Tech/Ops
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MILLIPAK PUMP CONTROLLER MANUAL

Document History

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Introduction

The MillipaK PUMP (series 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 both power and logic circuitry, as well as all suppression components.

MillipaK supports Sevcon's existing MOS90 calibrator for adjustment of pump characteristics.

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 Series power frame comprising Armature circuit only. Armature currents are monitored. 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 truck may not drive.

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

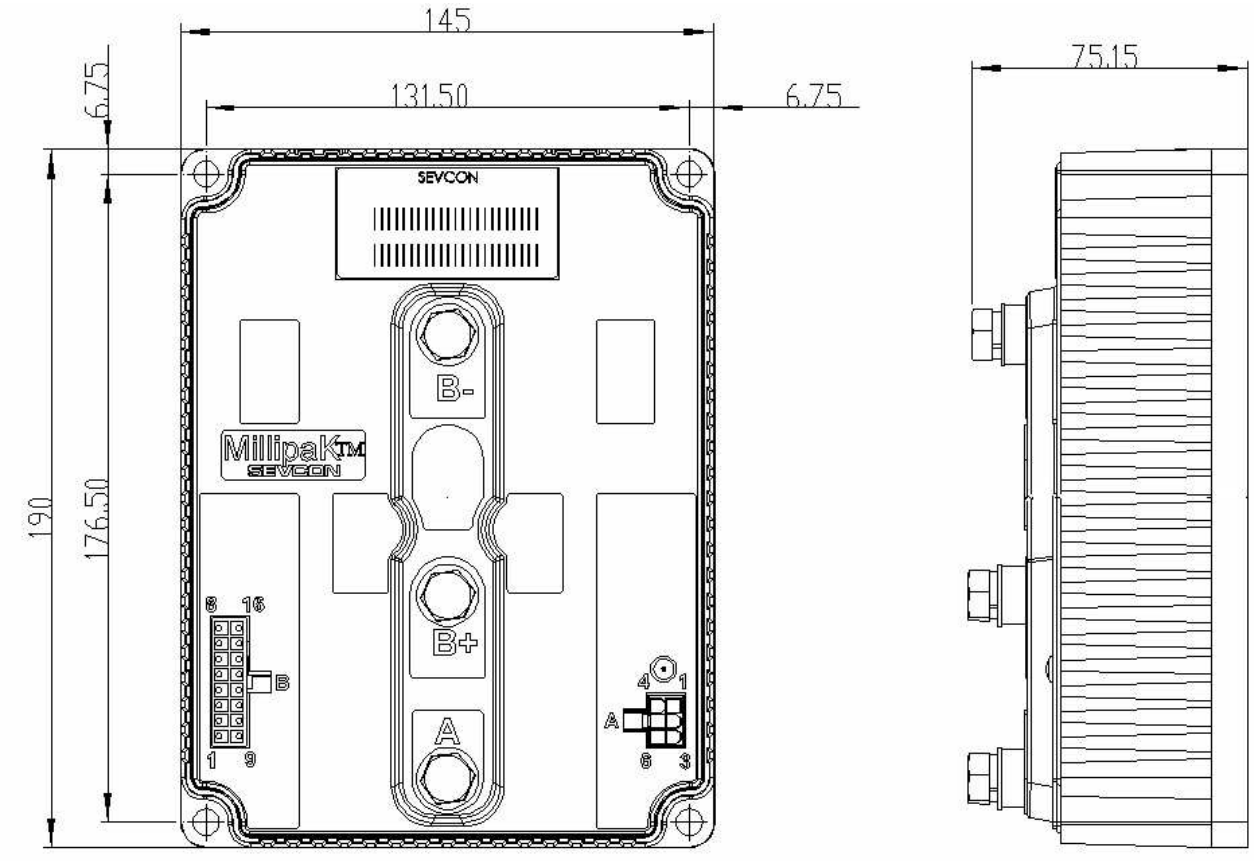
Installation

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

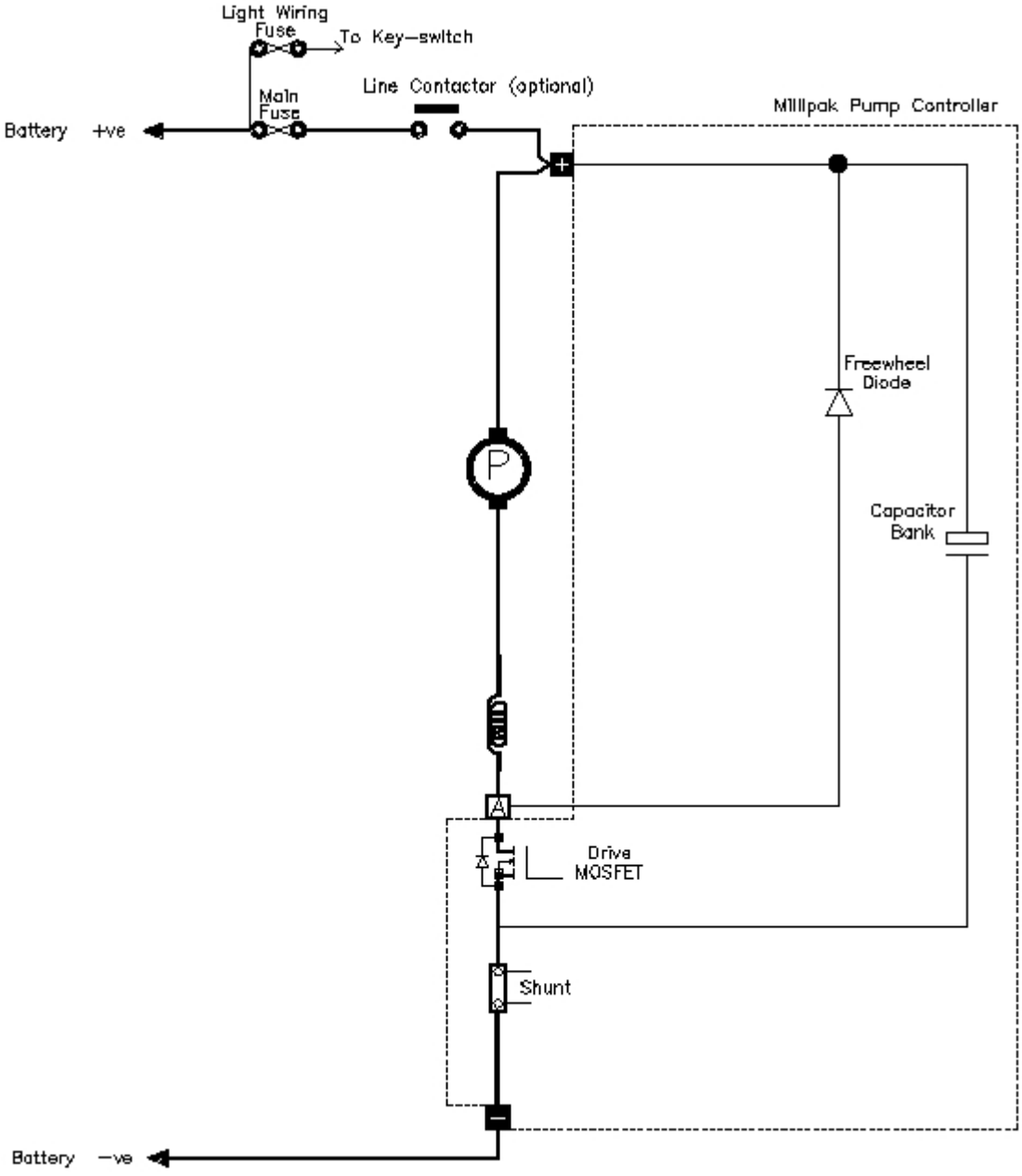
The MillipaK and MillipaK HP units provide 4 x M6 clearance holes for mounting. The controllers should be mounted onto a metal base plate, as large as possible to provide heat-sinking. The surface finish should be flat, clean and burr free and thermal compound should be applied to the controller base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

