Dancer Position Card

Instruction Manual
Model D10541-000

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

Table of Contents

1 General Description

Model D10541-000 Dancer Position Card, also referred to as a P.I.D. control, is designed for applications where dancer positioning is used to maintain control of motorized operations. In addition to dancer positioning, this card is also suitable for most any type of P.I.D. control application. The electronic circuitry utilizes the Proportional, Integral, and Derivative functions to condition the output. Each function can be adjusted independently to control the amount of change in the output voltage.

The output of the proportional circuit is a voltage level proportional to the dancer and position inputs.

The output of the integral circuit is dependent on S1 and the DEADBAND and INTEGRAL RATE adjustments and can also be scaled by an external reference voltage applied to the scaling input. The scaling input can be modified via multi-turn OFFSET, BIAS, and GAIN potentiometers. The resulting voltage then becomes reference to a 12 bit digital to analog converter which is a four quadrant multiplying type. This converter allows the circuit to ratio the reference input and provide a percentage of the reference as output.

The derivative circuit adds to the output during changes in the dancer input. The response and level of the derivative function are independently adjustable to allow for flexible and stable operation.

The output of the proportional, integral, and derivative are summed together to formulate the final output. This output can be further modified by an output range potentiometer.

A summing input is provided to allow an external voltage to be summed directly with the output. A selection is supplied to change the function, addition or subtraction, of the summing input as required.

Positive, negative, and bipolar connection terminals are available for use. The positive output will only allow the positive portion of the output to be used. The negative output will only allow the negative portion of the output to be used. The bipolar output will allow both positive and negative signals to be used.

2 Specifications

A.C. Input

- 115 VAC ±10%, 50/60 Hz., Internally fused at 0.3 amps

Isolation Voltage

- 2400 V PEAK at 1 second or 1500 VRMS max.

NOTE: The Scaling input is the only input that is isolated from the output

Scaling Input

D.C. Voltage Input	Input Impedance
0 - 25V	1M OHMS
0 - 50V	1M OHMS
0 - 100V	1M OHMS
0 - 200V	1M OHMS

Position Potentiometer Input

- -15 VDC available to supply a 2K to 10K ohm potentiometer

Dancer Potentiometer Input

- +15 VDC available to supply a 2K to 10K ohm potentiometer

Summing Input

- Fixed or variable -10 VDC to +10 VDC with a selection to change the function, addition or subtraction as required. Isolation is not maintained between this input and the output.

External Reset Input

- Contact closure required to reset internal control circuits.

NOTE: This contact should be closed anytime the dancer drive is disabled.

MIN. and MAX. Count Output

- Minimum and maximum count on the digital to analog converter are each indicated by a normally open contact rated at 120VAC at 1 amp.

Voltage Output

Bipolar: This output can source up to ±10VDC into a minimum resistance of 1K ohms.

Positive: This output can source up to +10VDC into a minimum resistance of 1K ohms.

Negative: This can source up to -10VDC into a minimum resistance of 1k ohms.

3 Description of Programing & Adjustments

Jumpers

J1

Selects between the 4 Scaling Voltage Input Ranges: 0 - 25, 0 - 50, 0 - 100, 0 - 200.

J2

Selects the function, addition (+) or subtraction to be performed by the summing input.

J3 & J4

The dancer and position input signals at TB1 terminals 7 and 10 must have opposite polarities for proper operation. When using the +15V and - 15V supplies at TB1 terminals 6 and 9, the signals will have opposite polarities, and both jumpers should be placed in the STD or standard position. If two external signals of like polarity are being used, one of the signals will need to be inverted. This can be achieved by placing either J3 or J4 in the INV or invert position. The card output polarity will be based on the logic of the input signals and the polarity of the net sum of the corrected signals. Usually, the position or setpoint signal has a negative polarity, and the dancer or feedback signal has a positive polarity.

Switch S1

Sets the operating mode of the D to A converter circuit that provides the INTEGRAL function. With the BI (bipolar) position selected, the integral signal will be reset to zero volts at mid-count of the D to A converter. The D to A can then count up from this point to produce positive output and down to produce negative output. The maximum integral output, regardless of polarity, will be the level of voltage present at TP12, Scaled Output.

NOTE: The ability of the integral output to go negative can effectively be used with a regenerative type motor control to cause the motor to reverse. This could be an advantage in a loop control application where the dancer/loop can automatically return to position after threading or emergency stop or to allow running in reverse.

When negative integral outputs are undesirable, the UNI (unipolar) position can be selected. This will allow the D to A converter to be reset to zero volts at minimum count. The output will increase positive as the count increases and can range up to the TP12, Scaled Output level.

Potentiometers

Scaling Offset

Used to null the first stage amplifier of the Scaling Input to 0.0 VDC with minimum reference input.

Scaling Gain

Sets the maximum reference to the digital to analog converter with maximum scaling input.

Scaling Bias

Sets the desired reference to the digital to analog converter with the minimum scaling input.

Deadband

Sets a level of tolerance that will allow the integral circuit to ignore small dancer movements.

Internal Position

Sets the position level internally when an external potentiometer is not used.

Output Range

Sets the range of the output from 0 to 100%.

Integral Rate

Sets how fast the Integral circuit counts up or down. Its range is approximately 0.5 to 15 seconds from minimum to maximum extremes.

Proportional Level

Sets the amount of the proportional voltage level to be used in the final output (full CCW will disable the proportional level).

Derivative Level

Sets the amplitude of the derivative voltage level to be used in the final output. (full CCW will disable the derivative function)

Derivative Response

Sets the rate at which the derivative responds.

4 Quick Start Adjustment Procedure

(Dancer position application)

Step 1

Refer to connection diagram C10542 in section 5 to insure proper connection of the model D10541000 Dancer Position Card.

Step 2

Initial potentiometers settings: (100% = full CW)

Internal Position	0%
Proportional Level	50%
Integral Rate	50%
Deadband	50%
Derivative Response	0%
Derivative Level	0%
Output Range	100%
S1	*see S1 description in section 3*

Step 3

Apply 115 VAC to the dancer position card.

Step 4

(Omit this step if using an external scaling reference signal)

Select the 0-25V range at jumper J1. Adjust the SCALING GAIN potentiometer full CW and the SCALING BIAS potentiometers full CCW. Monitor TP13 with a DC voltmeter and adjust the OFFSET potentiometer for 0.0 VDC at TP13 witb 0.0 volts input to terminal 4 with respect to terminal 5 at TB1. Jumper terminals 3 and 4 at TB1 and adjust the SCALING GAIN potentiometer for the desired reference to the integral circuit.

Step 5

(Omit this step if an external scaling reference is not used)

Determine the maximum input reference voltage and select the lowest input range which is greater than or equal to this at J1. Adjust the SCALING GAIN potentiometer full CW and the SCALING BIAS potentiometer full CCW. With the reference input at minimum, adjust the SCALING OFFSET potentiometer for 0.0 VDC at TP13. Turn the SCALING GAIN potentiometer full CCW. Adjust the SCALING BIAS potentiometer for the minimum output level desired with the minimum reference input at TP12. Normally 5 to 10% of the maximum desired reference to the integral circuit is a suitable Bias level. Apply full reference input voltage and adjust the SCALING GAIN potentiometer for the desired reference to the integral circuit.

Step 6

If the Summing Input is used, select the function, addition or subtraction, as required at jumper J2.

Step 7

Manually move the dancer to the desired operating position. With the dancer in position, monitor TP5 with a DC voltmeter. If using a remote position potentiometer, adjust the potentiometer for 0.0 VDC at TP5. If a remote position potentiometer is not used to set position, rotate the on board POSITION potentiometer clockwise to obtain 0.0 VDC at TP5.

