DEVAR Inc.

MODEL 3019, 3019A

C UL US LISTED 51JB

INDUSTRIAL CONTROL EQUIPMENT

HIGH LEVEL PROCESS SIGNAL INPUT
INDICATOR - CONTROLLER
Rev: 03 November 2005

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INTRODUCTION:

The 3019/19A are accurate, sophisticated, easy to configure and operate, indicating controllers with highly visible displays. The 3019A utilizes different electronics from the 3019, but remains functionally identical. For milliamp inputs, the 3019A requires a jumper from the +mA IN to +V IN terminal. This jumper is not required on the 3019, and will not affect it's operation.

FEATURES

- 6 character alphanumeric display, 4 digits indicate the process, 2 characters are used for descriptors
- High efficiency red LED characters, 0.54" high.
- 15 segments characters for easy to read prompts. "No more hieroglyphics!"
- Square root extraction or linearization with up to 17 user entered breakpoints.
- Scrolling multi-word configuration prompts for clarity.
- Indicate process in true units of measure, ie. 4/20mA loop corresponding to 0/23.1 feet of water can indicate 0.00ft/23.10ft
- Zero, two, or four alarms channels with front panel LED indication.
- Each alarm channel has one 10Amp SPDT relay.
- Each alarm channel has independently configured trip and reset points
- Each alarm can be independently configured to latch.
- Sensor failure detection puts the alarm channels into a known state on sensor failure.
- Each alarm can be independently configured to activate a horn.
- Four separate, menu selectable, horn actions.
- Display can be set to flash when any alarm trips.
- A security code can be set to prevent unauthorized access.
- Isolated 24V nominal loop power supply.
- Optional analog retransmission.

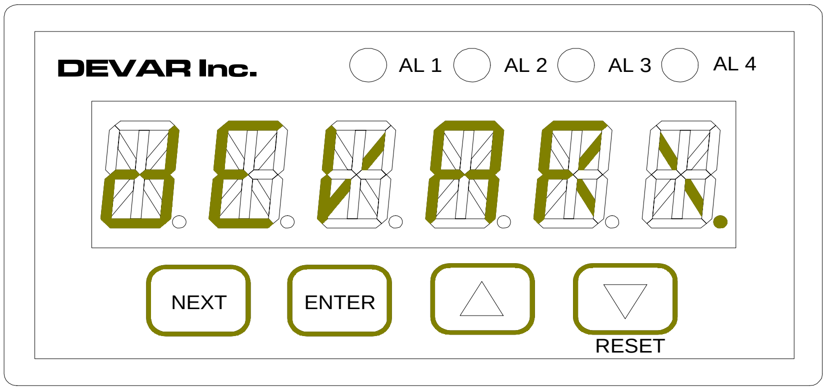


Figure 2:Front Panel

GENERAL INFORMATION

PHYSICAL LAYOUT

Front Panel

The six character display provides a process indication or plain English configuration prompts. The first four characters are utilized for process indication. The last two characters can be set to any printable ASCII character, or one of several custom characters. They can be used to indicate units of measure, such as °C, °F, mV, mA, a dummy zero and V, two dummy zeros, blanks, etc. Four LEDs indicate the status of each alarm. Four keys enable configuration and user input. See figure 1 above.

Rear Panel

All electrical connections are made through screw clamp terminal blocks that plug into headers attached to the printed circuit boards. A fifteen terminal connector is provided for AC power and relay contacts. A nine terminal connector is provided for input signals, isolated 24VDC loop power supply, and optional retransmission connections. The connectors accept 24 to 14 AWG wire.

Mounting

The 3019 case is designed for panel mounting in a 1/8 DIN cutout, 48mm X 96mm. Two clamping brackets attach to and slide in milled slots on either side of the case. The brackets are clamped by screws attached to the rear panel.

BASIC OPERATION

After applying or cycling the power, the 3019 puts the relays in the power off, fail safe mode, displays "DEVAR MODEL 3019 <either ZERO, TWO or FOUR> ALARMS WITH FAIL SAFE POLAR- ITY BUILD <time> <day> <month> <year> START <selected input signal> <selected linearization>", and proceeds to indicate a process quantity based on the input signal. The unit periodically scans the front panel switches to detect any user input. At this point only NEXT and RESET are operational. Pressing NEXT causes the unit to enter the menu system. RESET is used to silence the horn and clear latched alarms, if these options are enabled.

ACCEPTABLE INPUTS

As shipped, the 3019 is ready to signal condition and indicate the process value for either a -10V to 10V, 0V to 10V, 1V to 5V, 0V to 5V, 0V to 1V, 0mA to 20mA, or 4mA to 20mA input signal. Selecting the input type is accomplished by utilizing the front panel buttons. The calibration process for the various inputs is detailed in the 'INPUT CAL.' section.

PROCESS INDICATION

Four characters indicate a process quantity in the range of -1999 to 9999, with a decimal point placed to the right of any digit. One or two dummy zeros can be added to extend the indication from -199900 to 99900. If the input signal results in a process quantity outside of this indication range, or the input signal becomes too large for the selected input, the unit displays '-OVERF' or '+OVERF', depending on the polarity of the input. Placing the decimal point, scaling the display , and defining the label are discussed in the 'SETUP dISPLY' section, and is accomplished by utilizing the front panel buttons. Nonlinear input signals are accommodated by either a preprogrammed square root extraction or a user defined input/output transfer curve. The input/output transfer curve can have as many as 17 user defined breakpoints .

DIP SWITCH SW2

Accessed through a hole in the bottom of the case, this switch controls various functions of the 3019, which are:

Pole 4: SETUP PROTECTION

Set ON causes an access code check to enter the menu system.

Pole 3: AUDIBLE ALARM

Set ON enables the horn to sound.

Pole 1: SYSTEM CALIBRATION

Set ON enables calibration of the optional Analog Retransmit board. The 'TRIM MIN. OUTPUT' and 'TRIM MAX. OUTPUT' menu items are activated. Under normal operating conditions, this position is OFF and these prompts do not appear.

Pole 2: SYSTEM INITIALIZATION

If all poles of SW2 are ON, the RESET front panel button is pressed and held, and the unit is restarted, the 3019 enters a menu where the option cards can be enabled, the EEPROM can be initialized with nominal configuration settings and calibration constants, or the input calibration can be performed. Note that ALL of these procedures should only be attempted AFTER contacting and under the advise from the factory. If the EEPROM is reinitialized an input calibration must be performed before placing the 3019 into service. If the input calibration is performed incorrectly the 3019 will not operate and will require being returned to the factory for recalibration, for which a fee will be charged. After initialization the configuration settings will be set to the values tabulated below. A diagram of this menu is at the end of this document.

Table: Configuration Settings after EEPROM initialization:

Security code:	'000000' (six zeros)
Decimal point:	012.345
Input Output Curve	Linear Input
Label:	<blank>V
Input type	4/20mA
Minimum display range:	000.0
Maximum display range:	100.0
Flashing Display	NEVER

	trip	reset	horn	latch
ALARM 1	250	200	silent	do not latch
ALARM 2	500	400	silent	do not latch
ALARM 3	750	700	silent	do not latch
ALARM 4	1000	900	silent	do not latch

MENU SYSTEM

Utilize the menu system to set and view the parameters that define how the 3019 operates. The menu system is activated and controlled through the front panel keypad. The parameters that can be configured are: selecting the input type, performing an input calibration, offsetting the process indication (for tare weight), setting the alarm trip points, setting the alarm reset points, defining how and when the audible alarm operates, activating latching alarms, activating a flashing display on alarm, defining a security code, and controlling the action of any option cards. The menu system is also used to view or reset the peak and valley readings.

Inactivity time out

The 3019 is not operational while in the menu system. If no key is pressed, after approximately 40 seconds the 3019 returns to the process indication mode.

Menu Navigation

ENTER, NEXT, and RESET are used to move through the menu options. A diagram of the menu system can be found at the end of this document. The buttons used to move between different points on the diagram are clearly labeled. Press ENTER to enter a submenu or entry routine and to accept a selection. Press RESET to exit the current menu level. Press NEXT to move to the next available menu option.

example: NEXT moves from 'ALARM1' to 'ALARM 2'
ENTER moves from 'ALARM1' to submenu 'TRIP 1'
RESET returns from submenu 'TRIP 1' to 'ALARM1'

Selecting a parameter from a list

Certain parameters, such as input type, are selected from a list. ENTER is used to start the selection process. Scroll through the available choices with the <up arrow> and <down arrow> keys. Press ENTER to make the displayed item the current setting, 'STOREd' will be displayed as confirmation. NEXT cancels the selection process and returns to the menu prompt.

Entering a number or text

ENTER is used to start the entry process. The currently selected character will be flashing. Press NEXT to select which character to edit. Press <up arrow> or <down arrow> to change the value of the currently selected character. Press ENTER to accept the displayed value and return to the menu prompt.

DETAILS OF THE MENU SYSTEM

‘PEAK AND VALLEY’

This menu item is not blocked by setup protection. Submenu choices provide a method to observe and / or reset the largest and smallest process value detected.

‘SELECT INPUT TYPE’

Press ENTER at this menu prompt to enter the selection routine. The current selection is displayed, use <up arrow> and <down arrow> to scroll through the options ‘-/+10V’, ‘0/10V ’, ‘0/5V ‘, ‘1/5V ‘, ‘0/1V’, ‘0/20mA’, and ‘4/20mA’. When ENTER is pressed to select the displayed option, ‘STORED’ is displayed as confirmation. Press NEXT to return without making a new selection.

‘SETUP dISPLY’

The submenu options available under this menu prompt provide the means to scale the display to a desired process value.

‘SET dP’

Pick the decimal point location. Press ENTER and the current setting is displayed in the form of ‘012.345 ‘. The flashing digit with the decimal point will be the current selection, and may be different than the one indicated here. Use <up arrow> and <down arrow> to change the decimal point location, ENTER to accept the current location, and NEXT to exit this selection routine. A decimal placed after 4 or 5 will override the label setting and place either one or two dummy zeros in the process indication.

‘PICK LABEL’

Select the process descriptor. Dummy zero(s) added through the placement of the decimal point will overwrite the label positions as necessary when indicating the process. Press ENTER and the current label selection will be displayed in the form of "SET _ _", where the last characters "_ _" are the current values and the flashing character is the current character to edit . Use <up arrow> and <down arrow> to modify the current character, NEXT changes which is the current character. The displayable ASCII character set is available, along with a few custom characters. Press ENTER to complete the process.