MillipaK HP Controller Dimensions



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

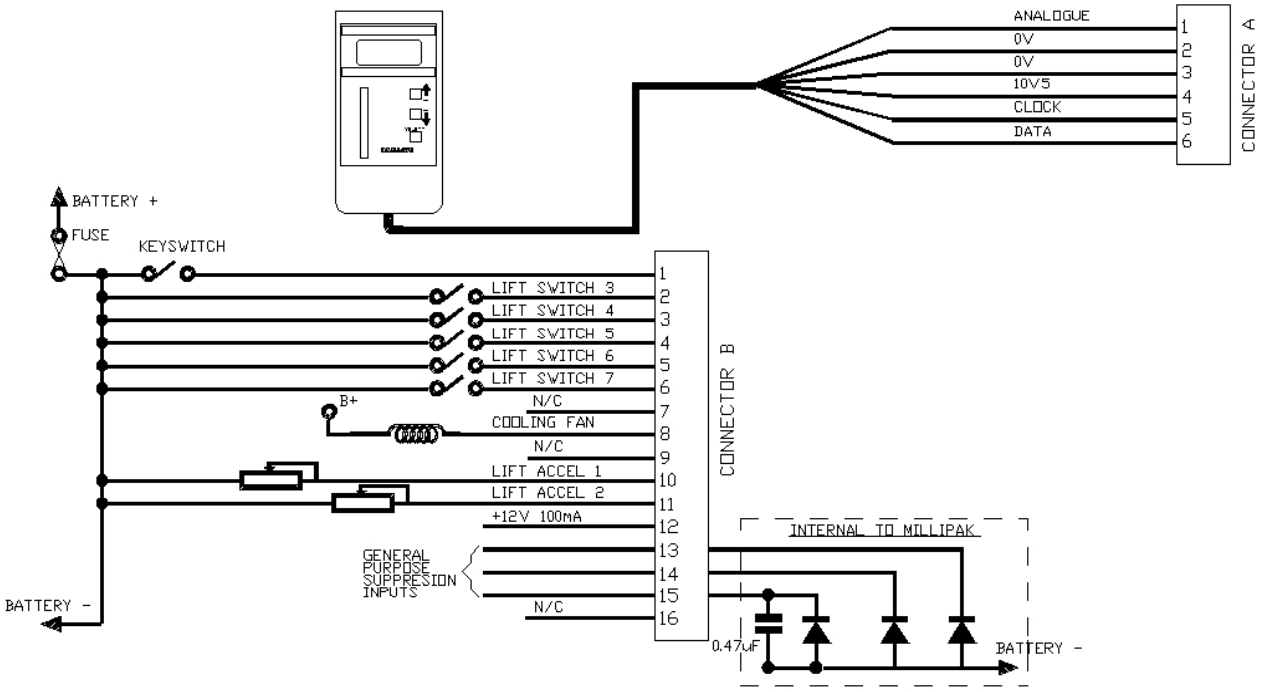
MillipaK Pump Power Wiring



NOTE: The Pump battery positive power terminal may be wired directly to the battery positive (via a suitable fuse) or via a line contactor if used in a Traction / Pump system.

It should be considered whether or not pump operation is required if a traction fault causes the line contactor to drop out.

MillipaK Pump Light Wiring



NOTES:
The line and auxiliary contactors coils 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.

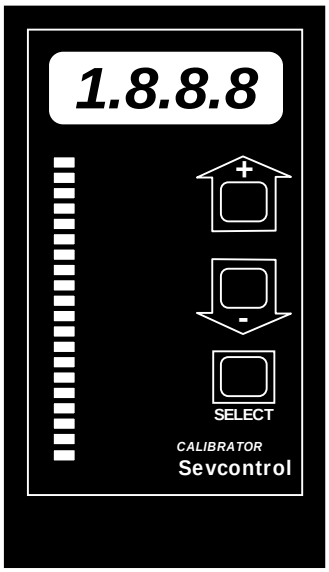
Pin 12 on the Core and Standard HP variants is available for 100mA supply, typically used for (but not limited to) accelerator modules.

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.

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.



Calibrator Security Levels

Which personalities and status items which can be viewed on the Calibrator is restricted using passwords. There are three levels of Calibrator access. These are shown in the table below:

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	Only items shown in the Calibrator Map with a thick or thin solid border are displayed.
All Adjust	All	Contact SEVCON	All items are displayed.

