# ALLEN-BRADLEY BULLETIN 1336 PLUS ENCODER FEEDBACK & PULSE TRAIN INPUT

**APPLICATION NOTE # 1336S - 21**

**June 24, 1997**

## PURPOSE

The purpose of this document is to provide guidelines for wiring and control schemes for the Bulletin 1336 PLUS AC Drive. This document is to be used as a suggestion only. Users must ensure that installations meet applicable codes and are suitable for the existing conditions.

## WHAT THIS NOTE CONTAINS

The 1336 PLUS drive can be configured with an encoder feedback card that allows closed-loop control of induction motors. This feature allows the motor to react quickly to changes in the load to maintain the desired RPM. The drive hardware and parameter set up will be examined to allow simple integration of this feature.

## INTENDED AUDIENCE

This application note is intended to be used by personnel familiar with the hardware components and programming procedures necessary to operate the Bulletin 1336 PLUS.

## WHERE IT IS USED

The diagrams, parameter settings, and auxiliary hardware used in this application note are designed to address specific issues in many different applications. Some changes by the Users may be necessary to apply the concepts of this document to a specific application.

## TERMS AND DEFINITIONS

| | |
|---|---|
| GROUP | Categorized block of parameters with related functions. |
| ELEMENT | Individual parameters within a group. |
| [ ] | Denotes a parameter name. |
| L4E | TTL interface board with encoder inputs. |
| L5E | 24Vdc interface board with encoder inputs. |
| L6E | 115Vac interface board with encoder inputs. |

**NOTE**: The Encoder Feedback and Pulse Train Reference inputs are mutually exclusive. Refer to Pulse Train description for further information.

## DESCRIPTION
## ENCODER FEEDBACK

Encoder Feedback control of the 1336 PLUS drive performs closed-loop velocity regulation. The response characteristic is defined in terms of recovery time. This type of control strategy allows the simplest integration of velocity regulation by allowing the User to manipulate a single parameter to achieve the desired response. Refer to Figure #1 for software diagram.

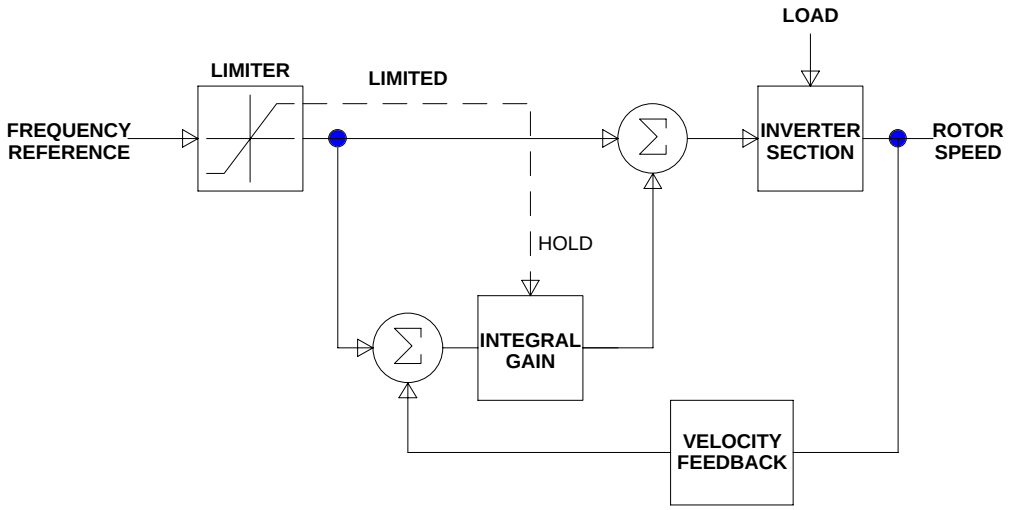


**Figure 1**

To program the 1336 PLUS for Encoder Feedback the [Speed Control] parameter, located in the FEATURE SELECT group, must be set to "Encoder Fdbk". Next, the ENCODER FEEDBACK group must be set up. [Encoder Type] is used to select either a "pulse" or "quadrature" type encoder. The value programmed in [Pulse/Enc Scale] is the nameplate PPR of the encoder. [Maximum Speed] sets the upper limit for the encoder feedback operation. To operate above this setting, program [Maximum Freq] to a value greater than [Maximum Speed]. The integral gain is adjusted with parameter [Speed Ki]. The nameplate rpm of the motor is entered into [Motor NP RPM]. The nameplate rated frequency is set in parameter [Motor NP Hertz]. An example of parameter settings is shown in Table #1.

