

Proportional Integral Loop Module

**Instruction Manual
PI240-000**



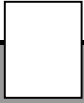


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General Description

Model PI240-000 is designed for industrial applications that require a basic Proportional-Integral (PI) loop controller. Some example applications include Dancer Positioning and Loadcell Tension Control.

The PI module includes onboard multi-turn potentiometers for adjusting the Setpoint (SP), Proportional Gain, Integral Time, and PI Trim. The module provides terminals for connecting the process variable (PV or feedback) signal and an optional summing input signal. Additional terminals also provide for an Enable and Teach inputs. Furthermore, the Teach input can also be used to control the polarity (unipolar/bipolar) of the Integral component. An internal jumper allows selection of a voltage or current output. Onboard EEPROM is used to backup and retain the feedback calibration values during a power loss.

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Specifications

2.1 Electrical

D.C. Power Input

- 24 VDC $\pm 10\%$, 60mA max, internally fused

+10VDC Reference Output

- 10mA max

Feedback/Sum Inputs

- Range: 0-10VDC
- Input Impedance: $10^{12} \Omega$

Potentiometers

- Turns: 15

Signal Output

• Voltage Output

Selected by position V on J2. This circuit allows the output to source a voltage level of up to +10 VDC into a minimum resistance of 600 Ohms. If resistance is too low, output linearity may be affected.

• Current Output

Selected by position I on J2. This circuit allows the output to source a regulated current up to 20mA into a maximum resistance of 500 Ohms.

Temperature Range

- 0-55[°]

2.2 Physical

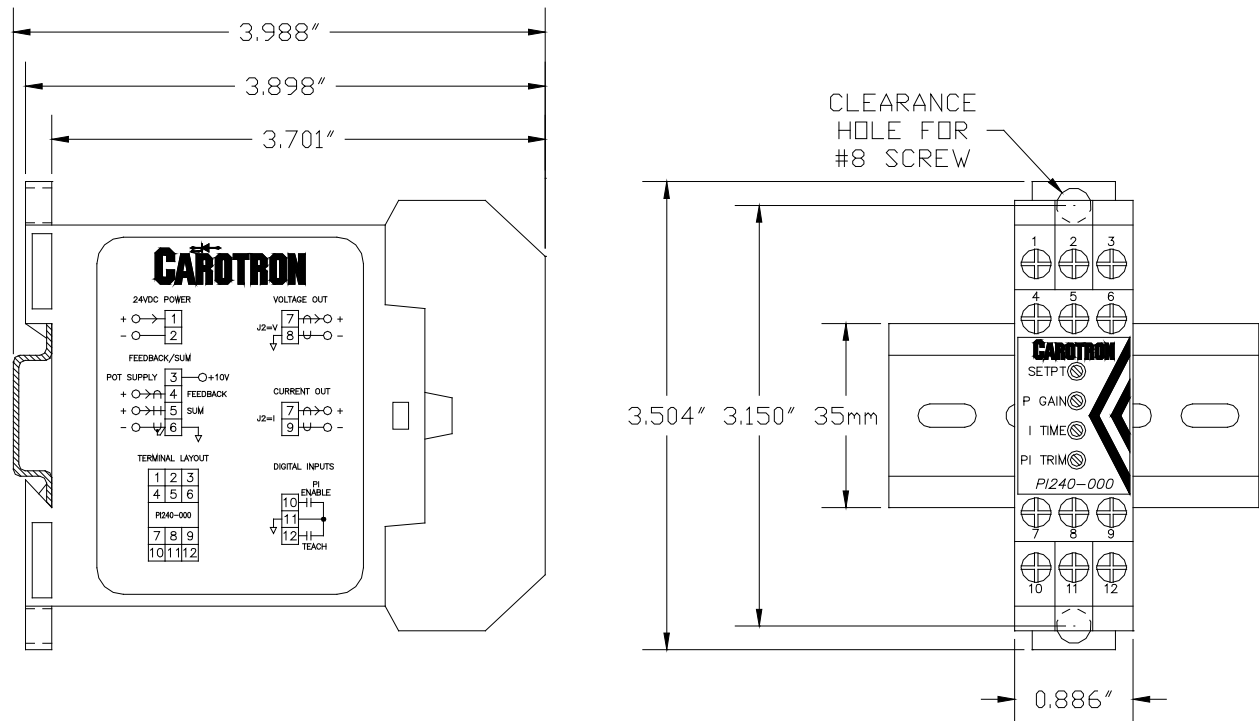


Figure 1: Physical Dimensions

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Installation

3.1 Wiring Guidelines

To prevent electrical interference and to minimize start-up problems, adhere to the following guidelines:

Use fully insulated and shielded cable for all signal wiring. The shield should be connected to circuit common at one end only. The other end of the shield should be clipped and insulated to prevent the possibility of accidental grounding.

Signal level wiring such as listed above should be routed separately from high level power wiring (such as the A.C. line, motor, operator control, and relay control wiring). When these two types of wire must cross, they should cross at right angles to each other.

Any relay, contactor, starter, solenoid or other electro-mechanical device located in close proximity to or on the same line supply as the PI240-000 should have a transient suppression device such as an MOV or R-C snubber connected in parallel with its coil. The suppressor should have short leads and be connected as close to the coil as possible.

3.2 Signal Connections

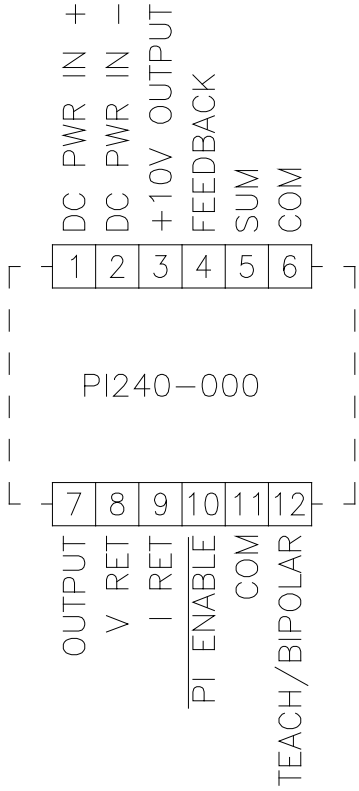


Figure 2: General Connections

JUMPER J2

Selects the Output Mode between Voltage or Current. Position V on J2 selects the Voltage Mode and the output is sourced from terminals 7 & 8. Position I on J2 selects the Current Mode and the output is sourced on terminals 7 & 9.