Note, in Service or Engineering mode, only items appropriate to the current system configuration are displayed. For example, if lift switch 5 is not configured, then the Speed personality will not be displayed for that switch. In All Adjust mode, all items are shown regardless of configuration.

The password can only be entered just after power up when the Pump 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. 6 times to enter 6). 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.

When the password has been completely entered press either the '+' button or the SELECT button to initiate verification. If the password has been entered correctly, the text shown in the table above appropriate to the required level will be displayed for 1s indicating the password was accepted. If the password was incorrect or no password was entered, the system always defaults to Service mode.

After the Security Level has been displayed, the system enters the normal menu structure shown in the Calibrator Map. To change the password level, you need to recycle the Keyswitch.

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 Current Limit personality was selected, then the ID would be 0.01 (menu 0, item 1). This allows the operator to locate where they are in the map.

If the '+' and '-' buttons are held down together for more than 3 seconds, the direction through the menu structure is reversed. Now when the SELECT button is pressed the direction is from right to left, bottom to top. In this mode, the LED on the Calibrator will flash. If the '+' and '-' buttons are held down together for more than 3 seconds again, the direction reverts back to the first direction 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). To navigate the Test menu, you need to use the '+' and '-' buttons. The '+' button moves up the Test menu and the '-' button moves back down. 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 – Lift Speed 1).

The items which are displayed depends 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	Speed 1	Used to set pump speed for lift accelerator 1.
1	Speed 2	Used to set pump speed for lift accelerator 2.
2	Speed 3	Used to set pump speed for switch input 3.
3	Speed 4	Used to set pump speed for switch input 4.
4	Speed 5	Used to set pump speed for switch input 5.
5	Speed 6	Used to set pump speed for switch input 6.
6	Speed 7	Used to set pump speed for switch input 7.
7	Unused	Unused.
8	Creep Speed	Used to set creep speed.
9	Ramps	Used to set lift and power steer ramp times.
10	Power Steer	Used to set-up power steer function.
11	Current Limit	Used to set motor current limit, seat delay and low voltage start and cut levels.
12	System Set-up	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 Keyswitch is recycled.

Status and Test Information

Menus 13 to 19 are primarily used for providing information about the system. Every parameter which the system measures in 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 Keyswitch 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 Current	Used to show the PUMP motor current Measurement.
18	Heatsink Temperature	Used to access the Heatsink Temperature measurement and the Maximum Heatsink 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.

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 will interface with connected hardware such as the system battery, lift control switches, accelerator and the pump 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 12.05
Minimum	Maximum	Step Size	Default
24v	48v	2v	24v

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. The table below 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	Normal switch inputs are used for lift switches. Lift Inhibit is available via the last switch input on the MillipaK Core or via the second analogue input on the MillipaK HP.
2	Normal switch inputs are used for lift switches. Power Steer Trigger is available via the last switch input on the MillipaK Core or via the second analogue input on the MillipaK HP.
3	4 of the normal switch inputs are used for lift switches. Power Steer Trigger is available on a normal switch input. Lift Inhibit is available via the last switch input on the MillipaK Core or via the second analogue input on the MillipaK HP. Lift Switch 5 is dropped to leave 2 switches with compensation and 2 additive switches.
4	4 of the normal switch inputs are used for lift switches. Lift Inhibit is available on a normal switch input. Power Steer Trigger is available via the last switch input on the MillipaK Core or via the second analogue input on the MillipaK HP. Lift Switch 5 is dropped to leave 2 switches with compensation and 2 additive switches.
5	3 of the normal switch inputs are used for lift switches. Lift Inhibit and Power Steer Trigger are available on normal switch inputs. Lift Switch 4 is available via the last switch input on the MillipaK Core or via the second analogue input on the MillipaK HP. Lift Switch 5 is dropped to leave 2 switches with compensation and 2 additive switches.
6	2 of the normal switch inputs are used for lift switches. Lift Inhibit, Power Steer Trigger and Seat Switch are available on normal switch inputs. Lift Switch 4 is available via the last switch input on the MillipaK Core or via the second analogue input on the MillipaK HP. Lift Switches 5 and 7 are dropped to leave 2 switches with compensation and 1 additive switches. There is one contactor drive, the Cooling Fan Drive.

