MillipaK SEM Controller Manual

For System Version V1.54.03

Document History

Author		Reviewer		Version	Reason for Modification
Initials	**Date**	**Initials**	**Date**		
PB	24 Oct 00			00.01	Original
PB				00.02	References to 4QPM removed
PB	22 Feb 01			00.03	Block ratings added, PSS note, new calibrator map, various text updated
CEH	1 Jul 01			UK0003	New Personalities added and document brought up to date for new generic release
PMR	8 Jan 02			UK0046	Updated fault description table Removed bypass contactor, quick pick and high speed switch Added new descriptions for Brake Override and High Mast
TSN	6 Feb 03			1.54.01	Added new feature description for: Reverse Speed Alarm Buzzer Line Contactor Dropout Direction Switch Checking FS1 Recycle SRO Delay
PG	17 Jul 06			UK0216	Software Version Scrolling
DC	15 Jan 08			UK0278	Added new digital i/o configuration 18.

CONTENTS

Introduction

The MillipaK SEM (separately excited motor) range of controllers provides a new range of power frames for 24V-48V, 180A - 600A in one of two small, highly efficient packages. This is achieved using a Sevcon patented power switching scheme and radical new construction techniques, which enable large powers to be incorporated into very small packages.

The MillipaK provides a completely sealed (IP66) unit containing power and logic circuitry, as well as all suppression components and an optional integrated pump soft start/stop chopper.

MillipaK supports Sevcon's existing MOS90 calibrator for adjustment of vehicle performance characteristics. MillipaK is ideally suited to applications requiring a single traction controller, for example walkies, golf cars and basic ride-on trucks.

Controllers are FLASH microprocessor based enabling field re-programming for new features and have numerous user set-up options. The MillipaK uses high frequency (silent) MOSFET power switching technology, to control a SEM power frame comprising Armature circuit and Field Bridge. Armature and Field currents are monitored. Motor feedback should not be necessary. Controllers have been designed to satisfy the requirements of the relevant UL and EC standards.

Safety

The MillipaK controller contains a triple fail-safe system to give a high level of safety. If the diagnostic LED is not illuminated or flashes, the safety circuit may have tripped and the system may not drive.

The controller must be used with a line contactor as indicated in the wiring diagrams.
As blow-out magnets are fitted to contactors (except 24V) ensure that no magnetic particles can accumulate in the contact gaps and cause malfunction. Ensure that contactors are wired with the correct polarity to their power terminals as indicated by the + sign on the top molding.

The MillipaK controller may be used with suitable onboard chargers, as supplied by Sevcon.

There are several software features which are intended to prevent inadvertent or unexpected vehicle movement – SRO, Accelerator power up fault and sequence checking.

Some of these features cannot be disabled and the appropriate signals must be supplied to the controller before drive will be allowed.

Installation

The small footprint of the MillipaK controller gives maximum flexibility to the user for mounting options. The following section gives details of certain criteria that should be considered when situating the controller on a vehicle.

Mounting

The MillipaK and MillipaK HP units provide 4 x M6 clearance holes for mounting. The controllers should be mounted onto a metal base plate, as large as possible to provide heat-sinking. The surface finish should be flat, clean and burr free and thermal compound should be applied to the controller base before fitting.

