

# 1205R/1209R/1221R Series Motor Regenerative Braking Controllers

## FEATURES

The features of the 1205R/1209R/1221R Regenerative Braking Controllers are an extension of the Curtis 1200 series controllers and include the following:

- Smooth Stepless Operation
- Current Multiplication
- Acceleration Ramp Control
- Current Limiting
- Undervoltage Protection
- Overvoltage Protection
- Thermal Protection
- Accelerator Pot Fault Protection
- Controller Fault Protection
- High Pedal Protection
- Regenerative Braking
- Isolated and Non-isolated Models

## GENERAL OPERATION

The controller operates in two distinct modes, Drive and Regen Braking. These modes are selected by asserting the corresponding Enable inputs. If both inputs are asserted, no operation occurs. These Enable inputs are wired to switches on the throttle and brake pedals of the vehicle and through auxiliary contacts on the Regen and Drive contactors as shown on the wiring diagrams. In the drive mode, the controller delivers energy to the motor under control of the throttle pot in the same way as other Curtis PMC controllers. In the Regen mode, the controller slows the motor returning braking energy to the battery. The motor current may be held constant during the braking time, or it may be variable, by a potentiometer that senses the position of the brake pedal. Variable regen braking current provides the "best feel" and is standard. In either case, the maximum motor current during regen braking is adjustable by a trimpot accessible through a hole in the side of the case.

These controllers are available with two different forms of control circuitry. A controller with Isolated control circuitry should be specified for use in vehicles in which the contactors and control switches operate from a 12 volt battery separate from the traction battery, and/or with a DC/DC converter. There is no galvanic connection between the motor drive circuits and the control circuits, and voltages up to 1000 volts may exist between the two. The Non-isolated type of controller should be specified for use in vehicles in which the contactors are to be powered from the full traction battery voltage. In this type of controller, the control wiring return (control connector pin 5) is connected internally to the B- bus bar.

## 1205R/1209R/1221R MODELS

CURTIS PMC MODEL	NOMINAL VOLTAGE	DRIVE CURRENT	UNDER VOLTAGE POINT	OVER VOLTAGE POINT	CHARGE VOLTAGE ADJ. RANGE	CHARGE VOLTAGE SETPOINT	MOSFET ON RES. @ 25° C
1205R-11XX	36 V	350 A	21 V	87 V	40-45 V	43 V	2.3 mΩ
1205R-11XX	48 V	350 A	21 V	87 V	53-60 V	58 V	2.3 mΩ
1209R-11XX	36 V	450 A	21 V	87 V	40-45 V	43 V	2.2 mΩ
1209R-11XX	48 V	450 A	21 V	87 V	53-60 V	58 V	2.2 mΩ
1209R-11XX	60 V	450 A	29 V	87 V	66-75 V	72 V	2.2 mΩ
1209R-11XX	72 V	450 A	45 V	103 V	80-90 V	86 V	1.8 mΩ
1209R-11XX	78 V	450 A	45 V	103 V	86-98 V	94 V	1.8 mΩ
1209R-11XX	84 V	275 A	45 V	159 V	92-105 V	101 V	5.6 mΩ
1209R-11XX	96 V	275 A	45 V	159 V	106-120 V	115 V	5.6 mΩ
1209R-11XX	108 V	275 A	45 V	159 V	119-135 V	130 V	5.6 mΩ
1209R-11XX	120 V	275 A	45 V	159 V	132-150 V	144 V	5.6 mΩ
1221R-11XX	36 V	550 A	21 V	87 V	40-45 V	43 V	1.6 mΩ
1221R-11XX	48 V	550 A	21 V	87 V	53-60 V	58 V	1.6 mΩ
1221R-11XX	60 V	550 A	29 V	87 V	66-75 V	72 V	1.6 mΩ
1221R-11XX	72 V	550 A	45 V	103 V	80-90 V	86 V	1.3 mΩ
1221R-11XX	84 V	400 A	45 V	159 V	92-105 V	101 V	4.0 mΩ
1221R-11XX	96 V	400 A	45 V	159 V	106-120 V	115 V	4.0 mΩ
1221R-11XX	108 V	400 A	45 V	159 V	119-135 V	130 V	4.0 mΩ
1221R-11XX	120 V	400 A	45 V	159 V	132-150 V	144 V	4.0 mΩ

## CONTROL CONNECTORS

With the exception of the throttle pot, which connects to 1/4 inch push-on terminals, all control connections to the controller are made by a 10 pin Molex connector near the A2 bus bar. Figure 1 shows the location of these connections. The connector is of the Molex "Mini-Fit, Jr." family. The mating receptacle is Molex part number 39-01-2100. The Molex part number for the female contact (wire size AWG 18-24) is 39-00-0039. The manufacturer's address is:

Molex, Inc.  
2222 Wellington Ct.  
Lisle, IL 60532  
Phone. 708-969-4550

European Headquarters: Munich, Germany  
Tel: 49-89-413092-0

## CONNECTIONS

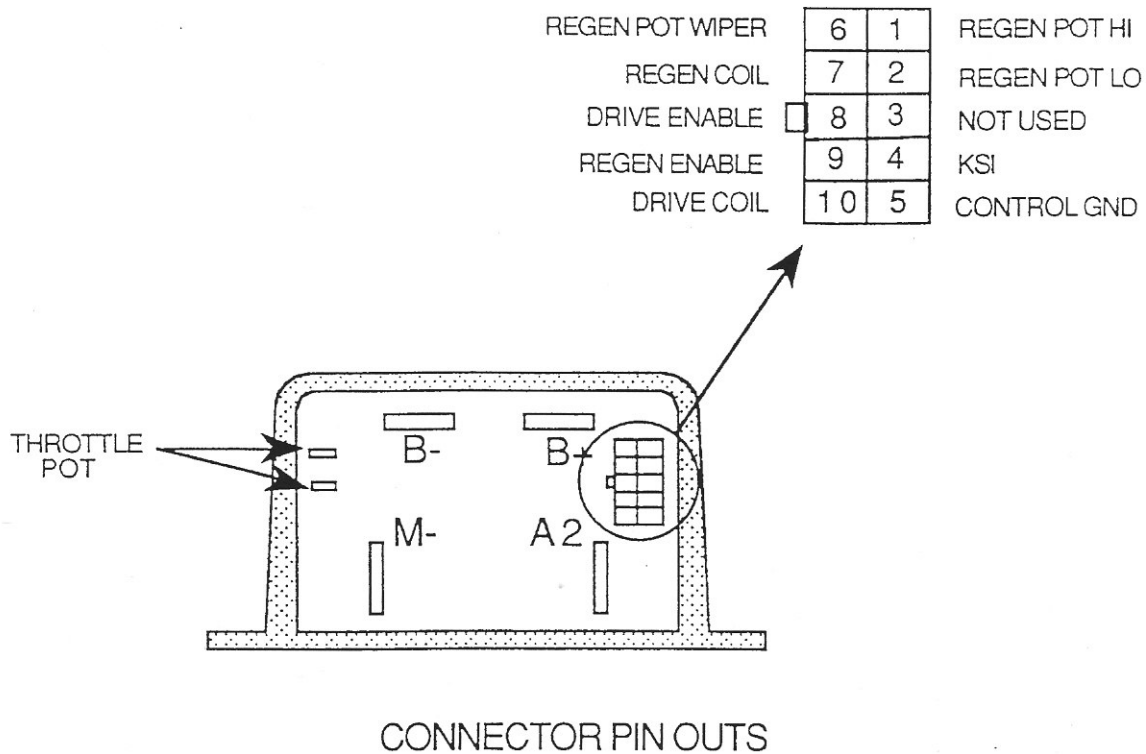


Figure 1

## CONTROL CONNECTION DESCRIPTIONS

Regen Pot High (pin 1)Regen Pot Low (pin 2)Regen Pot Wiper (pin 6)

These are the connections to the regen braking current control pot. If no pot is used (fixed regen current), a 4.7 k $\Omega$  resistor must be connected between pins 1 and 2, otherwise, the controller will interpret the lack of a pot as a fault. If a pot is used, its resistance should be in the range of 2k $\Omega$  to 5k $\Omega$ . A three wire connection is used so pots with a high wiper contact resistance (e.g. linear slide types), which would be unsuitable for use as a two wire rheostat, may be used here.

Key Switch Input (pin 4)

This input has the same function as in other Curtis PMC controllers. In Isolated control systems, the KSI is turned on by connection to the positive isolated supply (+12 Volts). In Non-isolated systems, full traction battery voltage is used. In either case, it is recommended that the control circuitry feed to the keyswitch be fused to prevent wiring damage in the event of accidental short circuits. If it is desired to provide protection against damage due to reversed polarity of either the control or traction batteries, this can be done with a diode in series with the keyswitch line, as shown on the drawings. This diode must, of course, be rated to carry the full current of all the contactors that may be operated at once (power dissipation in the diode may need to be considered) and withstand the control circuit voltage in the reverse direction.

Control Wiring Return (pin 5)

In Isolated control systems, this is the negative terminal of the isolated supply. In order to maintain the integrity of the isolation, care should be taken that no connection from this return, or any other point in the control wiring is made to the traction battery wiring. The controller can withstand up to 1000 Volts between the two circuits. In Non-isolated systems, this pin is internally connected to the controller B- bus and must be left unconnected.