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
Lift Switch 3	B2	B2	B2	B2	B2	B2
Lift Switch 4	B3	B3	B3	B3	B3	B3
Lift Switch 5	B4	B4				
Lift Switch 6	B5	B5	B5	B5	B5	B5
Lift Switch 7	B6	B6	B6	B6	B6	
Lift Inhibit	B5		B5	B2	B2	B2
Power Steer Trigger		B5	B2	B2	B3	B3
Seat Switch						B4
Cooling Fan Drive						B8

Notes:
1. Dx refers to Digital Switch input x.
2. Cx refers to Contactor Drive output x.
3. If the Analogue Input 2 is set to Digital, switch input D6 is read from the Analogue input and not the switch input.

Analogue Functions

Analogue Function	Value of Analogue Input Configuration Item	
	1	2
Lift Accelerator 1	Ana.1 (B10)	Ana.1 (B10)
Lift Accelerator 2	Ana.2 (B11)	
Digital		Ana.2 (B11)

Digital Configuration			Power Up
Calibrator Menu Reference:			12.02
Minimum	Maximum	Step Size	Default
1	6	1	

Analogue Configuration			Power Up
Calibrator Menu Reference:			12.03
Minimum	Maximum	Step Size	Default
1	2	1	

Current Limit

The current limit personality is 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.

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

Where CBR is Controller Block Rating.

Accelerator Full /Zero Setting

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

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% demand would start at 0.20V at the input, increasing to 100% demand 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 1 Zero Volts			Immediate
Calibrator Menu Reference:			0.03
Minimum	Maximum	Step Size	Typical Value
0.00V	4.50V	0.02V	0.20V

Accelerator 1 Full Volts			Immediate
Calibrator Menu Reference:			0.04
Minimum	Maximum	Step Size	Typical Value
0.00V	4.50V	0.02V	3.50V

Accelerator 2 Zero Volts			Immediate
Calibrator Menu Reference:			1.03
Minimum	Maximum	Step Size	Typical Value
0.00V	4.50V	0.02V	0.20V

Accelerator 2Full Volts			Immediate
Calibrator Menu Reference:			1.04
Minimum	Maximum	Step Size	Typical Value
0.00V	4.50V	0.02V	3.50V

The PWM demand will vary between the Creep level and Maximum Speed for that lift accelerator 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.

Lift and Power Steer Ramps

Theses are adjustable delays to ramp up the pulsing from 0% on to 100% on, and can be used to ensure smooth start / stop.

Lift Ramp Up Calibrator Menu Reference:			Immediate 9.01
Minimum	Maximum	Step Size	Typical Value
0.1S	5.0S	0.1S	1.5S

Power Steer Ramp Up Calibrator Menu Reference:			Immediate 9.02
Minimum	Maximum	Step Size	Typical Value
0.1S	5.0S	0.1S	1.5S

Ramp Down Calibrator Menu Reference:			Immediate 9.03
Minimum	Maximum	Step Size	Typical Value
0.1S	0.5S	0.1S	0.1S

Creep Speed

The Creep speed is adjustable and is used to select a minimum pulsing level as soon as any pump function is requested, to minimise delays and dead-bands. The motor voltage is rapidly ramped to the creep level (equivalent to a 100mS ramp time).

Creep Speed			Immediate
Calibrator Menu Reference:			8.01
Minimum	Maximum	Step Size	Typical Value
0%	25%	1%	0%

Maximum Speed

Adjustment limits the maximum applied %on to the motor. There are seven speed settings available, one for each input (two analogue accelerators and 5 digital switches). These settings can be used to set different pump motor speeds for the various vehicle functions.