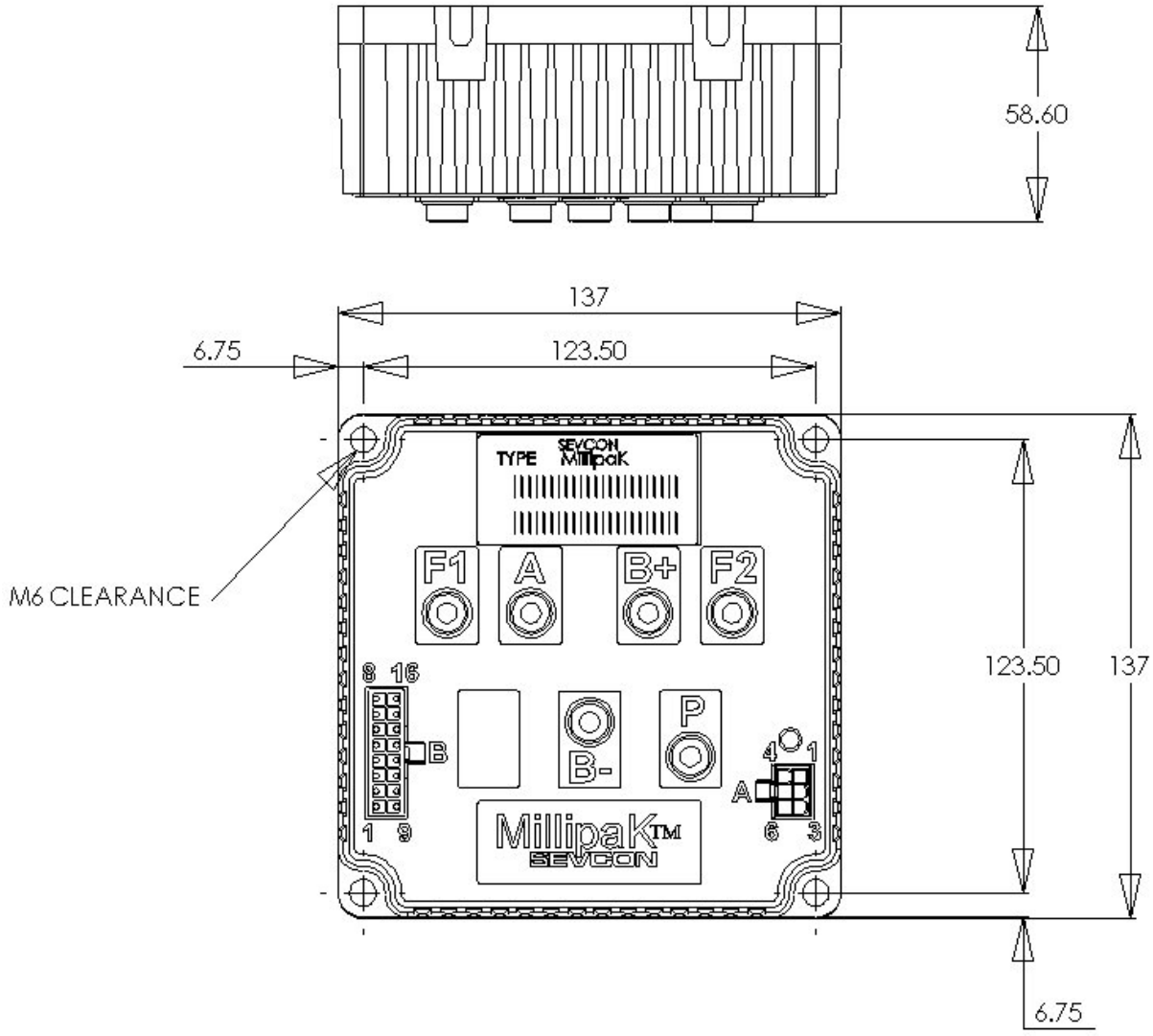


Figure 1: MillipaK Core Dimensions

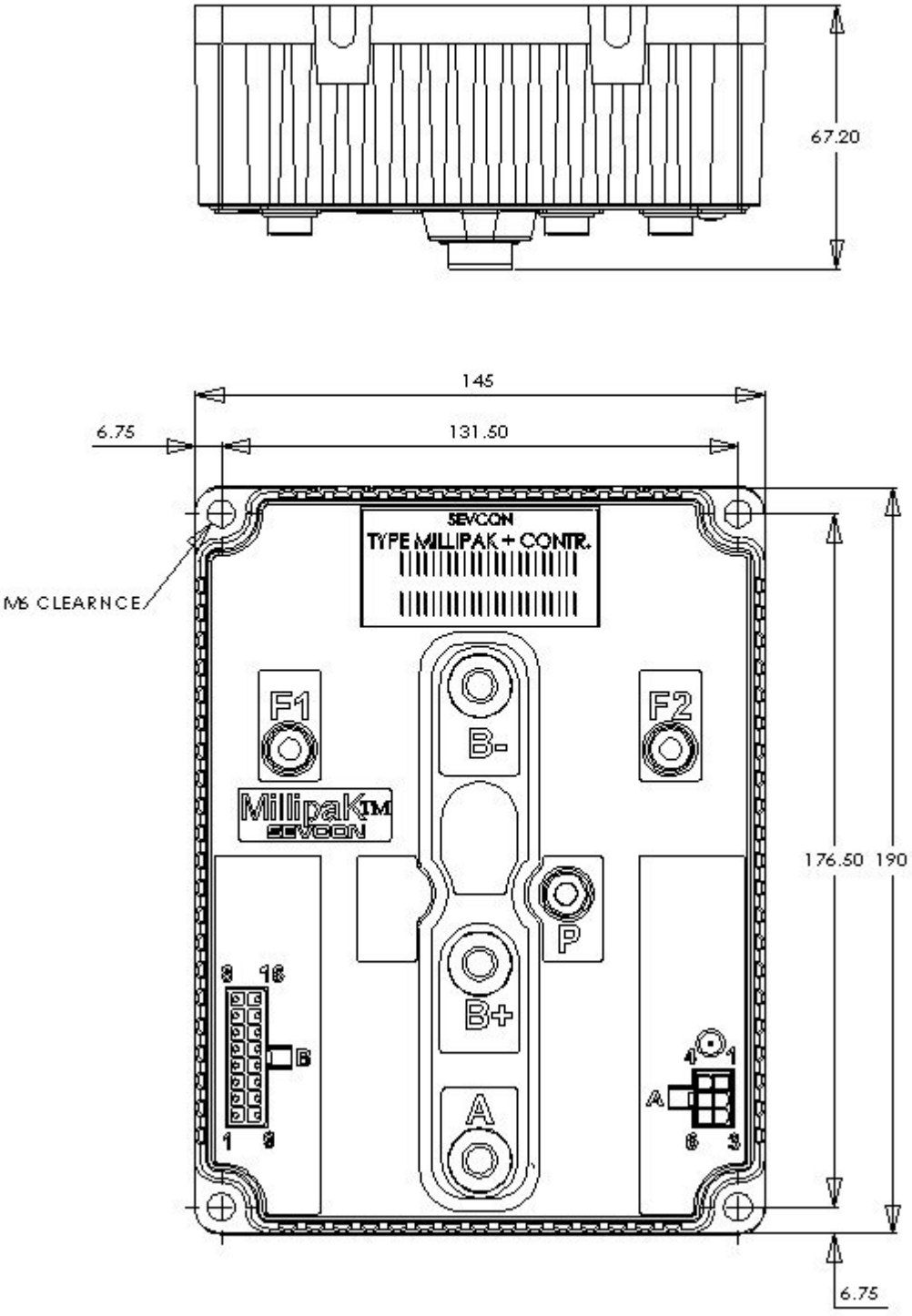


Figure 2: MillipaK HP Dimensions

Maximum terminal torque: M8 terminals – 10NM
M6 terminals – 7NM

MillipaK SEM Power Wiring

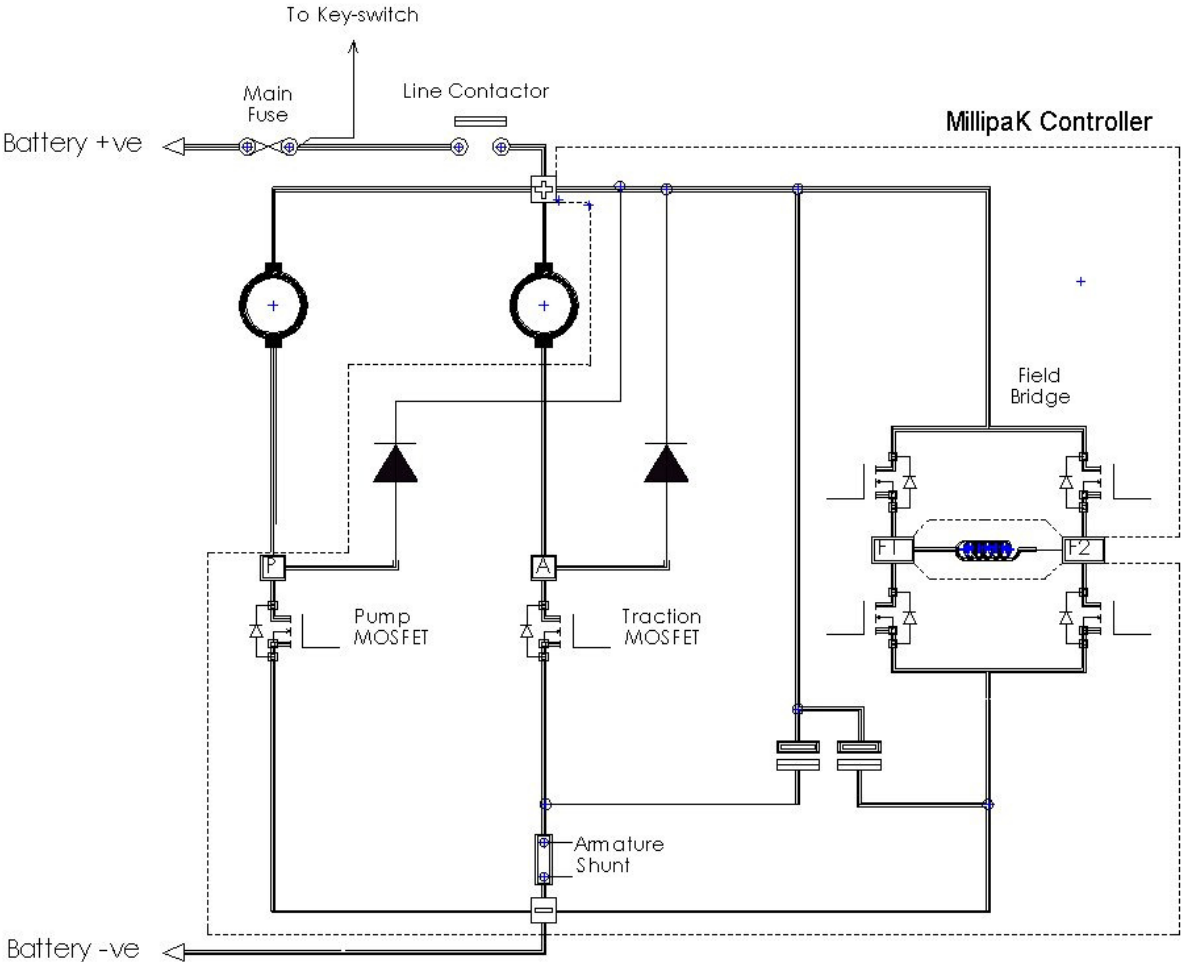
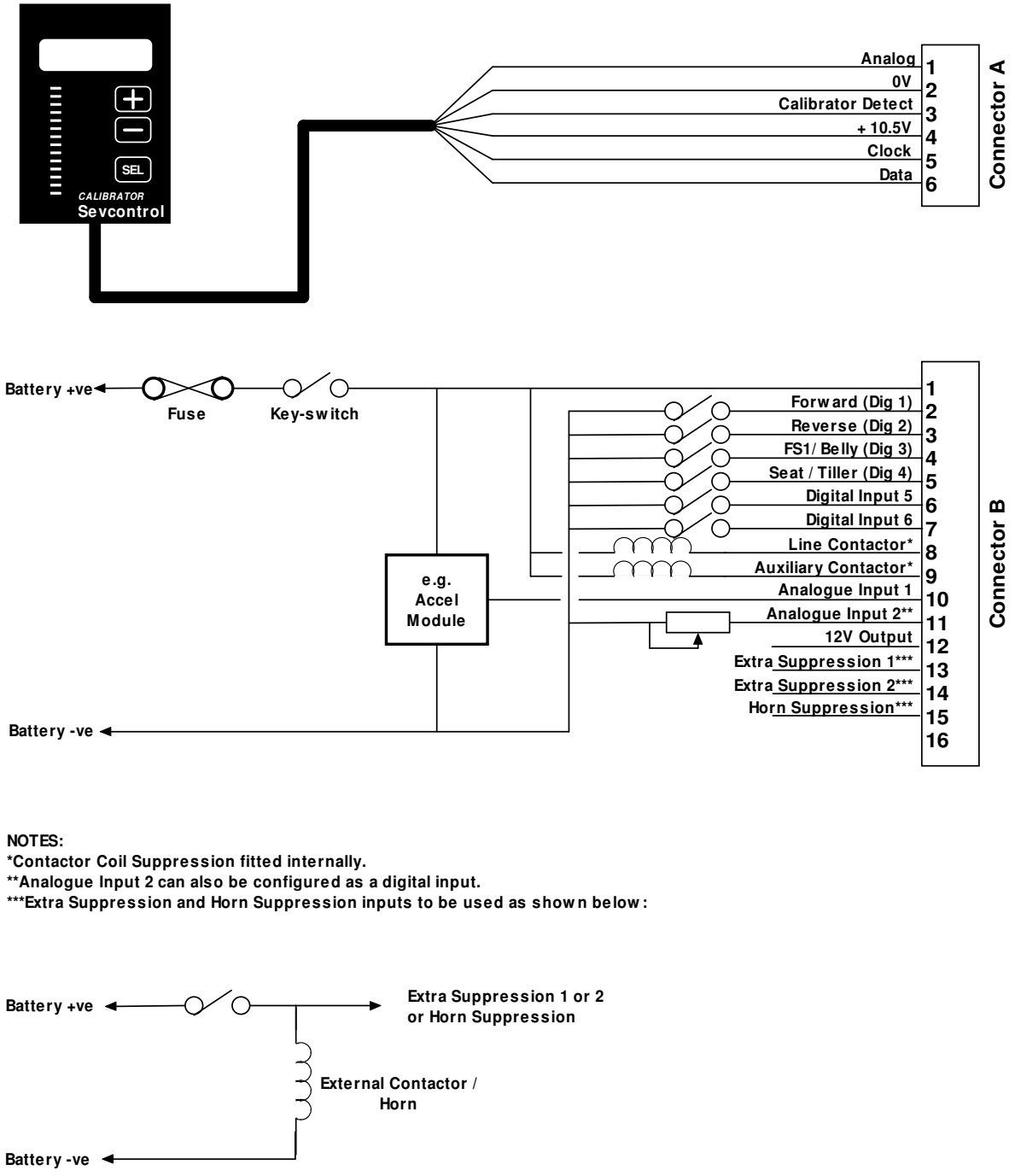


Figure 3: MillipaK SEM Power Wiring

NOTE: The Pump MOSFET's are optional (soft start versions only).

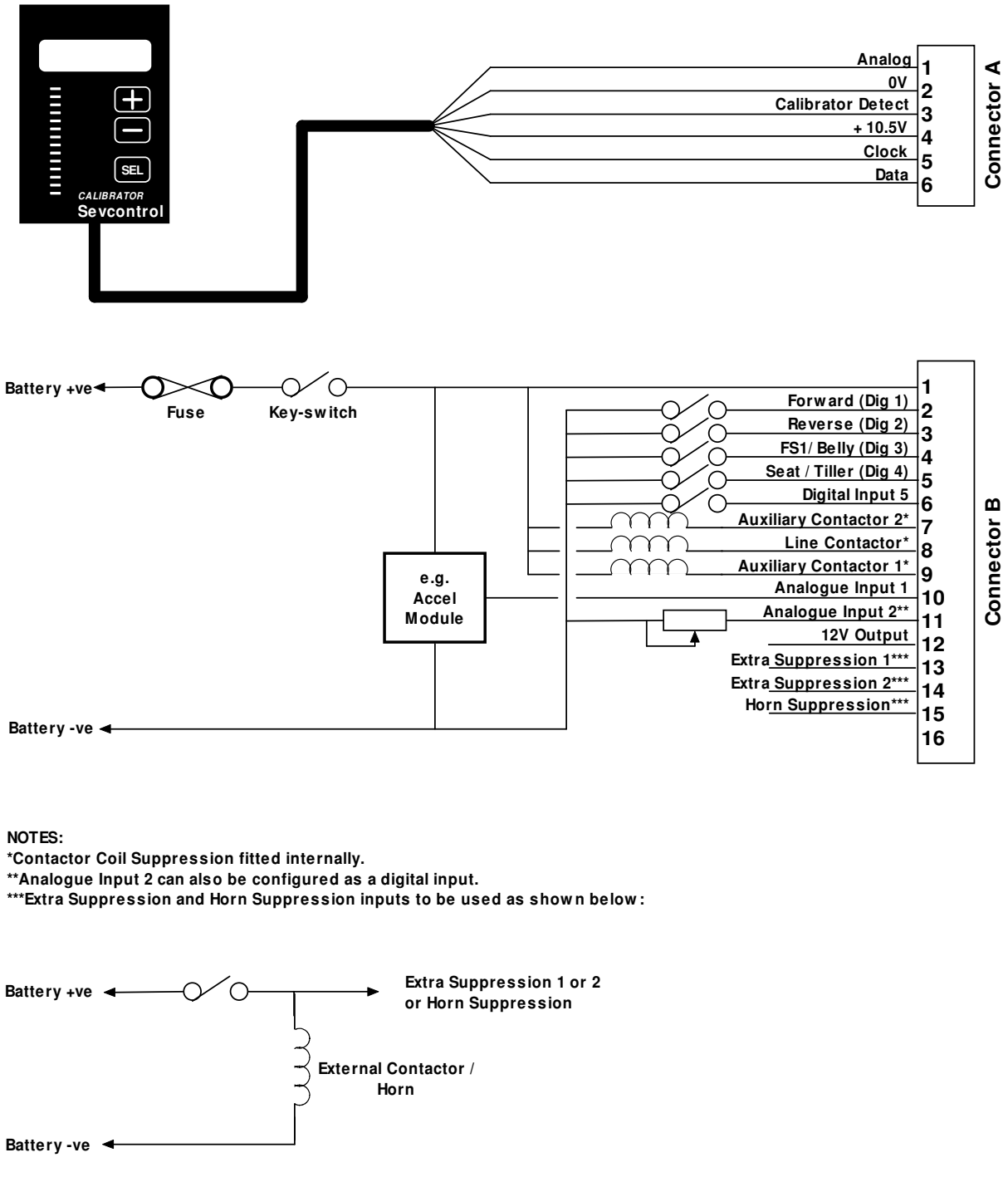
MillipaK Core Light Wiring



NOTES:
***Contactor Coil Suppression fitted internally.**
****Analogue Input 2 can also be configured as a digital input.**
*****Extra Suppression and Horn Suppression inputs to be used as shown below:**

Figure 4: MillipaK Core Light Wiring

MillipaK Standard HP Light Wiring



NOTES:
***Contactor Coil Suppression fitted internally.**
****Analogue Input 2 can also be configured as a digital input.**
*****Extra Suppression and Horn Suppression inputs to be used as shown below:**

Figure 5: MillipaK Standard HP Light Wiring

NOTES:
The line and auxiliary contactors are wired to B+, on the switched side of the key-switch.

The second analogue input on pin 11 is also available for use as a digital input. See system configuration section for how to configure the second analogue input as a digital switch input.

Pin 12 on the Core and Standard HP variants is available for 100mA supply, typically used for (but not limited to) accelerator modules.

Pins 13, 14 & 15 are general-purpose suppression connections and may be used to suppress spikes generated by contactors opening / closing. The internal configuration is shown below:

Pin 16 on the Core and Standard HP variants is used to select FLASH memory program update mode and should normally be left unconnected. However, if it is necessary to reprogram the controller's FLASH memory, the pin 16 must be connected to Battery Voltage through the Key switch Line.

PCpaK

PCpaK allows a PC to communicate with an individual MillipaK controller. PCpaK can perform all the functions provide by the Calibrator, along with a great number of additional features.

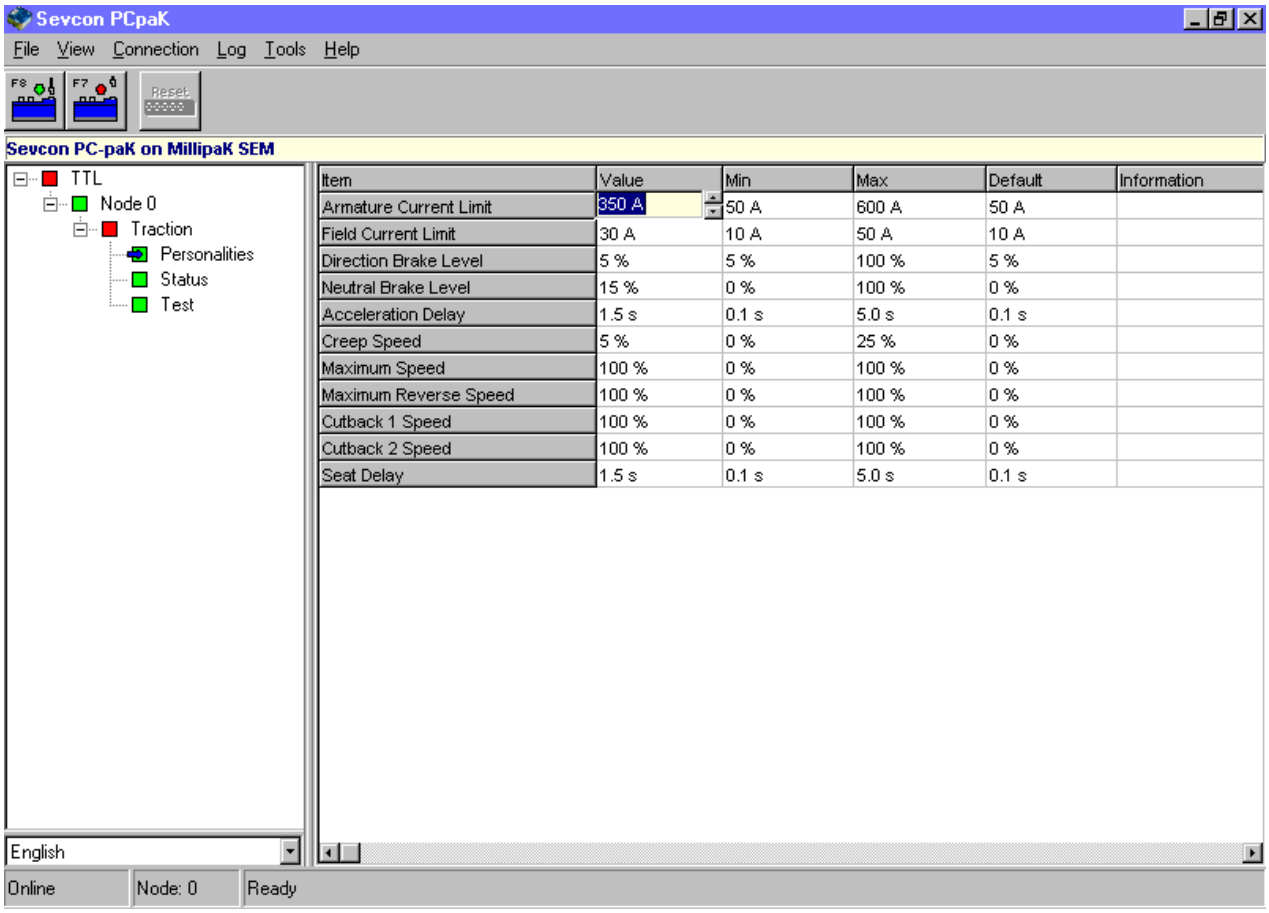


Figure 6: PCpaK Window

PCpaK provides many advantages over using the standard calibrator and allows access to the following features:

- Easy to use Windows Explorer style GUI.
- Personalities can be easily modified by typing new values in directly.
- Configuration (personality) profiles can be saved and loaded to and from a file.
- Previously saved configurations can be quickly downloaded using the Rapid Download wizard.
- Service log analysis.
- Controller status checking.
- Quick viewing of entire controller menu structure.
- “Offline” viewing of previously stored configurations. A controller does not need to be connected to view a saved configuration.
- Flash program capability. PCpaK can reprogram the software in the MillipaK controller.

PCpaK is a powerful tool. Some of the typical uses are:

- Analyzing controllers in the field and recording information, such as personality profiles, to a file.
- Upgrading the MillipaK Controller software. The MillipaK Controller does not need to be removed from the vehicle for the software to be upgraded.
- As a tool in a production line to program controller software and / or personalities; this allows customers to stock one part number for the Controller hardware and simply reconfigure it when the controller is installed onto the vehicle.

For more information about PCpaK, please contact Sevcon.

Calibrator

The Calibrator is a hand-held adjustment unit which can be used to configure and test the system. The MillipaK is designed to work with the Calibrator currently in use with SEVCON's MOS90 system. See diagram below. The menu structure is shown in the Calibrator Map located near the end of this manual.

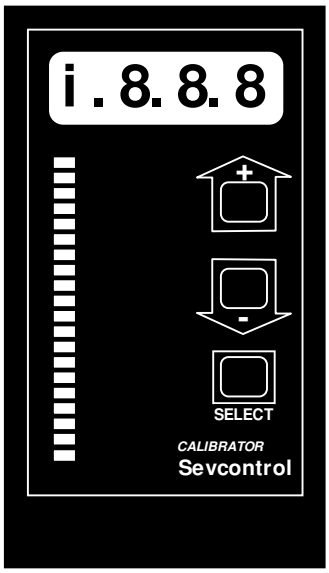


Figure 7: MillipaK Calibrator

Traction Drive Hours Counter

When the Calibrator is first plugged into the unit after power up, the Calibrator shows the Traction Drive Hours Counter. Refer to the Traction Drive Hours Counter section for more information on this function.

With no buttons pressed, the number displayed shows the number of minutes (accurate to 0.5 minutes). Pressing the '-' button displays the number of hours under 1000 and pressing the '-' button displays the number of 1000 x hours.

For example, if the hours counter was 12, 345 hours, 13 minutes and 40 seconds, with no buttons pressed, the display would show 13.5. Minutes are only shown to the nearest 0.5 minutes. If the '-' button was pressed, the display would show 345 (number of hours under 1000) and if the '+' button was pressed, the display would show 12 (number of 1000 x hours).

This is the only time that the hours counter can be viewed. Once the Select button has been pressed to enter the normal calibrator menu structure, it is not possible to return to this point. To view the hours counter again, you must recycle the Key switch.

This is also the point at which you can enter a password to enable different levels of access to personalities. Refer to the section below on Calibrator Security Levels for more details.

Calibrator Security Levels

Which personalities and status items can be viewed on the Calibrator is restricted by the use of passwords. There are two levels of Calibrator access. These are shown in Table 1.

Access Level	Text	Password	Description
Service	Ser	-	Default. This level is selected when no password or an invalid password is entered. Only items shown in the Calibrator Map with a thick solid border are displayed.
Engineering	Eng	1645	All items could be displayed.

Table 1: Calibrator Security Levels

Note, only items appropriate to the current system configuration are displayed. For example, if none of the switch inputs are configured as a Cutback 1 Speed Switch, then the Cutback 1 Speed personality will not be displayed.

The password can only be entered immediately after power up when the Traction Drive Hours Counter is displayed. The '+' and '-' buttons are used to enter the password. The first digit is entered by pressing the '+' button the appropriate number of times (i.e. once to enter 1). The second digit is entered by pressing the '-' button the appropriate number of times (i.e. 2 times to enter 2). The third digit is entered using the '+' button again and the final digit is entered using the '-' button again. Note that when the '+' or '-' buttons are pressed, the display still changes to show hours or 1000 x hours.

Upon completing the password, press either of the '+' or SELECT buttons to initiate verification. If the password has been entered correctly, the text shown in Table 1, appropriate to the required security level will be displayed for 1s, indicating the password was accepted. If the password was incorrect or no password was entered, the system will default to Service mode.

After the Security Level has been displayed, the system enters the normal menu structure shown in the Calibrator Map. Changing the security level requires a Key switch recycle.

Navigation

The Calibrator uses all three buttons for navigating through the menu structure.

Use the SELECT button to move through the menu structure. When the SELECT button is pressed the next menu item is displayed. The default direction is from left to right, top to bottom.

If the '+' and '-' buttons are held down together, the ID of the currently displayed menu item is shown. For example, if the Armature Current Limit personality was selected, then the ID would be 0.01 (menu 0, item 1). This allows the operator to locate the current map position.

If the '+' and '-' buttons are held down together for more than 3 seconds, the direction through the menu structure is reversed. Consequently, when the SELECT button is pressed again the direction of navigation through the menu will be from right to left, bottom to top. In this mode, the Calibrator LED will flash constantly. If the '+' and '-' buttons are held down together for more than 3 seconds again, the direction reverts back to the initial direction (left to right, top to bottom) and the Calibrator LED stops flashing.

The SELECT button is used to navigate through most of the menu structure; however, the Test menu (menu 19) is slightly different. Pressing the SELECT button will take you to the first item in the Test menu, (item 19.01 - Accelerator Demand). Navigating the Test menu requires the use of the '+' and '-' buttons. The '+' button will access the NEXT Test menu item while the '-' button will access the PREVIOUS item (no wrap around). Pressing the SELECT button at any time exits the Test menu and moves to the first item in the menu structure (menu item 0.01 - Armature Current Limit).

The items displayed depend on the current system configuration and the Security Level.

Adjustments

Menus 0 to 12 are primarily used for configuring the system. All the personalities that the system uses to configure each function are in one of these menus. A brief description of the purpose of each menu is listed below. For more complete descriptions of each personality refer to the appropriate section in this manual.

Menu	Name	Purpose
0	Current Limits	Used to setup maximum currents for motor.
1	Braking Levels	Used to setup braking strength and performance.
2	Accelerator	Used to setup acceleration and deceleration performance and to configure the accelerator input voltage range.
3	Creep Speed	Used to setup creep speed.
5	Maximum Speed	Used to setup the maximum speed.
6	Cutback 1 Speed	Used to setup the speed for Cutback Speed 1.
7	Cutback 2 Speed	Used to setup the speed for Cutback Speed 2.
8	Motor Setup	Used to setup the Armature / Field Map.
9	Power Steer Timer	Used to setup the Power Steer timer.
10	Seat Delay	Used to setup the Seat Switch debounce delay.
11	Additional Personalities	Used to setup additional personalities. These are personalities which do not belong in any of the menus shown above, or they are deemed to be unsuitable for modification by service engineers or end users.
12	System Setup	Used to configure the system at a high level. Items to configure the system I/O and performance are located in here. It is recommended that items in this menu are configured first before any of the other personalities. Unlike the personalities in the other menus, changes to items in this menu do not take affect until the Key switch is recycled.

Table 2: Adjustment Menus

Status and Test Information

Menus 13 to 19 are primarily used for providing information about the system. Every parameter, which the system measures, is located in one of these menus. A brief description of the purpose of each menu is listed below.

Menu	Name	Purpose
13	System Status	If there is a fault active in the system, this menu provides information about what the fault is. Refer to the Diagnostics section for more information.
14	-	Reserved for future use.
15	System Voltages	Used to display Battery and Capacitor Voltage measurements. The Battery Voltage measurement shows the voltage measured at the Key switch pin (pin 1 on connector B). The Capacitor Voltage measurement shows the voltage measured at the B+ terminal.
16	Motor Voltages	Used to show the voltage measured at the Point A terminal.
17	Motor Currents	Used to show the Armature and Field Current Measurements.
18	Heat sink Temperature	Used to access the Heat sink Temperature measurement and the Maximum Heat sink Temperature log. Refer to the Temperature Monitoring section.
19	Test Menu	Used to access items which allow for testing of all the Analogue and Digital inputs available on connector B. Also displays unit information such as the Software Version, Controller Serial Number and the Personality Checksum. Refer to the appropriate sections for more information on each of these items.

Table 3: Status and Test Information Menus

Configuration

Configuration of the MillipaK controller is split into two categories – system and performance, which will be discussed in turn.

System Configuration

The MillipaK system configuration items relate to how the MillipaK controller will interface with connected hardware such as the system battery, vehicle control switches, accelerator and the traction motor.

System Voltage

The system voltage usually refers to the main system supply battery voltage. The controller uses this information to ensure low and high voltage settings are within an appropriate range.

System Voltage Calibrator Menu Reference:			Power Up 12.18
Minimum	Maximum	Step Size	Default
24v	48v	2v	48v

System I/O Configuration

The digital inputs, analogue inputs and contactor drive outputs available on socket B can be configured in a number of ways to suit various applications. Table 4 shows a range of pre-determined settings which are available to the user and should cover the majority of applications, see below:

Digital I/O Value	Description
1	Walkie vehicle with Speed Cutback 1 switch, Pump Trigger switch and Electromagnetic Brake. Pump Trigger activates Pump Soft Start function.
2	Walkie vehicle with High Mast switch, Pump Trigger switch and Pump Contactor.
3	Walkie vehicle with High Mast switch, Pump Trigger switch and Electromagnetic Brake. Pump Trigger activates Pump Soft Start function.
4	Walkie vehicle with Speed Cutback 1 switch, Pump Trigger switch and Pump Contactor.
5	Walkie vehicle with Quick Pick switch, High Speed switch, Electromagnetic Brake and Hours Counter Drive.
6	Walkie vehicle with Pump Trigger switch, Brake Override switch, and Electromagnetic Brake.
7	Ride On vehicle with Speed Cutback 1 and 2 switches and external LED drive.
8	Ride On vehicle with Speed Cutback 1 switch, Handbrake switch and external LED drive.
9	Ride On vehicle with Handbrake switch, Power Steer Trigger switch and Power Steer Contactor.
10	Ride On vehicle with Speed Cutback 1 switch, Power Steer Trigger switch and Power Steer Contactor.
11	Ride On vehicle with Handbrake switch, Pump Trigger switch and Pump Contactor.
12	Ride On vehicle with Handbrake switch, Pump Trigger switch and Pump Contactor.
13	Ride On vehicle with Power Steer Trigger switch, Pump Trigger switch and Power Steer Contactor. Pump Trigger activates Pump Soft Start function.
14	Ride On vehicle with Traction Motor Overtemperature switch, Handbrake switch and external LED drive.
15	Ride On vehicle with Power Steer Trigger switch, Footbrake switch and Power Steer Contactor.
16	Walkie vehicle with Speed Cutback 1 switch, Handbrake switch and Electromagnetic Brake.
17	Ride On vehicle with Speed Cutback 1 and 2 switches and buzzer alarm drive.

18	Ride On vehicle with Speed Cutback 1 switch, Handbrake switch, Power Steer Contactor and External LED drive.

Table 4: Description of each Digital I/O configuration

WARNING: Incorrect configuration could cause a vehicle to move unexpectedly, for example if FS1 was inadvertently configured as a belly switch.