Regen Enable (pin 9)Drive Enable (pin 8)

These are the control inputs to put the controller into the Drive or Regen operational modes. In Isolated control systems, these inputs are turned on by connection to the positive isolated supply (+12 Volts). In Non-isolated systems, full traction battery voltage is used.

Regen Coil (pin 7)Drive Coil (pin 10)

These are contactor driver outputs which control the contactors to achieve the interlocks and fault protection functions described below. The contactor coil current may be as high as 2 Amps for Isolated models and 1 Amp for Non-isolated models. Coil suppression diodes are not required for the Drive and Regen contactor coils, as they are built into the controller.

**CONTACTOR CONFIGURATIONS**

All installations should have a main contactor, wired as shown in the diagrams. A precharge resistor may be used if desired. The same considerations that apply to the main contactor for other Curtis PMC controller applications also apply here. In order to change the motor/controller wiring to provide the drive and regen braking functions, a rather specific contactor configuration is required. The configuration is different if the motor is reversed electrically. These contactor configurations are discussed below.

Motor not reversed

Two contactors are required, each having two normally open contacts (i.e., dpst, N.O.). In addition, as discussed below under Contactor Interlocks, each of the contactors must have an auxiliary low power contact that is normally closed (i.e., spst, N.C.). The paired Albright models work well for this, although only the outer links can be used because of the auxiliary switches. A typical Albright part number for this is SW192AB-46, but size depends upon current.

Motor reversed electrically

In this case, two dpst, N.O. contactors are required for the reversing function. These do not need auxiliary switch contacts, so the connecting links provided with the Albright paired sets may be fully utilized. In addition, two contactors each having one normally open contact (spst, N.O.) are required, and these must have the auxiliary spst, N.O. low power contacts. A typical Albright part number for this is SW200A-16, but size depends upon current. The reversing wiring also requires a small dpdt relay to interchange the coils of the reversing contactors. The contacts of this relay must be able to switch the coil currents of the contactors.

**CONTACTOR INTERLOCK**

In order to prevent simultaneous operation of the Drive and Regen contactors, the two contactors are interlocked by using auxiliary microswitches on the contactors. Albright contactors fitted with these switches are specified by an "A" after the number (e.g. SW 192A). Note on the wiring diagrams that these auxiliary microswitches allow only one of the contactors to be operated at a time. These are the recommended contactors for the Drive and Regen contactors.

Alternately, dual contactors with a mechanical interlock between them may also be used. This type of contactor is generally used for motor reversing and have a "teeter-totter" type arrangement, where only one contact may be closed at a time. This also provides positive protection from both contacts being closed simultaneously.

## REGEN CURRENT CONTROL

Curtis PMC controllers usually operate in such a way as to translate the throttle input demand into a corresponding output duty cycle, which forces a certain voltage across the motor. During the drive mode, the R series controllers operate this way. During regenerative braking, however, the controller operates as a motor current control rather than as a voltage control. The motor current during regenerative braking is determined by the regen demand signal.

The regen current demand signal may be either variable or fixed. In general, the ability of the driver to vary the motor current during braking will give far better vehicle performance. If this type of operation is desired, it will be necessary to provide a potentiometer input to the controller for the regen demand signal. This potentiometer must be mechanically operated by the vehicle brake pedal in such a way that its travel precedes or overlaps the operating stroke of the mechanical (hydraulic) brake system. As the vehicle brake pedal is depressed, the following sequence of actions should occur:

- 1) The brake light switch should close,
- 2) the regen enable switch should close (this may be the same switch as 1),
- 3) the regen demand pot should move through its travel, and then
- 4) the mechanical brake should move through its operating stroke.

The mechanical design of the brake pedal linkage to achieve this operation may be quite tricky, and careful attention should be given to it. Take care that the actions of the switch(es) and pot are correct and that excessive forces are not applied to them during any conditions of brake adjustment or wear.

Any type of potentiometer that is mechanically suitable and has a resistance in the range of  $2k\Omega$  to  $5k\Omega$  may be used. A Curtis PMC potbox, such as the model PB-1 may be used. A 3-wire true potentiometer type connection is employed, rather than the 2-wire rheostat type as is used for the drive throttle input, so that potentiometers that have a high wiper resistance (such as linear slide types) can be used. The choice of what type of potentiometer used should be made on the basis of what will work best with the particular mechanical arrangement of the vehicle's brake pedal and linkage.