Step 8

With no material in the machine, move the dancer out of position to insure that the dancer controlled drive will move in the direction that will bring the dancer back to the desired operating position.

Step 9

With the line stopped, thread the machine with some scrap material. The web should not be too tight or slack.

Step 10

Position the dancer at one end of its travel and start the dancer controlled drive. The drive should move the dancer to the desired position for normal operations.

NOTE: Reversing to correct dancer position may depend on type of drive used and position of S1. Refer to section 3 for explanation.

If the dancer does not position properly, adjustments will have to be made in order to fine tune the operation. Most applications will only require adjusting the INTEGRAL RATE, DEADBAND, OUTPUT RANGE, and PROPORTIONAL LEVEL potentiometers. The DERIVATIVE RESPONSE and DERIVATIVE LEVEL potentiometers should be adjusted in applications where the dancer responds too slowly. Refer to section 3 for a description of the function of each potentiometer.

5 Discussion

A general understanding of several terms and processes will be helpful in utilizing the full capabilities and benefits of the **D10541-000, PID / Dancer Position Card.** Refer to the Block Diagram C10712 and the following discussions for more insight on these subjects.

5.1 Open Loop and Closed Loop Control

This unit provides control in what is known as **closed loop** (as opposed to open loop) control. In **open loop**, the **setpoint reference** causes an output condition of temperature or speed or torque or tension, etc. that depends on the ability of the controller **by itself** to give an accurate control output. In **closed loop** control, the reference or setpoint signal is combined with a **feedback** signal to give output signal correction for more accurate control.

Examples of both types of controls appear in our homes. **Open loop** can be represented by a light dimmer or by a manually controlled gas stove burner that emits light or flames respectively according to where we set the control. In an electric iron or a heat-pump, the addition of a temperature sensing device (thermostat) to **feed back** to the control an accurate temperature signal **"closes the loop"** and lets the control know when the temperature reaches the setpoint level. An automobile cruise control is another example of **closed loop** control where drive shaft magnets and a sensor provide velocity **feedback** that is matched to the speed **setpoint** by an engine control.

An electronic **feedback** signal usually is a real-time representation of the controlled condition such as **speed** from an encoder or tachometer or **tension** from a loadcell. It is usually scaled to have about the same signal range as the setpoint but affects the output in a manner opposite to that of the setpoint. The job of the closed loop controller is to **increase** or **decrease** its output to cause the difference or **error** between the **setpoint** and **feedback** to be minimized.

Closed loop control can be provided for many applications such as **dancer positioning, web tension control, liquid level control, load sharing**, etc.

In the basic temperature control examples given above, the source of heat is simply cycled on and off. This works well enough because the iron or house temperature cannot change quickly and tends to be averaged. In the auto cruise control and most industrial motor applications, the engine or motor cannot be cycled on and off - it must change at a controlled rate until correct speed is achieved and then hold RPM constant.

In industrial motor control, operation variables such as line speed, acceleration and deceleration rates, load size, friction, inertia, position and others can affect the **total correction** to the output signal.

In these applications, required response to varying operating conditions demonstrates the need for several different signal-processing methods such as provided by the D10541-000, Dancer Position or **P.I.D**. card.

5.2 P.I.D. Processing

The three types of signal processing - signified by **P.I.D.** - are **Proportional, Integral, and Derivative.** In Carotron's Dancer Position Card, each of these signals can be generated **independently** in response to a setpoint/feedback error. They are then summed to provide a total closed loop output.

PROPORTIONAL

The *Proportional* signal results from the **error signal** being amplified 1-1/2 times and trimmed by the **P3, Proportional Level**, pot. This signal has fast response and is used to provide an immediate response component of the total output. In a Dancer position control application, <u>the Proportional signal is only present when the dancer is out of position,</u> i.e. when position error exists.

INTEGRAL

The *Integral* signal is **time related** to the presence of the error signal. The error polarity controls the direction or logic of change, increasing or decreasing, of the Integral signal.

When an error signal appears, the Integral signal begins changing and as long as the error is present, the signal continues to increase or decrease at a linear rate until the output reaches the **level that causes the error** (and Proportional signal) **to be minimized.** Because the <u>Integral output signal is the only one of the P.I.D. signals present once error has been minimized,</u> its' operating characteristics can be critical to accurate closed loop control.

DERIVATIVE

Derivative signal is also **time related** to the presence of the error signal. The **rate of change,** whether increasing or decreasing, affects the amplitude of Derivative output. A faster rate causes a higher output level. So then Derivative signal is only present and available when error signal is not only present, but is also changing.

Derivative feedback is a signal type, whose benefit is difficult to evaluate because its requirement can vary greatly with changes in load conditions such as speed, size or weight.

It is normally required in electro-mechanical systems **only** when there is some shortcoming or deficiency in the feedback signal accuracy, response, level or stability. It can then sometimes help by providing correction based on rate of change such as given by a dancer with limited storage or small range of rotation from the dancer pot.

5.3 D10541-000 Dancer Position Card Enhancements:

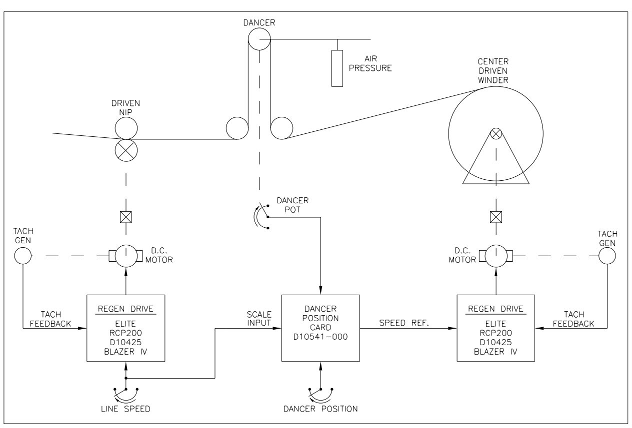
The Carotron Dancer Position Card gives control superior to conventional P.I.D. loops by virtue of several enhancements to its signal processing capability.

<u>Digital</u> <u>Integrator</u>

The Integral function's use of a **12 bit D to A Converter** and an **Isolated Integral Scaling** circuit gives several benefits. The D to A converter provides a very stable Integral signal. When setpoint/feedback error is minimized, the converter count is frozen. D to A converter operation is easily monitored during operation via 4 LED's that indicate COUNT UP, COUNT DOWN, MIN COUNT and MAX COUNT.

<u>Integral</u> <u>Scaling</u>

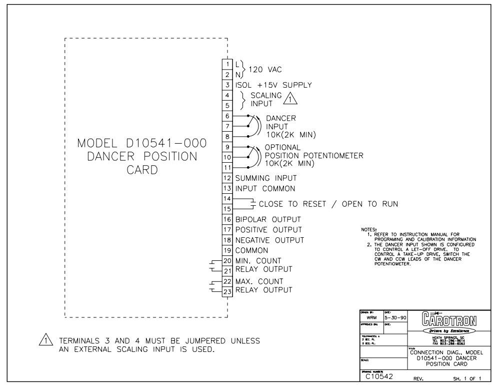
The <u>maximum</u> available Integral output signal can either be set by internal adjustment or be controlled by an external input signal such as line speed. This can give a dancer feedback mechanism consistent control sensitivity over variations in the line speed. Refer to Figure 1.



DANCER CONTROL OF A
CENTER DRIVEN WINDER
FIGURE 1

In the Center Driven Winder in Figure 1, the Dancer pot signal must initiate winder speed correction for two reasons.

First, the **change in diameter** requires that the Winder motor RPM decreases along a Hyperbolic curve as the diameter increases to keep the web surface speed constant. Refer to Figure 2. A three to one increase in diameter would mean that the motor RPM at core would be three times faster than the speed at full roll diameter.