PI ENABLE Input

This input is used to enable the PI loop. Typically, a dry contact is wired between terminals 10 & 11. When the ENABLE contact is closed, the signal output on terminal 7 will be composed of the PI+Summing Input (terminal 5). Opening the contact will disable the PI loop and only the Summing Input signal will be on the output.

SETPOINT Potentiometer

This adjustment is used to define the PI setpoint (SP). Range is from 0.00% (fully counter-clockwise) to 100.00% (fully clockwise).

PROPORTIONAL GAIN Potentiometer

Sets the amount of the loop output signal that is based on the error (Setpoint-Feedback). Increasing the gain improves the loop response but can also increase overshoot and cause instability if set too high. Range is from 0 (fully counter-clockwise) to 10 (fully clockwise).

INTEGRAL TIME Potentiometer

The **Integral Time** adjustment eliminates steady-state error. Decreasing the integral time improves loop response. However, setting it too low can cause oscillation. The adjustment is in seconds and corresponds to the amount of time that the **PI Output** signal would take to integrate from 0% to 100%. Range is from 0.010s (fully counter-clockwise) to 60s (fully clockwise).

PI TRIM Potentiometer

This adjustment controls the amount of correction that the PI loop can provide. Range is from 0% (fully counter-clockwise) to 100% (fully clockwise). 100% signal corresponds to 10V or 20mA depending upon jumper J2.

SUM Input

In many industrial applications, the PI output is only needed to provide a slight correction. In these cases, there is often another signal that can provide the majority of the output. The Sum Input provides a means to sum an external signal with the PI output. There is no scaling for this input. Thus, whatever signal level is present on the Sum Input will also be present on the output (terminal 7) in addition to the PI signal.

An example is where two material handling rolls (nip rolls/ S-Wraps) are separated by a dancer. It is desired for the follower roll to match speed with the lead roll. A speed signal from the lead drive can be connected to the Summing Input. This input signal will be present on the output (terminal 7) that is connected as a reference to the follower drive. The follower drive can now be calibrated to track the speed of the lead drive very closely. The PI loop (using a dancer or a loadcell) then only needs to provide a very small correction to this "Line Speed" summed signal so that the follower drive provides the desired speed.

TEACH/BIPOLAR INPUT

Often, the process variable (PV, feedback) signal may not be a nominal 0 to 10VDC signal due to mechanical limitations (especially on dancer feedback applications). The Teach input can be used to calibrate the minimum and maximum voltage inputs levels. Transitions on the Teach input (within one minute of applying power) cause the module to learn the signal level currently applied to terminal 4. The order in which the minimum and maximum signal levels are taught will affect the logic of the control loop. With dancer systems, this would be the same as swapping the outer leads of the dancer feedback potentiometer.

The Teach function must be **initiated** (not completed!) within one minute of power being applied to the module. Initially start with the Teach input terminal disconnected and apply power to the module. Apply either the minimum or maximum signal level (typically minimum) to terminal 4. Teach this level by connecting the Teach input (terminal 12) to circuit common (terminals 11). Next, apply the other extreme signal (typically the maximum) to terminal 4. Teach this level by disconnecting the Teach input from circuit common. If an error is made during the teach process, simply power down the module and repeat the process above.

The Teach Input is also used to select the polarity of the integral component. In Unipolar mode, the integral component is positive only and thus can only add to the Summing signal. In Bipolar mode, the integral component can be positive or negative and can add or subtract to the Summing Signal. Note that the unipolar/bipolar mode only reflects the polarity of the integral component, not the polarity of the final output on terminal 7. The final output (PI + Summing) on terminal 7 is a unipolar output only (i.e., it cannot go negative).

After the one minute teach window has elapsed, the Teach input can be used to select the polarity of the integral component. If terminal 12 is left unconnected, the INTEGRAL component can only have a positive output (UNIPOLAR mode). If terminal 12 is connected to common (terminal 11), the INTEGRAL component can have either a positive or a negative polarity (BIPOLAR mode). If the Teach input is connected to common when power is applied to the module, the teach function is bypassed and the PI loop immediately enters the bipolar mode of operation.

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Adjustment Procedure



WARNING! DURING CALIBRATION, THE PI240-000 MODULE WILL PRODUCE AN OUTPUT. PLEASE DISCONNECT ANY EQUIPMENT FROM THE MODULE THAT COULD BE DAMAGED OR CAUSE INJURY DURING THIS PROCESS.

Proceed to Section 5.1, 5.2, 5.3 or 5.4 depending upon your application.

5.1 Surface Follower Adjustment Procedure

In a surface follower application, a Line Speed signal from the lead drive is connected to the Summing Input on the PI module. This speed signal will pass through the module and be present on the output, which is connected to the speed reference of the follower drive. The follower drive's surface speed should then be scaled to match the lead drive as close as possible. A feedback device, such as a dancer or loadcell, can then be used with the PI module to trim (slightly add or subtract) to the Line Speed signal to obtain the desired speed and/or tension (Figure 3).