‘INPUT OUTPUT CURVE’

Pick the input output transfer curve, which defines how the process indication reacts to the input. Most times, this selection will be LINEAR INPUT. Certain transmitters, such as those measuring flow, will use SQUARE ROOT extraction. Some applications can utilize the CUSTOM CURVE to fit the input signal to a desired output process indication. Examples of the uses for the CUSTOM CURVE include linearizing the signal from a nonlinearized thermocouple transmitter and indicating the volume of liquid in a horizontal tank based on the height of liquid in the tank. These two examples are detailed below. Most of the following menu options utilize numeric entry which is explained in the section <u>Entering a number or text</u>.

<u>Define the process indication: 'LINEAR INPUTS'</u>

The user is presented with two entry points: <u>'DEFINE MAX. RANGE'</u>, which corresponds to the process value to be displayed for a full scale input (ie. 20mA, 10V, 5V, 1V), and <u>'DEFINE MIN. RANGE'</u>, which corresponds to the process value to be displayed for a bottom scale input (ie. 0mA, 4mA, 1V, 0V).

<u>Define the process indication: 'SQUARE ROOT'</u>

The user is presented with <u>'DEFINE MAX. RANGE'</u> to define the process value to be displayed for a full scale input (ie. 20mA, 10V, 5V, 1V). For these signals, the process value to be displayed for a bottom scale input (ie. 0mA, 4mA, 1V, 0V) will always be zero.

<u>Define the process indication: 'CUSTOM CURVE'</u>

The user can utilize from 2 to 17 breakpoints to describe how to transform the input signal to an output process indication. The menu system allows the user to add, modify, and delete breakpoints. Valid breakpoints exist in the range of 0.00% to 100.00% of the input signal. The valid breakpoints are presented in increasing order corresponding to the input percentage at the breakpoint, and are labeled from BP 0 up to BP 16. Upon selecting a breakpoint with the ENTER key, the user first describes what percentage of the input signal the break point falls on, then defines the desired process value at that point. No two breakpoints can have the same input percentage, but they can have the same output values. Breakpoints that have the input percentage set at a value larger than 100.00% are removed from the list of active breakpoints. If there are less than 17 valid breakpoints, more can be added by pressing the ENTER key at the 'ADD BREAK- POINT' prompt. Breakpoints can be edited or added in any order. The program will sort the breakpoints into an ascending order after entry is completed. Before accepting an input percentage, the program checks for duplication and prompts the user if a conflict exists. The most difficult aspect of a custom curve is to determine where to put the breakpoints. Examples are presented in Appendix A to illustrate the process of placing breakpoints.

The first, and most important, step in the process of determining the breakpoints is to <u>GRAPH THE DATA!</u> Graph the data in a form that would best illustrate the nonlinearity. Use of a spreadsheet program, like Quatro, Excel, or 1-2-3 is highly recommended. A simple spreadsheet template is available, or additional help can be obtained - contact the Devar sales department @ 1(800) 566-6822 for more information.

'AdJUST OFFSET'

The offset allows a fixed value to be added to, or subtracted from, the indication. For example, in a scale application, the tare weight can be removed, so the indication would be entirely of the material to be weighed. Determining the appropriate offset can be a simple matter of direct observation. The following example illustrates the versatility of the 3019 by showing how to indicate a liquid volume based on a weight measurement.

EXAMPLE: A tank holds 500 gallons, weights 350lbs when empty and 3750lbs when full. The strain gage transmitter measuring the weight of the tank is calibrated 4/20mA for 0/5000lbs. A gallon indication is desired. The weight of 500 gallons of the liquid is the weight of the empty tank subtracted from the full weight, so 3750lbs - 350lbs = 3400lbs. The weight of the liquid is 3400lbs/500gal = 6.8lbs/gal. Enter the 3019 DISPLAY SETUP submenu. For SET dP pick 012.3, for 'PICK LABEL' use gl, and for 'INPUT OUTPUT CURVE' pick 'LINEAR INPUT'. For 'dEFINE MAX. RANGE', 5000/6.8 = 735.29gal., enter 735.3. For 'dEFINE MIN. RANGE', 0lbs is 0gal., enter 000.0. The tank empty weight looks like 350/6.8 = 51.5gal., go to 'ADJUST OFFSET' and enter -51.5. Note that the offset could also have been determined by observing the process indication for the tank when it is empty.

ALARMS

The 3019 is available with either zero, two, or four alarms. The status of each alarm is indicated by a front panel LED. Each alarm controls one SPDT relay. A 3019 with zero alarms does not have the 'ALARMx', 'DETECT SENSOR FAILUR', or 'HORN ACTION' menu items, relays, or any front panel alarm indication LEDs.

'ALARMx', were x will be either 1, 2, 3 or 4.

Allows access to the parameters that control how each alarm acts.

'TRIP x' and 'RESETx'

Independent trip and reset points allow alarm action (high or low alarm) and hysteresis (value between trip and reset points) to be precisely controlled. Setting the trip point to a value higher than the reset point configures that alarm as a high alarm. Setting the trip point to a value lower than the reset point configures the alarm as a low alarm. Setting the trip and reset points to the same value disables the alarm, which is held in the nonalarm condition.

'HORN x'

Each alarm can be set to activate the horn.

'LATCHx'

An alarm configured to latch will return to the nonalarm condition when the process meets the reset condition and the RESET button is pressed.

'FLASH SCREEN'

Each alarm can be set to cause the screen to flash.

'FAIL SAFE POLAR-ITY x'

Each alarm can be set so that on a power failure the relay will go to either the tripped or reset state. The combinations of settings and wiring can make setting up the 3019 confusing, but the following procedure will always produce the desired results. First, wire up the relays so the controlled function is in the proper state for failsafe. If failsafe is a closed contact, wire between "P" and "NC". If failsafe is an open contact, wire between "P" and "NO". Second, change the failsafe configuration setting to agree with the alarm state when in failsafe.

Example: The 3019 is measuring the level of a wet well and is controlling two pumps and an external horn that sounds if the level goes beyond an extreme. Should the power fail to the 3019, we want the pumps to be off and the external horn to be on. Channel 1 and 2 will be used for the pumps, channel 4 for the horn. An open contact turns off the pump, which corresponds to a reset alarm, so relays 1 and 2 are wired to 'P' and 'NO'. A closed contact activates the horn, which corresponds to a tripped alarm, so relay 4 is wired to 'P' and 'NC'. In the configuration menu, pump 1 and pump 2 failsafe mode are set to 'FAIL RESET' and alarm 4 failsafe mode is set to 'FAIL TRIPPd'.

The failsafe polarity setting should only be used to set the correct polarity for failsafe operation, and should NEVER be used to compensate for improper wiring. After installation, perform this safety test: turn everything on except for the 3019. If the controlled functions are all in their failsafe condition, the relays are wired correctly.

'DETECT SENSOR FAILUR'

This provides a method to control the relay outputs should the sensor fail.

'RELAY LOCK-OUT'

Selecting either 'ENABLE' or 'IGNORE' controls sensor failure detection.

'LIMIT1' and 'LIMIT2'

These two values define the valid signal range endpoints. When a sensor fails, it usually outputs a signal either above or below the valid signal range. If the input signal goes beyond the valid range, relay control is locked out, and the relays are put into the state defined by the user settings.

'RELAY1' through 'RELAY4'

These settings define what state each relay will default to if the input signal goes beyond the valid range. The relays can be configured to default to either the 'TRIPPd' or 'RESET' state.

'HORN ACTION'

DIP switch SW2 pole 3 set ON allows the horn to sound. The horn is controlled by the change in the status of an alarm. Each alarm has a setting that causes the horn to sound, therefore, none, any, or all of the alarms can activate the horn. The horn can be set to operate in any of the methods detailed below. Note: 'RESET' is a front panel button and ‘reset’ is an alarm condition. To avoid confusion, an alarm which has been reset will be called clear.

'SOUND WITH ALARM'

The horn will sound when an alarm is set and is silent when all alarms are clear. If any of the alarms are configured to latch, one must press RESET to unlatch those alarms that are clear.

'SOUND UNTIL RESET'

The horn will sound when an alarm is set and is silent when either all alarms are clear or the RESET button is pressed. If any of the alarms are configured to latch, pressing RESET a second time will unlatch those alarms that are clear.

'LATCH GOING ACTIVE'

The horn will sound and stay on after an alarm trips. The horn can only be silenced by pressing the RESET button. If any of the alarms are configured to latch, pressing RESET a second time will unlatch those alarms that are clear.

'LATCH WITH CHANGE'

The horn will sound and stay on after an alarm either trips or clears. The horn can only be silenced by pressing the RESET button. If any of the alarms are configured to latch, pressing RESET a second time will unlatch those alarms that are clear.

'CHANGE ACCESS CODE'

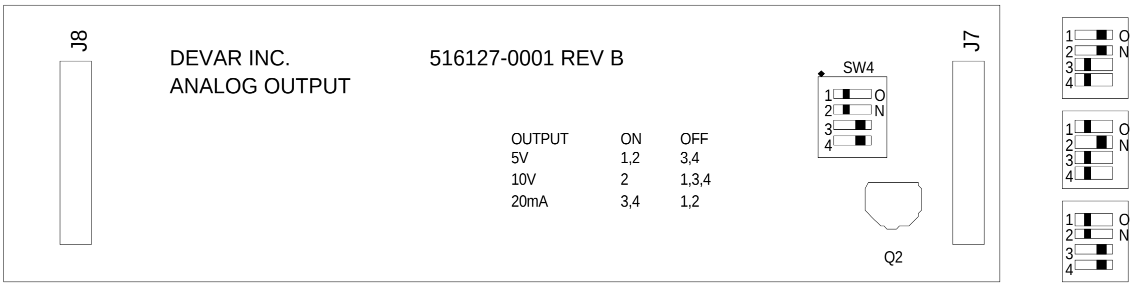
The entry routine for changing the access code is described in Entering a number or text on page 6. The access code can be any six digit number from 000000 to 999999. The factory default is 000000.