Second, **changes in line speed** require an accompanying proportional change in the winder motor speed.

<u>EXAMPLE</u>:

When operated at 10 YPM line speed during "thread-up", the winder RPM will be 1/10 of the maximum required RPM when operating at 100 YPM speed.

Both changes mean that a total (3 x 10) 30:1 Winder motor speed range is required. Consider the factor with the greater change, line speed, and its affect on the dancer correction or resolution.

Remember, for the dancer pot to control in a "zero error" or at **Set** position, the Integral signal **alone** must be able to provide 100% of the required Winder speed reference. In a typical center wind application with no Integral scaling, the "100% speed" Integral signal range will be 10 times more signal than required when running at 10% line speed - **regardless** of diameter. This could cause over-sensitive or even unstable dancer control at low speeds.

With Integral Scaling, the proportional line speed Scaling signal would range the maximum available Integral signal down to 10% which keeps the dancer sensitivity more constant.

If the Winder drive was operating in **Torque** Mode instead of **Velocity** Mode, we could take advantage of the fact that winder torque must increase in direct proportion to the diameter (for Constant Tension). For wide changes from core to maximum, a diameter signal could be used as the Scaling Input.

With additional signal processing from Carotron's Multiplier/Divider Card or **CORTEX**, diameter signal can also be used to develop the hyperbolic reference signal for **velocity** scaling a center driven winder or unwinder.

Integral Deadband

A “window comparator” circuit and **Deadband** pot give the ability to set a range of ± error signal that can be ignored by the Integral circuit. This allows undesirable error signal such as produced by a bent roll or “loose coupled” Dancer Pot and that is less than the Deadband Setpoint to be rejected and not affect the stability of the Integral signal.

For Dancer mechanisms with limited material storage, Deadband signal can stabilize operation by allowing a “window” of acceptable error in dancer position before making corrections with the Integral signal. The D/A converter Integrator count then will remain frozen between small bursts of correction.

“Reset” Function

Contact closure at the RESET terminals can clear the D/A converter count and set all outputs to zero. A NC, normally closed, contact that opens when “Start” is initiated will assure that a wind/unwind motor will ramp from zero instead of “surging” on.

Unipolar/Bipolar Integrator Action

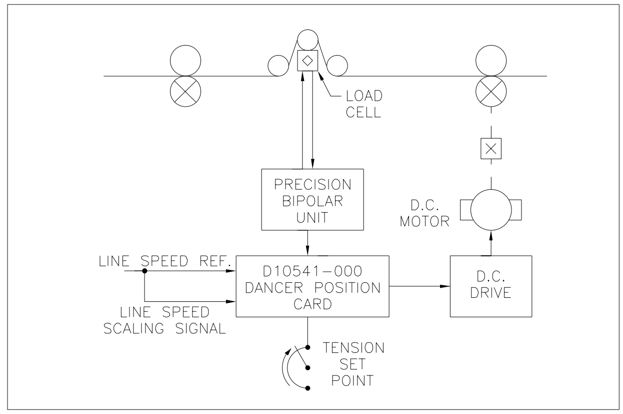
When the Integrator only has to make an increasing positive signal correction, such as required with torque control of a Center Driven Winder or in some velocity control applications, UNIPOLAR operation can be selected. This uses the full 4096 counts of the 12-bit D/A converter to produce “positive only” signal up to the Scaled Integral Signal Level at TP12.

When negative polarity signal is required for reversing or to subtract from a Summing Input signal, BI-POLAR operation can be selected. 50% D/A Converter count is preset when the “RESET” is opened to give zero volts Integral signal. “Count-Up” will give one polarity of Integral signal and “Count-Down” will give the opposite polarity.

Summing Input

An external signal can be added to or subtracted from the P.I.D. signal. This is very convenient in applications where a dancer or other feedback mechanism may be suitable for limited control or correction only.

For example, a dancer or load cell may provide accurate trimming ability but may be limited in response, storage, signal span, etc. Conversely, in some applications, a major portion of the output torque or speed reference may be directly proportional to roll size or line speed or some other readily available but sometimes less accurate signal. In these cases a pre-scaled speed or diameter signal can be connected to the Summing Input to set a coarse and initial output reference that it is combined for accuracy with the limited P.I.D. output signal.



ZONE TENSION BY LOAD CELL
FIGURE 3

As shown in Figure 3, control techniques are combined. A line speed signal is summed to provide a major portion of the NIP roll speed reference and is also used to scale the amount of Integral correction caused by the load-cell Tension feedback.

Setpoint/Feedback Signal Inversion

The inputs for the Setpoint, Position, and Feedback, Dancer, can be inverted in polarity by use of programming jumpers J3 and J4.

This can be used to correct for reversed logic from the Dancer pot signal, i.e. the dancer may be rotating to give decreasing signal when increasing signal is required.

They can also be used to invert the polarity of the card output if required.

They can be used to invert one input signal when the setpoint and feedback signals are the same polarity as in some load sharing applications.

6 Application Hints

When planning how to apply the Dancer position Card, think about the load and operating characteristics through a complete cycle of start-up, acceleration, process loading, deceleration and stopping. Answer the following questions:

- What changes occur and account for the largest variation in speed and/or load?
- Is direct control of torque more appropriate than speed control?
- Can line speed or diameter be used to scale the integral range or to directly sum as part of the total output?
- Does the card output need to increase rapidly upon start-up or slowly over a period of time?

• Does the Integral signal have to provide positive and negative output or can it be selected for UNIPOLAR, positive only output?

For example: A center driven **velocity mode winder** must initially accelerate a new core up to a line speed match. A scaled line speed signal could be **summed** to initially match the core with line speed while the Bi-polar integral could then subtract speed reference as diameter increases. Line speed could also be used to scale the maximum integral signal.

A center driven **torque mode winder** may require breakaway, dynamic friction and inertia compensating torque, but the largest change usually occurs with diameter change. A diameter signal could provide "diameter sensitivity" to the integral signal range to directly compensate for diameter increase.

A center driven **velocity mode unwinder or letoff** would start the heaviest and largest diameter roll size. A scaled line speed signal could be summed to initially match the full roll with line speed while Uni-polar integral could add speed as diameter decreases.

7 Adjustment Hints

- PID adjustments are to be made in the order spoken, i.e. **P**roportional, **I**ntegral, and **D**erivative last if used at all.
- The effect of any adjustment must be evaluated under all conditions of operation.
- Try to make and evaluate only one adjustment at a time. If trial adjustment makes no improvement to operation, return it to original setting before attempting new adjustment.
- The **Integral** signal is normally most responsible for closed loop accuracy because it is the only of the three present when error is minimized.
- It is important to understand that on the Model D10541-000, several things control the **Integral** signal rate-of-integration or response.
- INTEGRAL RATE, P6, controls the frequency of the trigger or clock of the counter circuit. Clockwise rotation means higher frequency and faster response.
- The Scaled Integral signal (TP12) is ranged over the D/A's 4096 total counts. When UNIPOLAR operating mode is selected by S1, each step or count equates to the TP12 voltage divided by 4096. In BIPOLAR mode each count equals the TP12 volts divided by 2048. Therefore in UNI mode, D/A signal resolution is finer (steps are smaller) than in BI mode. This also explains why the SCALED INTEGRAL signal should ideally be set (whether Internally or Externally scaled) no higher than needed for the highest level of correction required.
- Introduction of DEADBAND signal with P7 at TP8 has the effect of delaying Integral response by setting a voltage level that the setpoint/feedback error must exceed for the Integrator to begin correction.