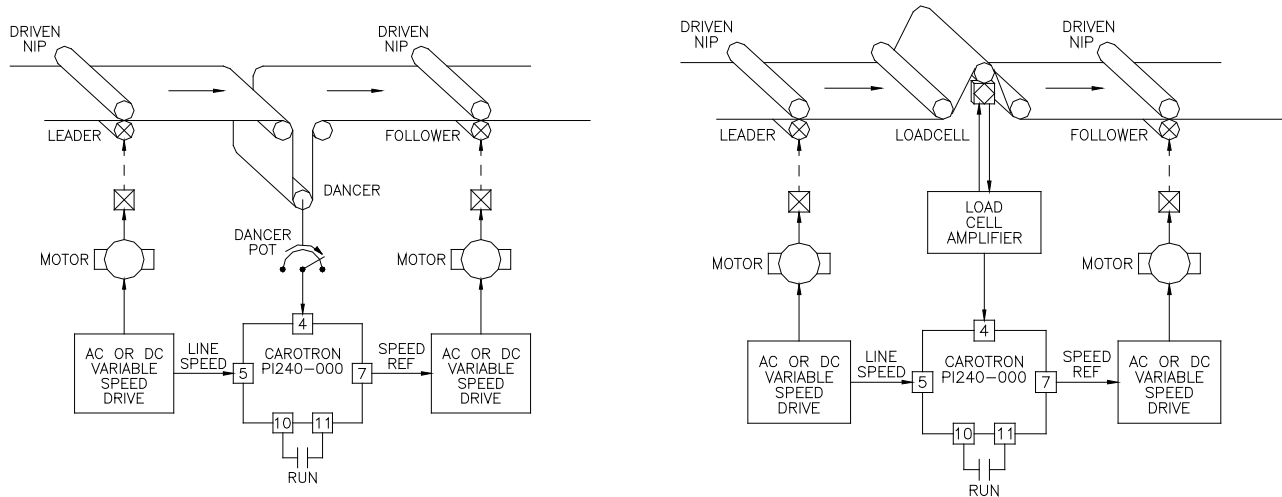


Figure 3: Surface Follower Application Example

Step 1: Select Output Type

1. Select the type of output desired using Jumper J2. If a Voltage output is desired, select V on J2 and use output terminals 7 (OUTPUT) and 8 (VOLTAGE RETURN). If a Current output is desired, select I on J2 and use output terminals 7 (OUTPUT) and 9 (CURRENT RETURN).

Step 2: Connections

1. Make connections per drawing C13703 on page 19. Initially, there should be no connection on the Teach input on terminal 12.

Step 3: Initial Setup

1. Initial commissioning should be performed without product in the machine.
2. Set all potentiometer to 8 turns clockwise. If the current positions are unknown or in doubt, rotate pot counter clockwise 20 turns, then clockwise 8 turns.
3. For dancer systems, verify that the full range of motion of the dancer does not exceed the allowable electrical range (i.e., the potentiometer does not rollover from min to max or vice versa).

Step 4: Teach Process Variable (Feedback)

1. The order in which the two extreme feedback levels (minimum and maximum) are taught determines the logic of the control loop.
2. For Dancer systems, position the dancer at the extreme position that should force the follower drive to increase in speed. For Loadcell systems, apply either no load or full load (by hanging weights in the material path) to the loadcell that should cause the follower drive to increase in speed.

3. Apply power to the PI240-000 Module. Within one minute, connect the Teach input (terminal 12) to circuit common (terminal 11).
4. For Dancer systems, position the dancer at the other extreme position that should force the follower drive to decrease in speed. For Loadcell systems, apply the other extreme signal (either no load or full load) that should cause the follower drive to decrease in speed.
5. Disconnect the Teach input (terminal 12) from circuit common (terminal 11).

Step 5: Select Bipolar Integral¹

1. Wait at least one minute after applying power to the module and place a jumper from the Teach input (terminal 12) to circuit common (terminal 11).

Step 6: Speed Match

1. Ensure the enable contact between terminals 10 & 11 is open.
2. Enable the lead and follower drives. Run the lead drive up to maximum desired speed. The line speed reference signal that is connected to the Summing Input on terminal 5 should be scaled to a maximum of approx. 8 volts (this allows an additional 2 volts for the PI component).
3. Since any signal present on the Summing Input is also present on the output, the follower drive should also be running. Using a handheld tachometer, adjust the speed of the follower drive until its surface speed matches the lead drive. The follower drive speed would typically be scaled by using its Max Speed or Analog Input Gain adjustment.

Step 6: PI Trim

1. Manually force the dancer or loadcell feedback sensor so it is in the “speed up” state.
2. Enable the PI loop by closing the contact across terminals 10 & 11. Verify that the module output increases and causes the follower drive to increase in speed.
3. Likewise, manually force the dancer or loadcell feedback sensor so it is in the “slow down” position and verify that the follower drive decreases in speed.
4. If the module exhibits opposite logic (i.e. increases speed when it should decrease speed), then repeat Step 4 teaching the feedback levels in the opposite order.
5. With the feedback sensor in the “speed up” state, wait until the PI output saturates (stops increasing) and adjust the PI Trim potentiometer until the follower drive achieves the desired overspeed level (typically about 10%).
6. Stop all drives.

Step 7: Tune

1. Load material and run machine. For dancer systems, adjust the Setpoint potentiometer to set the desired operating position of the dancer. For loadcell systems, adjust the Setpoint potentiometer until the desired tension level is achieved.
2. If necessary, adjust the Prop Gain and Integral Time potentiometers if any instability is noticed or response time is sluggish.

¹NOTE! An alternate setup to the above would be to configure the PI module for unipolar operation. This would then only allow the PI to add to the summed Line Speed signal. In this case, the follower drive speed scaling performed in step 6 should be set slightly slower (5-10%) than the lead drive instead of a speed match.

5.2 Takeup (Winder) Adjustment Procedure

In a takeup application, a Line Speed signal from the lead drive should be connected to the Summing Input on the PI module. This speed signal will pass through the module and be present on the output, which is connected to the speed reference of the takeup drive. The takeup drive's empty core surface speed should then be scaled to match the lead drive as close as possible. A feedback device, such as a dancer or loadcell, can then be used with the PI module to subtract from the Line Speed signal as the diameter builds and slow the takeup drive down (Figure 4).

