 16, will be scaled to represent a 0 - 5% overspeed. This is accomplished using the FGAIN function, and the analog input bias and gain functions.

The schematic on the left shows the correct wiring for the analog input (terminal 16) using a potentiometer.

Parameter number **H3-05** needs to be set to a “1” which sets terminal 16 to the FGAIN function.



Parameter numbers **H3-06** & **H3-07** (terminal 16 gain & bias) need to be adjusted so that 0V on terminal 16 results in 100% gain (1 : 1) and 10V on terminal 16 results in 105% gain (1 : 1.05). In order to set this up, parameter **H3-06** needs to be set to the maximum amount of draw required plus 100% (5% + 100% = 105%). Parameter **H3-07** needs to be set to the minimum amount of draw required plus 100% (0% + 100% = 100%).