**Table #1**

| NUMBER | GROUP | NAME | SETTING |
|---|---|---|---|
| 77 | Feature Select | Speed Control | Encoder Fdbk |
| 152 | Encoder Feedback | Encoder Type | Pulse |
| 46 | Encoder Feedback | Pulse/Enc Scale | 1024 |
| 151 | Encoder Feedback | Maximum Speed | 60 |
| 165 | Encoder Feedback | Speed Ki | 2000 |
| 177 | Encoder Feedback | Motor NP RPM | 1750 |
| 178 | Encoder Feedback | Motor NP Hertz | 60 |

Other parameters, located in the ENCODER FEEDBACK group are "read only" type. Those parameters are shown in Table #2.

**Table #2**

| GROUP | PARAMETER | TYPICAL VALUE |
|---|---|---|

| | | |
|---|---|---|
| **Encoder Feedback** | **Motor Poles** | **4** |
| **Encoder Feedback** | **Speed Error** | **0.0 - +1.0** |
| **Encoder Feedback** | **Speed Integral** | **0.0 - +1.0** |
| **Encoder Feedback** | **Speed Adder** | **0.0 - +1.0** |
| **Encoder Feedback** | **Pulse/Enc Hertz** | **operating frequency** |

Required Hardware - For interconnection of the encoder signals to the drive, one of the control interface boards (L4E,L5E or L6E), with the encoder inputs, is necessary. The control interface board has two jumpers, JP3 & JP4, that must be set to the voltage level of the encoder output. When utilizing the drive (internal) power source with JP3 & JP4 set for 12 volts, the minimum on voltage is 7Vdc. When JP3 & JP4 are set for 5 volts, the minimum on voltage is 3Vdc. With an external power source, the minimum on voltage is 3Vdc. Refer to Figure #2 for typical encoder connection diagrams.

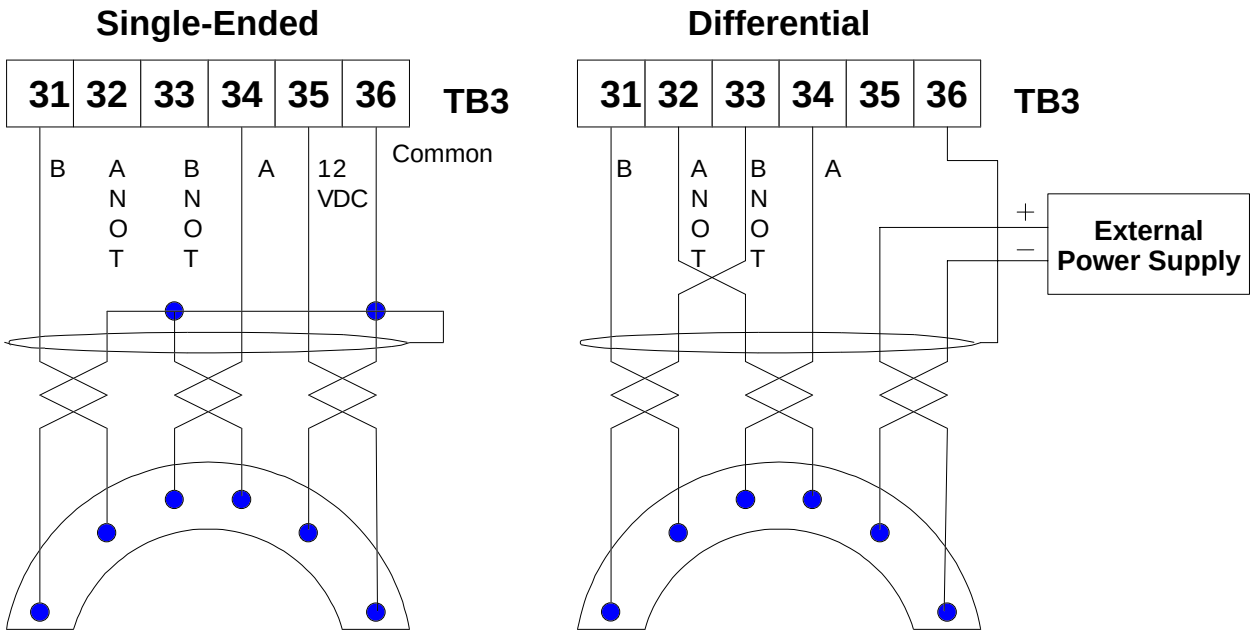


**Figure 2**

Encoder Specifications

- Line Driver 5Vdc or 8-15Vdc output
- Minimum current of 10ma per channel
- Quadrature or Pulse type
- Single Ended or Differential