8 Troubleshooting

When evaluating operation of the Dancer Position Card, there are different considerations to be made according to the specific type of feedback device being used. In many cases mechanical or physical shortcomings can affect how well the electronics are perceived to work. These devices should be inspected for proper application and/or function before electronic adjustments are attempted.

DANCERS:

Dancer pots are usually connected to a dancer mechanism, arm, accumulator, etc. by either direct in-line coupling or indirectly via belt or chain.

• Dancer motion, whether rotational or linear must be transferred to the pot or sensor with no lost "motion versus signal change". Chains and belts should be tensioned properly without forming slack in either direction of rotation. Coupling hardware must be tight to prevent slippage and should be sized to prevent twisting when rapidly positioned.

• The dancer must be connected or geared so that the sensor provides maximum signal change. For example; the pivot shaft of a swing arm type dancer that has 30 degrees of rotation should be coupled to the dancer pot (typically with 300 or more degrees of rotation) by gearing that will cause it to rotate most of its range. This gives the benefit of better control resolution by producing more position error and in the above example up to 10 times more proportional signal correction.

Use care though to make sure that the pot mechanical rotation range does not exceed the usable electrical range.

• The amount of dancer "running time storage" capacity is always an important issue. More material in a loop or multiple pass type dancers or accumulators can make operation more forgiving and extend process operating range.

ULTRASONICS:

Ultrasonic sensors can provide non-contact position or diameter information that be used in lieu of dancers, rider arms, etc.

Several things affect the detection ability and accuracy of ultrasonic detectors.

• Shape of target and ultrasonic sound beam: Ultrasonic detection "cone diameter" usually increases with distance and can cause undesirable targets not directly in front of the sensor to give erroneous measurements. Concave targets can focus echoes and improve detection of small or distant targets.

• Distance between sensor and target: Because echo signal strength rapidly attenuates with distance increase, distant targets generally need to be larger. Detection of sound deadening or dispersing material such as open cell foam or loosely woven or knit materials require shorter detection ranges.

• Alignment of sensor and target: For example; in web loop detection the sensor should be placed over the section of loop that will reflect an echo directly back to the sensor, usually the valley of the loop. The valley of a loop that is formed on one side by a center driven roll will change position under the sensor as the roll diameter changes.

Loop position in both the X and Y-axis or across the width as well as length should be examined.

If cutting inspection samples leaves holes in the loop, the sensor must be positioned so as not to "see through and beyond" the target or the sensor electronics must be able to ignore targets outside of the normal detection range.

• Other sources of ultrasonic sound such as compressed air leaks, high speed spindles or other ultrasonic detectors can interfere with accurate measurement.

LOADCELLS:

Properly applied loadcells can provide accurate and direct tension or force feedback in a variety of applications. In continuous web applications though, they can sometimes be thought of as "zero storage" dancers. In these cases loadcells are best used to provide limited correction or fine tuning of less accurate tension control that is provided by calculation or "open loop" means of control.

• Undersizing as well as oversizing of loadcells is to be avoided. Alignment and percentage wrap of loadcell mounted rolls are important to proper operation.

TACHOMETERS/ENCODERS:

Tachometers and encoders must be tightly coupled with minimal tortional twisting. Use of wiring techniques such as shielding and proper routing can prevent distortion and errors in their outputs. Excess loading can cause error that may not be immediately apparent.

SYMPTOMS AND POTENTIAL CAUSES:

Card output and controlled speed, torque, tension, etc. surges upon "start".

1. External RESET contact not closing to initially set integrator count and all output voltage signals at zero. Use N.C. contact that opens upon "start".

Dancer oscillates or hunts all of the time.

1. Dancer pot coupled by loose belt or chain.
2. Dancer pot resistance element dirty or worn in spots.
3. Dancer pot rotating past usable electrical range. Integral Rate set too fast.
4. Motor control Accel/Decel not set to minimum time or fastest rate.

Dancer oscillates or hunts with larger material rolls.

1. Too little dancer storage.
2. Drive/motor undersized
3. Current range or limit set too low.
4. Integral Scaling too low when torque controlling. Must set at full roll.
5. Integral Scaling set too high when speed controlling. Must be set at core.
6. Too much Derivative signal

Dancer oscillates or hunts at lower line speed.

1. Integral Scaling set too high when velocity controlling.
2. Too much Derivative signal

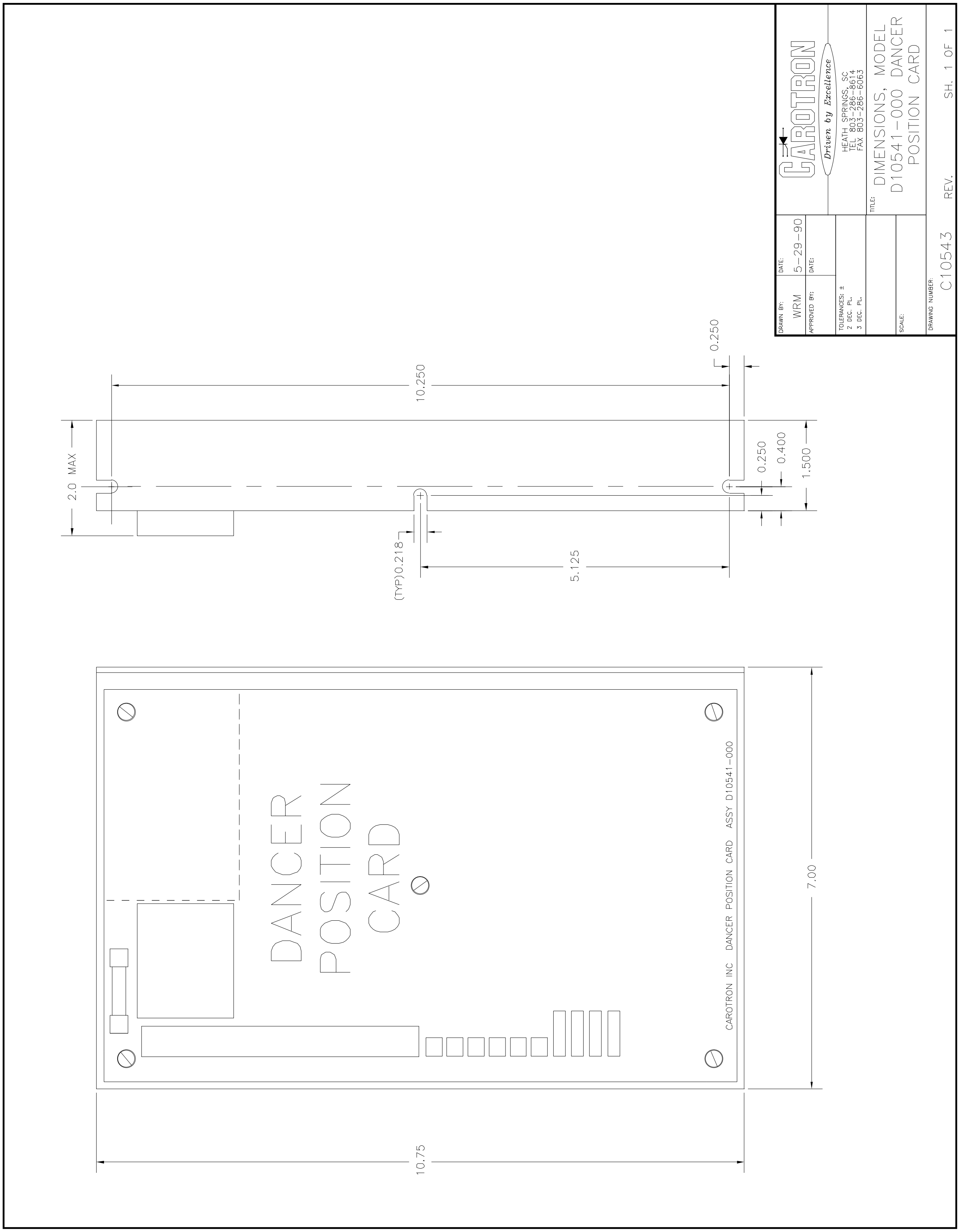
Dancer takes time to settle or dampen with line speed change but is stable at steady line speed.