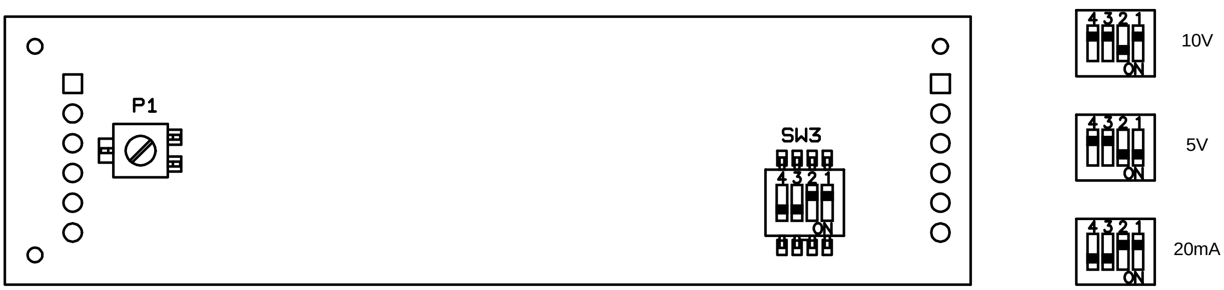
When enabled by setting DIP switch SW2 pole 4 ON, the correct access code must be entered to access the menu system. The access code check entry routine starts with an indication of 000000. Enter the code and, if correct, “OKAY” is displayed before proceeding, otherwise “dENIED” is displayed before returning to process indication.

OPTION CARD: ANALOG RETRANSMISSION

Configure the card

The analog output card is located within the case, and can be configured to produce a full scale output of either 5V, 10V or 20mA by setting DIP switch SW3 according to the following table. Note that the retransmitted signal does NOT have to be the same type of signal as the input, so a 0/10V input can be retransmitted as a 4/20mA signal.





OUTPUT	ON	OFF
10V	2	1, 3, 4
5V	1, 2	3, 4
20mA	3, 4	1, 2

Enable firmware support

Support for the analog card is provided through the 'ANALOG REXMIT' menu item, which is activated in the system initialization routine. The system initialization routine can only be activated by turning all poles of SW2 ON, then press and hold the RESET button and apply power. When 'Cont' is displayed, release the RESET button. Press NEXT until 'enable option card' is displayed, press ENTER, then press NEXT until "analog card" is displayed. Press ENTER and 'OKAY' is displayed to confirm the choice. Press RESET to return to 'Cont' and press ENTER.

Analog retransmission calibration overview

The retransmitted signal is controlled by, and linear to, the displayed process value. Any linearization applied to the input is incorporated into the retransmitted signal. The two process values that define the points at which the minimum and maximum retransmitted signal are produced are set in the menu system. The independent settings allow the retransmitted signal to have a scaling different from the input. For example, if the scaling on the input signal is -20.0ºF to 500.0ºF, the scaling of the output signal can be set to something such as 0.0ºF to 400.0ºF or any other values that were found useful. The observed resolution of the output signal will not be better than the resolution of the display, and will never be better than 0.05% of the output signal span. To access the menu items that allow the adjustment of the settings that control the analog retransmission, press NEXT repeatedly to navigate to 'ANALOG REXMIT' and press ENTER.

Analog retransmission calibration details: set process values

Press ENTER at the menu items 'dISPLY @ MIN OUTPUT' or 'dISPLY @ MAX OUTPUT' to review or edit the process values that correspond to the minimum and maximum analog retransmission output levels.

Analog retransmission calibration details: adjust output signal

Do not attempt to trim the output signal without monitoring it! The output of the analog retransmission board is controlled by sending it a number. The number can be from 0 to 4095, and the larger the number, the larger the output. Calibration consists of adjusting the value of the number to achieve the desired output level. The menu items 'TRIM MIN OUTPUT' and 'TRIM MAX OUTPUT' allow the numbers that control these signal levels to be adjusted.

Connect an appropriate meter to the correct output terminals on the real panel, navigate to the 'TRIM <XXX> OUTPUT' menu item, and press ENTER. The display indicates the number that produces the current output level for this calibration point. Adjust the value of the displayed number to achieve calibration. The value of the flashing digit can be increased and decreased with the UP and DOWN arrow buttons. Changing the value of the displayed number will cause a decimal point to appear, which indicates that the analog output no longer corresponds to the displayed number. Press the NEXT button to update the analog output and remove the decimal point. Press the NEXT key when the decimal point is NOT displayed to select which digit to edit. ENTER acts just like NEXT if the decimal point is on, otherwise press ENTER to accept the displayed value as the calibration point and return to the menu system.

SPECIFICATIONS

GENERAL

Power		90-140VAC Single Phase 50/60Hz or 130 - 190VDC, 10VA max	
Operating Temperature		0ºC to 70ºC	
Dimensions	Front Bezel	48mm H x 96mm W x 12mm	polycarbonate NEMA 4X
	Panel Cutout	45mm H x 91mm W	
	Overall	48mm H x 96mm W x 166mm D	
		1-$^{15}/_{16}$"H x 3-$^{3}/_{4}$"W x 6-$^{1}/_{2}$" D	Black anodized aluminum body
Environmental Rating		Type 1 (for front face only)	
Weight		0.522Kg = 1.15lbs. = 18.4oz	
Display		Six characters, 0.54" high, 15 segment, high efficiency red LED.	
User Input		Four button integrated membrane switch front panel keypad	
Relay Output		SPDT (form C) relays; 1 Phase; 7.5A at 240VAC / 24VDC ; 1/3 HP at 120VAC (7.2 FLA); ½ HP at 240VAC (4.9 FLA)	
Max Terminal Screw Torque		7 lb./in.	
Relay Operation		1) Relay de-energizes on power failure, which causes closure between P and NC. An energized relay has closure between P and NO. 2) A failsafe polarity of fail tripped de-energizes the relay in the alarm (tripped) condition, the LED is lit. A failsafe polarity of fail reset de-energizes the relay in the non-alarm (reset) condition, the LED is dark. 3) When enabled, detected sensor failure will cause all relays to go to the selected states, either tripped or reset.	
Loop Power Supply		24V @ 100mA MAX, 150mA short circuit	
Isolation Strength		500VAC to input terminals or earth	

INPUT

A/D converter	24 bit Delta - Sigma type
Reference	2.5V ±15ppm / ºC typical
Voltage Input Impedance	1M Ohms
Current Input Impedance	10 Ohms
-3dB frequency	12Hz.
Acceptable inputs	± 10V, 0/10V, 0/5V, 1/5V, 0/20mA, 4/20mA, 0/1V
Display update rate	2 Hz
Accuracy	± 0.01% of selected input

INDICATION

Displayable numeric range	-1999 to 9999 with decimal point to right of any digit
Scaling linear response	define process values at minimum and maximum signal input
Scaling square root response	define process value at maximum signal input
Linearization error:	< 0.5% for input below 1% of full scale, < 0.001% otherwise
Scaling custom curve	user defines 2 to 17 values at a percentage of input level.

OPTIONAL ANALOG RETRANSMISSION

D / A converter	12 bits
Available full scale outputs	5V, 10V, 20mA
Accuracy relative to display	<0.05% of full scale output

CUSTOM CURVE EXAMPLE 1

A 4/20mA output signal is being generated by a type J thermocouple transmitter which is calibrated for 0ºF to 500ºF. The millivolt signal a thermocouple generates is not a linear function of the measured temperature. The milliamp output of the transmitter is a linear function of the millivolt input signal, so the output is not linear to the measured temperature. The indicated temperature is a linear function of the milliamp output, so the indicated temperature is also not linear to the measured temperature. The custom curve of the 3019 provides a method to make the indicated temperature a nonlinear function of the milliamps output, so the indication can be adjusted to conform to the measured temperature.

The output error is the measured temperature subtracted from the indicated temperature. So, if the measured temperature is 250ºF and the indicated temperature is 243.63ºF, the output error is -6.37ºF. Table 1 was created to determine the output error and %Input values for breakpoints arbitrarily placed at 50ºF intervals along the input range. Breakpoints should be placed to create a best fit piecewise linearization. Graph 1 compares the results of table 1 to an accurate plot of the temperature error. After observing the general shape of the resultant curve, breakpoints can then be more wisely selected.

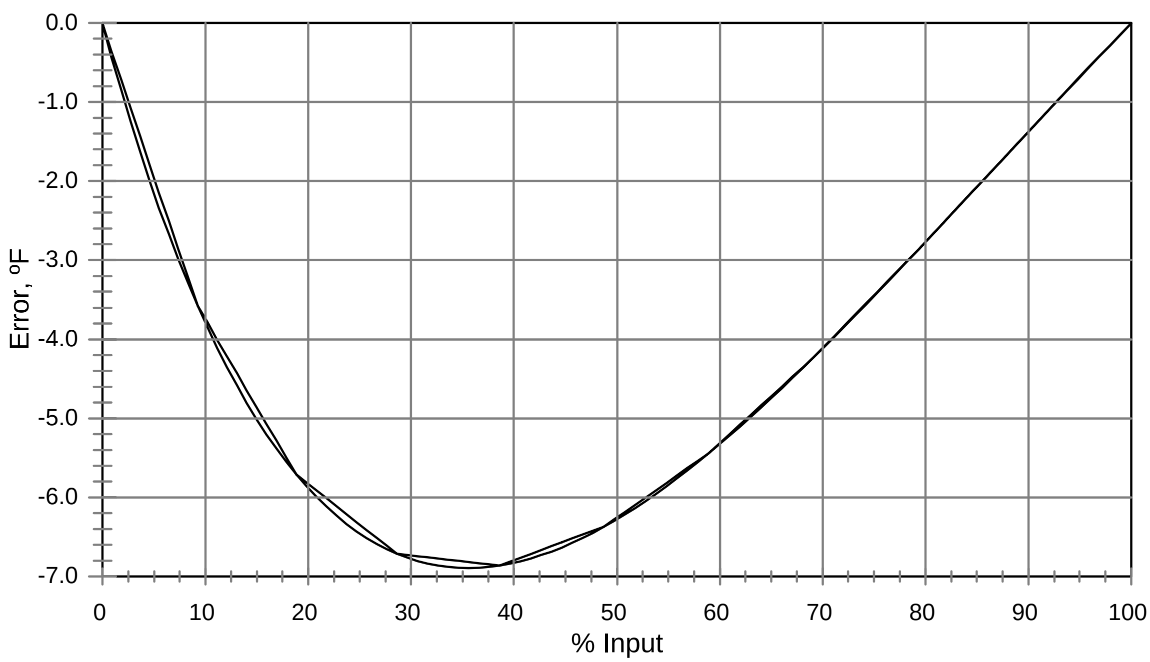
Observe on Graph 1, 60% and 100% of the input, the curve is almost a straight line. Between 20% and 40% there is some mismatch between the two curves. This illustrates how a graph aids in placing breakpoints. The mismatch between the ideal response and the linearization response are directly observable, and breakpoints can be selected to obtain a best fit. When observing the error generated by the selection of breakpoints, please remember that these errors can be reduced, not eliminated. In other words, setting up 17 breakpoints when 6 breakpoints does the job is a waste of time and effort.