If your application doesn't fit any of the above, please contact Sevcon with details of your requirements.

Each of the above configurations allocates the controller i/o as shown below:

Digital Function	Value of Digital I/O Configuration Item																	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Forward	B2	B2	B2	B2	B2	B2	B2	B2	B2	B2	B2	B2	B2	B2	B2	B2	B2	B2
Reverse	B3	B3	B3	B3	B3	B3	B3	B3	B3	B3	B3	B3	B3	B3	B3	B3	B3	B3
Belly	B4	B4	B4	B4	B4	B4										B4		
Tiller	B5	B5	B5	B5	B5	B5										B5		
FS1							B4	B4	B4	B4	B4	B4	B4	B4	B4		B4	B4
Seat							B5	B5	B5	B5	B5	B5	B5	B5	B5		B5	B5
Speed Cutback 1	B6	B6					B6	B6		B6		B6				B6	B6	B6
Speed Cutback 2							*Bw*										B11	
Handbrake								*Bw*	*Bw*		*Bw*			*Bw*		*Bw*		Bw
Power Steer Trigger									B6	*Bw*			B6		*Bw*			
Pump Trigger	*Bw*	*Bw*	*Bw*	*Bw*		*Bw*					B6	*Bw*	*Bw*					
High Mast			B6	B6														
Motor Over Temperature														B6				
High Speed					B6													
Quick Pick					*Bx*													
Brake Override Switch						B6												
Footbrake Switch															B6			
Line Contactor	B8	B8	B8	B8	B8	B8	B8	B8	B8	B8	B8	B8	B8	B8	B8	B8	B8	B8
Power Steer Contactor									B9	B9			B9		B9			B9
Pump Contactor		B9		B9							B9	B9						
Electromagnetic Brake	B9		B9			B9										B9		
External LED							B9	B9						B9				By
Hours Counter Drive					*By*													
Alarm Buzzer									*By*								B9	

Table 5: Digital Functions

Notes:

1. All vehicles have Forward and Reverse Switches and a Line Contactor.
2. All Walkie vehicles have Belly and Tiller Switches.
3. All Ride On vehicles have FS1 and Seat Switches.
4. Connector pins shown in *italics* depend on the controller variant in use. Table 6 shows which pin is used for each variant:

ID		Actual Pin	
		Core	Standard HP
Switch Inputs	*Bw*	B7	B11*
	Bx	B11*	N/A**
Contactor Drive Outputs	*By*	N/A**	B7

Table 6: Pin Allocations

* B11 can only be used as a digital input if Analogue Input 2 is configured as a digital input. See below.
** N/A means this input or output is not available on that variant.

5. Pump Trigger will trigger Pump Soft Start function as well as the Pump Contactor. This is why some configurations have a Pump Trigger but no corresponding Pump Contactor.

Analogue Functions

Analogue Function	Value of Analogue Input Configuration Item			
	1	2	3	4
Accelerator	B10	B11	B10	B10
Digital			B11	
Footbrake				B11

Table 7: Analogue Functions

Notes:
1. Bx refers to Socket B pin numbers.
2. All vehicles have an Accelerator input.

Table 7 details which analogue functions are configured for each value of the Analogue Input Configuration Item.

Digital Configuration			Power Up
Calibrator Menu Reference:			12.16
Minimum	Maximum	Step Size	Default
1	18	1	

Analogue Configuration			Power Up
Calibrator Menu Reference:			12.17
Minimum	Maximum	Step Size	Default
1	4	1	

System / Motor Set-up

There are various settings available to the user to tailor the MillipaK controller to specific motors and applications.

Armature Field Map

The Armature-Field map is used to calculate a Required Field Current and direction by taking the Required Armature Voltage and Torque and applying the relationship as shown in Figure 8.

This is done as follows:

1. The controller will set the field current direction equal to the direction in which drive is required.
2. The controller will apply a minimum field current for a given armature current.
3. The controller will allow the relationship between the minimum field current and the armature current to be defined by the specification of 3 points on a graph showing field current against armature current.

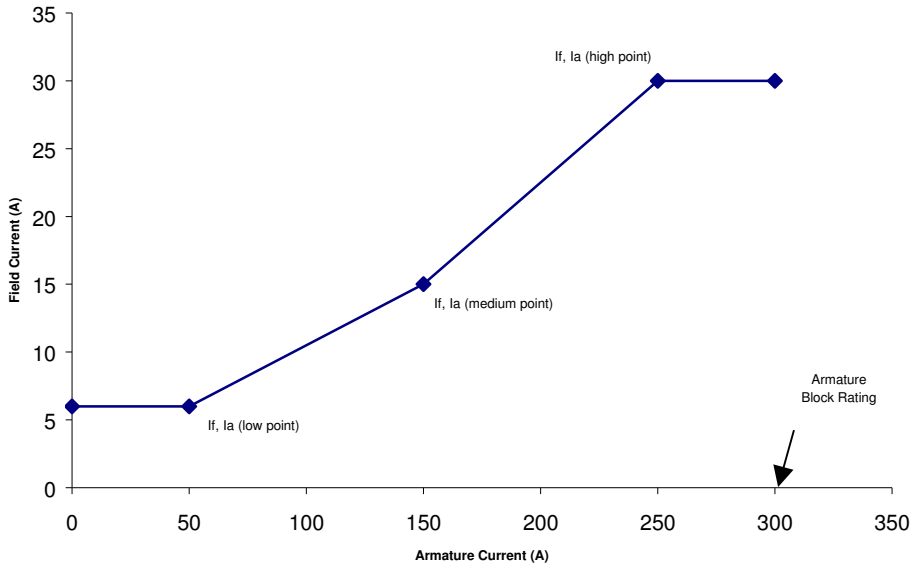


Figure 8: Relationship between Required Field Current and Measured Armature Current

4. These 3 points will defined using 6 motor setup personalities:

I_{field} Low personality Calibrator Menu Reference:			Power Up 8.01
Minimum	Maximum	Step Size	Typical Value
2.0A	Field I_{mid} or 19.75A	0.25A	5.00A
I_{arm} Low personality Calibrator Menu Reference:			Power Up 8.02
Minimum	Maximum	Step Size	Typical Value
10A	Arm I_{mid} – 10A	10A	10A
I_{field} Mid personality Calibrator Menu Reference:			Power Up 8.03
Minimum	Maximum	Step Size	Typical Value
I_{field} Low	I_{field} High	1A	50% of FBR
I_{arm} Mid personality Calibrator Menu Reference:			Power Up 8.04
Minimum	Maximum	Step Size	Typical Value
I_{arm} Low + 10A	I_{arm} High – 10A	10A	50% of ABR
I_{field} High personality Calibrator Menu Reference:			Power Up 8.05
Minimum	Maximum	Step Size	Typical Value
I_{field} Mid	FBR	1A	FBR
I_{arm} High personality Calibrator Menu Reference:			Power Up 8.06
Minimum	Maximum	Step Size	Typical Value
I_{arm} + 10A	ABR	10A	ABR

ABR – **A**rmature **B**lock **R**ating
FBR – **F**ield **B**lock **R**ating

The ABR & FBR refer to the controller maximum peak currents.

Armature and Field Current Limit

The armature and field current limit personalities are provided to allow the user to limit the maximum current supplied to the motor to a value lower than the peak rating of the controller.

Armature Current Limit Calibrator Menu Reference:			Immediate 0.01
Minimum	Maximum	Step Size	Typical Value
50A	ABR	10A	ABR

Field Current Limit Calibrator Menu Reference:			Immediate 0.02
Minimum	Maximum	Step Size	Typical Value
10A	FBR	1A	FBR

There are also personalities, Drive Current Limit Start and Ramp which will allow the user to set-up an armature current limit ramp after braking. These personalities are used in conjunction with the Direction Braking Exit Level personality in the Braking section to optimize the Direction Braking change over time.

Drive Current Limit Start Calibrator Menu Reference:			Immediate 0.03
Minimum	Maximum	Step Size	Typical Value
50A	Ia Limit	10A	50A

Ia Limit - Armature Current Limit personality.

Drive Current Limit Ramp Calibrator Menu Reference:			Immediate 0.04
Minimum	Maximum	Step Size	Typical Value
0.00s	2.50s	0.01s	1.00s

When the system is direction braking, the Direction Braking Exit Level personality will allow braking to finish early when the vehicle is still moving at a reasonable speed. The system then enters drive and ramps up the armature current limit from the Drive Current Limit Start level to the Armature Current Limit personality in the time specified by the Drive Current Limit Ramp personality.

This ramp up acts as a torque ramp and has the effect of completing the braking effort before the vehicle accelerates away in the new direction.

Contactor chopping

This feature allows 24 V contactors to be used at all battery voltages 24V - 48V, by continuously monitoring the battery voltage and chopping the contactor output pins accordingly, to present an average voltage suitable for 24V coils. Chopping is selectable by the calibrator. Care must be taken to ensure that chopping is always selected if 24V contactors are being used on battery voltages higher than 24V. In applications > 24 volts contactors must be fitted with blow out magnets. Chopping can reduce the overall dissipation in the coils and allows only one set of contactors to be stocked for all battery voltages.

Chopping Frequency = 667Hz (Slightly audible).

Typical contactor coil voltage during chopping = 16 volts.
Typical contactor coil voltage during energisation = 24 volts for 1 second.

There are 3 contactor chopping options available via the setup menu: Off, On and 24V. The off setting is used for nominal battery voltage coils, and the On setting is for 24V coils on higher voltage vehicles. Setting to 24V provides chopping for 24V coils and lamps without the drop to 16V after 1s.

Chop Select			Power Up
Calibrator Menu Reference:			12.01
Options			Default
OFF	ON	24V	OFF

Accelerator Full /Zero Setting

The accelerator/analogue inputs are flexible in the range of signal sources they can accommodate and can be adjusted to minimize dead-bands and mechanical tolerances. Each analogue input has 2 adjustments associated with it to allow the input voltage range to be determined.

For the Traction Accelerator, for example, the 2 adjustments are called the "Accelerator Zero Level" and the "Accelerator Full Level". If these were set to 0.20V and 4.80V then 0% pulsing would start at 0.20V at the input, increasing to 100% pulsing at 4.80V. For accelerators with decreasing voltage outputs, the Zero adjustment might be set to 3.5V and the Full adjustment to 0.0V. The Calibrator test menu shows the instantaneous voltage reading, and the equivalent % "push" for each input.

Accelerator Zero Voltage			Immediate
Calibrator Menu Reference:			2.03
Minimum	Maximum	Step Size	Typical Value
0.00V	4.50V	0.02V	0.10V

Accelerator Full Voltage			Immediate
Calibrator Menu Reference:			2.04
Minimum	Maximum	Step Size	Typical Value
0.00V	4.50V	0.02V	3.50V

Note that a 6 flash fault will occur if the full and zero levels are set within 0.50V of each other.

The PWM demand will vary between the Creep level and Maximum Speed level as the accelerator voltage varies between "Accelerator Zero" and "Accelerator Full".

Performance

Various parameters may be adjusted to tailor the performance of the vehicle to customer requirements.

Acceleration Delay

This is an adjustable delay to ramp up the pulsing from 0% on to 100% on, and can be used to ensure smooth acceleration.

Acceleration Delay			Immediate
Calibrator Menu Reference:			2.01
Minimum	Maximum	Step Size	Typical Value
0.1S	5.0S	0.1S	1.5S

Deceleration Delay

This is an adjustable delay to ramp down the pulsing from 100% on to 0% on, and can be used to provide a smooth reduction of power to the motor.

Deceleration Delay			Immediate
Calibrator Menu Reference:			2.02
Minimum	Maximum	Step Size	Typical Value
0.1S	0.5S	0.1S	0.1S

Control Mode

The method of motor control may be switched between Torque and Speed control.

Control Mode Calibrator Menu Reference:		Power Up 12.03
Options		Default
Torque	Speed	Torque

Currently only torque control mode is available.

Regen Braking

At present regen braking is not used in the MillipaK SEM controller.

Plugging

For plug braking, the field direction is reversed and ramped up to give smooth braking down to zero speed.

Types of Braking

Braking can be initiated in one of 3 ways:

(i) Direction Braking. Initiated when the direction switch inputs are reversed during drive. i.e., Reverse is selected when driving in forward or Forward is selected when driving in reverse.
(ii) Footbrake Braking. Initiated when the operator depresses the Footbrake pedal and a footbrake input is configured. See section below for more information about setting up and configuring the system for Foot braking.
(iii) Neutral braking. Initiated when the vehicle is put into neutral during drive and neutral braking level is greater than 0%.