1. Too little dancer storage.
2. Integral Scaling too high
3. Integral rate too fast
4. Too much Derivative signal

Dancer stable but not in set position.

1. Too little Integral Scaling. Indicated by MAX COUNT LED with UNIPOLAR S1 selection and MAX COUNT or MIN COUNT with BIPOLAR S1 selection.
2. Too much DEADBAND signal

9 Prints



CAROTRON
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HEATH SPRINGS, SC
TEL 803-286-8614
FAX 803-286-6063
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DRAWN BY: WRM
DATE: 5-29-90
APPROVED BY:
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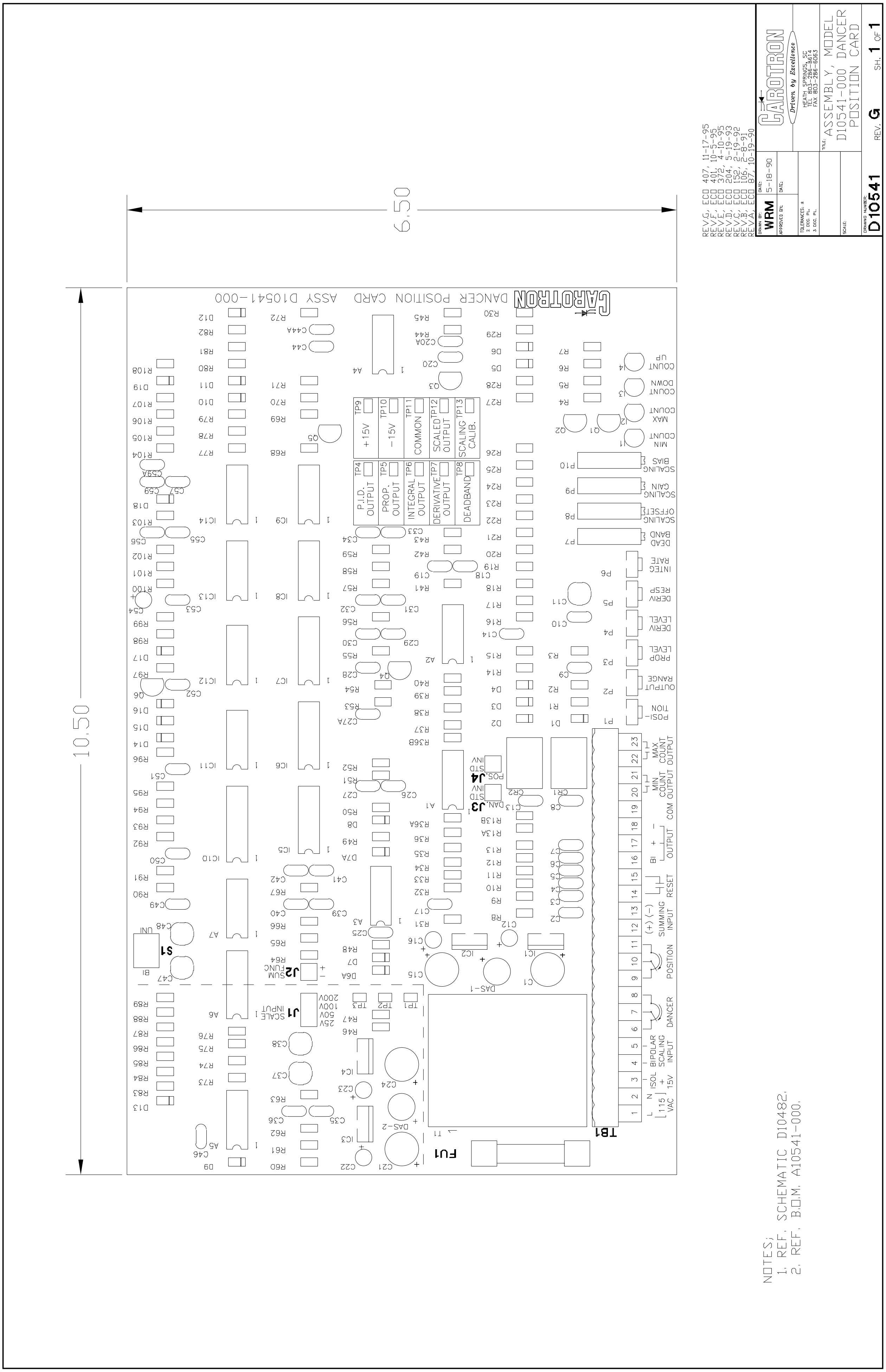
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HEATH SPRINGS, SC
TEL 803-286-8614
FAX 803-286-6063
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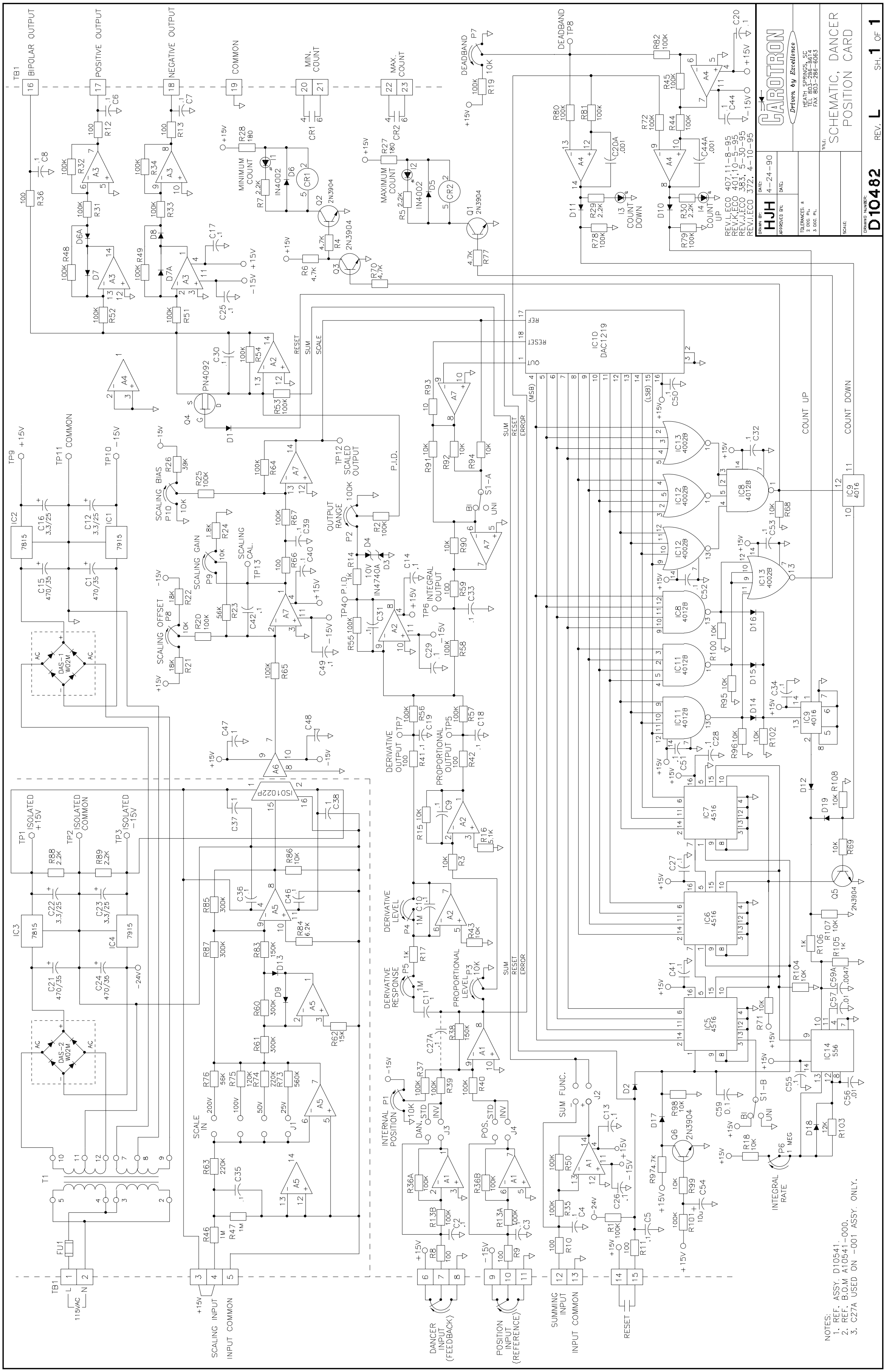
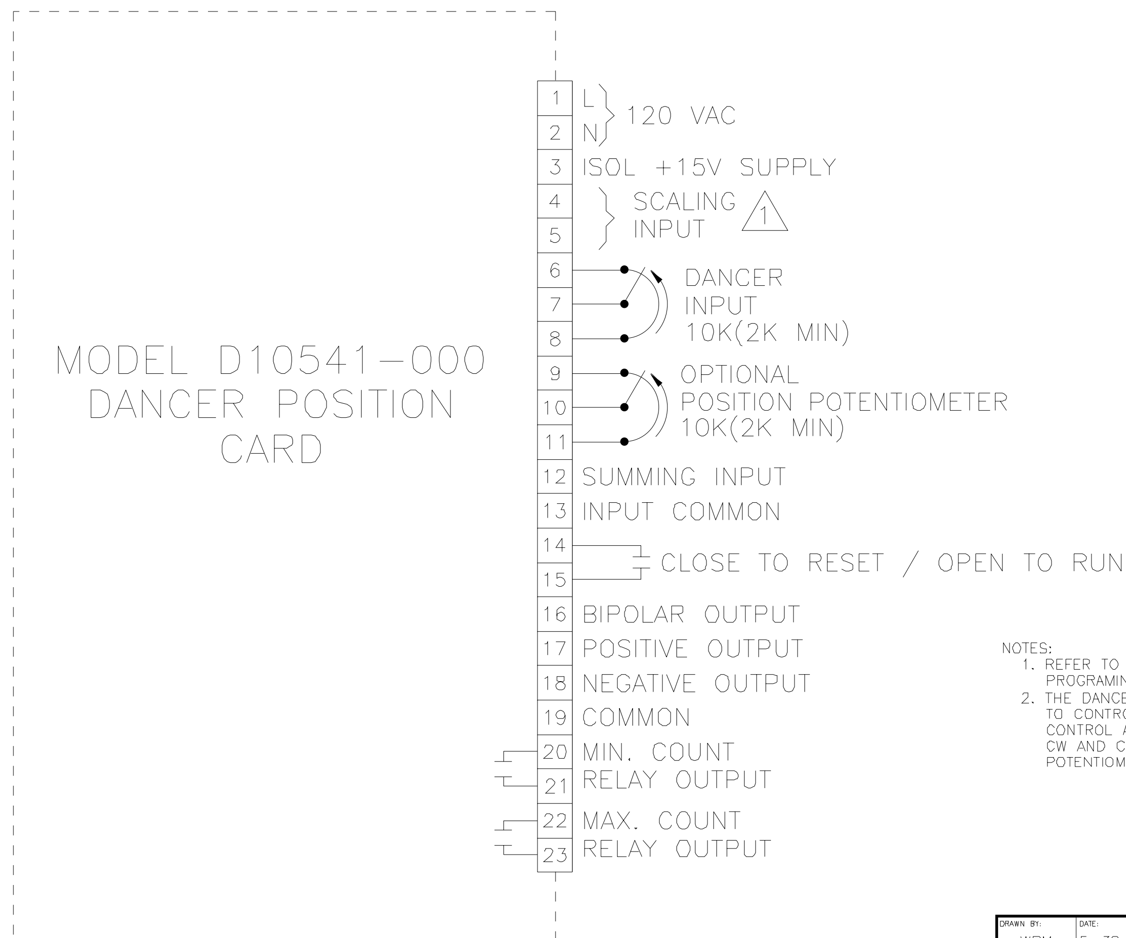
1. REF. SCHEMATIC D10482.
2. REF. B.O.M. A10541-000.