The following interpolation equation was used to generate the values in the mA Output and Indicated Temperature columns, the values in the mV Input column are used for the input variables.

$$Output_{now} = \frac{(Input_{now} - Input_{Min}) * (Output_{Max} - Output_{Min})}{(Input_{Max} - Input_{Min})} + Output_{Min}$$

Table 1: J thermocouple 4/20mA transmitter inputs, outputs and errors

Measured Temperature °F	mV Input	%Input	mA Output	Indicated Temperature °F	Error, °F
0	-0.886	0.00	4.000	0.00	0.00
50	0.506	9.28	5.486	46.42	-3.58
100	1.942	18.86	7.017	94.29	-5.71
150	3.412	28.66	8.585	143.29	-6.71
200	4.907	38.63	10.180	193.14	-6.86
250	6.421	48.73	11.796	243.63	-6.37
300	7.949	58.91	13.426	294.56	-5.44
350	9.485	69.15	15.065	345.77	-4.23
400	11.025	79.43	16.709	397.15	-2.85
450	12.568	89.72	18.353	448.58	-1.42
500	14.110	100.00	20.000	500.00	0.00



Graph 1: Type J Thermocouple Nonlinearity

CUSTOM CURVE EXAMPLE 2

A transmitter is detecting the height of liquid in a horizontal tank. The desire is to indicate the volume of liquid in the tank. The volume of liquid in a horizontal tank can be expressed as a function of the height of the liquid through a complex mathematical formula. Table 2 tabulates the normalized relationship between the height and volume of liquid in a tank. The results in table 2 are plotted in graph 2a, which includes a straight line for comparison. The volume to height nonlinearity is plotted in graph 2b. Graph 2b demonstrates how plotting the nonlinearity instead of the absolute relationship allows the user to rapidly select the optimal breakpoint locations.

Observe graph 2b. The response is virtually straight between 35% and 65%. The response is rapidly changing from 5% to 25% and from 75% to 95%. Table 3 and Graph 3 illustrate selecting breakpoints based on these observations. Graph 3 has an accurate plot of the nonlinearity for comparison. The linearization curve follows the actual curve very well, reducing the maximum error to ±0.14% of the span, compared to ±5.8% for the uncorrected response.

Now apply this to a 5000 gallon horizontal tank, 7ft in diameter and 18ft long. A sensor and 4/20mA transmitter measures the height of liquid in the tank and is calibrated so that 4mA corresponds to an empty tank and 20mA corresponds to a full tank. A two alarm 3019 is being used to power the loop, sound a horn for a low tank position, and activate a pump to refill the tank, all while indicating the volume of liquid in the tank. Using the menu system, alarm 1 is set to trip at 800, reset at 900, and sound the horn. Alarm 2 is set to trip at 600 and reset at 4800, which will refill the tank. The final task to accomplish is to setup the display to indicate the process values. In the SETUP DISPLY section of the menu system, make these settings:

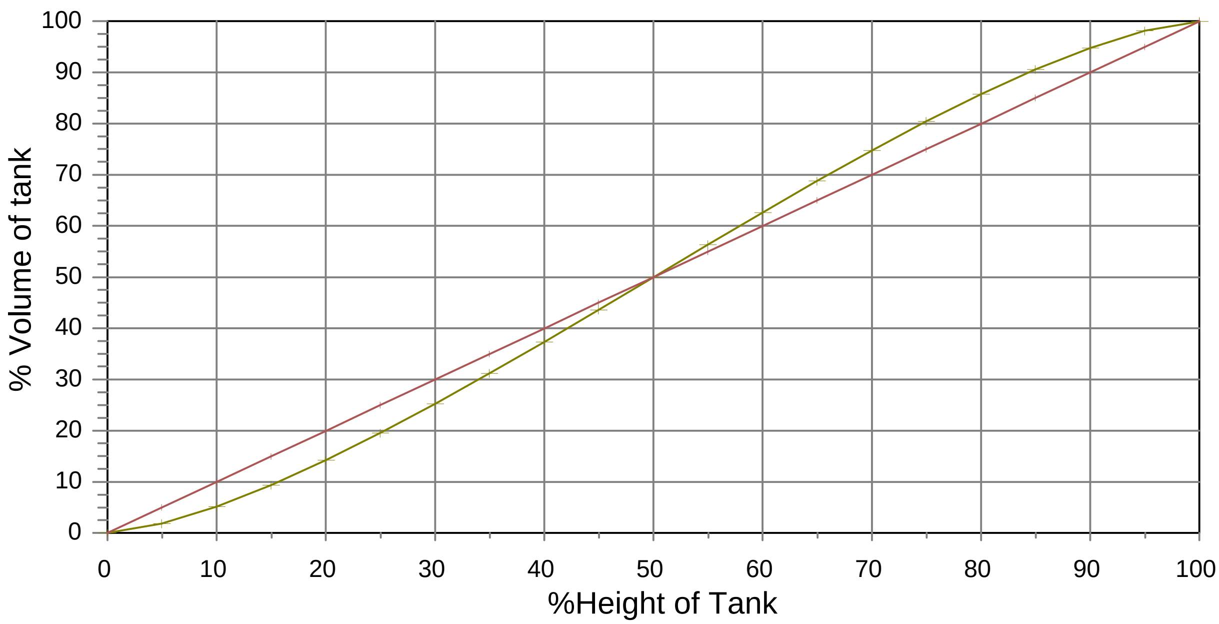
SETdP as: 0123.
PICK LABEL as: SET gl
INPUT OUTPUT CURVE as: CUSTOM CURVE

Create a table using the values in Table 3. The values in the %Height column correspond to the %Input @ BP entries. The values in the %Vol. column are transformed into display @BP entries by multiplying each value by 5000 and dividing by 100. This result is presented in table 5. After this table is entered into the 3019, it will be configured to operated as initially described. The maximum linearization error is reduced from ±290 gallons to ±7.5 gallons out of 5000 gallons .

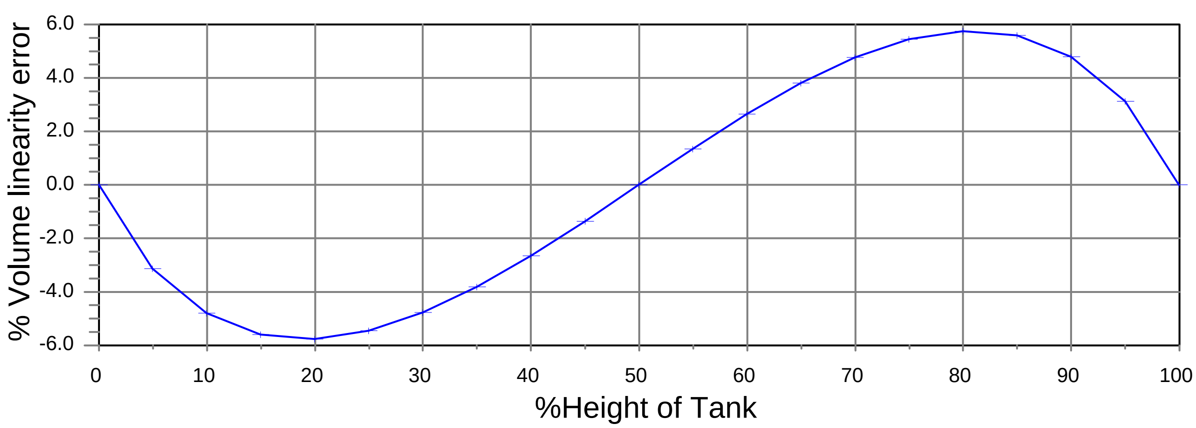
Table 2:

Normalized Height to Volume and Height to Linearity Error of a horizontal tank

%Height	%Vol.	%Error	Height	%Vol.	%Error	%Height	%Vol.	%Error
0.00	0.00	0.00	35.00	31.19	-3.81	70.00	74.77	4.77
5.00	1.87	-3.13	40.00	37.35	-2.65	75.00	80.45	5.45
10.00	5.20	-4.80	45.00	43.64	-1.36	80.00	85.76	5.76
15.00	9.41	-5.59	50.00	50.00	0.00	85.00	90.59	5.59
20.00	14.24	-5.76	55.00	56.36	1.36	90.00	94.80	4.80
25.00	19.55	-5.45	60.00	62.65	2.65	95.00	98.13	3.13
30.00	25.23	-4.77	65.00	68.81	3.81	100.00	100.00	0.00



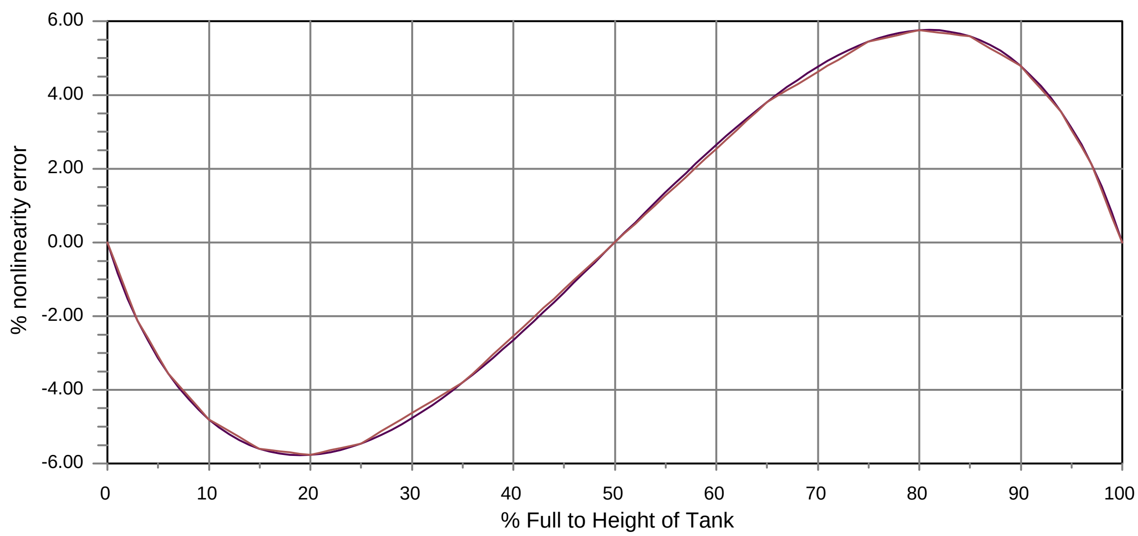
Graph 2a: Height of Liquid to Volume of Horizontal Tank