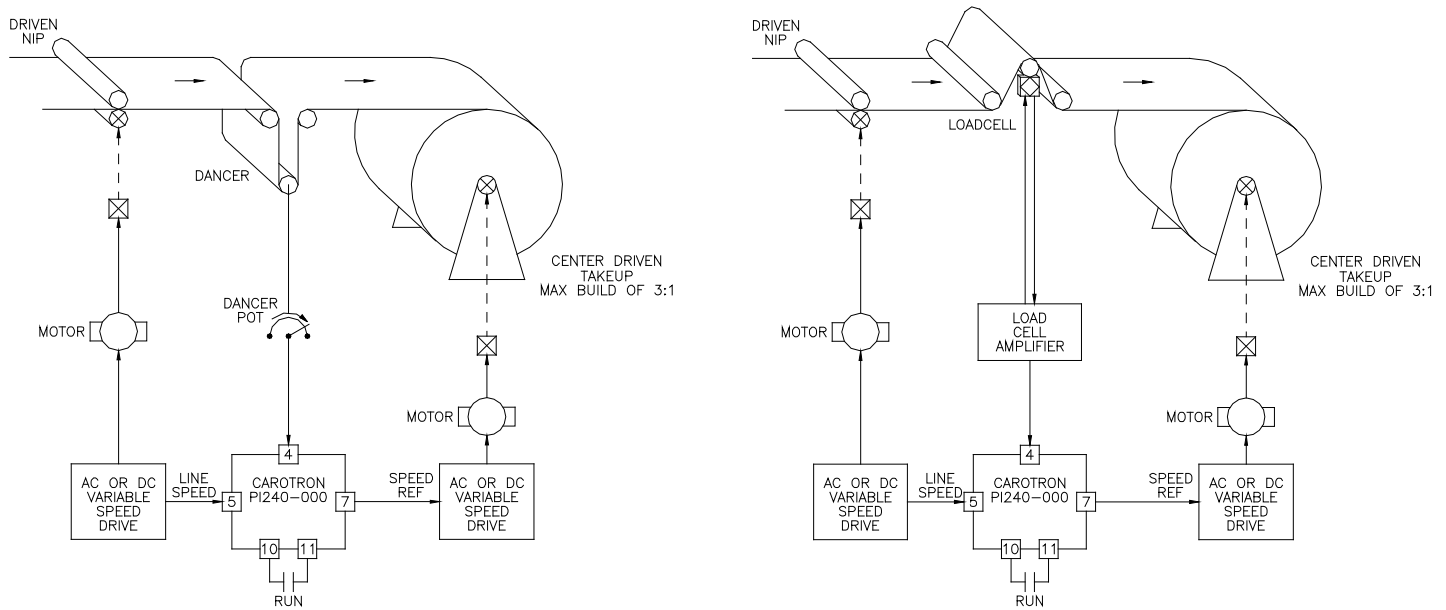


Figure 4: Takeup (Winder) Application Examples

Step 1: Select Output Type

1. Select the type of output desired using Jumper J2. If a Voltage output is desired, select V on J2 and use output terminals 7 (OUTPUT) and 8 (VOLTAGE RETURN). If a Current output is desired, select I on J2 and use output terminals 7 (OUTPUT) and 9 (CURRENT RETURN).

Step 2: Connections

1. Make connections per drawing C13703 on page 19. Initially, there should be no connection on the Teach input on terminal 12.

Step 3: Initial Setup

1. Initial commissioning should be performed with the smallest winder core that will ever be used and without product in the machine.
2. Set all potentiometer to 8 turns clockwise. If the current positions are unknown or in doubt, rotate pot counter clockwise 20 turns, then clockwise 8 turns.
3. For dancer systems, verify that the full range of motion of the dancer does not exceed the allowable electrical range (i.e., the potentiometer does not rollover from min to max or vice versa).

Step 4: Build Ratio

1. Determine the *Build Ratio* of the winder. If multiple sizes are used, calculate with the smallest core diameter and largest maximum diameter. Note that the PI240-000 module is only designed to handle build ratios of approximately 3 or less. For larger *Build Ratios*, contact Carotron, Inc. for assistance.

$$\text{BuildRatio} = \frac{\text{MaximumRollDiameter}}{\text{MinimumRollDiameter}}$$

Step 5: Teach Process Variable (Feedback)

1. The order in which the two extreme feedback levels (minimum and maximum) are taught determines the logic of the control loop.
2. For Dancer systems, position the dancer at the extreme position that should force the follower drive to increase in speed. For Loadcell systems, apply either no load or full load (by hanging weights in the material path) to the loadcell that should cause the follower drive to increase in speed.
3. Apply power to the PI240-000 Module. Within one minute, connect the Teach input (terminal 12) to circuit common (terminal 11).
4. For Dancer systems, position the dancer at the other extreme position that should force the follower drive to decrease in speed. For Loadcell systems, apply the other extreme signal (either no load or full load) that should cause the follower drive to decrease in speed.
5. Disconnect the Teach input (terminal 12) from circuit common (terminal 11).

Step 6: Select Bipolar Integral

1. Wait at least one minute after applying power to the module and place a jumper from the Teach input (terminal 12) to circuit common (terminal 11).

Step 7: Speed Match

1. Ensure the enable contact between terminals 10 & 11 is open.
2. Enable the lead and takeup drives. Run the lead drive up to maximum desired speed. The line speed reference signal that is connected to the Summing Input on terminal 5 should be scaled to a maximum of 9 volts.
3. Using a handheld tachometer, measure the surface speed of the lead drive. This is the *MaximumSurfaceSpeed*. Adjust the (empty core) speed of the takeup drive until its surface speed is slightly faster (10%) than this value. The takeup drive speed would typically be adjusted by using its Max Speed or Analog Input Gain adjustment.

Step 8: PI Trim

1. Manually force the dancer or loadcell feedback sensor so it is in the “slow down” state.
2. Enable the PI loop by closing the contact across terminals 10 & 11. Verify that the module output decreases and causes the takeup drive to decrease in speed.
3. Likewise, manually force the dancer or loadcell feedback sensor so it is in the “speed up” state, and verify that the takeup drive increases in speed.
4. If the module exhibits opposite logic (i.e. increases speed when it should decrease speed), then repeat Step 5 teaching the feedback levels in the opposite order.
5. With the dancer or loadcell in the “slow down” state, wait until the PI module output on terminal 7 saturates (stops decreasing). Adjust the PI Trim

potentiometer until the takeup drive surface speed matches the *FinishSurfaceSpeed*.

$$FinishSurfaceSpeed = \frac{MaximumSurfaceSpeed}{BuildRatio} \times 0.90$$

For example, if the *MaximumSurfaceSpeed* (measured in step 7 above) is 300 Ft/Min, and the *BuildRatio* is 2.5, the *FinishSurfaceSpeed* is 108 Ft/Min.