The regen current demand signal may also be fixed during the regen braking interval. That is, the regen current may be adjusted to some fixed value and when the regen mode is entered, by closing the switch on the vehicle brake pedal, the controller will cause regenerative braking at that current until the vehicle is stopped. The fixed braking current may be set by a potentiometer external to the controller connected as shown in the wiring diagrams, or the potentiometer may be omitted, and the current adjusted by means of the trimpot located where the plug current adjustment is located on standard Curtis PMC controllers. Note that if the external regen current pot is not used, a  $4.7k\Omega$  fixed resistor must be connected between pins 1 and 2 of the control connector, so that the controller does not sense the lack of a pot as a fault.

## ADJUSTMENTS

The four adjustments available on the controller (See Figure 2) are: Acceleration Ramp, Main Current Limit, Regen Current Limit, and Charge Voltage Limit. All parameters are user adjustable, but Charge Voltage Limit is critical and should not be adjusted unless the proper equipment is available. Charge Voltage is properly adjusted at the factory and no further adjustment should be necessary.

## CHARGE VOLTAGE LIMIT ADJUSTMENT

These controllers have a feature which causes the regeneration current to be reduced as the battery reaches full charge. In this way, overcharging of the traction battery is avoided. This could occur, for example, by braking down a long hill with an already fully charged battery. While this feature is effective in preventing battery damage due to overcharging (by overheating, excessive gassing, etc.), it will cause a reduction or elimination of available regen braking effort when the battery is fully charged.

The end-of-charge voltage is adjustable by a trimpot located near the rear of the controller and on the side opposite the other trimpot adjustments (see Figure 2). The end-of-charge voltage can be adjusted over the range from 2.2 to 2.5 Volts per cell (clockwise = higher voltage), and is factory set to 2.4 Volts per cell. For proper operation, the controller model must be chosen for the exact nominal battery voltage (i.e. number of cells x 2.0 volts per cell). Adjustment of the charge voltage trimpot will be required if the end-of-charge voltage appropriate for the particular battery used in the vehicle is different from the 2.4 Volts per cell set at the factory (other factory settings are available on request). The best setting may be a compromise since the appropriate voltage will vary with battery temperature and life.

The adjustment may be performed by trial-and-error, changing the setting and driving the vehicle downhill with fully charged batteries to verify that overcharging does not occur. Alternately, the adjustment can be made by applying the desired battery end-of-charge voltage to the controller (e.g. with an adjustable power supply), selecting the regen mode, and adjusting the trimpot so that the controller M- output just turns off. This can be observed by preventing operation of the regen contactor (M- output is disconnected) and measuring the voltage from M- to B-. When the adjustment is properly made, the voltage should increase to nearly full battery voltage.



