Introduction To Speed Compensation

What Is It?

"Speed compensation" refers to the ability of the PL-1746 controller to automatically advance or retard setpoints in any output channel depending on the speed of the machine. Speed compensation allows devices with fixed response times, such as glue guns, to perform their functions with high accuracy over a wide range of machine speeds. Without speed compensation, a glue bead may tend to "drift" out of position as machine speed increases. By properly programming speed compensation for the output channel controlling the glue gun, the glue bead position can be maintained precisely over the complete range of machine speeds.

Benefits

Proper use of speed compensation can provide substantial benefits:

- **Increased Productivity—**If a machine incorporates components with fixed response times, the use of speed compensation can often increase line speeds by as much as 50%.
- **Reduced Scrap Rate—**Speed compensation maintains the accuracy of critical operations such as gluing, thereby reducing rejects, rework, and scrap.
- **Simplified PLC Systems—**Programming speed compensation into standard motion control equipment such as PLC's, stepper motors, and stepper motor controls is difficult. In addition, to perform speed compensation at high machine speeds, the PLC hardware must be extremely fast, and therefore expensive. Integrating a PL-1746 into the control system eliminates the need to write custom PLC speed compensation programming, and provides excellent high speed control at a fraction of the hardware cost.

Fixed Response Times

Electromechanical components of automated systems often have fixed response times regardless of the line speed. For example, a glue gun may require ten milliseconds from the time the gun is actuated to the time that glue begins flowing. At the slowest line speed, the gun might need to be triggered when the carton is one inch away, so that the carton arrives under the gun just as glue begins flowing. As the line speed increases and the product travels faster, the lead distance from the carton to the gun must increase in order for the gun, with its fixed response time, to still hit the correct spot on the product. By programming speed compensation into the PL-1746, the timing of glue guns and similar mechanisms can be automatically advanced as speed increases, maintaining proper operation over a wide range of machine speeds.

Standard Speed Compensation

Example

The illustration on page 5-2 shows a simple carton gluing application. A conveyor moves cartons under a glue gun which releases glue onto the flaps. The conveyor is connected through a timing chain and sprocket to a transducer which rotates one revolution for each carton that passes under the gun.

As the transducer dial shows, SHAFT POSITION has been programmed so that the leading edge of the box passes under the gun at 110° and the trailing edge at 360°. Glue begins flowing ten msec after the gun is energized, and it stops flowing ten msec after the gun is de-energized. Once the glue leaves the nozzle, it requires another five msec to travel to the carton. Combining the glue gun response time with the travel time results in a system response time of 15 msec, regardless of line speed.

At very slow, or essentially zero speed, the gun would be energized at a transducer position of 110° and de-energized at 360°. As the line speed increases, however, the gun needs to be energized before 110° to allow the glue to hit the carton in the correct spot. The faster the line speed, the earlier in the transducer cycle the gun must be triggered.

(continued)

Standard Speed Compensation (cont'd)

Calculation

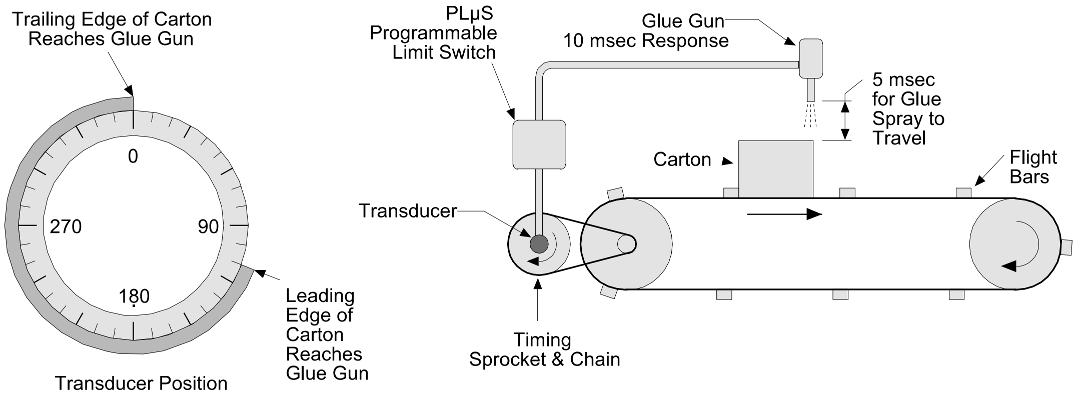
To calculate the amount of speed compensation required, use the following relationships between the transducer's RPM (revolutions per minute) and degrees of rotation:

1 RPM = 360°/min = 6°/sec = 0.006°/msec,

RPM x 0.006 = deg/msec,

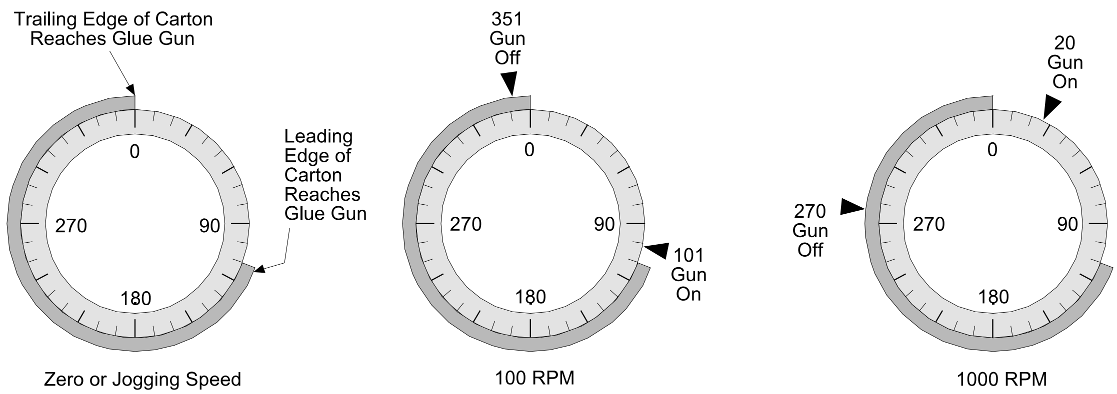
thus: @ 100 RPM, the transducer will rotate 0.6°/msec
@ 1000 RPM, the transducer will rotate 6.0°/msec

Simple Application Using Speed Compensation



In the previous example, the gluing system requires 15 msec from the time the gun is energized to the time the glue hits the carton. At 100 RPM, the transducer will rotate 0.6°/msec. Therefore, in the 15 msec response time, the transducer will rotate (15 msec x 0.6°), or 9°. This means the glue gun must be energized at 101°, which is 9° before the box arrives under the gun, and de-energized at 351°. At 1000 RPM, the transducer will rotate (15 msec x 6°), or 90° during the response time, and the gun must be energized at 20° and de-energized at 270°. These values are visually represented in the illustration below.

Speed Compensation at Various Speeds



Setting Speed Comp

In many applications, speed compensation can be set by jogging the line to determine ON and OFF edges at zero speed, then entering the speed compensation value into the controller. In the previous example, the line would be jogged until the leading edge of the box reaches the gun at 110° of transducer rotation. The glue gun output would be set to turn on at this point. Then, the line would be jogged until the trailing edge is under the gun at 360°, and the glue gun output would be set to turn off.

Once these on and off edges are entered, the glue system response time of 15 msec would be entered through SPEED COMP programming as described in Chapter 4. As line speed increases, the PL-1746 will automatically advance the edges to maintain the accuracy of the glue bead position.

Standard Speed Compensation (cont'd)

IMPORTANT — **When setting speed compensation on a system where zero-speed pulses have been established, always adjust the speed compensation value. Do not adjust the individual pulse edges!**

Response Time Unknown

Suppose that in the previous example, the response time was unknown.
To set up the machine, jog a carton through the machine and set the glue gun ON and OFF edges as described earlier. Then, estimate a response time and enter it into the controller using the SPEED COMP function described in Chapter 4.