6. Stop all drives.

Step 9: Tune

1. Load material and run machine. For dancer systems, adjust the Setpoint potentiometer to set the desired operating position of the dancer. For loadcell systems, adjust the Setpoint potentiometer until the desired tension level is achieved.
 2. If necessary, adjust the Prop Gain and Integral Time potentiometers if any instability is noticed or response time is sluggish.
-

5.3 Letoff (Unwinder) Adjustment Procedure

In a letoff application, a Line Speed signal from the lead drive should be connected to the Summing Input on the PI module. This speed signal will pass through the module and be present on the output, which is connected to the speed reference of the letoff drive. The letoff drive's empty core surface speed should then be scaled to its max diameter speed match. A feedback device, such as a dancer or loadcell, can then be used with the PI module to add to the Line Speed signal as the diameter decreases and the letoff speed increases (Figure 5).

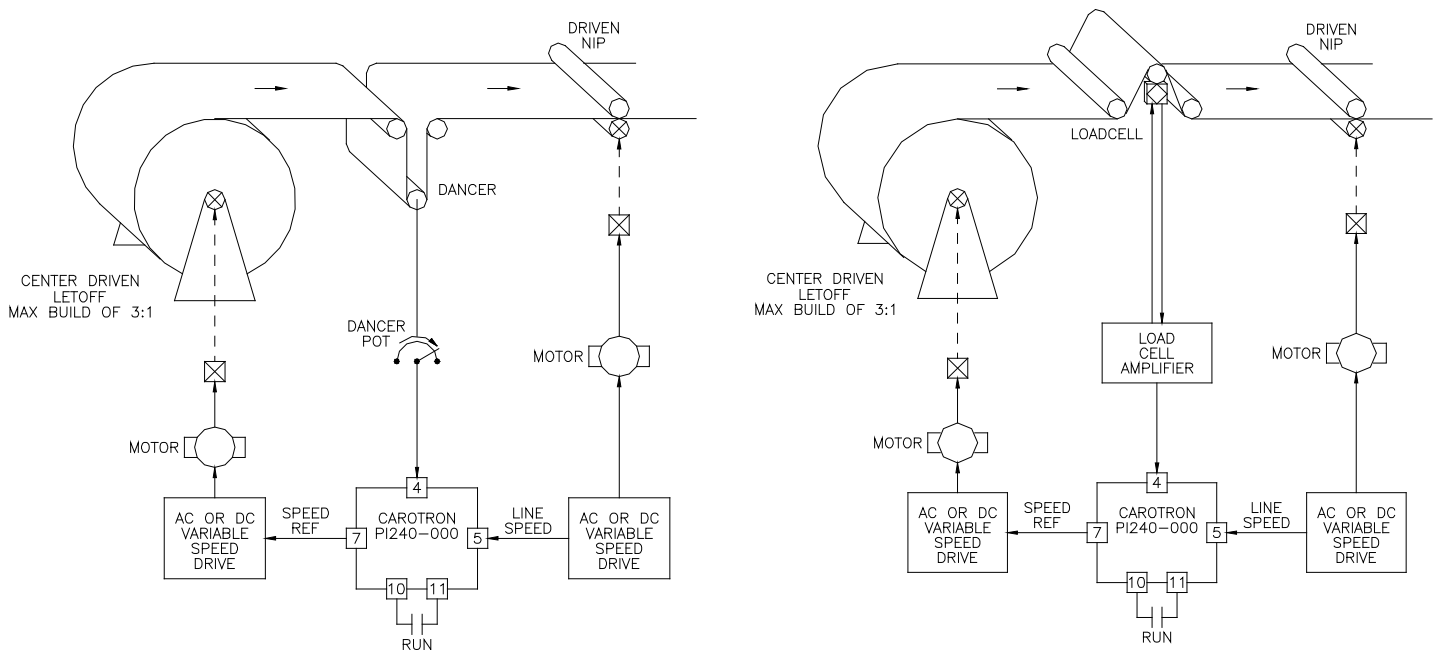


Figure 5: Letoff (Unwinder) Application Examples

Step 1: Select Output Type

1. Select the type of output desired using Jumper J2. If a Voltage output is desired, select V on J2 and use output terminals 7 (OUTPUT) and 8 (VOLTAGE RETURN). If a Current output is desired, select I on J2 and use output terminals 7 (OUTPUT) and 9 (CURRENT RETURN).

Step 2: Connections

1. Make connections per drawing C13703 on page 19. Initially, there should be no connection on the Teach input on terminal 12.

Step 3: Initial Setup

1. Initial commissioning should be performed with the smallest core that will ever be used and without product in the machine.
2. Set all potentiometer to 8 turns clockwise. If the current positions are unknown or in doubt, rotate pot counter clockwise 20 turns, then clockwise 8 turns.
3. For dancer systems, verify that the full range of motion of the dancer does not exceed the allowable electrical range (i.e., the potentiometer does not rollover from min to max or vice versa).

Step 4: Build Ratio

1. Determine the *Build Ratio* of the letoff. If multiple sizes are used, calculate with the smallest core diameter and largest maximum diameter. Note that the PI240-000 module is only designed to handle *Build Ratios* of approximately 3 or less. For larger *Build Ratios*, contact Carotron, Inc. for assistance.

$$\text{BuildRatio} = \frac{\text{MaximumRollDiameter}}{\text{MinimumRollDiameter}}$$

Step 5: Teach Process Variable (Feedback)

1. The order in which the two extreme feedback levels (minimum and maximum) are taught determines the logic of the control loop.
2. For Dancer systems, position the dancer at the extreme position that should force the follower drive to increase in speed. For Loadcell systems, apply either no load or full load (by hanging weights in the material path) to the loadcell that should cause the follower drive to increase in speed.
3. Apply power to the PI240-000 Module. Within one minute, connect the Teach input (terminal 12) to circuit common (terminal 11).
4. For Dancer systems, position the dancer at the other extreme position that should force the follower drive to decrease in speed. For Loadcell systems, apply the other extreme signal (either no load or full load) that should cause the follower drive to decrease in speed.
5. Disconnect the Teach input (terminal 12) from circuit common (terminal 11).

Step 6: Select Unipolar Integral

1. Wait at least one minute after applying power to the module and place a jumper from the Teach input (terminal 12) to circuit common (terminal 11).