Graph 2b: linearity error of a horizontal tank

Table 3: 16 point Height to Volume relationship for a horizontal tank

%Height	%Vol.	Error	%Height	%Vol.	Error	%Height	%Vol.	Error
0.00	0.00	0.00	25.00	19.55	-5.45	90.00	94.80	4.80
3.00	0.87	-2.13	35.00	31.19	-3.81	94.00	97.55	3.55
6.00	2.45	-3.55	65.00	68.81	3.81	97.00	99.13	2.13
10.00	5.20	-4.80	75.00	80.45	5.45	100.00	100.00	0.00
15.00	9.41	-5.59	80.00	85.76	5.76			
20.00	14.24	-5.76	85.00	90.59	5.59			

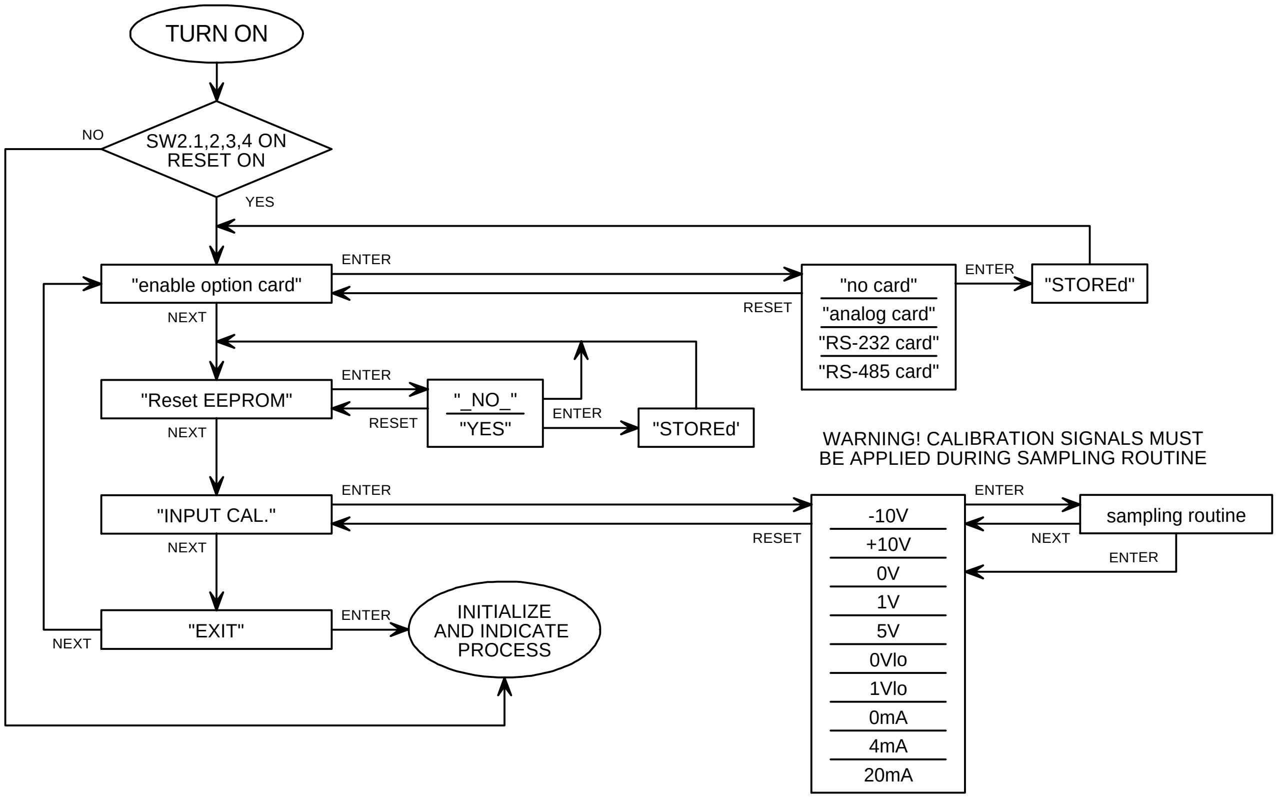


Graph 3

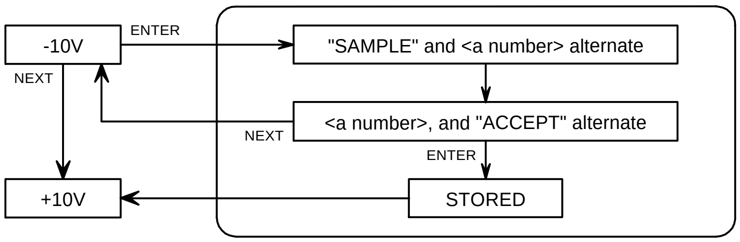
Table 4: linearization breakpoints for a 5000 gallon horizontal tank

%Input @BP	dISPLY @BP	%Input @BP	dISPLY @BP	%Input @BP	dISPLY @BP
000.00	0000	025.00	0978	090.00	4740
003.00	0044	035.00	1560	094.00	4878
006.00	0122	065.00	3440	097.00	4956
010.00	0260	075.00	4022	100.00	5000
015.00	0470	080.00	4288		
020.00	0712	085.00	4530		

SYSTEM INITIALIZATION ROUTINE

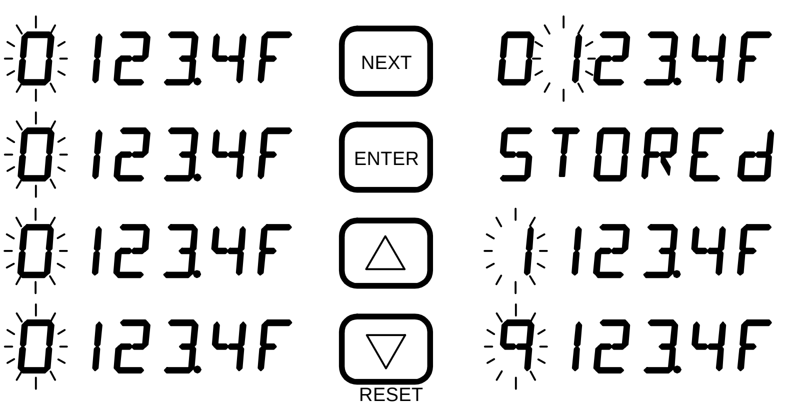


SAMPLING ROUTINE



Apply the appropriate calibration input signal before proceeding. The number represents the relative magnitude of the input signal during the sampling process.