Start the line and run cartons through it at a fixed line speed. Program SPEED COMP to adjust the **speed compensation value** as required for proper gluing. This can be done while the line is in motion. Once programmed, vary the line speed to confirm proper operation at all speeds, and fine tune the SPEED COMP value if necessary.

Can't Be Jogged?

Some machinery can't be jogged to determine ON and OFF edges. To set up this type of equipment, set speed comp to zero, start the line, run cartons through it at a fixed line speed, and set the ON and OFF edges as required for proper gluing. Write them down for reference in the next step.

Next, increase the line speed and adjust the edges to restore proper gluing. You might be tempted to enter a speed compensation value to do this. However, since the edges were adjusted at the first speed with zero compensation, any change in compensation value now will upset the first pair of edges.

Once the second pair of edges is established, compare them to the first pair that you wrote down. Establish a ratio of degrees the edges advance versus the speed as shown in the example below. Convert this ratio to response time and enter it as the speed compensation value.

Since the new speed compensation value will affect the ON and OFF edges already programmed, you will need to start the line one more time and, at a constant speed, adjust the **ON and OFF edges** for proper gluing. Once set, vary the line speed to confirm that the speed compensation value is accurately adjusting the edges over the operating speed range.

Example for Calculating Speed Compensation

	RPM	Glue On	Glue Off	Difference
1st Line Speed:	200	73°	156°	83°
2nd Line Speed:	680	49°	132°	83°

Difference in Position: 73° - 49° = 24°
Difference in Speed: 680 RPM - 200 RPM = 480 RPM

Speed Compensation Value: Divide difference in position by difference in speed:

24°/480 RPM = 0.05° per 1 RPM

Since a shaft at 1 RPM rotates 0.006°/msec, this shaft would require (0.05/0.006), or 8.3 msec to rotate 0.05°. So the correct speed compensation value to enter is 8.3.

Leading/Trailing

In the previous example, the response time of the glue gun was the same whether turning on or turning off. While this applies to many systems, some devices have different on/off response times. For these devices the Leading/Trailing Edge feature provides the ability to program different speed compensation values for the leading and trailing edges of the pulse driving the device.

Setting Leading/Trailing Speed Comp

If the ON and OFF response times are known, jog the line to determine ON and OFF setpoints at zero speed. Then enter the speed compensation values through SPEED COMP programming, as described in Chapter 4. When programming SPEED COMP, enter the leading edge, or ON response time at the “LE” prompt, and the trailing edge, or OFF response time at the “TE” prompt.

IMPORTANT

When setting speed compensation on a system where zero-speed edges have been established, always adjust the speed compensation value. Do not adjust the individual pulse edges!

Response Times Unknown

If the response times are unknown, jog the line to determine ON and OFF edges at zero speed. Estimate both ON and OFF response times and enter them through the SPEED COMP function. The leading edge, or “LE” value will control the ON timing, while the trailing edge, or “TE” value will control the OFF timing. Start the line, run product through it at a fixed speed, and adjust each **speed compensation value** as required for proper gluing. This can be done while the line is in motion. Once programmed, vary the line speed to confirm proper operation at all speeds, and fine tune the SPEED COMP values if necessary.

Can’t Be Jogged?

If it is impossible to jog the line, run the line at a fixed speed and set the ON and OFF edges as required with SPEED COMP set to zero for both the leading and trailing edges. Write down the ON and OFF edges.

Next, increase the line speed and adjust the edges to restore proper gluing. You might be tempted to adjust speed comp values to do this. However, since the edges were adjusted at the first speed with zero compensation, any change in compensation value now will upset the first pair of edges.

Once the second pair of edges is established, calculate separate leading and trailing edge speed comp values, as shown in the previous example.

Since the new speed compensation value will affect the ON and OFF edges already programmed, you will need to start the line one more time and, at a constant speed, adjust the **ON and OFF edges** for proper gluing. Once set, vary the line speed to confirm that the speed compensation values are accurately adjusting the edges over the operating speed range.