## APPLICATION CONSIDERATIONS

Smaller settings of parameter [Speed Ki] are associated with slower speed recoveries. Figure 3 shows the different elements involved with speed control through encoder feedback. Starting at the left, the motor is running at some speed when the load is decreased. Just as the load decreases the speed increases. The drive senses the change in speed through the encoder and stabilizes the speed according to the setting in [Speed Ki]. Further along, the load increases and the speed decreases. The same type of speed recovery occurs. Later in figure 3 you can see what happens when accelerating with encoder feedback enabled. The speed will "overshoot" before recovering according to [Speed Ki].

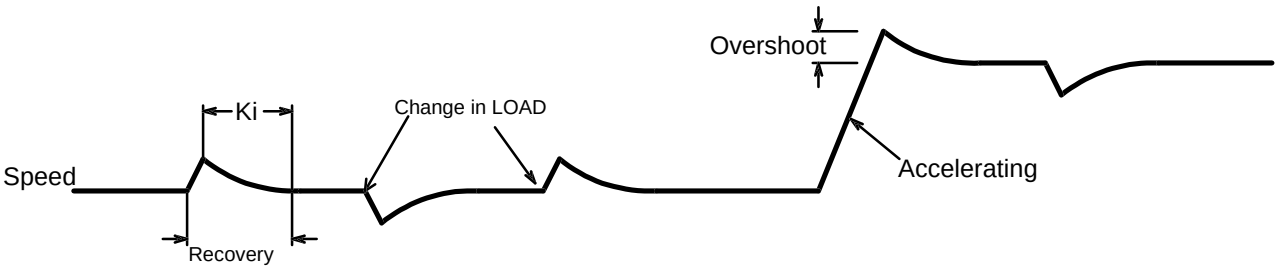


**Figure 3**

Figure 4 shows what happens to the speed graph when the [Speed Ki] is set higher than in figure 3. Speed recovery is quicker.

**Figure 4**

Figure 5 shows when the [Speed Ki] parameter is set too high. This type of behavior is dependent on load and frequency. Typically the drive will oscillate at low load conditions on recovery. This is due to the speed compensation being greater than the speed error.

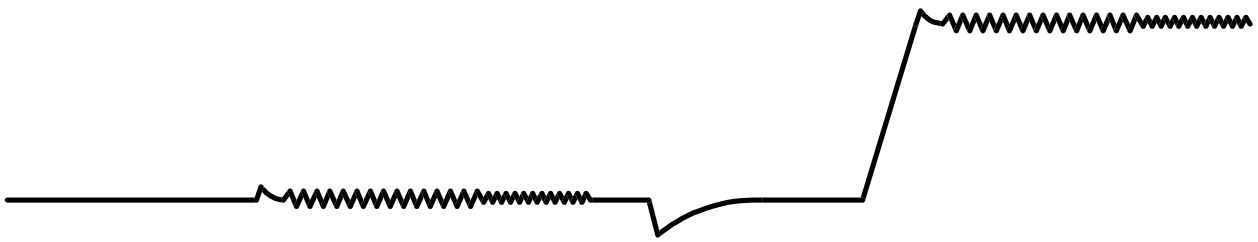

**Figure 5**

## "S" - Curve

Figure 6 shows the effect that "S"-curve has on the speed when running in encoder feedback mode.