USER AND NUMERIC INPUT KEYS

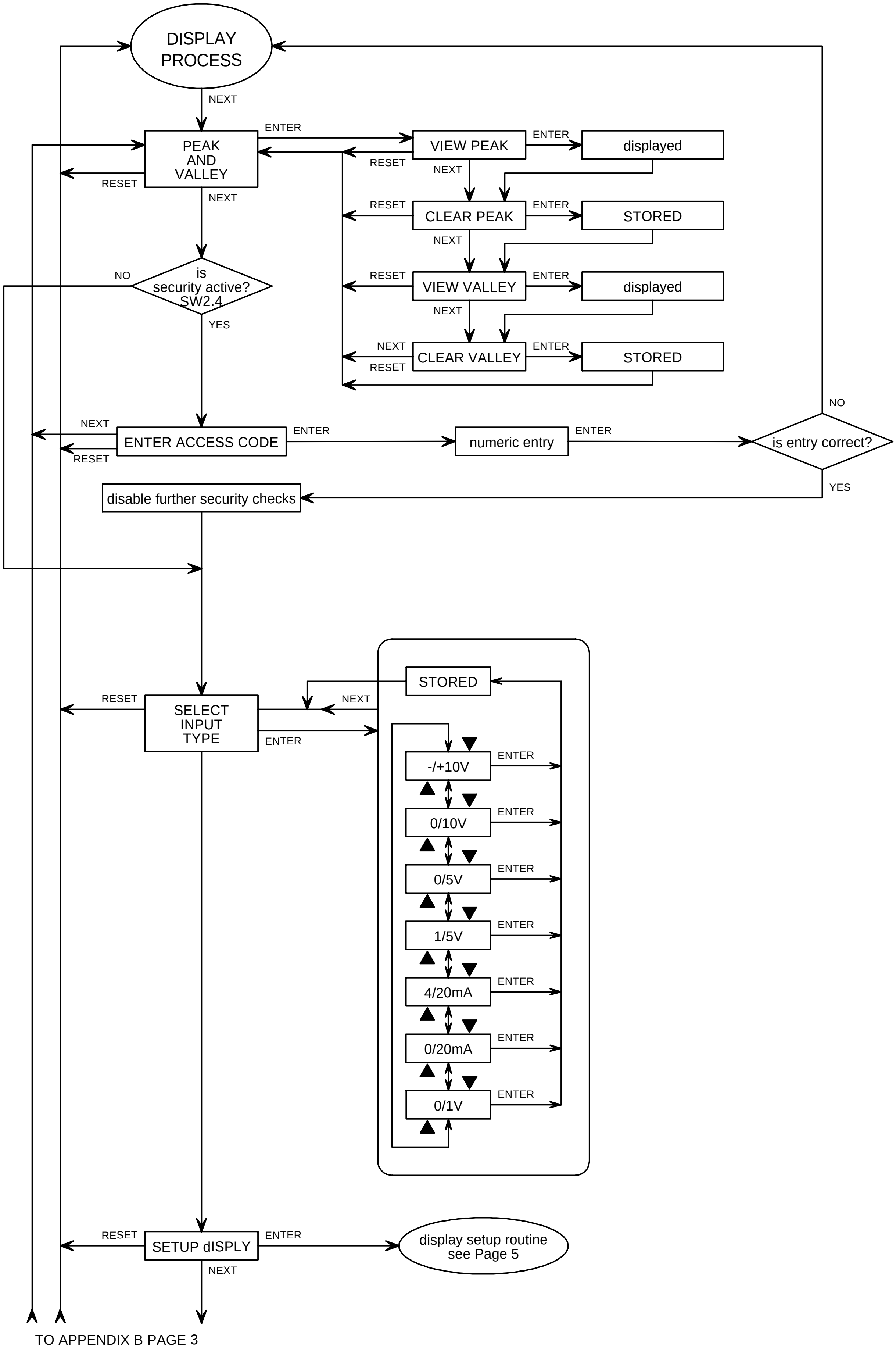


Make the next character the flashing character

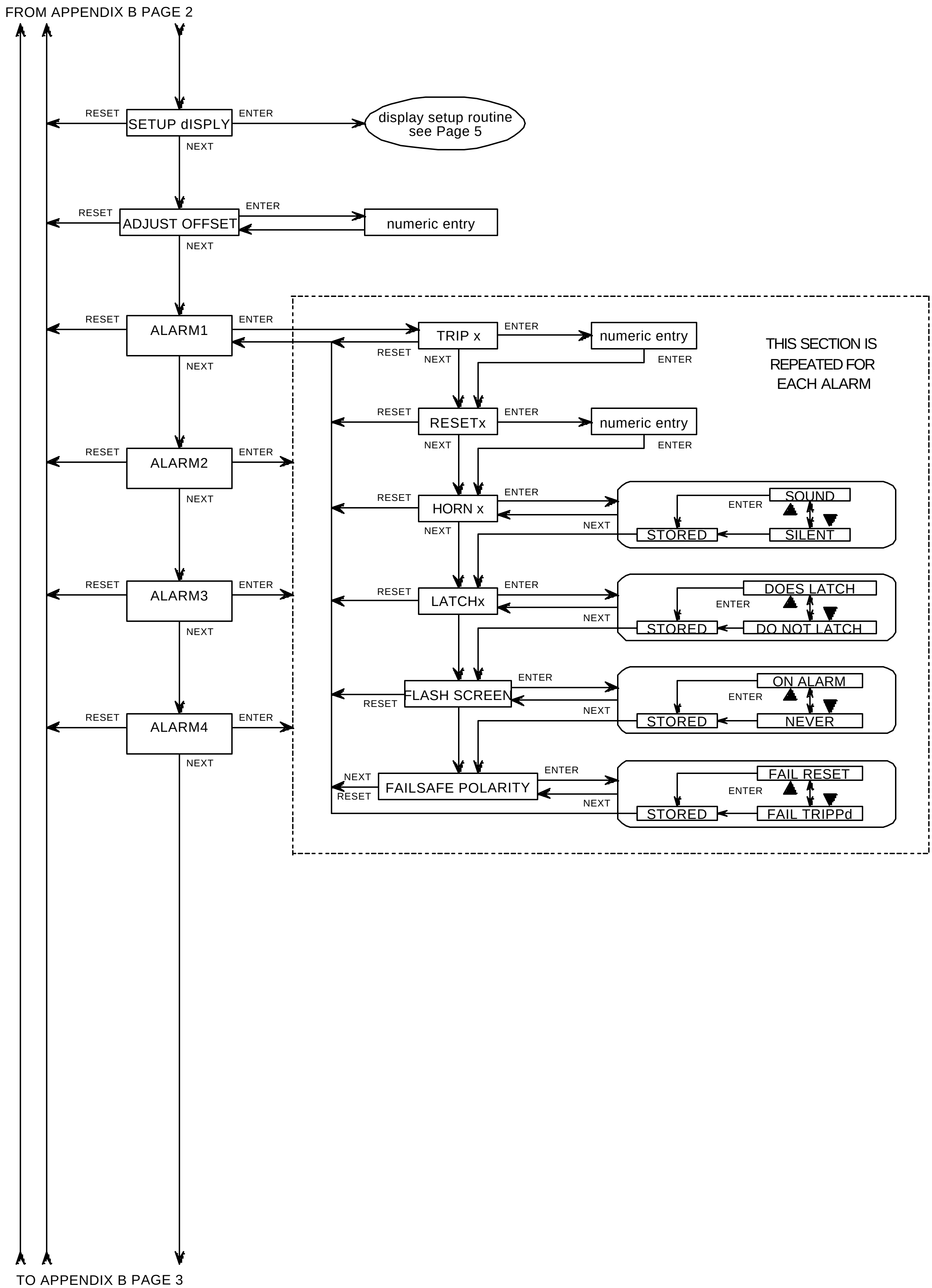
Accept input

Value of the flashing character increases

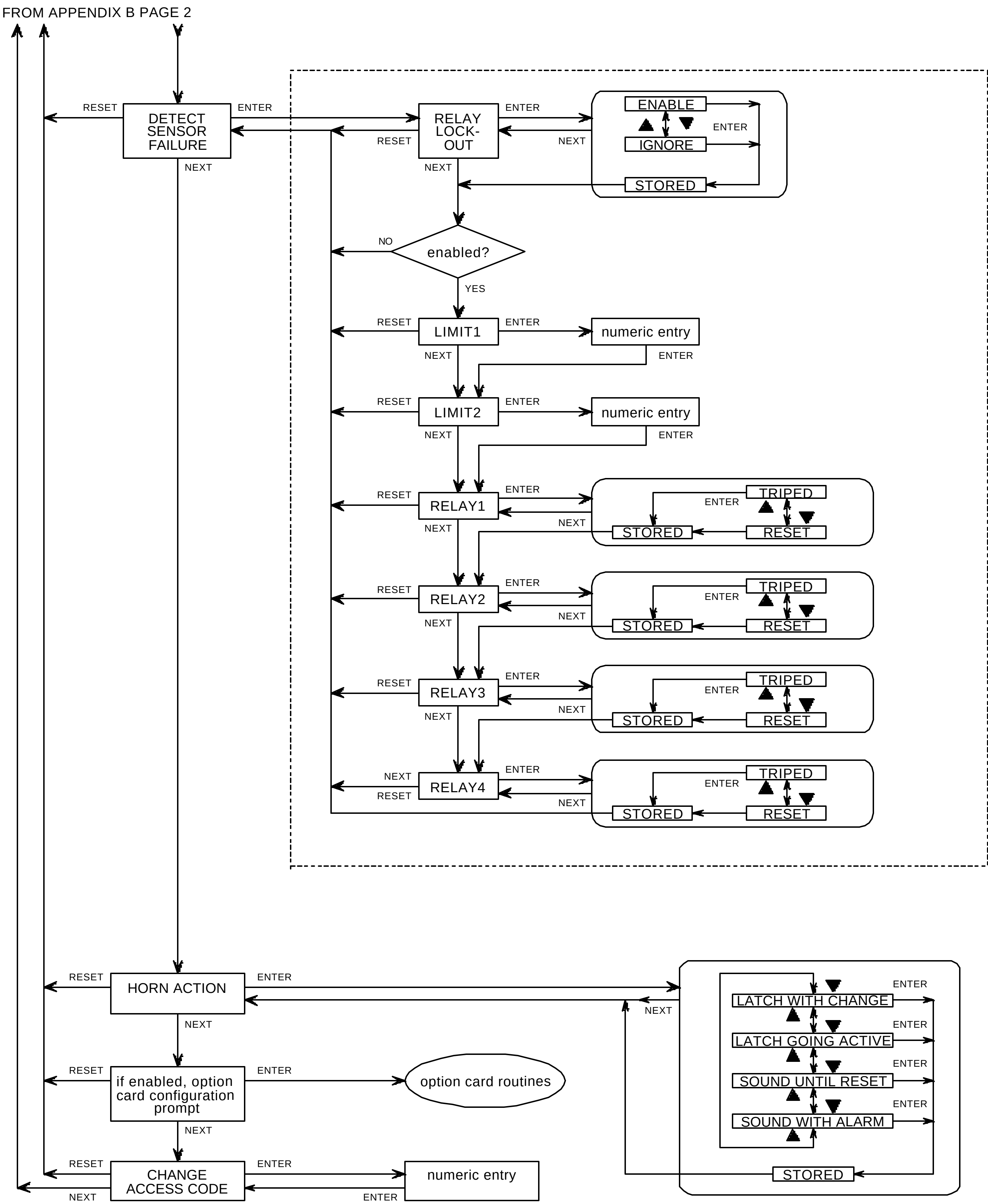
Value of the flashing character decreases


DISPLAY PROCESS
NEXT
PEAK AND VALLEY
ENTER
RESET
VIEW PEAK
displayed
CLEAR PEAK
STORED
VIEW VALLEY
displayed
CLEAR VALLEY
STORED
is security active? SW2.4
NO
YES
ENTER ACCESS CODE
numeric entry
is entry correct?
disable further security checks
SELECT INPUT TYPE
STORED
-/+10V
0/10V
0/5V
1/5V
4/20mA
0/20mA
0/1V
SETUP dISPLY
display setup routine see Page 5
TO APPENDIX B PAGE 3