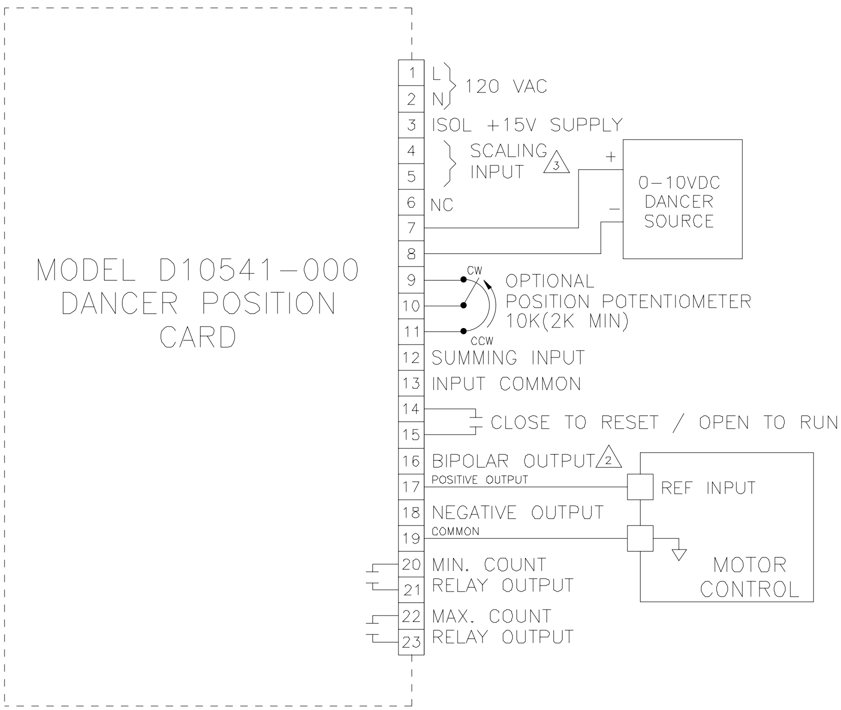

CAROTRON
Driven by Excellence
HEATH SPRINGS, SC
TEL 803-286-8614
FAX 803-286-6063
SCHEMATIC, DANCER POSITION CARD
D10482
REV. L
SH. 1 OF 1
HJH
4-24-90
REV.L ECO 407,11-8-95
REV.K ECO 401,10-5-95
REV.J ECO 383, 5-30-95
REV.I ECO 372, 4-10-95
NOTES:
1. REF. ASSY. D10541.
2. REF. B.O.M A10541-000.
3. C27A USED ON -001 ASSY. ONLY.