(Continued)

Example for Calculating Leading and Trailing Edge

	RPM	Glue On	Glue Off	Difference
1st Line Speed:	200	73°	156°	83°
2nd Line Speed:	680	49°	144°	95°

Note that the length of the pulse is 83° at 200 RPM, and 95° at 680 RPM. This means that the leading and trailing edges require different speed compensation values.

Leading Edge: **Difference in Position:** 73° - 49° = 24°
Difference in Speed: 680 RPM - 200 RPM = 480 RPM

Speed Compensation Value: Divide difference in position by difference in speed:

24°/480 RPM = 0.05° per 1 RPM

Since a shaft at 1 RPM rotates 0.006°/msec (see page 4-2), this shaft would require (0.05/0.006), or 8.3 msec to rotate 0.05°. So the correct leading edge speed compensation value to enter is 8.3.

Trailing Edge: **Difference in Position:** 156° - 144° = 12°
Difference in Speed: 680 RPM - 200 RPM = 480 RPM

Speed Compensation Value: Divide difference in position by difference in speed:

12°/480 RPM = 0.025°/1 RPM

Since a shaft at 1 RPM rotates 0.006°/msec, this shaft would require (0.025/0.006), or 4.2 msec to rotate 0.05°. So the correct trailing edge speed compensation value to enter is 4.2.

Negative Speed Compensation

Negative Speed Comp

Normal speed compensation **advances** the pulse edges in an output channel to compensate for a fixed response time in the device being controlled. In some applications, however, **negative** speed compensation is required to **retard** the edges in an output channel. Negative speed compensation is usually found in two situations:

"Wrap-Up"

As some machines increase in speed, the drive train at some point between the resolver and the product "wraps-up," or shifts with respect to the resolver. If the wrap-up is proportional to machine speed, negative speed compensation can be used to retard an output channel's setpoints from the true resolver position, thus maintaining output accuracy.

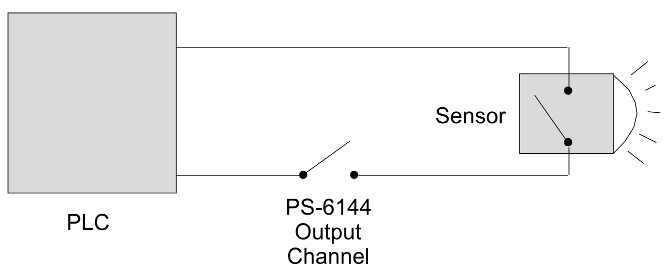
Sensor Lag

While output channels are usually used to switch devices on and off, another use is to "gate" a sensor into a PLC or other computer. The illustration below shows a basic sensor gating scheme. In the illustration, the signal from the sensor reaches the PLC only when the output channel from the PLS is turned on.

Most sensing devices have very fast response times. However, if a sensor's response time is slow, its signal will appear later and later in the machine cycle as the machine speeds up. Eventually, the sensor may lag the resolver so much that its signal fails to appear during the window programmed into the PL-1746's output channel.

Negative speed compensation will correct this problem by causing the output channel to lag its programmed machine position by a specified number of milliseconds. Negative speed compensation is calculated using the same method as standard speed compensation. See SPEED COMP in Chapter 4 for details on programming negative speed comp.

Simple Sensor Gating Scheme



Speed Compensation Guidelines

Device Placement

For speed compensation to work most effectively, the device being controlled by the output channel should be located on the machine in a position where the product is moving past the device at a constant speed. The illustration below is an example. In the case of a glue gun, if the gun is ON when the speed is changing, the glue distribution may be inconsistent from carton to carton at varying machine speeds.

Speed Comp & Modes

When using Operating Modes as discussed in Chapter 6, be aware of the effects of speed compensation on the relationship between the pulse edges, the Group Input signal, and the pulse programmed into the Group Channel. **Speed compensation will not affect Group Channels (channels 91-96).**

Product Speed Should be Constant Past Controlled Device