## ADJUSTMENTS

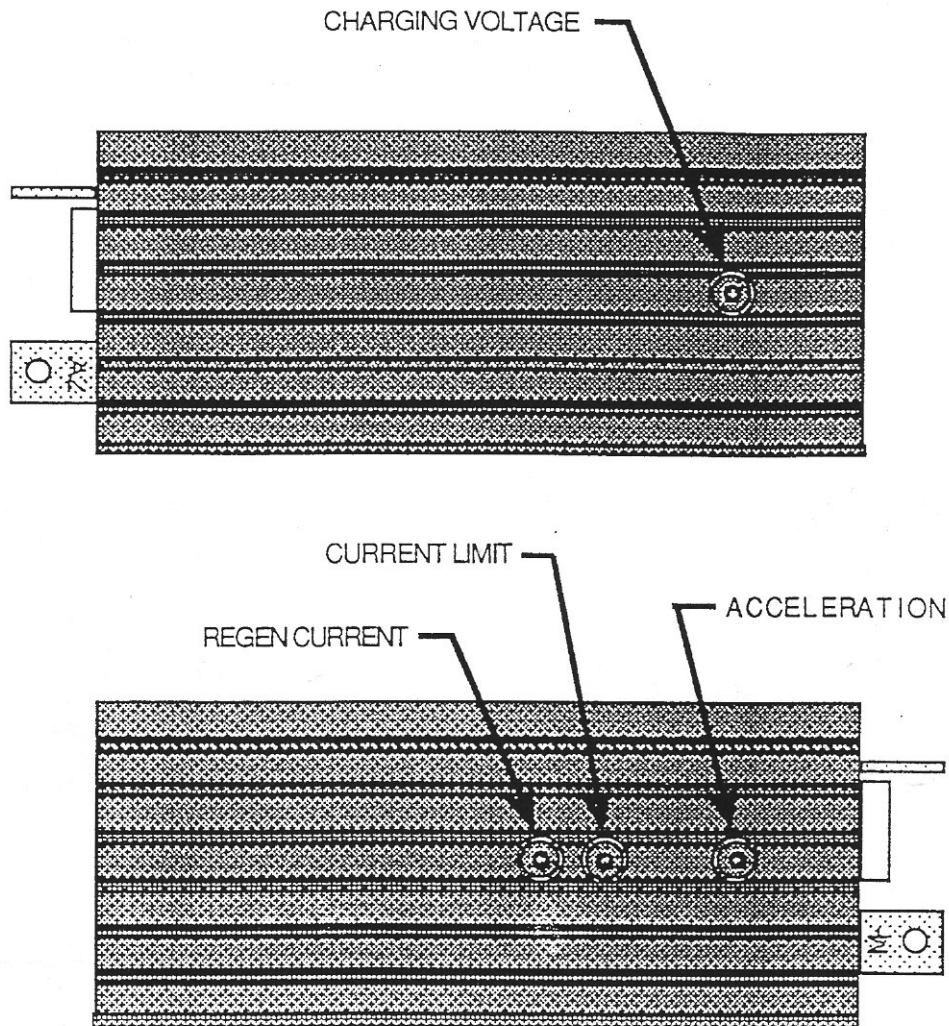
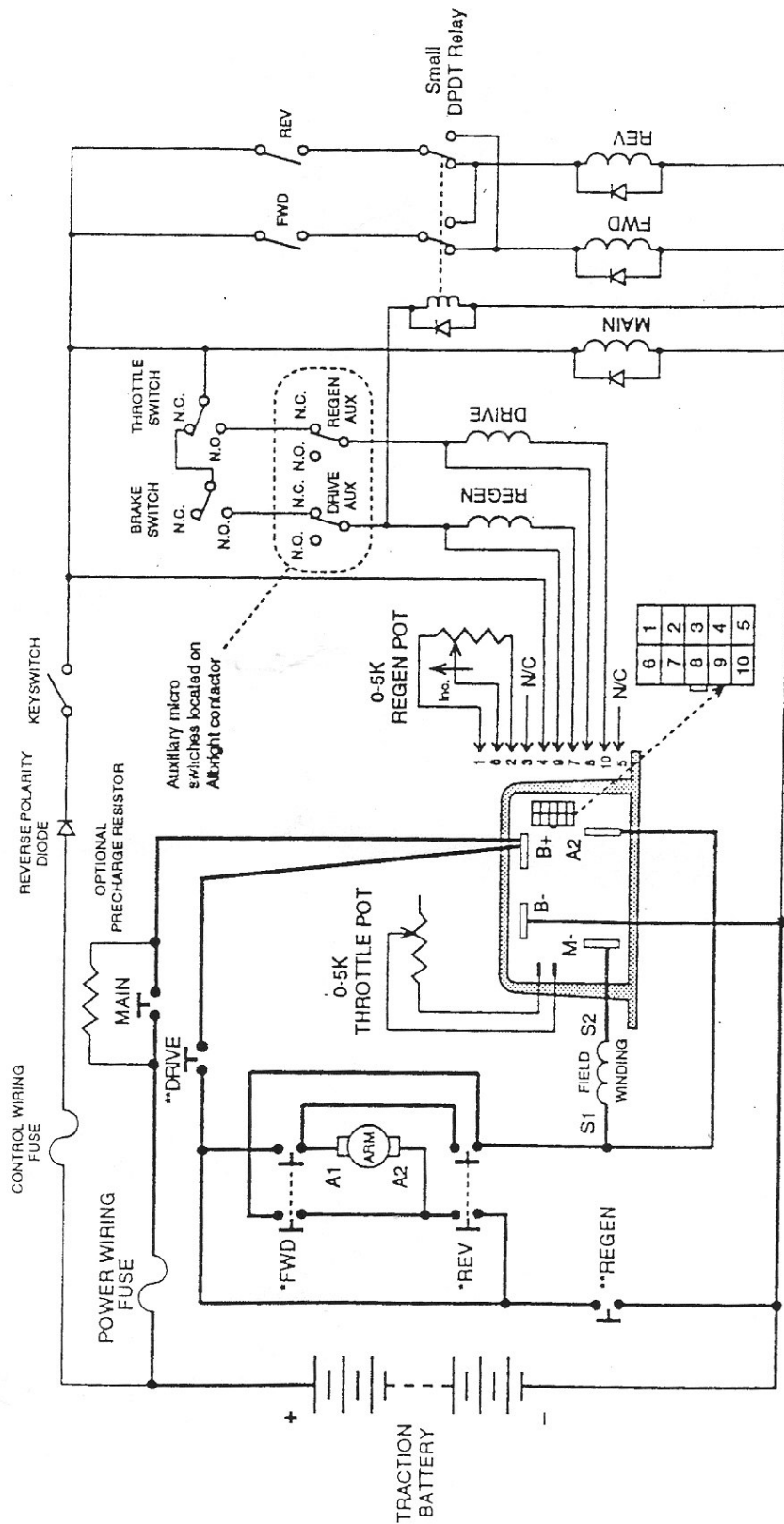


Figure 2

## WIRING DIAGRAMS

Wiring diagrams for the four basic configurations are shown on the following pages. These are; 12 volt isolated wiring without electrical reversing, 12 volt isolated wiring with electrical reversing, non-isolated wiring without electrical reversing and non-isolated wiring with electrical reversing.