Braking Levels

Each Braking Type has its own personality for setting the required braking level. These are shown below:

Direction braking level			Immediate
Calibrator Menu Reference:			1.01
Minimum	Maximum	Step Size	Typical Value
5%	100%	1%	75%

Neutral braking level			Immediate
Calibrator Menu Reference:			1.02
Minimum	Maximum	Step Size	Typical Value
0%	100%	1%	10%

Footbrake braking level			Immediate
Calibrator Menu Reference:			1.03
Minimum	Maximum	Step Size	Typical Value
0%	100%	1%	0%

Direction Braking Exit Level			Immediate
Calibrator Menu Reference:			1.04
Minimum	Maximum	Step Size	Typical Value
0%	100%	1%	0%

The three braking levels for direction, neutral and foot braking are used to determine the strength of the braking. Setting the level to 0% disables braking (Note: Direction Braking cannot be disabled), 1% sets the braking strength to minimum (weakest braking) and 100% sets the braking strength to maximum (strongest braking).

Direction Braking also has an additional personality used to setup the system to exit braking early. This personality, Direction Braking Exit Level, is used to increase the exit level and is specified as a percentage, where 0% uses the same exit level as Neutral and Foot braking and 100% increases the exit level by approximately 2 times. Refer to the current limit section for a more detailed description on how to use this personality.

Foot braking

Foot braking can be initiated in one of two ways:

- Via an analogue input configured as a Footbrake Pot. Using a potentiometer allows the operator to vary the amount of braking needed. See below.
- Via a digital input configured as a Footbrake switch. When the switch is active, the system will brake at the footbrake level.

Footbrake Pot

If the system is configured to use a Footbrake Pot, then the system will allow the operator to vary the amount of foot braking depending on the position of the footbrake pedal. Similar to the Accelerator input there are 2 personalities which can be used to setup the input voltage range of the Footbrake Pot.

Footbrake Zero Voltage			Immediate
Calibrator Menu Reference:			11.12
Minimum	Maximum	Step Size	Typical Value
0.00V	4.50V	0.02V	0.10V

Footbrake Full Voltage			Immediate
Calibrator Menu Reference:			11.13
Minimum	Maximum	Step Size	Typical Value
0.00V	4.50V	0.02V	3.50V

As the input voltage varies from the Zero level to the Full level, the footbrake demand varies from 0% to 100%. When the footbrake demand is at 0%, foot braking is disabled. As the footbrake demand increases from 1% to 100%, the braking level applied by the system increases from 50% of the Footbrake Level personality to 100% of the Footbrake Level personality.

For example, assume the system is configured to have a footbrake pot and the Footbrake Level personality is set to 60%. If the operator has not depressed the footbrake pedal, then the voltage into the controller will be outside of the Footbrake Zero Level personality and the footbrake demand will be 0%. There will be no Foot braking.

If the operator starts to press the footbrake pedal, then the footbrake demand will increase. When the demand increases above 0% the system will start braking and will set the braking effort according to the following formula:

$$\text{braking effort} = \left(\frac{\left(\frac{\text{footbrake demand}}{2} \right) + 50}{100} \right) \times \text{footbrake level personality}$$

So, for this example, at 1% demand the braking effort would be

$$\text{braking effort} = \left(\frac{\left(\frac{1}{2} \right) + 50}{100} \right) \times 60$$

$$= 30\%$$

And at 75% demand the braking effort would be

$$\text{braking effort} = \left(\frac{\left(\frac{75}{2} \right) + 50}{100} \right) \times 60$$

$$= 52.5\%$$

Footbrake Priority

Footbrake priority can be set to drive or brake and this determines the controller action in the case of the accelerator and footbrake pedal both being active at the same time.

Footbrake Priority		Power Up
Calibrator Menu Reference:		12.14
Options		Default
Drive	Brake	Drive

Creep Speed

The Creep speed is adjustable and is used to select a minimum pulsing level as soon as drive is requested, to minimize delays and dead-bands. The motor voltage is rapidly ramped to the creep level (equivalent to a 100ms acceleration delay).

Creep Speed			Immediate
Calibrator Menu Reference:			3.01
Minimum	Maximum	Step Size	Typical Value
0%	25%	1%	0%

Maximum Speed

Adjustment limits the maximum applied %on to the armature.

Maximum Speed			Immediate
Calibrator Menu Reference:			5.01
Minimum	Maximum	Step Size	Typical Value
0%	100%	1%	100%

Maximum Reverse Speed

In some instances the maximum reverse speed of the vehicle is required to be slower than the forward speed. This can be achieved by enabling the reverse speed limit and setting the Maximum Reverse Speed personality accordingly.

Maximum Reverse Speed Calibrator Menu Reference:			Immediate 5.02
Minimum	Maximum	Step Size	Typical Value
0%	100%	1%	100%

Reverse Speed Limit Enable Calibrator Menu Reference:		Power Up 12.06
Options		Default
OFF	ON	OFF

Accelerator Characteristics

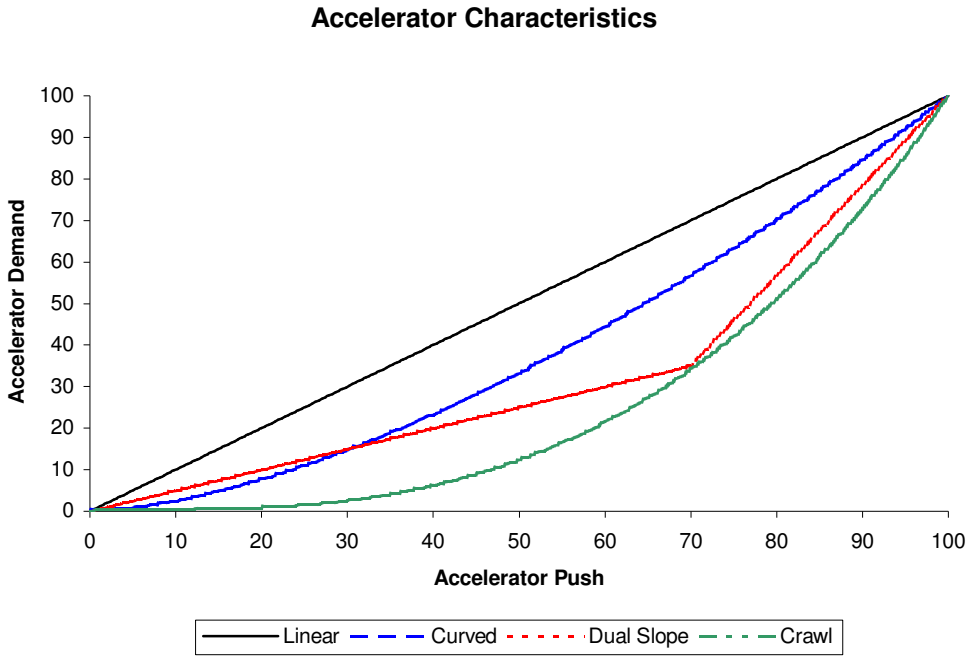


Figure 9: Accelerator Characteristics

Accelerator Characteristics				Power Up
Calibrator Menu Reference:				12.10
Options				Default
Linear	Curved	2*Slope	Crawl	Linear

This function is used to vary how much speed is demanded depending on the accelerator position. Setting either Curved, Dual Slope or Crawl gives a smaller change in speed for large changes in accelerator position and is useful for low speed maneuvering.

The accelerator push refers to how much the operator has the accelerator depressed. This is the value which is displayed on item 19.01 in the Test menu on the Calibrator. The Accelerator Demand refers to how much accelerator demand is requested after the Characteristic function is applied. This accelerator demand is then used along with the Creep Speed and Maximum Speed personalities to determine the speed demand for the vehicle.

If a valid direction is selected and the accelerator demand is at 0%, the speed demand will be set to the Creep Speed personality. As the accelerator demand is increased to 100%, the speed demand increases linearly to the Maximum Speed personality.

Examples:

1. The Accelerator Characteristic is set to Dual Slope, the Creep Speed personality is set to 0% and the Maximum Speed personality is set to 100%. If the accelerator push was at 70%, then the accelerator demand and the vehicle speed demand would be 35%.
2. Same conditions as (1) but the Creep Speed personality is set to 10% and the Maximum Speed is set to 75%. The accelerator push is still 70% and the accelerator demand is still 35%, but now the vehicle speed demand is 32.75%. i.e.:

$$\text{Speed Demand} = \text{Creep Speed} + \left((\text{Maximum Speed} - \text{Creep Speed}) \times \frac{\text{Accelerator Demand}}{100} \right)$$

$$= 10 + \left((75 - 10) \times \frac{35}{100} \right)$$

$$= 32.75\%$$

Features

The MillipaK controller has several features designed to offer the user maximum flexibility, safety and performance whilst ensuring the controller is protected against adverse or harsh driving conditions. These features can be split into three categories – standard controller features, safety features and controller protection features.

Standard Controller Features

The following section details the standard features found on a MillipaK controller.

Power Steer

A contactor drive is available to control a separate Power Steer motor. An adjustable delay allows the motor to operate for a set time, after the power steer trigger or power steer demand has been removed.

The following triggers are available and configurable for power steer:

Power Steer Trigger Configuration Item	Triggers		
	FS1 switch	Fwd or Rev switch	Seat switch
0	No	No	No
1	Yes	No	No
2	No	Yes	No
3	Yes	Yes	No
4	No	No	Yes
5	Yes	No	Yes
6	No	Yes	Yes
7	Yes	Yes	Yes

Table 8: Internal Power Steer Triggers

The software also monitors the motor for movement (if the Anti-Roll-Off feature is enabled) and activates the power steer driver accordingly.

Power Steer Personalities:

Power Steer Timer			Immediate
Calibrator Menu Reference:			9.01
Minimum	Maximum	Step Size	Typical Value
0S	60S	1S	2S

Power Steer Trigger			Power On
Calibrator Menu Reference:			12.13
Minimum	Maximum	Step Size	Default
0	7	1	0

See also contactor drive output configuration (System/Digital IO).

High Speed Switch and Anti-Tie Down

Vehicles with a High Speed Switch configured will normally drive at the Cutback 1 Speed, but will allow the maximum speed of the vehicle to increase to 100% in Reverse or the Cutback 2 Speed in Forward when the High Speed Switch is active. This is usually used for a Walkie type vehicle with a ride on platform where Reverse (Power unit forward, Forks trailing) is the normal driving direction.

This function has two modes, Normal and Latched. Normal mode only activates this feature so long as the switch is active, Latched mode activates this feature when the switch is active, and keeps the High Speed Operation active after the switch is released. High Speed Mode is configurable via the Calibrator.

High Speed Mode		Power On
Calibrator Menu Reference:		12.11
Options		Typical Value
Normal (NOR)	Latched (LAT)	Normal (NOR)

There are two separate options for High Speed Operation:
- **Normal (Unlatched).** High Speed Operation is only active when the switch is active.
- **Latched.** High Speed Operation is active as soon as the switch is made active and remains active after the switch is released until any of the Anti-Tie Down conditions become true.

High Speed Operation will be activated when the following conditions are TRUE:

Normal mode:
- The High Speed Switch is active, and,
- Anti-Tie Down is not inhibiting the feature. Anti-Tie Down is used to prevent High Speed operation under conditions where the operator may not be expecting it.

Latched mode:
- The High Speed Switch has been active at least once to initiate the function, and,
- Anti-Tie Down is not inhibiting the feature.

The speed demand in the Reverse direction (Power Unit Forward) is limited to the Cutback Speed 1 configuration item, if High Speed Operation is not active.

The speed demand in the Forward direction (Forks Forward) is limited to one of the following:
- The lower of the Cutback Speed 1 configuration item or the Cutback Speed 2 configuration item, if High Speed Operation is not active.
- The Cutback Speed 2 configuration item, if High Speed Operation is active.

Other speed demand limits may be applied whether High Speed Operation is active or not.

Anti-Tie Down inhibiting to the High Speed Switch Feature will be applied if any of the following conditions are TRUE:

- The system has just powered up.
- A change in direction has just occurred; i.e. the reverse direction is selected after the forward direction and vice versa.
- The Tiller Switch is inactive.

Anti-Tie Down inhibiting will be kept active until the High Speed Switch is cycled through its inactive state. Anti-Tie Down is used to prevent High Speed operation under conditions where the operator may not be expecting it.

Quick Pick

The Quick Pick function is used to drive a Walkie vehicle at a set speed in the Reverse direction (Power Unit First) when a switch is active on the Tiller arm. This feature is usually set up so that the vehicle will drive at walking speed. This allows the operator to drive the Walkie using one switch whilst they walk along side it.

Drive in the Reverse direction (Power Unit First) will be applied at a speed demand specified by the Walk Speed personality, when all the following conditions are TRUE:
- The Quick Pick switch is active.
- The Tiller switch is active.
- All Drive Switches Are Deselected.
- No Drive Inhibit or Severe faults are active.

The Walk Speed personality can be adjusted via the calibrator, i.e.

Walk Speed			Immediate
Calibrator Menu Reference:			11.02
Minimum	Maximum	Step Size	Typical Value
0%	100%	1%	As required

Quick Pick speed demand will be treated exactly the same way as a normal accelerator demand, where any cutbacks apply (Cutback Speeds, etc) and the demand will be treated appropriately in both Torque and Speed Control modes.

The following inputs will be ignored during Quick Pick operation:
- Forward Switch.
- Reverse Switch.
- FS1 Switch.
- Accelerator Demand.