Step 7: Speed Match

1. Ensure the enable contact between terminals 10 & 11 is open.
2. Enable the lead and letoff drives. Run the lead drive up to maximum desired speed. Using a handheld tachometer, measure the surface speed of the lead drive. This is the *MaximumSurfaceSpeed*.
3. Divide 10V by the *Build Ratio* value to determine the maximum Summing Input value. The line speed reference signal (from the lead drive) that is connected to the Summing Input on terminal 5 should be scaled to slightly lower than this value. For example, a *Build Ratio* of 2 would yield 10/2=5V. The Sum signal should then be scaled approximately 10% lower to yield 4.5V.
4. Adjust the speed of the letoff drive until its surface speed matches the *StartSurfaceSpeed*.

$$\text{StartSurfaceSpeed} = \frac{\text{MaximumSurfaceSpeed}}{\text{BuildRatio}} \times 0.90$$

For example, if the *MaximumSurfaceSpeed* (measured above) is 350 Ft/Min, and the *BuildRatio* is 2, the *StartSurfaceSpeed* is 158 Ft/Min. The letoff drive speed would typically be adjusted by using its Max Speed or Analog Input Gain adjustment.

Step 8: PI Trim

1. Manually force the dancer or loadcell feedback sensor so it is in the “speed up” state.
2. Enable the PI loop by closing the contact across terminals 10 & 11. Verify that the module output increases and causes the letoff drive to increase in speed.
3. Likewise, manually force the dancer or loadcell feedback sensor so it is in the “slow down” state, and verify that the letoff drive decreases in speed.
4. If the module exhibits opposite logic (i.e. decreases speed when it should increase speed), then repeat Step 5 teaching the feedback levels in the opposite order.
5. With the feedback sensor in the “speed up” state, wait until the PI output saturates (stops increasing) and adjust the PI Trim potentiometer until the letoff drive surface speed is approximately 10% faster than the *MaximumSurfaceSpeed*.
6. Stop all drives.

Step 9: Tune

1. Load material and run machine. For dancer systems, adjust the Setpoint potentiometer to set the desired operating position of the dancer. For loadcell systems, adjust the Setpoint potentiometer until the desired tension level is achieved.
 2. If necessary, adjust the Prop Gain and Integral Time potentiometers if any instability is noticed or response time is sluggish.
-

5.4 General PI Adjustment Procedure

The following is a generic procedure for setting up the PI module.

Step 1: Select Output Type

1. Select the type of output desired using Jumper J2. If a Voltage output is desired, select V on J2 and use output terminals 7 (OUTPUT) and 8 (VOLTAGE RETURN). If a Current output is desired, select I on J2 and use output terminals 7 (OUTPUT) and 9 (CURRENT RETURN).

Step 2: Connections

1. Make connections per drawing C13703 on page 19. Initially, there should be no connection on the Teach input on terminal 12.

Step 3: Initial Setup

1. Initially set all potentiometer to 8 turns clockwise. If the current positions are unknown or in doubt, rotate pot counter clockwise 20 turns, then clockwise 8 turns.

Step 4: Teach Process Variable (Feedback)

1. The order in which the two extreme feedback levels (minimum and maximum) are taught determines the logic of the control loop.
2. Apply the feedback signal level (either minimum or maximum) to terminal 4 that should cause the output to increase. Apply power to the module and within one minute, connect the Teach input (terminal 12) to circuit common (terminal 11).
3. Apply the other extreme feedback signal level (either minimum or maximum) to terminal 4 and disconnect the Teach input (terminal 12) from circuit common (terminal 11).

Step 5: Select Unipolar or Bipolar

1. If bipolar operation is desired, wait at least one minute after the unit has been powered and place a jumper from the Teach input (terminal 12) to circuit common (terminal 11). No connection on terminal 12 selects unipolar.

Step 6: PI Trim

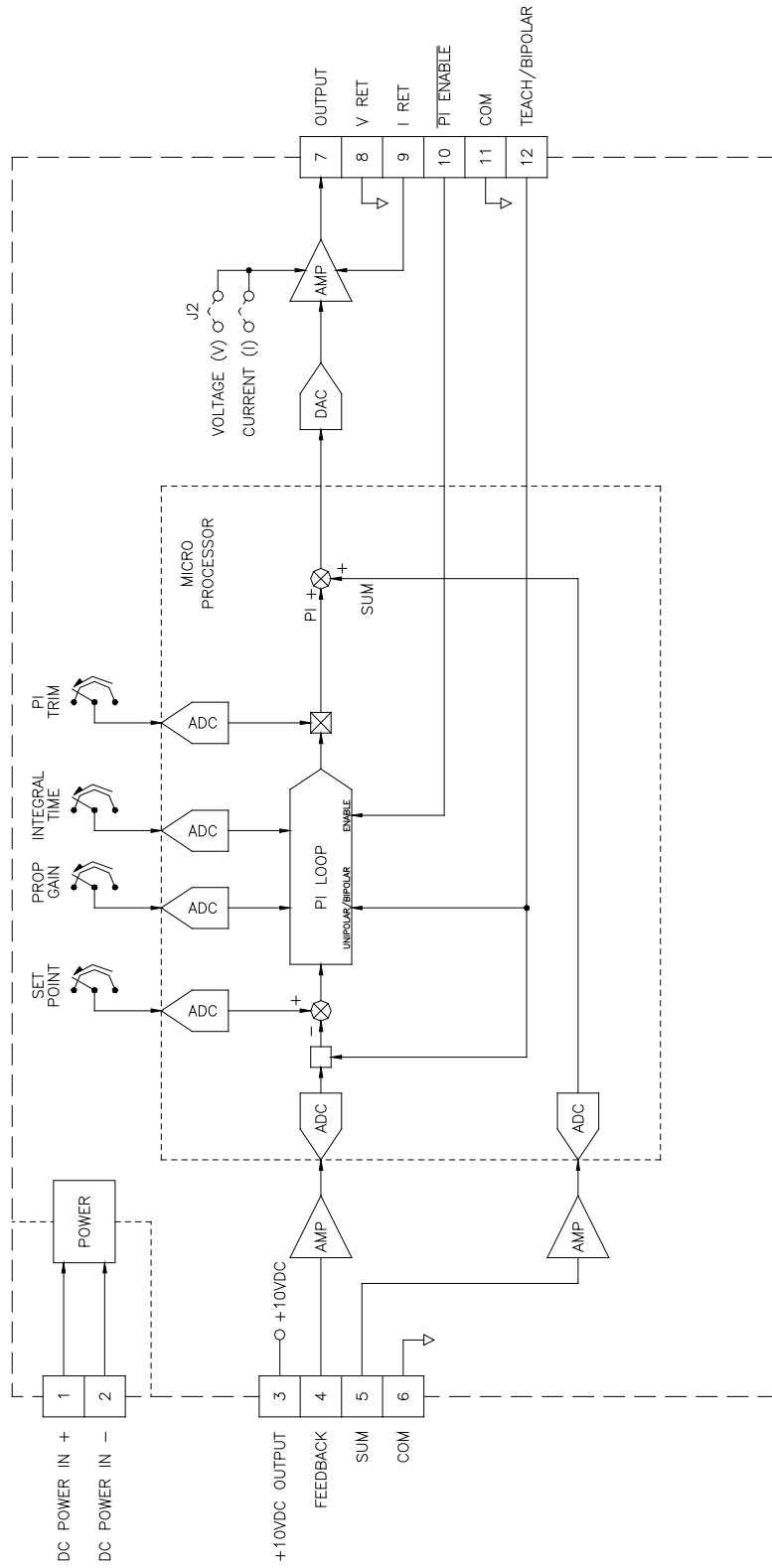
1. Manually force the feedback sensor so it is in the "increase output" state. Enable the PI loop by closing the contact across terminals 10 & 11.
2. Verify that the module output signal increases.
3. Likewise, manually force the feedback sensor so it is in the "decrease output" state and verify that the output decreases.
4. If the module exhibits opposite logic (i.e. increases speed when it should decrease speed), then repeat Step 4 teaching the feedback levels in the opposite order.
5. Wait until the PI output saturates (stops increasing or decreasing) and adjust the PI Trim potentiometer until the desired output level is achieved.