**CAUTION:** When using the Curtis PMC Regenerative Controllers, no deviation from the applications shown in the wiring diagrams should be attempted without express approval from the Curtis PMC Engineering Department.



\* Albright SW192B contactors must be used for FWD and REV contactors  
 \*\* Albright SW200A contactors must be used for Drive and Regen contactors

Wiring Option:  
 Non-isolated Control and Reverse operation

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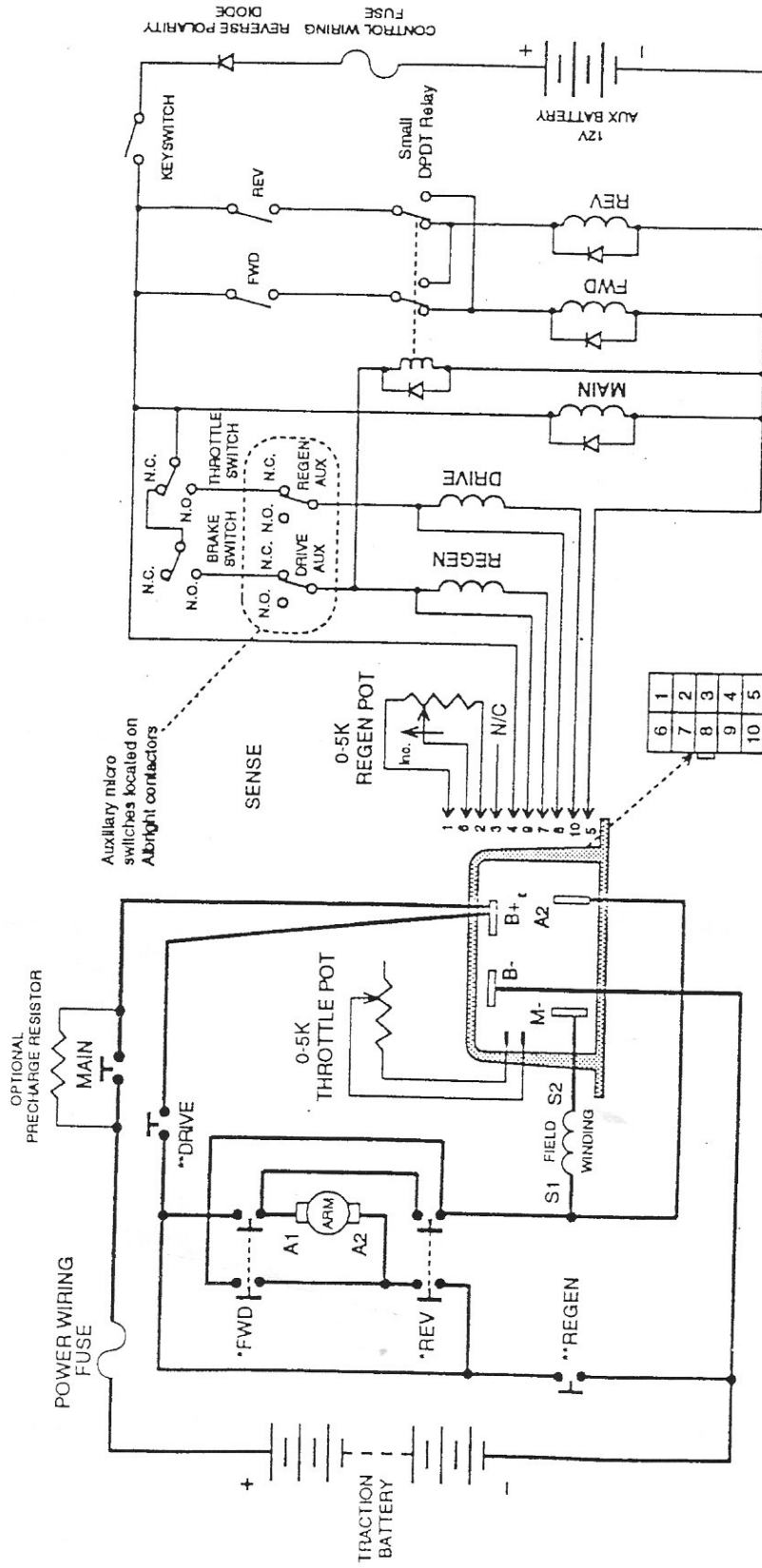
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3 PLACES DEC +	Q.A.	
	ENGR.	4/16/83
	CHECKED	4/16/83
	DRAWN	4/16/83
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN		