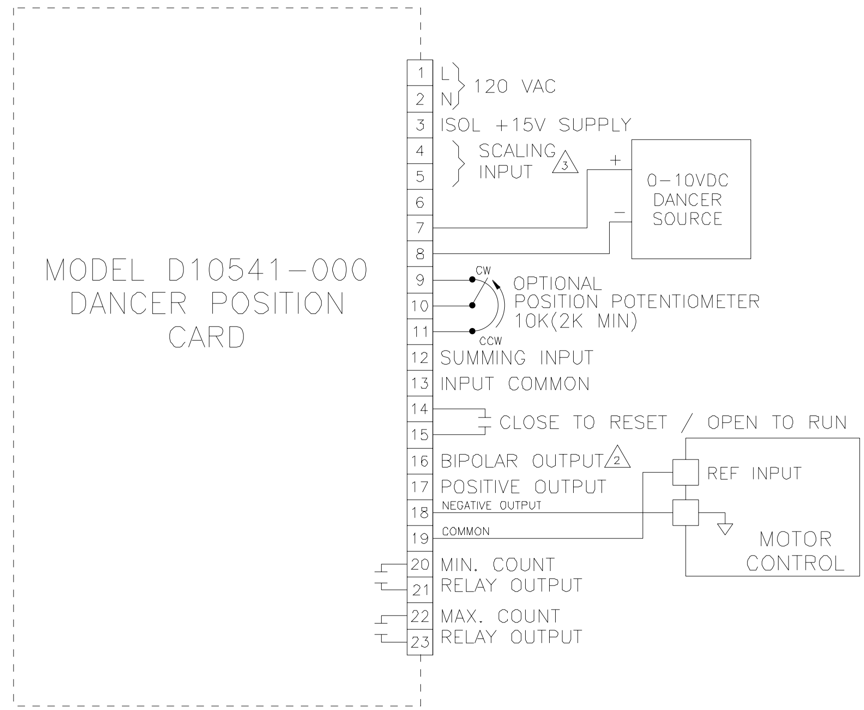
⚠1 TERMINALS 3 AND 4 MUST BE JUMPERED UNLESS AN EXTERNAL SCALING INPUT IS USED.

NOTES:
1. REFER TO INSTRUCTION MANUAL FOR PROGRAMING AND CALIBRATION INFORMATION
2. THE DANCER INPUT SHOWN IS CONFIGURED TO CONTROL A LET-OFF DRIVE. TO CONTROL A TAKE-UP DRIVE, SWITCH THE CW AND CCW LEADS OF THE DANCER POTENTIOMETER.

DRAWN BY: WRM	DATE: 5-30-90	CAROTRON *Driven by Excellence* HEATH SPRINGS, SC TEL 803-286-8614 FAX 803-286-6063
APPROVED BY:	DATE:	
TOLERANCES: ± 2 DEC. PL. 3 DEC. PL.		TITLE: CONNECTION DIAG., MODEL D10541-000 DANCER POSITION CARD
SCALE:		
DRAWING NUMBER: C10542	REV.	SH. 1 OF 1



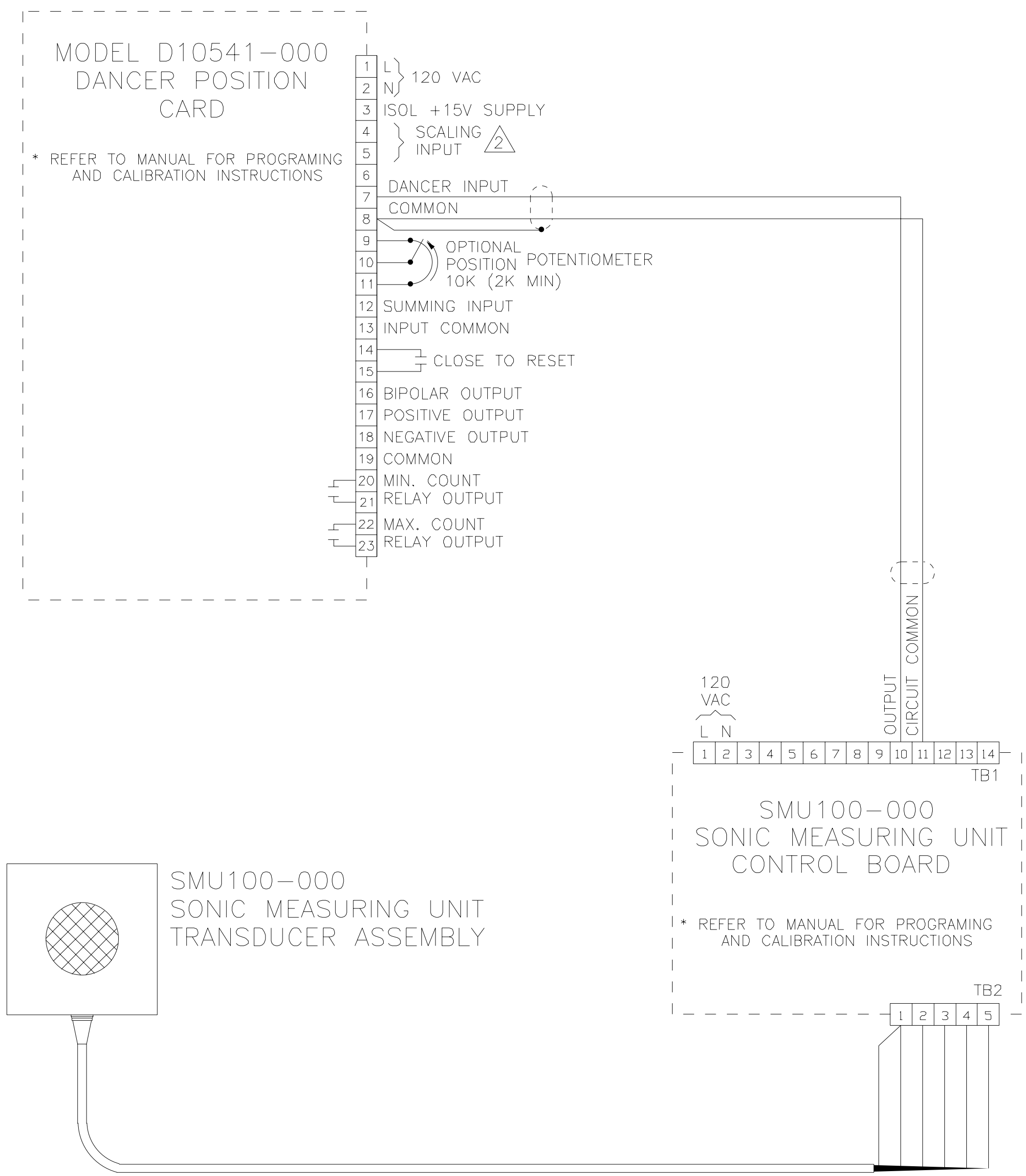
ALTERNATE CONNECTIONS TO
CONTROL A LET-OFF (UNWIND) DRIVE
WITH A 0-10VDC DANCER INPUT



ALTERNATE CONNECTIONS TO
CONTROL A TAKE-UP (WINDER) DRIVE
WITH A 0-10VDC DANCER INPUT

NOTES:
1. REFER TO INSTRUCTION MANUAL FOR PROGRAMING AND CALIBRATION INFORMATION
2. IF THE DRIVE IS TO OPERATE AS A TAKE-UP AND A LET-OFF, USE THE BIPOLAR OUTPUT AS THE REFERENCE TO THE MOTOR CONTROL.
3. TERMINALS 3 AND 4 MUST BE JUMPERED UNLESS AN EXTERNAL SCALING INPUT IS USED.