Belly operation will still be allowed when the Quick Pick function is active.
Drive will be allowed after the Quick Pick switch is released only if all Drive Switches are deselected. For example, if the Forward switch is activated during the Quick Pick operation, Drive is inhibited when the Quick Pick switch is released until the Forward switch is deactivated.

Seat Switch

If the seat switch is opened and the seat switch timer has timed out during drive the controller will stop pulsing and a seat fault will be indicated. Before drive can be restarted the seat switch must be closed, and FS1 and the direction switch must be recycled through neutral. Note the start sequence for drive requires that the seat switch is closed and both the direction and FS1 switches are in the neutral position simultaneously before drive can be initiated. The time period is programmed by means of the Calibrator (Seat Switch Delay). As a setup menu option the seat switch can also inhibit pump operation if required.

Seat Delay			Immediate
Calibrator Menu Reference:			10.01
Minimum	Maximum	Step Size	Typical Value
0.1S	5.0S	0.1S	5.0S

Seat Cuts Pump		Power On
Calibrator Menu Reference:		12.04
Options		Typical Value
OFF	ON	OFF

Handbrake Switch

An input is provided for the connection of a handbrake switch, which if operated will disable armature pulsing but leave a low level field current to effect a minimum roll back hill start when drive is selected and the handbrake is released.

Tiller and Brake Override Switches

The Tiller and Brake Override switches are normally used on Walkie type applications to determine the position of the Tiller arm.

These switches are used to determine if the Electromagnetic Brake output needs to be active (brakes off) or inactive (brakes on) and what the maximum speed of the vehicle is. The following table shows what the controller will do depending on the state of the Tiller and Brake Override switches.

Tiller Switch	**Brake Override Switch**		**Electro-Brake Output**	**Speed Limit**
	Configured	State		
Inactive	No	Don't Care	Off (Brakes On)	N/A
Active	No	Don't Care	On (Brakes Off)	None
Inactive	Yes	Inactive	Off (Brakes On)	N/A
Active	Yes	Inactive	On (Brakes Off)	None
Inactive	Yes	Active	On (Brakes Off)	Cutback 2
Active	Yes	Active	On (Brakes Off)	None

Table 9: Tiller and Brake Override Switches

Typically, the system is setup so that the Brake Override switch closes before the Tiller switch as the Tiller arm is pulled down. If only the Brake Override switch is closed, the system will activate the Electromagnetic Brake output (brakes off), but limit the speed to the Cutback Speed 2 personality.

This feature is typically used for situations where the vehicle operator may park the vehicle so close to a wall that they can no longer pull the Tiller arm down far enough to active the Tiller switch. The Brake Override switch will allow the brake to come off even though the Tiller arm has only been pulled down a small amount.

High Mast

The High Mast switch input is typically used on Walkie type applications where the forks can be elevated to a very high position. It is used to provide additional safety in the event of the Belly switch being operated.

When the Belly switch is operated on a standard Walkie (with low fork height), the vehicle will brake at maximum strength and accelerate at maximum speed in the forks forward direction. On a Walkie with forks which can be elevated to a greater height, this action could be very dangerous if the forks are elevated with a load on. The harsh braking and fast acceleration could cause the load to fall from the forks.

To prevent this, the High Mast input can be used to detect when the forks are elevated. If the Belly switch is operated when this input is active, the system will perform the following actions rather than those specified for the Belly switch.

a) The controller brakes at the Direction Braking Level, rather than 100% braking.
b) The vehicle will accelerate in the Forward direction (forks forward) at the Acceleration Delay rate, rather than the 100ms ramp rate.
c) The maximum speed will be limited to the Speed Cutback 1 personality, rather than maximum speed.

Otherwise, the Belly Switch operation is as described in the Belly Switch section.

Cutback speeds

There are 2 cutback switch inputs as standard. Each one has an associated personality to adjust the maximum % on when the switch is active. When both switches are active together, the lower speed is selected. The cutback speed inputs are usually normally closed so that a wire off type fault or bad connection initiates a lower speed.

Cutback Speed 1			Immediate
Calibrator Menu Reference:			6.01
Minimum	Maximum	Step Size	Typical Value
0%	100%	1%	100%

Cutback Speed 2			Immediate
Calibrator Menu Reference:			7.01
Minimum	Maximum	Step Size	Typical Value
0%	100%	1%	100%

Traction Drive Hours Meter

The MillipaK maintains a log of the number of hours during which the controller is providing Traction functionality. The Traction Drive Hours Meter runs whenever the vehicle is driving or braking. The current number of logged Traction hours can be viewed using the Calibrator. Refer to the Calibrator section for more information.

Personality Checksum

As you can see from this Manual and the Calibrator Map, the MillipaK employs quite a few personalities to give the user as much flexibility as possible in setting up their system. After the personalities have been setup to give the desired functionality and performance, most customers will request the same setup for each subsequent controller they purchase.

In order to check that a controller had the correct personalities, it is very tedious and time consuming to check each individual personality in turn. To remove the need for this, the system calculates a checksum value based on the value of each of the personalities in its memory. The checksum value is simply a number between 0 and 255 which is calculated by passing all the personality values through an algorithm.

The Personality Checksum will be same on every unit (with the same number of personalities) for the same set of personality values. This can be used to instantly confirm that all the personalities are correct. The Personality Checksum is located in the Test menu.

Pump Soft Start

Both the MillipaK and MillipaK HP units may be fitted with a Pump Soft Start feature. This allows a pump motor (up to 100A on standard units and 180A on HP units) to be connected directly to the controller and eliminates the need for a contactor. It also has the added benefit of providing a 'soft start' to the pump motor by gently ramping up the voltage over a pre-determined period. After triggering, the pump will remain active for as long as the trigger input remains active or the pre-set timer expires, whichever is shorter.

Pump Soft Start Ramp Up Delay			Immediate
Calibrator Menu Reference:			11.04
Minimum	Maximum	Step Size	Typical Value
0.1S	0.5S	0.1S	0.1S

Pump Soft Start Timer			Immediate
Calibrator Menu Reference:			11.05
Minimum	Maximum	Step Size	Typical Value
0.5S	10.0S	0.1S	2.0S

WARNING: The pump soft start option, when fitted, is NOT current limited and care should be taken not to exceed the maximum current specified by the controller rating.

Alarm Buzzer

The Alarm Buzzer function is used to drive a warning buzzer when the vehicle is moving under certain conditions. The function works by activating the Buzzer output as follows:

Mode ‘OFF’
The buzzer will not sound at any time if the Buzzer contactor drive output is configured.

Mode ‘Rol’
The Reverse Switch is active or vehicle is traveling in reverse – continuous output.
The vehicle is moving without a direction selected – pulsed output.

Mode ‘All’
The Forward Switch is active or vehicle is traveling in forward – continuous output.
The Reverse Switch is active or vehicle is traveling in reverse – continuous output.
The vehicle is moving without a direction selected – pulsed output.

Buzzer Configuration			Power Up
Calibrator Menu Reference:			12.15
		Options	Default
Off	Rol	All	Rol

Line Contactor Dropout

The controller will close the line contactor once a successful power up sequence has been carried out, after which drive operation can be achieved. The line contactor will remain closed unless it is opened following a serious fault or power being disconnected.

A further configurable option is available where the line contactor is opened (dropped out) if no drive activity has occurred for a period exceeding the Line Contactor Dropout Timer personality. If drive operation is selected once the line has been opened then it will be closed again so that drive operation can occur. Line contactor dropout operation can be enabled or disabled in the setup menu. (NOTE: for proper RollOff detection following a line contactor dropout, a resistor must be installed across the line contactor in order to maintain the field sufficiently energized.)

Line Contactor Drop out		Power Up
Calibrator Menu Reference:		12.09
Options		Default
OFF	ON	OFF

Line Contactor Dropout Timer			Immediate
Calibrator Menu Reference:			11.06
Minimum	Maximum	Step Size	Typical Value
1S	60S	1S	60S

Safety Features

The features listed in this section are designed with the safety of the operator in mind.

Start Up Sequence

When the key switch is turned ON, the Direction and FS1 switches must be in the neutral position simultaneously at least once before drive can be selected. This is a safety feature to help prevent unexpected movement immediately after power up.

Direction Switch Checking

Following a key switch recycle, if the Direction Switch Checking is turned ON, the direction switches must be in the neutral position at least once before drive can be selected. When the feature is turned OFF, drive can be selected after a key switch recycle without first recycling the direction switches through neutral.

Direction Switch Checking		Power Up
Calibrator Menu Reference:		12.08
Options		Default
OFF	ON	OFF

FS1 Recycle

On some vehicles, such as Golf Cars it is desirable to force the driver to remove accelerator demand before allowing the vehicle to drive in the opposite direction to the one it has been traveling in. This feature is implemented as an option and is selected in the PERS setup:

FS1 Recycle Calibrator Menu Reference:		Power Up 12.07
Options		Default
OFF	ON	OFF

SRO (Static return to off)

This feature is optional in the setup menu and when specified, forces the following sequences of switch inputs to be followed before drive is allowed: Keyswitch-Direction-FS1 or Keyswitch-FS1-Direction (within SRO delay of FS1). Any other sequence will not allow drive. Drive will be inhibited if FS1 is active for more than the SRO Delay with no direction selected. In this case the FS1 will need to be recycled.

SRO Enable		Power Up
Calibrator Menu Reference:		12.02
Options		Default
OFF	ON	OFF

SRO Delay			Immediate
Calibrator Menu Reference:			11.07
Minimum	Maximum	Step Size	Typical Value
0S	5S	1S	2S

Belly Switch

A Belly Switch function is available when the controller is used on a Walkie type truck. The feature can be enabled in the setup menu. See this section and wiring diagrams for additional information. Basic operation is as follows:-

Truck moving in Reverse and activating the Belly Switch, accelerator in reverse position:-

d) The controller applies 100% braking.
e) The vehicle will accelerate in the Forward direction (Forks Forward) at full speed along the accelerator curve when the vehicle has stopped.
f) All drive will cease after driving for the time given by the Belly Delay personality (See below).
g) The controller will wait for neutral to be selected before drive will operate. If the Belly Switch is pressed again however, action starts at b) above.

The Belly operation may be set to NORMAL or CONTINUOUS. When set to NORMAL the vehicle will activate belly operation for the duration set by the personality Belly Delay (Calibrator Menu Item 11.03). When set to continuous the belly action will operate for as long as the Belly switch input is active.

Belly Delay			Immediate
Calibrator Menu Reference:			11.03
Minimum	Maximum	Step Size	Typical Value
0.1S	5.0S	0.1S	1.0S

Belly Style		Power Up
Calibrator Menu Reference:		12.12
Options		Default
Normal	Continuous	Normal

Anti-Rollback

This is a standard SEVCON feature and is used to help prevent roll back conditions on ramps. If the driver reselects the previous direction after a neutral condition, braking is not attempted, and full drive power is available to restart on a hill.

Anti-Rolloff

This feature is designed so that if a vehicle is powered up, without its handbrake applied, any non-drive condition on a gradient results in the vehicle braking slowly, in a controlled way, down a ramp without running away.

The Roll-Off Electro-brake option may be set so that the Electro-brake (if fitted & configured) is applied (brakes on) when Roll-Off is detected.

The Roll-Off strength is determined by the value of the Roll-Off Speed personality. 0% disables Roll-Off completely, 1% will apply maximum braking effort and 100% will apply minimum braking effort.

Roll-Off Speed			Immediate
Calibrator Menu Reference:			11.01
Minimum	Maximum	Step Size	Typical Value
0%	100%	1%	5%

Roll-Off E-Brake		Power On
Calibrator Menu Reference:		12.05
Options		Default
OFF	ON	OFF

Fail-safe

The controller's safety system includes a microprocessor watchdog which can detect software failure, and a hardware fail-safe system which can prevent dangerous runaway conditions in the event of certain hardware failures.
Every time the controller is powered-up, the software checks that the fail-safe circuit is able to switch off the MOSFETs and open the contactors.

Controller Protection Features

There are several in built features which are designed to protect the MillipaK controller from damage due to excessive load currents, voltages and prolonged periods of high demand.

Temperature Monitoring

If the temperature of either power frame exceeds 75°C its maximum available current will be reduced. Note, however, that if the set current limit is less than the maximum available current limit actual cutback will occur at progressively higher temperatures than 75°C. The thermal cutback ensures that the maximum heat sink temperature is limited to 90°C (See Figure 10). When actual cutback occurs the diagnostic LED will flash 8 times. Inspection of the calibrator fault messages will indicate which unit is in thermal cutback.