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 6591 Sierra Ln, Dublin, CA 95568

Wiring Diagram  
 Regenerative Braking Controller

CODE IDENT. NO. 18583  
 SIZE A  
 REV. A  
 WD14495R004

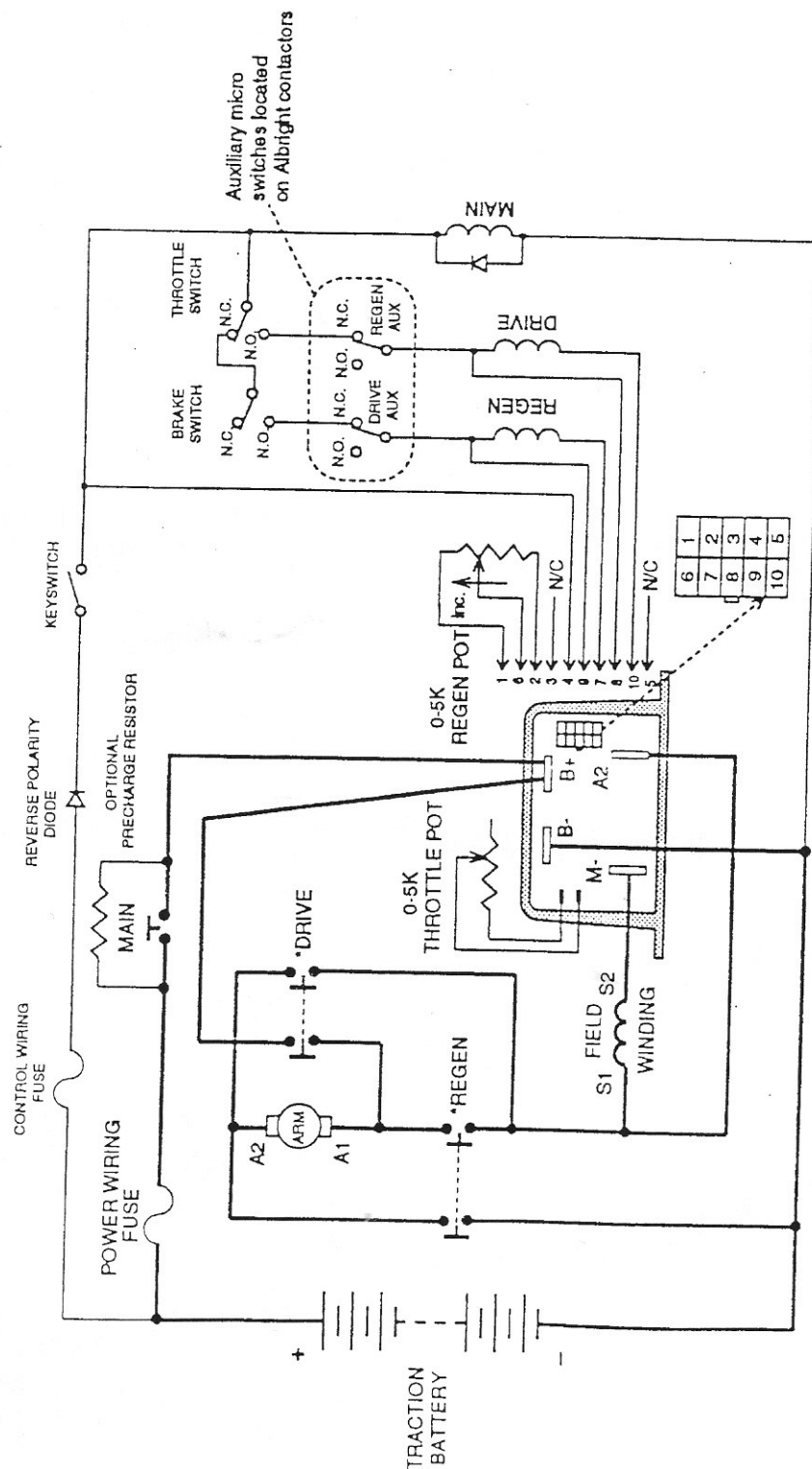




\* Albright SW192B-2 12CO contactors must be used for FWD and REV contactors  
 \*\* Albright SW200A-16 12CO contactors must be used for Drive and Regen contactors

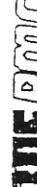
Wiring Option:  
 12V Isolated control and reverse operation.