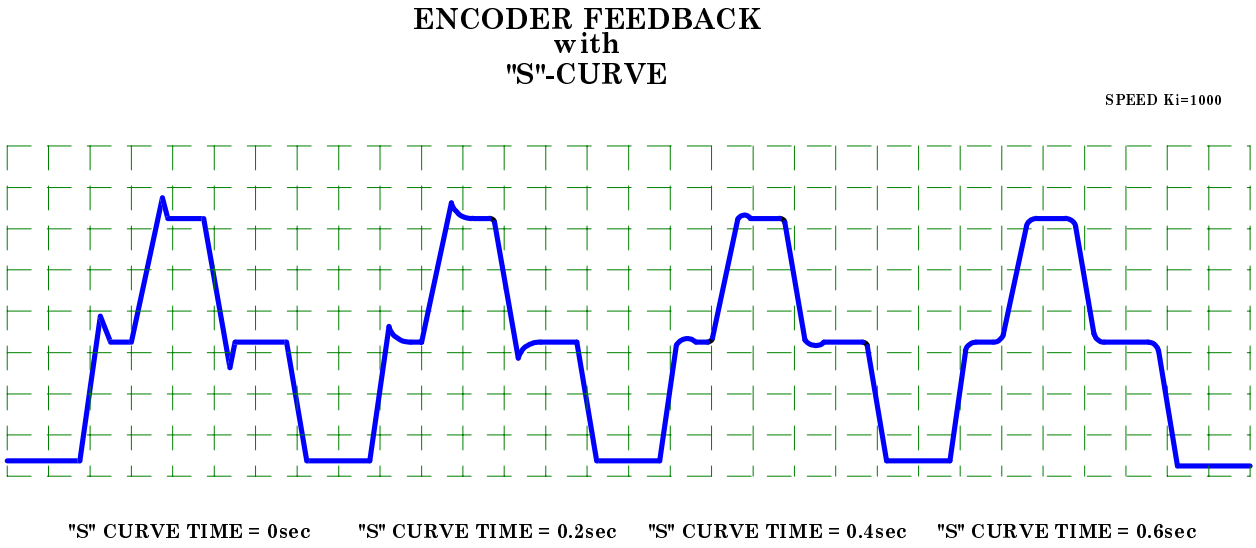


**Figure 6**

The following parameters need to be set in order to get S-Curve to function.

**Table #3**

| GROUP | PARAMETER | SETTING |
|---|---|---|
| **Feature select** | **S Curve Enable** | **"Enabled"=1/"Disabled"=0** |
| **Feature Select** | **S Curve Time** | **0.00-300.00 sec** |

Settings in [S Curve Time] greater than [Accel/Decel Time 1/2] will result in a fixed S-Curve thus doubling the settings in [Accel/Decel Time 1/2]. Example: [Accel Time 1] = 5 sec, [Decel Time 1] = 10 sec, [S Curve Time] = 6 sec. Since the 6 seconds exceeds the [Accel Time 1] the actual acceleration time will be 10 seconds (double the setting in [Accel Time 1]). The deceleration time, however, will be 16 seconds by an adjustable S-Curve with ½ the [S Curve Time] used at the start of deceleration then 10 seconds of linear decel, then the other ½ of the [S Curve Time] at the end of deceleration. S-Curve is also selectable in [Stop Select 1/2]. This causes the drive to S-Curve ramp to 0Hz by twice the setting in [Decel Time 1/2].

**DESCRIPTION**
**PULSE TRAIN INPUT**

The 1336 PLUS drive will accept a 5vdc pulse train input as a frequency reference to terminals 7 and 8 of TB2. This signal is optically isolated and routed to the microprocessor. Prior to the microprocessor, the encoder input signal "A" joins the pulse input signal. For this reason, only one of the two inputs can be used for any given application. Refer to figure 7.