Step 7: Tune

1. Any signal applied to the Summing Input (terminal 5) will sum with the PI signal and output on terminal 7.
2. If necessary, adjust the Prop Gain and Integral Time potentiometers if any instability is noticed or response time is sluggish.

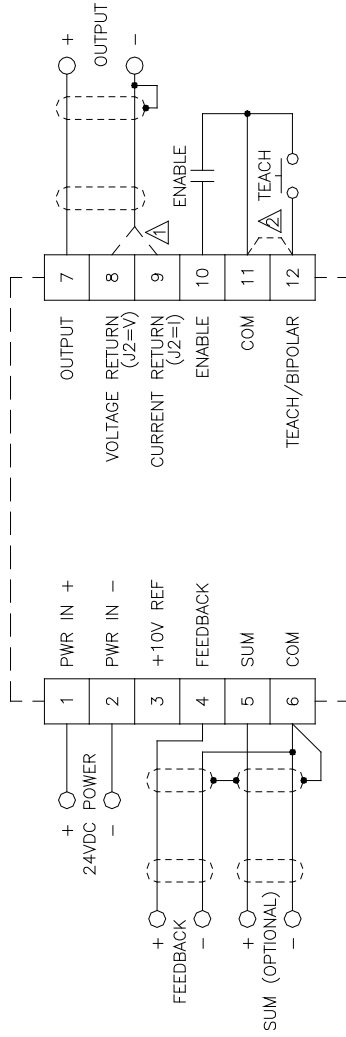
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Prints

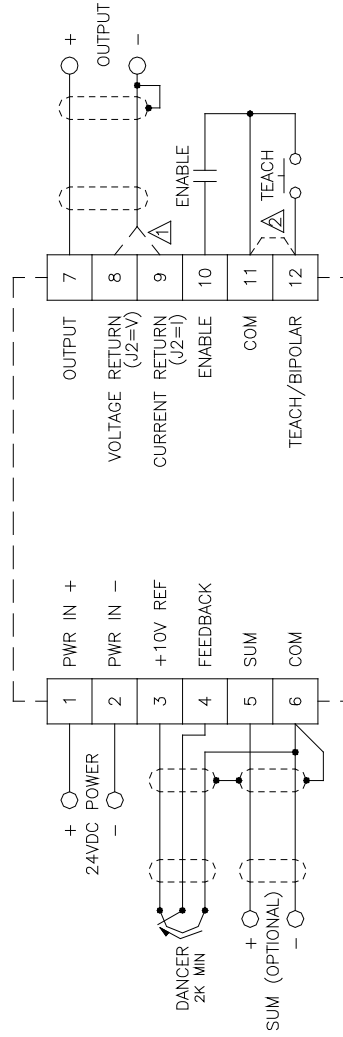


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GENERAL CONNECTIONS



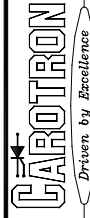
DANCER POTENTIOMETER CONNECTIONS



NOTES:

- △ FOR A VOLTAGE OUTPUT, SET J2=V AND CONNECT THE NEGATIVE OUTPUT WIRE TO TERMINAL 8. FOR A CURRENT OUTPUT, SET J2=I AND CONNECT THE NEGATIVE OUTPUT WIRE TO TERMINAL 9.
- △ TERMINAL 12 SERVES AS THE TEACH FUNCTION DURING THE FIRST MINUTE OF OPERATION AFTER POWER UP. IT ALSO SERVES AS A UNIPOLAR/BIPOLAR SELECTION FOR THE INTEGRAL CIRCUIT. BIPOLAR CAN BE SELECTED BY CONNECTING A JUMPER FROM 11 TO 12 AFTER THE UNIT HAS BEEN POWERED FOR LONGER THAN ONE MINUTE OR BY CONNECTING JUMPER AND THEN APPLYING POWER.

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TELEPHONE: * 803	SCALE:
2. BEC. PL. = .00"	
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TITLE: PI240-000 GENERAL CONNECTIONS	
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	SH. 1 OF 1



HEATH SPRINGS, SC
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PI240-000
 GENERAL
 CONNECTIONS

SCALE:

DRAWING NUMBER: **C13703**

REV. **A**

SH. **1** OF **1**

Standard Terms & Conditions of Sale

1. General

The Standard Terms and Conditions of Sale of Carotron, Inc. (hereinafter called "Company") are set forth as follows in order to give the Company and the Purchaser a clear understanding thereof. No additional or different terms and conditions of sale by the Company shall be binding upon the Company unless they are expressly consented to by the Company in writing. The acceptance by the Company of any order of the Purchaser is expressly conditioned upon the Purchaser's agreement to said Standard Terms and Conditions. The acceptance or acknowledgement, written, oral, by conduct or otherwise, by the Company of the Purchaser's order shall not constitute written consent by the Company to addition to or change in said Standard Terms and Conditions.