Thermal Cutback Characteristic

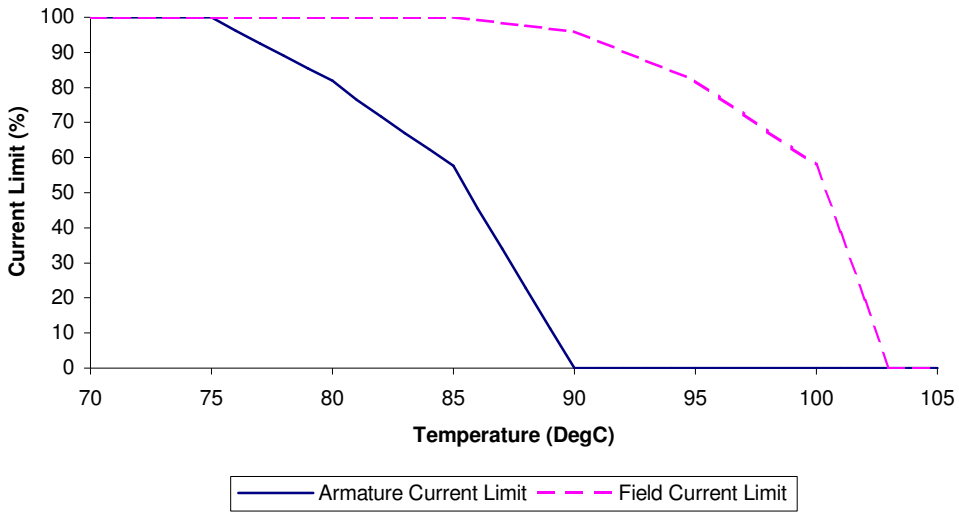


Figure 10: Armature Thermal Cutback Characteristic

Maximum Temperature Logging

The system maintains a log of the maximum heat sink temperature measured by the controller. The Maximum Temperature logged is displayed on the Calibrator next to Heat sink Temperature measurement.

To reset the log select the Maximum Temperature Log reset item on the Calibrator. It will display 'Log'. Press the '+' button and the display will show 'Clr' for 2s before returning back to 'Log'. The maximum temperature has now been reset to the current heat sink temperature.

Timed Current Cutback

During periods of high current usage the power components of the controller produce considerable heat. Under normal circumstances the controller will cutback the maximum current supplied to the load when the heat sink temperature rises above a safe level for the controller components. However, when the current supplied is close to the maximum rating of the controller the temperature rise of the components leads the heat sink temperature by up to 40°C. If this situation was allowed to arise damage may result in the controller. In order to prevent this situation a timed current cutback feature is incorporated in the MillipaK controller, which works as described below:

The controller monitors the power through the armature MOSFETs during a 60 second period and uses the average current seen over this time to determine the new current limit. The new current limit is then calculated as shown in Table 10.

Current Limit Now (% of ABR)	New Current Limit (% of ABR)		
	Low Power	Medium Power	High Power
100%	100%	80%	60%
90%	100%	80%	60%
80%	90%	70%	60%
70%	80%	70%	60%
60%	70%	60%	60%

Table 10: Timed Current Limit Cutback Levels

ABR - Is the Armature Block Rating.

The system will limit the current through the armature to the calculated limit during drive. The system will not apply any Timed Current Limit cutback during braking.

Safe Operating Area (SOA)

The controller's current may be limited at high and/or low duty cycles depending on its current and voltage specification. This is to reduce the thermal stress on the power components in order to increase long term reliability. See Figure 11.

The "Safe Operating Area" is a characteristic of the MOSFETs and Freewheel Diodes which make up the power-frame. The MOSFET SOA restricts current at high duty cycles on all configurations, and the Diode SOA tends to restrict the current at lower duty cycles on lower voltage applications.

For most applications SOA will have little or no effect on the operation of the controller. Its effect is more significant in protecting the controller against adverse loads such as damaged motors and static test rigs.

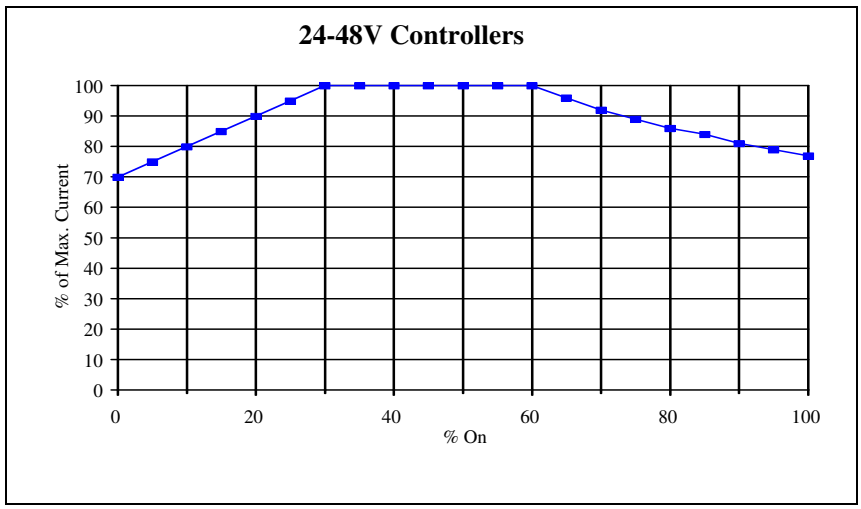


Figure 11: SOA Characteristic

Under-voltage and over-voltage protection

In order to prevent a sudden loss in power, the controller will begin to linearly ramp down the current limit, once the average battery voltage falls below a pre-set under-voltage start level. The current will be ramped down to 0 and a 7 flash fault indicated if the averaged battery voltage falls below the under-voltage cut-out level.

To protect the controller from over-voltage caused by prolonged regen braking, regen braking will be reduced when the average battery voltage reaches the over-voltage start level. If the voltage exceeds the over-voltage cut-out level in braking, then the line contactors will open and freewheeling will occur, requiring the vehicles foundation brakes to be used.

Under any other circumstances, if the battery voltage exceeds the over-voltage cut-out level, all pulsing is stopped and a 7-flash fault is indicated. This protects against incorrect battery connection.

Nominal Battery Voltage	Under-voltage Cutout	Under-Voltage Start (adjustable)	Over-voltage Start (adjustable)	Over-voltage Cut-out
24 V	14.5V	Under Voltage Cut-out up to System V	System V up to Over Voltage Cut-out	30.0V
36 V	14.5V			45.0V
48 V	14.5V			57.0 V

Table 11: Under and Over-Voltage Cutback Levels

The following calibrator menu items are used to set these values.

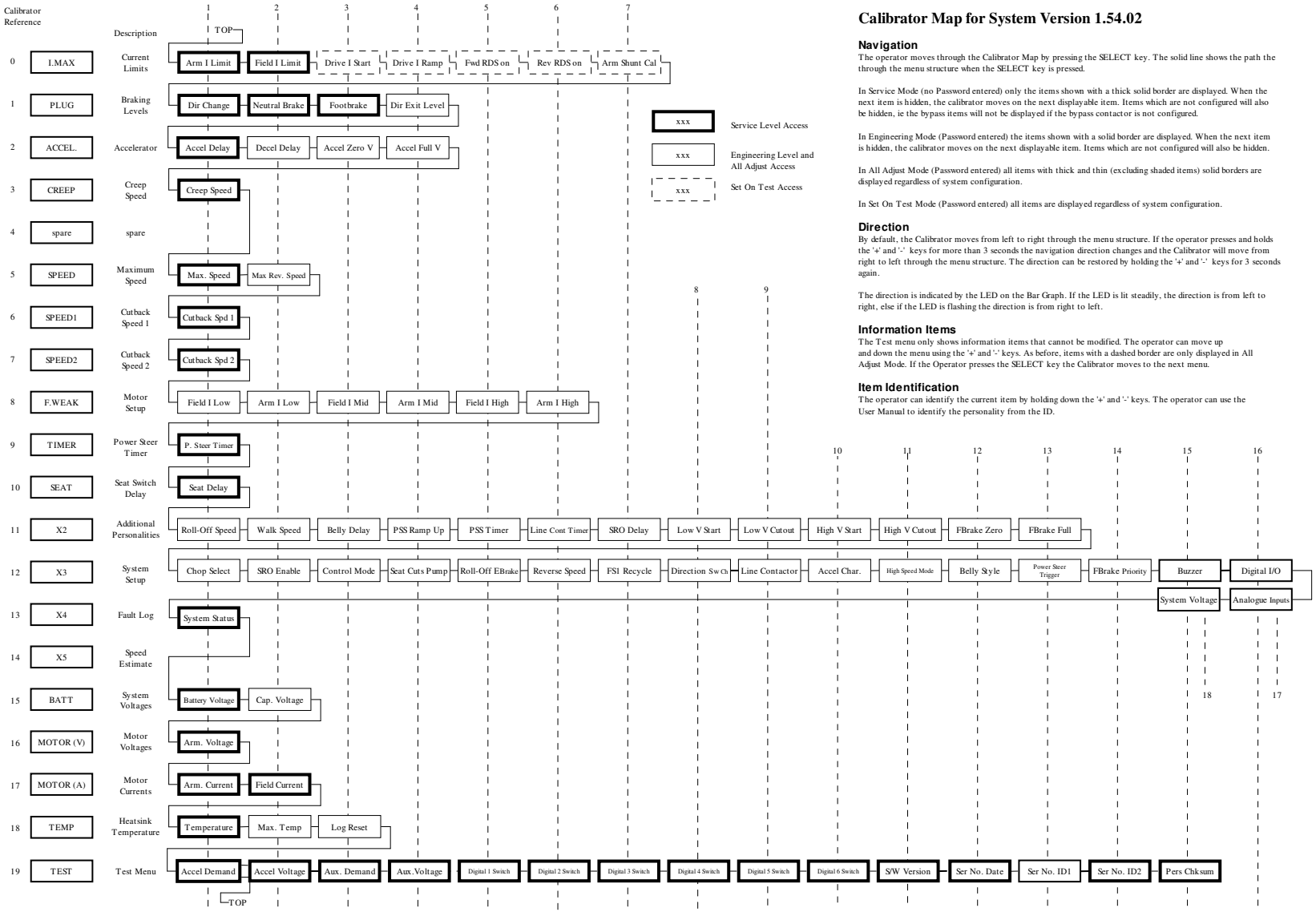
Low Voltage Start			Immediate
Calibrator Menu Reference:			11.08
Minimum	Maximum	Step Size	Typical Value
Low V Cutout	System Voltage	0.5V	18.0V

Low Voltage Cutout			Immediate
Calibrator Menu Reference:			11.09
Minimum	Maximum	Step Size	Typical Value
14.5V	Low V Start	0.5V	16.0V

High Voltage Start			Immediate
Calibrator Menu Reference:			11.10
Minimum	Maximum	Step Size	Typical Value
System Voltage	High V Cutout	0.5V	High V Cutout

High Voltage Cutout			Immediate
Calibrator Menu Reference:			11.11
Minimum	Maximum	Step Size	Typical Value
High V Start	50.0V or 58.0V	0.5V	50.0V or 58.0V

The maximum High Voltage Cutout depends on the level of the System Voltage item. If the System Voltage is set to 36V or lower, then the maximum is 50.0V. If the System Voltage is set greater than 36V, then the maximum is 58.0V.



Calibrator Map for System Version 1.54.02

Navigation

The operator moves through the Calibrator Map by pressing the SELECT key. The solid line shows the path the through the menu structure when the SELECT key is pressed.

In Service Mode (no Password entered) only the items shown with a thick solid border are displayed. When the next item is hidden, the calibrator moves on the next displayable item. Items which are not configured will also be hidden, ie the bypass items will not be displayed if the bypass contactor is not configured.

In Engineering Mode (Password entered) the items shown with a solid border are displayed. When the next item is hidden, the calibrator moves on the next displayable item. Items which are not configured will also be hidden.

In All Adjust Mode (Password entered) all items with thick and thin (excluding shaded items) solid borders are displayed regardless of system configuration.

In Set On Test Mode (Password entered) all items are displayed regardless of system configuration.

Direction

By default, the Calibrator moves from left to right through the menu structure. If the operator presses and holds the '+' and '-' keys for more than 3 seconds the navigation direction changes and the Calibrator will move from right to left through the menu structure. The direction can be restored by holding the '+' and '-' keys for 3 seconds again.

The direction is indicated by the LED on the Bar Graph. If the LED is lit steadily, the direction is from left to right, else if the LED is flashing the direction is from right to left.

Information Items

The Test menu only shows information items that cannot be modified. The operator can move up and down the menu using the '+' and '-' keys. As before, items with a dashed border are only displayed in All Adjust Mode. If the Operator presses the SELECT key the Calibrator moves to the next menu.

Item Identification

The operator can identify the current item by holding down the '+' and '-' keys. The operator can use the User Manual to identify the personality from the ID.

Commissioning Checklist

- Controller Mounted on suitable flat heat sink with appropriate heat sink compound?
- Power wiring checked, shortest routes taken where possible?
- Light wiring checked; use calibrator to verify controller correct switch operation.
- Accelerator set-up and checked 0 – 100%?
- Personalities all set, checked and record filled out?