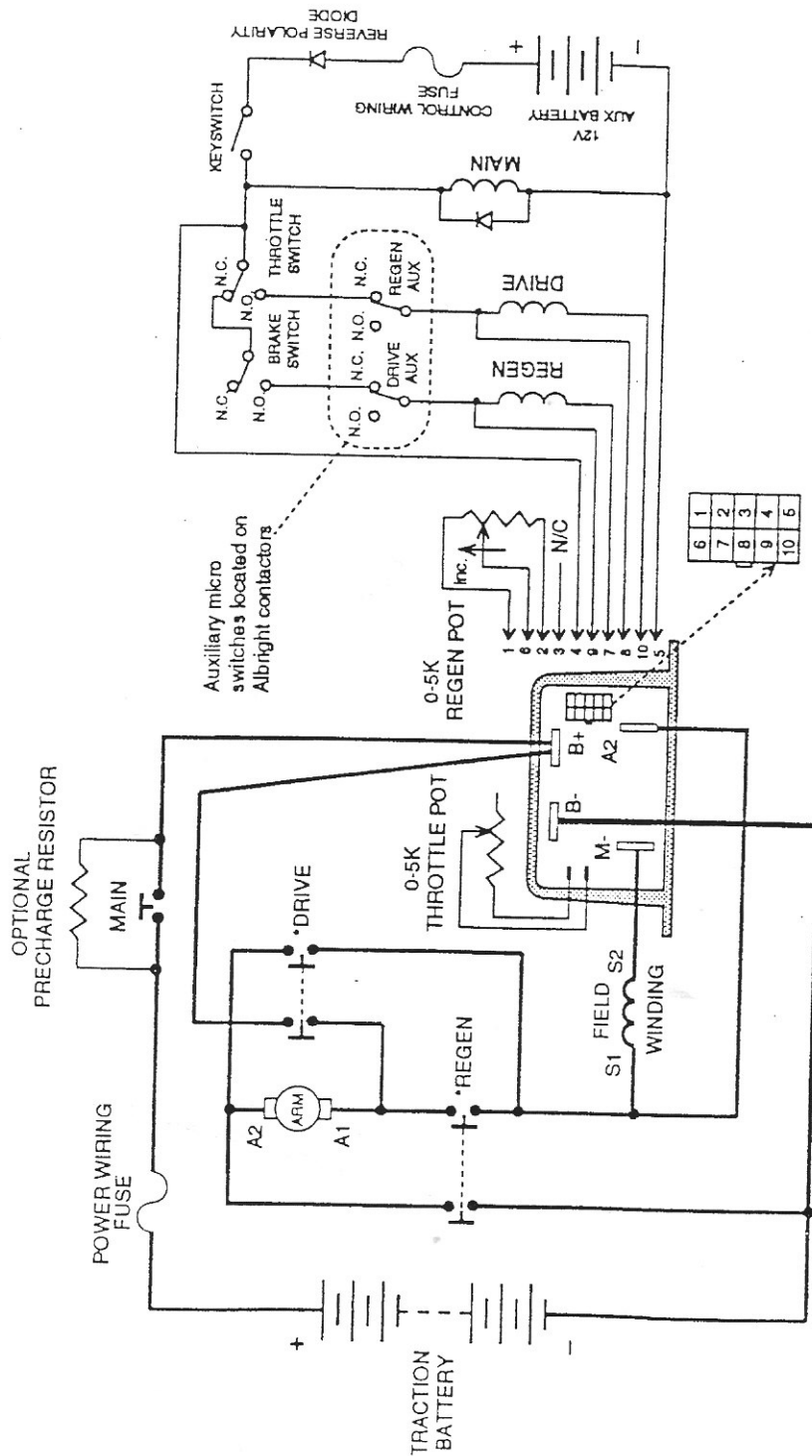
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			CURTIS <b>PAC</b> A DIVISION OF CURTIS INSTRUMENTS, INC. 4591 Sierra Ln. Dublin, CA 94568		WIRING DIAGRAM Regenerative Braking Controller		CODE IDENT NO. 15583		SIZE <b>A</b>		REV. <b>A</b>	



\* Albright SW192AB contactors must be used for Drive and Regen Contactors

Wiring Option:  
Non-isolated Control

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UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN										CODE IDENT. NO. 18583	SIZE <b>A</b>	WD 14495R003	REV. A



\*Albright SW192AB-46 12CO contactors must be used for Drive and Regen Contactors

Wiring Option:  
12V Isolated control.

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## REVISIONS

SYM	E.C.N.	DATE	APPR

## TOLERANCES

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## APPROVALS

MFG.	Q.A.	ENGR.	CHECKED	DRAWN

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## Wiring Diagram

## Regenerative Braking Controller

CODE IDENT. NO.  
18583

SIZE  
A

WD14495R001

REV.  
A