2. Prices

Prices, discounts, allowances, services and commissions are subject to change without notice. Prices shown on any Company published price list and other published literature issued by the Company are not offers to sell and are subject to express confirmation by written quotation and acknowledgement. All orders of the Purchaser are subject to acceptance, which shall not be effective unless made in writing by an authorized Company representative at its office in Heath Springs, S.C. The Company may refuse to accept any order for any reason whatsoever without incurring any liability to the Purchaser. The Company reserves the right to correct clerical and stenographic errors at any time.

3. Shipping dates

Quotation of a shipping date by the Company is based on conditions at the date upon which the quotation is made. Any such shipping date is subject to change occasioned by agreements entered into previous to the Company's acceptance of the Purchaser's order, governmental priorities, strikes, riots, fires, the elements, explosion, war, embargoes, epidemics, quarantines, acts of God, labor troubles, delays of vendors or of transportation, inability to obtain raw materials, containers or transportation or manufacturing facilities or any other cause beyond the reasonable control of the Company. In no event shall the Company be liable for consequential damages for failure to meet any shipping date resulting from any of the above causes or any other cause.

In the event of any delay in the Purchaser's accepting shipment of products or parts in accordance with scheduled shipping dates, which delay has been requested by the Purchaser, or any such delay which has been caused by lack of shipping instructions, the Company shall store all products and parts involved at the Purchaser's risk and expense and shall invoice the Purchaser for the full contract price of such products and parts on the date scheduled for shipment or on the date on which the same is ready for delivery, whichever occurs later.

4. Warranty

The Company warrants to the Purchaser that products manufactured or parts repaired by the Company, will be free, under normal use and maintenance, from defects in material and workmanship for a period of one (1) year after the shipment date from the Company's factory to the Purchaser. The Company makes no warranty concerning products manufactured by other parties.

As the Purchaser's sole and exclusive remedy under said warranty in regard to such products and parts, including but not limited to remedy for consequential damages, the Company will at its option, repair or replace without charge any product manufactured or part repaired by it, which is found to the Company's satisfaction to be so defective; provided, however, that (a) the product or part involved is returned to the Company at the location designated by the Company, transportation charges prepaid by the Purchaser; or (b) at the Company's option the product or part will be repaired or replaced in the Purchaser's plant; and also provided that (c) the Company is notified of the defect within one (1) year after the shipment date from the Company's factory of the product or part so involved.

The Company warrants to the Purchaser that any system engineered by it and started up under the supervision of an authorized Company representative will, if properly installed, operated and maintained, perform in compliance with such system's written specifications for a period of one (1) year from the date of shipment of such system.

As the Purchaser's sole and exclusive remedy under said warrant in regard to such systems, including but not limited to remedy for consequential damages, the Company will, at its option, cause, without

charges any such system to so perform, which system is found to the Company's satisfaction to have failed to so perform, or refund to the Purchaser the purchase price paid by the Purchaser to the Company in regard thereto; provided, however, that (a) Company and its representatives are permitted to inspect and work upon the system involved during reasonable hours, and (b) the Company is notified of the failure within one (1) year after date of shipment of the system so involved.

The warranties hereunder of the Company specifically exclude and do not apply to the following:

- a. Products and parts damaged or abused in shipment without fault of the Company.
- b. Defects and failures due to operation, either intentional or otherwise, (1) above or beyond rated capacities, (2) in connection with equipment not recommended by the Company, or (3) in an otherwise improper manner.
- c. Defects and failures due to misapplication, abuse, improper installation or abnormal conditions of temperature, humidity, abrasives, dirt or corrosive matter.
- d. Products, parts and systems which have been in any way tampered with or altered by any party other than an authorized Company representative.
- e. Products, parts and systems designed by the Purchaser.
- f. Any party other than the Purchaser.

The Company makes no other warranties or representation, expressed or implied, of merchantability and of fitness for a particular purpose, in regard to products manufactured, parts repaired and systems engineered by it.

5. Terms of payment

Standard terms of payment are net thirty (30) days from date of the Company invoice. For invoice purposed, delivery shall be deemed to be complete at the time the products, parts and systems are shipped from the Company and shall not be conditioned upon the start up thereof. Amounts past due are subject to a service charge of 1.5% per month or fraction thereof.

6. Order cancellation

Any cancellation by the Purchaser of any order or contract between the Company and the Purchaser must be made in writing and receive written approval of an authorized Company representative at its office in Heath Springs, S.C. In the event of any cancellation of an order by either party, the Purchaser shall pay to the Company the reasonable costs, expenses, damages and loss of profit of the Company incurred there by, including but not limited to engineering expenses and expenses caused by commitments to the suppliers of the Company's subcontractors, as determined by the Company.

7. Changes

The Purchaser may, from time to time, but only with the written consent of an authorized Company representative, make a change in specifications to products, parts or systems covered by a purchase order accepted by the company. In the event of any such changes, the Company shall be entitled to revise its price and delivery schedule under such order.

8. Returned material


If the Purchaser desires to return any product or part, written authorization thereof must first be obtained from the Company which will advise the Purchaser of the credit to be allowed and restocking charges to be paid in regard to such return. No product or part shall be returned to the Company without a "RETURN TAG" attached thereon which has been issued by the Company.

9. Packing

Published prices and quotations include the Company's standard packing for domestic shipment. Additional expenses for special packing or overseas shipments shall be paid by the Purchaser. If the Purchaser does not specify packing or accepts parts unpacked, no allowance will be made to the Purchaser in lieu of packing.

10. Standard transportation policy

Unless expressly provided in writing to the contrary, products, parts and systems are sold f.o.b. first point of shipment. Partial shipments shall be permitted, and the Company may invoice each shipment separately. Claims for non-delivery of products, parts and systems, and for damages thereto must be filed with the carrier by the Purchaser. The Company's responsibility therefor shall cease when the carrier signs for and accepts the shipment.



CAROTRON

Driven by Excellence

D.C. DRIVES, A.C. INVERTERS,
SOLID STATE STARTERS, SYSTEM INTERFACE
CIRCUITS AND ENGINEERED SYSTEMS

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