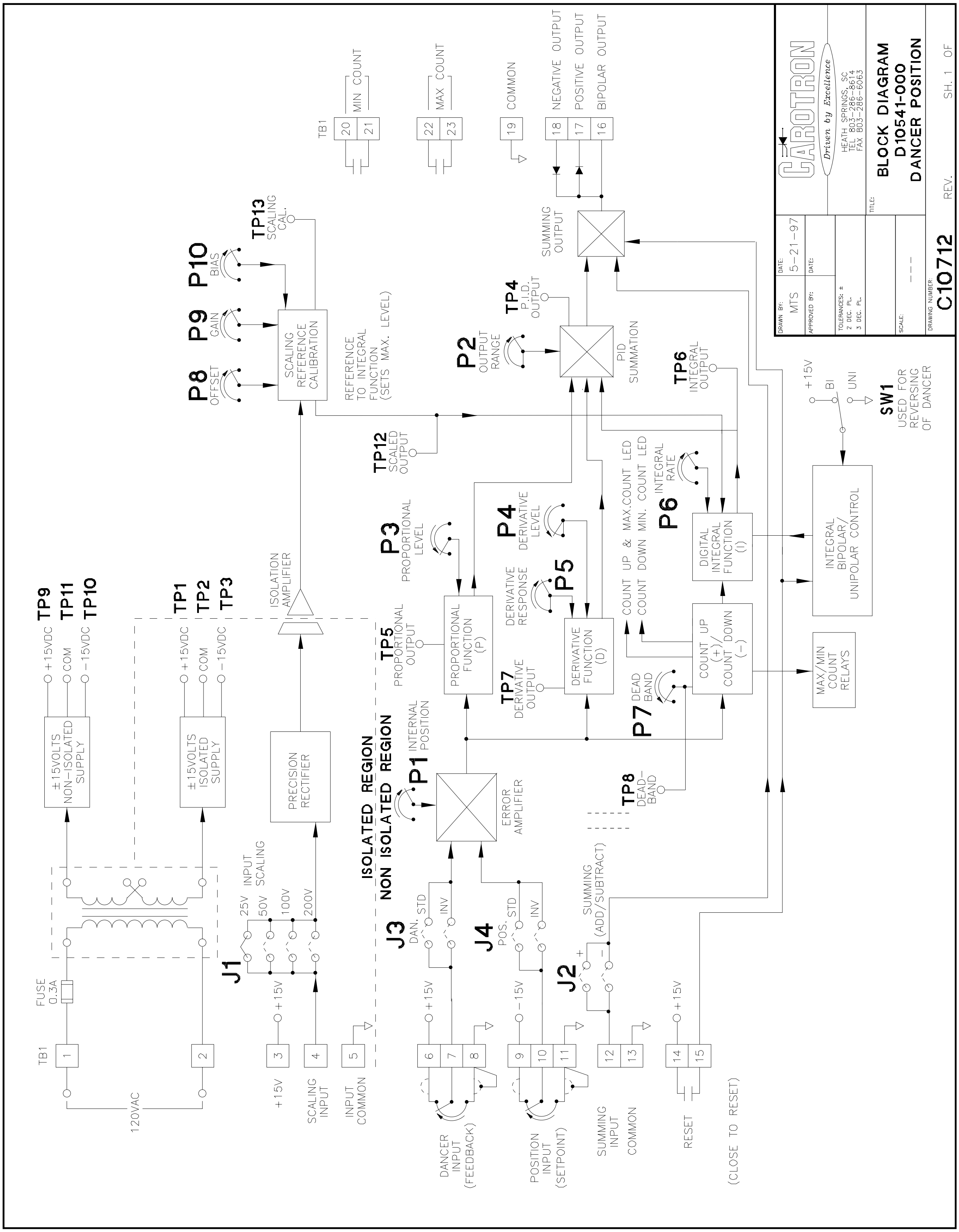
DRAWN BY: HJH	DATE: 8-14-90	CAROTRON Driven by Excellence
APPROVED BY:	DATE:	HEATH SPRINGS, SC TEL 803-286-8614 FAX 803-286-6063
TOLERANCES: ± 2 DEC. PL. 3 DEC. PL.		TITLE: ALTERNATE CONNECTIONS TO DANCER POSITION CARD
SCALE: ----		
DRAWING NUMBER: D10584	REV.	SH. 1 OF 1



NOTES:
1. REFER TO INSTRUCTION MANUALS FOR EACH CONTROL FOR PROGRAMING AND CALIBRATION INFORMATION

△2. TERMINALS 3 AND 4 MUST BE JUMPERED UNLESS AN EXTERNAL SCALING NPUT IS USED.

DRAWN BY: WRM	DATE: 5–30–90	CAROTRON *Driven by Excellence*
APPROVED BY:	DATE:	HEATH SPRINGS, SC TEL 803–286–8614 FAX 803–286–6063
TOLERANCES: ± 2 DEC. PL. 3 DEC. PL.		TITLE: CONNECTIONS, DANCER POSITION CARD TO SONICTRAC
SCALE:		
DRAWING NUMBER: C10556	REV.	SH. 1 OF 1



CAROTRON
Driven by Excellence
HEATH SPRINGS, SC
TEL 803-286-8614
FAX 803-286-8063
TITLE:
BLOCK DIAGRAM
D10541-000
DANCER POSITION
DRAWN BY: MTS
DATE: 5-21-97
APPROVED BY:
DATE:
TOLERANCES: ±
2 DEC. PL.
3 DEC. PL.
SCALE:
DRAWING NUMBER:
C10712
REV.
SH. 1 OF
TB1
120VAC
FUSE 0.3A
±15VOLTS NON-ISOLATED SUPPLY
+15VDC
COM
-15VDC
TP9
TP11
TP10
±15VOLTS ISOLATED SUPPLY
TP1
TP2
TP3
PRECISION RECTIFIER
ISOLATION AMPLIFIER
ISOLATED REGION
NON ISOLATED REGION
+15V
SCALING INPUT
INPUT COMMON
J1
25V
50V
100V
200V
INPUT SCALING
SCALING REFERENCE CALIBRATION
P8
OFFSET
P9
GAIN
P10
BIAS
TP13
SCALING CAL.
REFERENCE TO INTEGRAL FUNCTION (SETS MAX. LEVEL)
TP12
SCALED OUTPUT
MIN COUNT
MAX COUNT
COMMON
NEGATIVE OUTPUT
POSITIVE OUTPUT
BIPOLAR OUTPUT
SUMMING OUTPUT
TP4
P.I.D. OUTPUT
P2
OUTPUT RANGE
PID SUMMATION
TP6
INTEGRAL OUTPUT
+15V
BI
UNI
SW1
USED FOR REVERSING OF DANCER
P3
PROPORTIONAL LEVEL
P4
DERIVATIVE LEVEL
COUNT UP & MAX.COUNT LED
COUNT DOWN MIN. COUNT LED
P6
INTEGRAL RATE
DIGITAL INTEGRAL FUNCTION (I)
INTEGRAL BIPOLAR/ UNIPOLAR CONTROL
P5
DERIVATIVE RESPONSE
PROPORTIONAL FUNCTION (P)
DERIVATIVE FUNCTION (D)
COUNT UP (+)/ COUNT DOWN (-)
MAX/MIN COUNT RELAYS
TP5
PROPORTIONAL OUTPUT
TP7
DERIVATIVE OUTPUT
P7
DEAD BAND
TP8
DEAD-BAND
P1
INTERNAL POSITION
ERROR AMPLIFIER
J3
DAN.
STD
INV
J4
POS.
J2
SUMMING (ADD/SUBTRACT)
-15V
DANCER INPUT (FEEDBACK)
POSITION INPUT (SETPOINT)
SUMMING INPUT
COMMON
RESET
(CLOSE TO RESET)

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 Çompany. 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

3204 Rocky River Road
Heath Springs, SC 29058
Phone: (803) 286-8614
FAX: (803) 286-6063

MAN 1020-0E
Issued 11-17-11