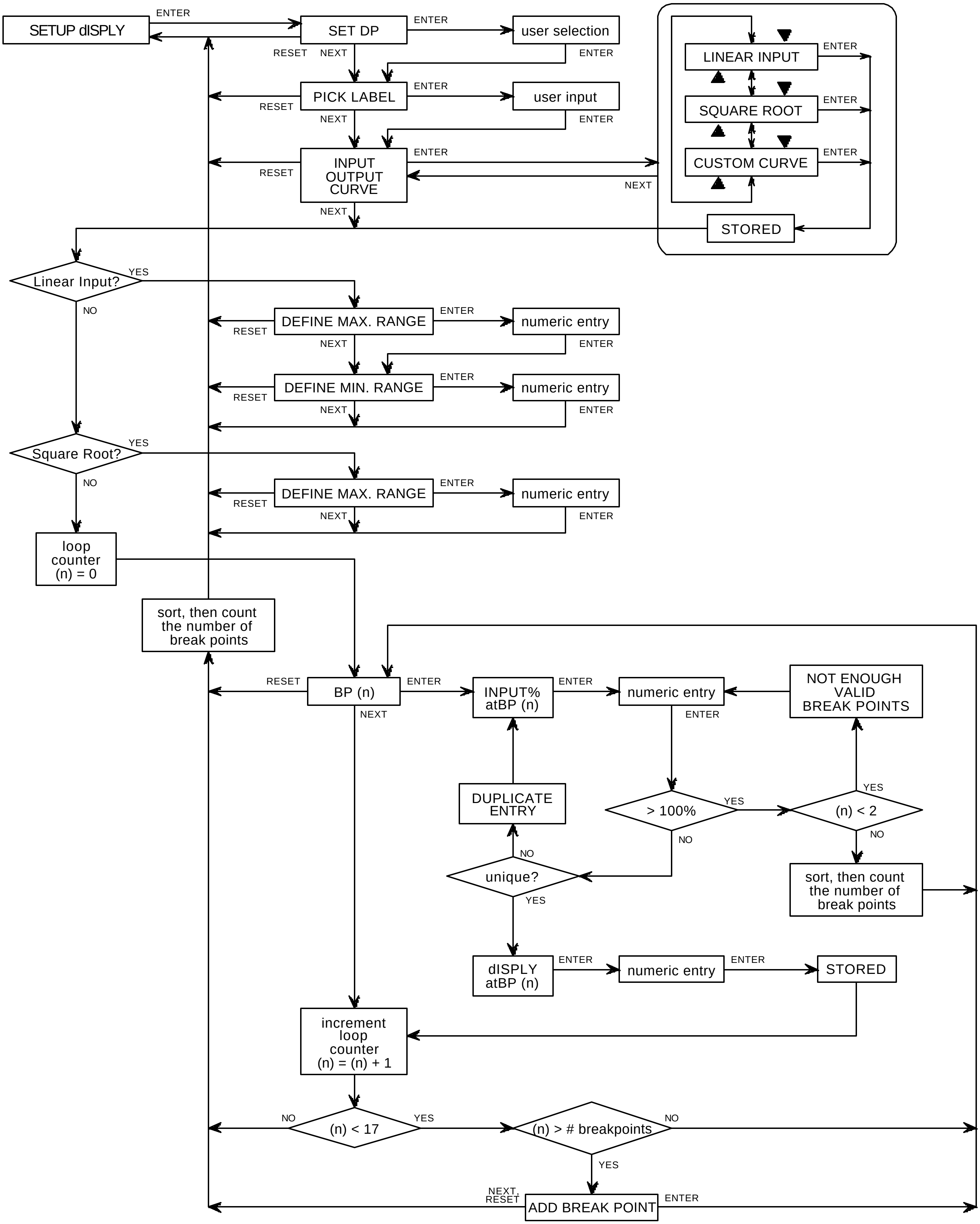
CONFIGURATION MENU FLOWCHART

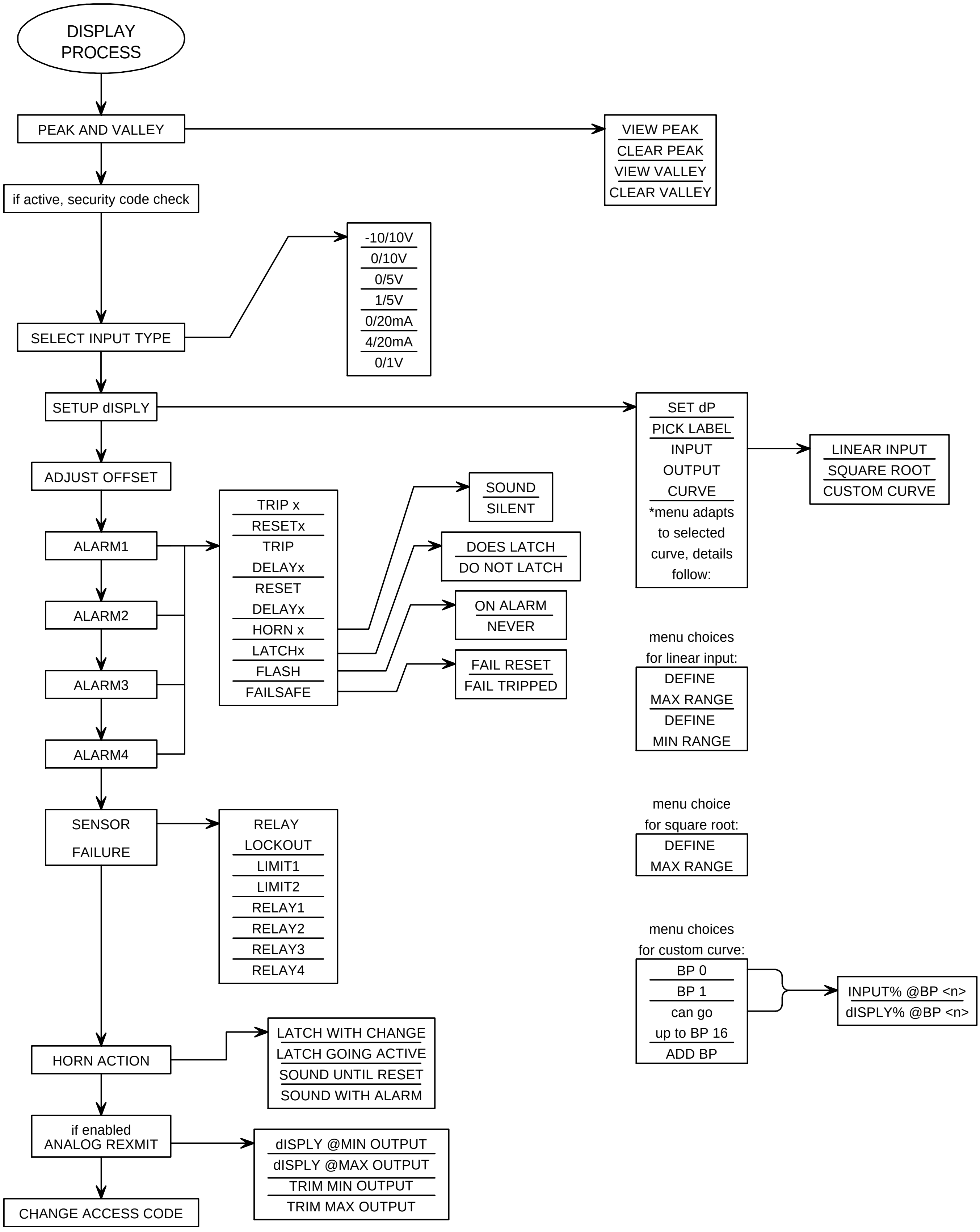


CONFIGURATION MENU FLOWCHART



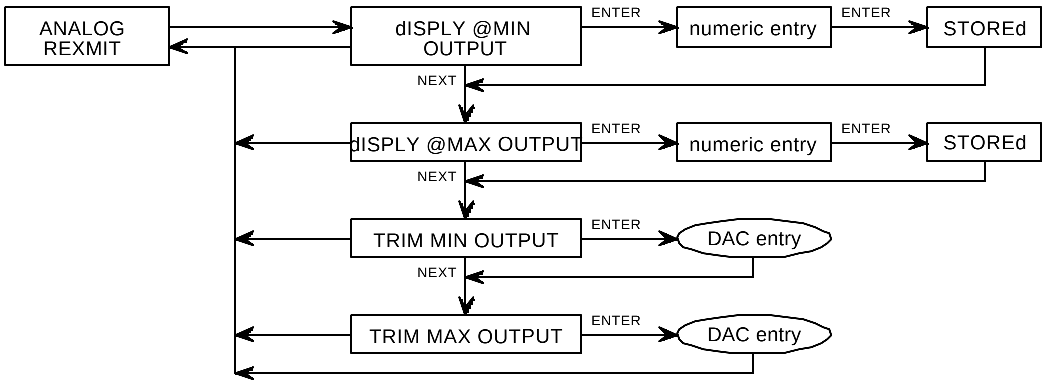
DISPLAY SETUP ROUTINE



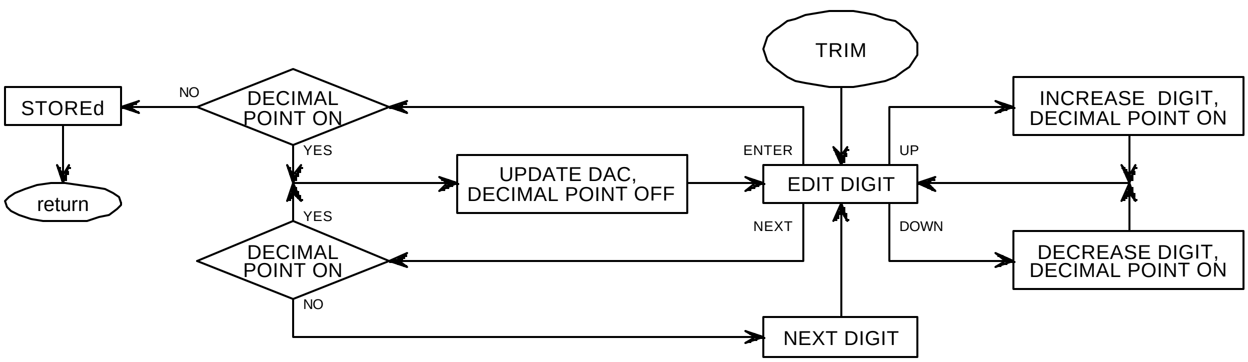

DISPLAY PROCESS
PEAK AND VALLEY
VIEW PEAK
CLEAR PEAK
VIEW VALLEY
CLEAR VALLEY
if active, security code check
SELECT INPUT TYPE
-10/10V
0/10V
0/5V
1/5V
0/20mA
4/20mA
0/1V
SETUP dISPLY
SET dP
PICK LABEL
INPUT
OUTPUT
CURVE
*menu adapts to selected curve, details follow:
LINEAR INPUT
SQUARE ROOT
CUSTOM CURVE
ADJUST OFFSET
ALARM1
ALARM2
ALARM3
ALARM4
TRIP x
RESETx
TRIP DELAYx
RESET DELAYx
HORN x
LATCHx
FLASH
FAILSAFE
SOUND
SILENT
DOES LATCH
DO NOT LATCH
ON ALARM
NEVER
FAIL RESET
FAIL TRIPPED
menu choices for linear input:
DEFINE MAX RANGE
DEFINE MIN RANGE
menu choice for square root:
DEFINE MAX RANGE
menu choices for custom curve:
BP 0
BP 1
can go up to BP 16
ADD BP
INPUT% @BP <n>
dISPLY% @BP <n>
SENSOR FAILURE
RELAY LOCKOUT
LIMIT1
LIMIT2
RELAY1
RELAY2
RELAY3
RELAY4
HORN ACTION
LATCH WITH CHANGE
LATCH GOING ACTIVE
SOUND UNTIL RESET
SOUND WITH ALARM
if enabled ANALOG REXMIT
dISPLY @MIN OUTPUT
dISPLY @MAX OUTPUT
TRIM MIN OUTPUT
TRIM MAX OUTPUT
CHANGE ACCESS CODE