Personality Record

Personality		New Setting	Range	
			Minimum	Maximum
0.01	Armature Current Limit		50A	ABR
0.02	Field Current Limit		10A	FBR
0.03	Drive Current Limit Start		50A	Armature I Limit
0.04	Drive Current Limit Ramp		0.00s	2.50s
1.01	Direction Change Braking		5%	100%
1.02	Neutral Braking Level		0%	100%
1.03	Foot-brake Braking Level		0%	100%
1.04	Dir. Braking Exit Level		0%	100%
2.01	Acceleration Delay		0.1s	5.0s
2.02	Deceleration Delay		0.1s	0.5s
2.03	Accelerator Zero Voltage		0.00V	4.50V
2.04	Accelerator Full Voltage		0.00V	4.50V
3.01	Creep Speed		0%	25%
5.01	Maximum Speed		0%	100%
5.02	Maximum Reverse Speed		0%	100%
6.01	Cutback Speed 1		0%	100%
7.01	Cutback Speed 2		0%	100%
8.01	Field Current Low		2.00A	I_f Mid or 19.75A
8.02	Arm Current Low		10A	Arm I Mid – 10A
8.03	Field Current Mid		Field I Low	Field I High
8.04	Arm Current Mid		Arm I Low + 10A	Arm I High – 10A
8.05	Field Current High		Field I Mid	FBR
8.06	Arm Current High		Arm I Mid + 10A	ABR
9.01	Power Steer Timer		0s	60s
10.01	Seat Delay		0.1s	5.0s
11.01	Roll-Off Speed		0%	100%
11.02	Walk Speed		0%	100%
11.03	Belly Delay		0.1s	5.0s
11.04	PSS Ramp Up Delay		0.1s	1.0s
11.05	PSS Timer		0s	10s
11.06	Line Cont. Dropout Timer		1s	60s
11.07	SRO Delay		0s	5s
11.08	Low Voltage Start		Low V Cutout	System Voltage
11.09	Low Voltage Cutout		14.5V	Low V Start
11.10	High Voltage Start		System Voltage	High V Cutout
11.11	High Voltage Cutout		High V Start	50.0V or 58.0V
11.12	Foot Brake Zero Volts		0.00V	4.50V
11.13	Foot Brake Full Volts		0.00V	4.50V

Personality		New Setting	Range	
			Minimum	Maximum
12.01	Chop Select		OFF/ON/24V	
12.02	SRO Enable		OFF/ON	
12.03	Control Mode		TORQUE/SPEED	
12.04	Seat Cuts Pump		OFF/ON	
12.05	Roll-Off Electro brake		OFF/ON	
12.06	Reverse Speed Limit		OFF/ON	
12.07	FS1 Recycle on Dir Change		OFF/ON	
12.08	Dir Switch Seq Fault Check		OFF/ON	
12.09	Line Contactor Dropout		OFF/ON	
12.10	Accelerator Characteristics		LINEAR/CURVED/2*SLOPE/CRAWL	
12.11	High Speed Mode		NORMAL/LATCHED	
12.12	Belly Style		NORMAL/CONTINUOUS	
12.13	Power Steer Trigger		FS1/SEAT/DIRECTION	
12.14	Foot-brake Priority		DRIVE/FOOTBRAKE	
12.15	Buzzer Configuration		OFF/REV+ROLL/ALL	
12.16	Digital I/O		1	17
12.17	Analogue I/P		1	4
12.18	System Voltage		24V	48V

Table 92: Personality Record

Fault Finding

The MillipaK controller includes a number of features designed to help the user track down operational faults, wiring faults or internal controller faults.
The **Diagnostic LED** mounted next to the calibrator connectors on the front of the controller serves as a simple diagnostic tool as explained below:

ON	No fault, normal condition
OFF	Internal controller fault
1 flash	Personality out of range
2 flashes	Illegal start condition (Traction)
3 flashes	MOSFET Short Circuit
4 flashes	Contactor fault or Motor Open Circuit
5 flashes	Not used
6 flashes	Accelerator wire off fault
7 flashes	Low or High battery voltage
8 flashes	Over temperature or timed cutback

Table 103: Flash Fault Descriptions

In addition to the LED indication a more detailed description of any faults detected may be found by using the calibrator. Menu item number 13.01 gives a code which corresponds to the following detected faults:

ID	Fault	Description	Flash Fault
0	System OK		On
1	Thermal Cutback	Maximum power available to the motor has been reduced due to excessive Heat sink temperature.	8
2	Timed Current Limit Cutback	Maximum power available to the motor has been reduced by the Timed Current Limit Cutback function.	8
3	Accelerator Wire Off	Input wire from accelerator has been disconnected.	6
4	Accelerator Pressed at Power Up	Accelerator pedal pressed at power up	6
5	Belly Fault	The Belly switch function has occurred	2
6	Seat Fault	Drive selected and no seat switch closed.	2
7	FS1 Recycle	FS1 switch needs to be recycled after a direction change	2
8	SRO Fault	Direction switch selected for greater than 2 seconds with FS1 open.	2
9	Two Direction Fault	Two directions selected together.	2
10	Sequence Fault	Direction or FS1 switch closed at power up.	2
11	Low Battery Fault	Battery voltage is too low.	7
12	High Battery Fault	Battery voltage is too high.	7
13	High Battery Fault with Line Contactor Open	Battery voltage is too high before the line contactor is closed	7

ID	Fault	Description	Flash Fault
14	Configuration Range Fault	A personality is out of range.	1
15	Configuration CRC Fault	The personality CRC is incorrect	1
16	Line Contactor Welded Fault	Line contactor is welded.	4
17	Line Contactor did not Close Fault	Line contactor is open circuit.	4
18	MOSFET Short Circuit	Short circuit Armature MOSFETs detected.	3
19	VA Detect Fail	12V Supply Failure	0
20	MOSFET Off	MOSFETs did not pulse during power on failsafe checks (failsafe circuit enabled).	0
21	MOSFET On	MOSFETs pulsed during power on failsafe checks (failsafe circuit disabled).	0
22	MOSFET Short Circuit during Power Up	Short circuit Armature MOSFETs detected during power on failsafe checks.	3

23	Drive 2 Off	Contactor 2 did not pulse during power on failsafe checks (failsafe circuit enabled).	0
24	Drive 2 On	Contactor 2 pulsed during power on failsafe checks (failsafe circuit disabled).	0
25	Drive 1 Off	Contactor 1 did not pulse during power on failsafe checks (failsafe circuit enabled).	0
26	Drive 1 On	Contactor 1 pulsed during power on failsafe checks (failsafe circuit disabled).	0
27	Drive 3 Off	Contactor 3 did not pulse during power on failsafe checks (failsafe circuit enabled).	0
28	Drive 3 On	Contactor 3 pulsed during power on failsafe checks (failsafe circuit disabled).	0

Table 114: Fault Numbers and Descriptions

Fault Clearance

Any fault indication will be cleared by re-initiating the start sequence after the cause of the fault has been removed.

Fault Reporting Form

Sevcon is committed to improving the quality of all of its products. Please help us by using this form to report faults to Sevcon. Please give as much detail as possible. Use extra sheets if required. Fax this form to +44 191 482 4223.

Your Name		Telephone Number	
Your Company		email address	
Vehicle Manufacturer		Vehicle Type	
Controller Type		Part number	
Serial Number		Software Version	
Date / Time that fault first occurred.			
Exact Fault Message (calibrator or display)			
When did the fault message appear?	during drive / when the vehicle stopped / in neutral / after a keyswitch off-on (delete as applicable)		
How did the fault occur? Please describe: The vehicle speed. The approximate gradient (up or down hill) Pedal and switch changes by the driver What happened to the vehicle when the fault occurred			
What is the status of the vehicle now? Is there a fault message at key-switch on? Can it be driven?			

Table 12: Fault Reporting Form

Software Version and Serial Number indication

For identification purposes and to assist in queries, the Software version, and the controller serial number are indicated in the calibrator Test Menu.

When giving the Software Version, the entire number should be quoted (i.e. MM.mm.ss).

The Software version is shown as a string, scrolling continuously across the calibrator display from right to left. The format is:

Test Item:	S/W Version
Version Number:	8 characters

Table 13: Software Version Format

The Serial is shown across three items in the Test menu. The first item is the date code and the next two are the identifier. All these items need to be used to get the complete serial number. The format is:

Test Item:	Ser No. Date	Ser No. ID1	Ser No. ID2
Serial Number:	MMYY	AA	BB

Table 14: Serial Number Format

MMYY gives the month and year when the controller was manufactured. (e.g. 0701 indicates July, 2001). AABB are combined to give a 4 digit identifier which is simply a number from 0001 to 9999. When giving the Serial Number, the entire number should be quoted (i.e. MMYYAABB).

The MillipaK range of controllers uses the latest FLASH technology to allow In System Reprogramming. This is achieved without having to remove the controller from its installation – all that is needed is connection to the 6-way calibrator socket.

Specifications

The following specifications apply to all MillipaK controllers.

Power Configurations

At present the MillipaK SEM controller is available in the following power configurations:

Housing	Armature	Field	Soft Start Option
(CORE) Small	180A	30A	100A Soft Start
(CORE) Small	300A	30A	100A Soft Start
(HP) Large	600A	50A	-
(HP) Large	500A	50A	180A Soft Start

Table 158: Power Configurations

All the MillipaK SEM range of controllers operate from 24-48v batteries.

WARNING: The pump soft start option, when fitted, is NOT current limited and care should be taken not to exceed the maximum current specified by the controller rating.

EMC standards

All MillipaK variants are tested to and conform to EN12895.

Socket B protection

All user connections on socket B are protected against indefinite short circuit to battery minus and battery positive.

Contactor drive ratings

All contactor drives are rated at 3A peak (10s) and 1.5A continuous. All the drives have reverse battery connection protection, inbuilt freewheel diode and are internally protected against short circuit.

Analogue Input Impedance

The two analogue inputs are internally pulled up to +12v via a 12k resistor. This is primarily designed for use with 5k potentiometers, but may also be used with suitable voltage sources.

Digital Input Impedance

The digital inputs are internally pulled up and are active LOW. They therefore must be connected to battery minus to operate a function. Maximum resistance to battery minus to operate is 500ohms.

EMC Guidelines

The following guidelines are intended to help vehicle manufacturers to meet the requirements of the EC directive 89/336/EEC for Electromagnetic Compatibility.
Any high speed switch is capable of generating harmonics at frequencies that are many multiples of its basic operating frequency. It is the objective of a good installation to contain or absorb the resultant emissions.
All wiring is capable of acting as a receiving or transmitting antenna. Wiring should be arranged to take maximum advantage of the structural metal work inherent in most vehicles. Vehicle metalwork should be electrically linked with conductive braids.

Power Cables

All cables should be routed within the vehicle framework and kept as low in the structure as is practical - a cable run within a main chassis member is better screened from the environment than one routed through or adjacent to an overhead guard.
Power cables should be kept short to minimize emitting and receiving surfaces
Shielding by the structure may not always be sufficient - cables run through metal shrouds may be required to contain emissions.
Parallel runs of cables in common circuits can serve to cancel emissions - the battery positive and negative cables following similar paths is an example.
Tie all cables into a fixed layout and do not deviate from the approved layout in production vehicles. A re-routed battery cable could negate any approvals obtained.

Signal Cables

All wiring harnesses should be kept short.
Wiring should be routed close to vehicle metalwork.
All signal wires should be kept clear of power cables or made from screened cable.
Control wiring should be kept clear of power cables when it carries analogue information - for example, accelerator wiring.
Tie all wiring securely and ensure wiring always follows the same layout.

Controller

Thermal and EMC (emissive) requirements tend to be in opposition.
Additional insulation between the controller assembly and the vehicle frame work reduce capacitive coupling and hence emissions but tend to reduce thermal ratings. A working balance needs to be established by experiment.
The complete installation should be documented, in detail, and faithfully reproduced on all production vehicles. When making any changes, consider their effect on compliance ahead of any consideration of cost reduction or other “improvement”.

Ordering Information

The controllers and contactor panels are allocated 633 numbers as shown. The lettering section gives the full listing of item types.

Item description	Voltage	Current	Logic	Customer Code
A=	2= 24	1= 100-199	1= SEM plug	XX
B=	3= 36	2=.200-299	2= SEM plug s/start	
C= Controller only	4= 48	3= 300-399	3= SEM regen	
D= Traction panel	7 = 72	4= 400-499	4= SEM regen s/start	
E= Traction + Pump Panel	8= 80	5= 500-599	5= Series Pump	
F= Twin Traction Panel	9= 96	6= 600-699	6= BPM	
G= Twin Traction + Pump Panel		7= 700-799	7= BPM s/start	
H=		8= 800-899	8= 4QPM	
J=		9= 900 +	9= 4QPM s/start	
K=				
L=				
M=				
N=				
P=				
R=				
S=				
T= HP Controller only				
W= HP Traction panel				
X= HP Traction + Pump Panel				
Y= HP Twin Traction Panel				
Z= HP Twin Traction + Pump Panel				

HP = High Power

For panels then the voltage, current and logic numbers should be used to describe the traction controller.

Examples:

300A SEM plugging controller with soft start 633C43101

600A SEM plugging controller 633T46101