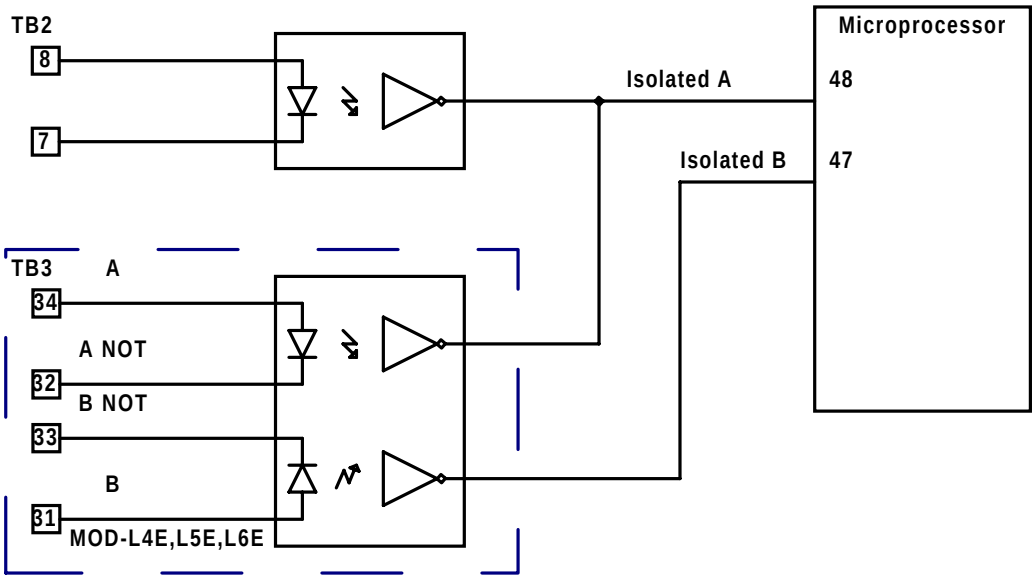


**Figure 7**

To configure the drive to use the Pulse Train Input as the frequency reference, the parameters listed in table 4 must be programmed.

**Table #4**

| GROUP | PARAMETER | TYPICAL VALUE |
|---|---|---|
| **Setup/Frequency Set** | **Freq Select 1** | **4** |
| **Frequency Set** | **Freq Select 2** | **4** |
| **Frequency Set** | **Pulse/Enc Scale** | **determined by formula** |
| **Encoder Feedback** | **Pulse/Enc Scale** | **Same as above** |

The frequency reference that the drive will follow [Freq Select 1] or [Freq Select 2] is determined by the logical state of the inputs to TB3 terminals 27 and 28. Refer to table 2-H in Publication 1336 PLUS-5.0 (User Manual)

To determine the proper [Pulse/Enc Scale] value use the following formula.

$$\text{Scale Factor} = \frac{\text{Incoming Pulse Rate (hz)}}{\text{Desired Command Freq.}} \bullet \frac{\text{Motor Poles}}{2}$$

Example: 1024PPR signal from a 4 pole motor running 0-60hz. (60 x 1024)

$$\frac{61440}{60} \bullet \frac{4}{2} = 2048$$

The pulse train input circuitry in the microprocessor uses a 1MHz clock and several counter buffers to determine the pulse count every microsecond. Every 10msec the pulse count and time are compared with the previous values. By using these new values, the frequency command can then be calculated.

## APPLICATION CONSIDERATIONS

For systems that require a digital reference and encoder feedback, several options are available. The 1336 PLUS can except digital references via the following options.

- Remote I/O Communications Adapter
- RS232/422/485 Serial Adapter using DF1/DH485 protocol
- DeviceNet Communications Adapter

Example:
For a system using two or more drives in a master/slave configuration with encoder feedback speed regulation required, Remote I/O is a solution.

The master drive can use the encoder feedback and then via Remote I/O send the value of [Pulse/Enc Hertz], after conditioning, to the input of the slave drives via one of the DATALINK parameters, located in the Adapter I/O group. The DATALINK is a discrete transfer (every scan) so update times are dependent on the PLC scan time. For faster update, use a selectable timed interrupt in the ladder logic to immediately update the signal at predetermined intervals. Refer to figure X for the I/O mapping. For better tracking of the master drive set the slave drive accel and decel times to very low values (fast rate of change).

**Master Drive** [Pulse/Enc Hertz] Scale = 0-32767 equals zero to maximum freq. The value when operating in the reverse direction will use the
2's complement of the above scale (-1 to -32768).

**Slave Drive** Use a [Preset Speed] as the reference. The scale for the preset speeds via a digital reference is the desired frequency times 100. For a 0-60Hz application the scale is 0-6000.

### PLC CODE

The PLC must scale the value of [Pulse/Enc Hertz] according to the values stated above. Remember that if the master drives is operating up to 60Hz with encoder feedback, [Maximum Speed] and [Maximum Freq] must be programmed as described on page 2. Scaling of the [Preset Speed]parameter for the slave drive will also change.

**Formula:** 32767/6000 = value sent to slave drive

This formula is only applicable to forward operation.