(optional) ANALOG RETRANSMISSION

ANALOG RETRANSMISSION CONFIGURATION MENU FLOWCHART



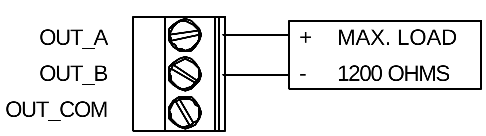
TRIM ANALOG OUTPUT



ANALOG RETRANSMISSION WIRING AND DIP SWITCH SETTING

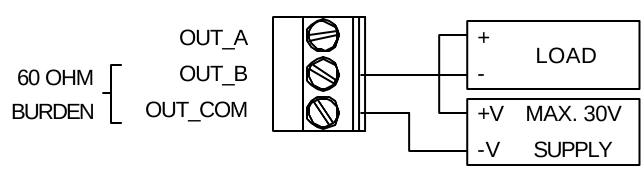
4/20mA OUTPUT

INTERNAL SUPPLY POWERS LOOP



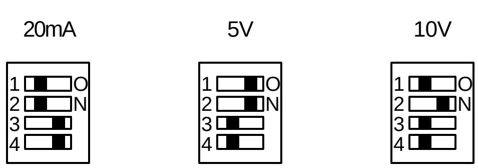
4/20mA OUTPUT

EXTERNAL SUPPLY POWERS LOOP

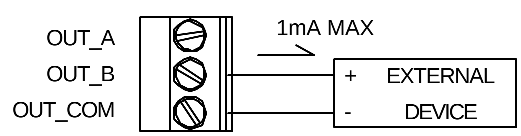


SETTING SW3 ON ANALOG BOARD

TO SELECT OUTPUT SIGNAL



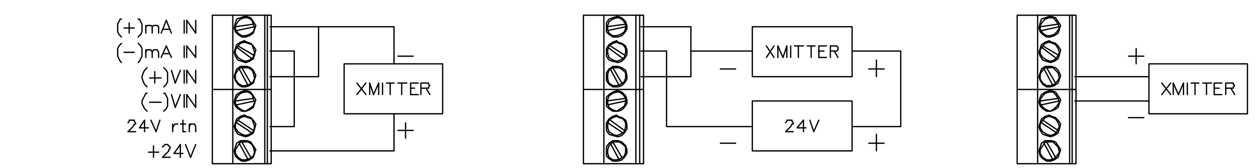
VOLTAGE OUTPUT



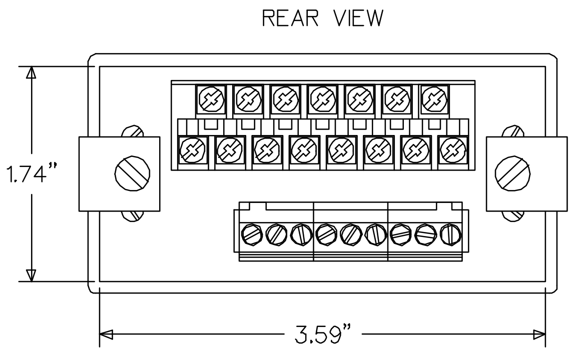
DWG NO.	516107	SH	1

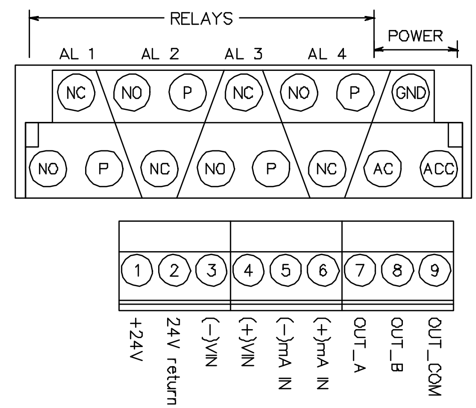
REV	DESCRIPTION	DATE	APPROVED
A	RELEASE: ECN 3155A	AUG 98	A.G.
B	SWAP OUT_A, OUT_B ECN 3178	APR 99	A.G.
C	ADD 3019A ECN 3155D	AUG 00	
D	WAS 125VDC, ADD FUSE NOTES ECN	SEPT 02	

WIRING



3019A/20A NOTE: JUMPER FROM +mA TO +VIN FOR mA INPUT

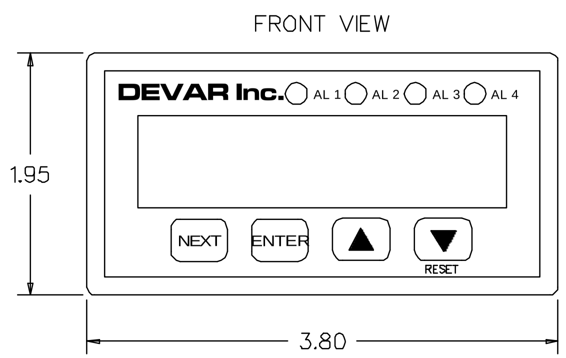


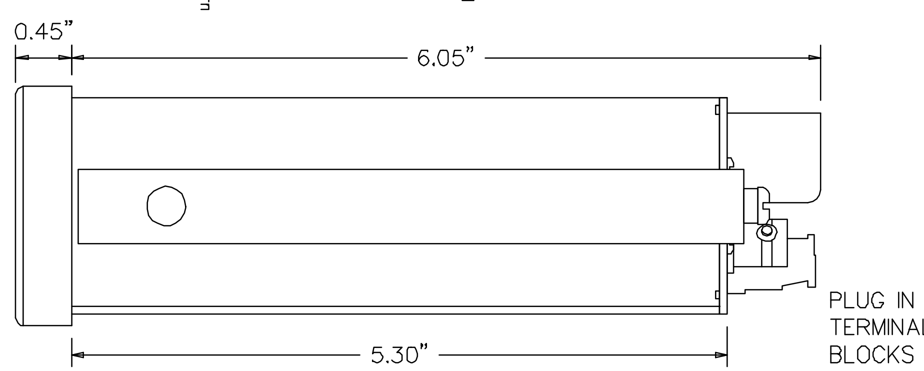


POWER: 90/140 VAC 50/60 Hz OR 130/190 VDC
ACC = AC NEUTRAL OR DC RETURN
AC = AC HOT OR ±DC (FUSED LINE)
FUSE: 1/8A 250V LITTELFUSE SERIES 230.
INSTALLED ON PC BOARD, NOT FIELD REPLACABLE

OPTION	OUT_COM	OUT_B	OUT_A
Vout	COMMON	Vout	NC
Isink	mA return	+mA in	NC
Isource	NC	mA return	+mA out
RS-232	COMMON	Tx	Rx
RS-485	COMMON	B	A

NOTE:
Isink: EXTERNAL SUPPLY DRIVES LOOP
Isource: INTERNAL SUPPLY DRIVES LOOP





PANEL CUTOUT
92 $^{+0.8}_{-0.5}$ X 45 $^{+0.8}_{-0.5}$ mm
3.622 $^{+0.032}_{-0.019}$ X 1.772 $^{+0.032}_{-0.019}$ INCHES

UNSPECIFIED DIMENSION TOLERANCE
DECIMAL +/− 0.005"
FRACTION +/− 1/64"
ANGLE +/− 1/2 DEGREE

MATERIAL −N/A−

FINISH −N/A−

NEXT ASS'Y NO. B/M 516113−AR

CONTRACT NO.		
PREPARED	SMJL	JUL 98
CHECKED		
MECH	LG	AUG 98
ELEC		
DESIGN		
APPROVED		
APPROVED		

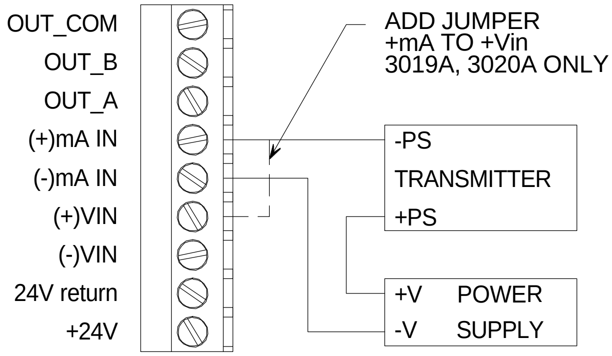
DEVAR Inc. 706 Bostwick Avenue, Bridgeport, Conn. 06605 TEL: (203) 368−6751 FAX; (203) 368−3747

GENERAL DIMENSIONS
3019, 3020 INDICATOR − CONTROLLER

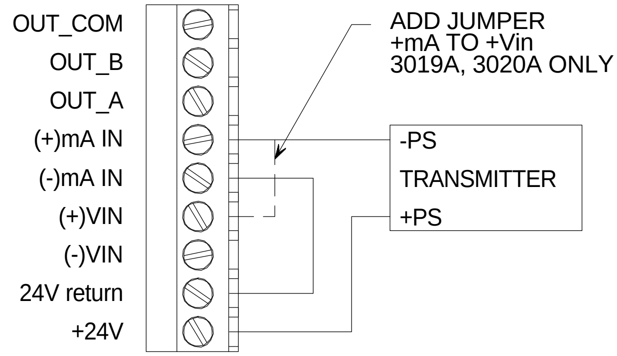
SIZE	DRAWING NO.	REV
B	516107	D

SCALE FULL | WT | SHEET 1 OF 1

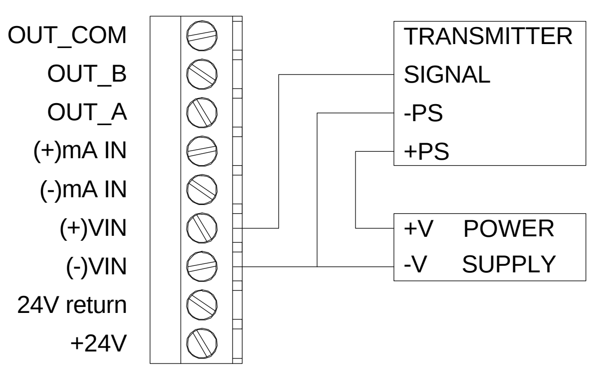
4/20mA INPUT, EXTERNAL SUPPLY



4/20mA INPUT, INTERNAL SUPPLY



VOLTAGE INPUT, EXTERNAL SUPPLY



VOLTAGE INPUT, INTERNAL SUPPLY