Speed 1			Immediate
Calibrator Menu Reference:			0.01
Minimum	Maximum	Step Size	Typical Value
0%	100%	1%	100%

Speed 2			Immediate
Calibrator Menu Reference:			1.01
Minimum	Maximum	Step Size	Typical Value
0%	100%	1%	100%

Speed 3			Immediate
Calibrator Menu Reference:			2.01
Minimum	Maximum	Step Size	Typical Value
0%	100%	1%	100%

Speed 4			Immediate
Calibrator Menu Reference:			3.01
Minimum	Maximum	Step Size	Typical Value
0%	100%	1%	100%

Speed 5			Immediate
Calibrator Menu Reference:			4.01
Minimum	Maximum	Step Size	Typical Value
0%	100%	1%	100%

Speed 6			Immediate
Calibrator Menu Reference:			5.01
Minimum	Maximum	Step Size	Typical Value
0%	100%	1%	100%

Speed 7			Immediate
Calibrator Menu Reference:			6.01
Minimum	Maximum	Step Size	Typical Value
0%	100%	1%	100%

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 fault 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.

Lift Switch Inputs - Priority

The two lift accelerators are normally referred to as inputs 1 & 2 and the digital switch inputs as 3 to 7. The priority assigned to each input is shown in the table below:

Priority	Input	Additional Comments
1(highest)	Lift Accelerator 1	
2	Lift Accelerator 2	
3	Lift Switch 3	
4	Lift Switch 4	
5	Lift Switch 5	Lift Switches 5, 6 and 7 are lower priority than the other Lift inputs only when they are configured as Priority. Additive switches are handled separately. See next section.
6	Lift Switch 6	
7	Lift Switch 7	

Assuming all the inputs are configured as priority, then even if more than one switch input (or accelerator) is active only one demand will be used. This demand will be that of the highest priority active input, even if this is the lowest demand. For this reason care must be taken in setting accelerator zero levels to ensure zero demand when the accelerator is inactive.

Speed 5 Priority / Additive		Power Up
Calibrator Menu Reference:		4.02
Options		Default
Priority	Additive	Priority

Speed 6 Priority / Additive		Power Up
Calibrator Menu Reference:		5.02
Options		Default
Priority	Additive	Priority

Speed 7 Priority / Additive		Power Up
Calibrator Menu Reference:		6.02
Options		Default
Priority	Additive	Priority

For example, if switches 5 – 7 are set as priority then activating all switches will result in the speed demand set for switch 5 being used.

Lift Switch Inputs - Additive

Lift input switches 5 to 7 may be configured as *Additive*. As the name implies if two or more switches configured as additive are active together then the speed demand set for each switch will be added together and this will be the final speed demand.

Additive also applies if a priority and an additive switch are active simultaneously.

For example if lift accelerator 1 input demand is at 20%, switch 3 is active with its maximum speed personality set to 20% and switch 5 is active and programmed as additive and with a speed setting of 30 % then the final demand would be 50% (lift accelerator 1 demand + switch 5 demand).

Compensation

A compensation factor can be programmed for lift accelerators 1 and 2, lift switches 3 and 4, and the power steer input (if configured).

The compensation factor is designed to help keep a constant lift speed or power steer assist level under varying load conditions.

The compensation feature works by calculating how much extra motor voltage is needed to keep the motor speed constant. The calculation uses the motor current and the relevant personality to determine the extra motor voltage required.

To set the compensation factors for the lift accelerators or switches you should first set the desired unloaded speed using the maximum speed personality for the lift input in question. The next step should be to activate the lift under full load and increment the compensation personality until the desired full load speed is achieved.

The following personalities may be programmed to provide compensation for the relevant inputs:

Compensation 1			Immediate
Calibrator Menu Reference:			0.02
Minimum	Maximum	Step Size	Default
0%	200%	1%	0%

Compensation 2			Immediate
Calibrator Menu Reference:			1.02
Minimum	Maximum	Step Size	Default
0%	200%	1%	0%

Compensation 3			Immediate
Calibrator Menu Reference:			2.02
Minimum	Maximum	Step Size	Default
0%	200%	1%	0%

Compensation 4			Immediate
Calibrator Menu Reference:			3.02
Minimum	Maximum	Step Size	Default
0%	200%	1%	0%

Power Steer Compensation			Immediate
Calibrator Menu Reference:			10.03
Minimum	Maximum	Step Size	Default
0%	200%	1%	0%

Power Steer Input

Any one of the digital switch inputs may be configured as a Power Steer trigger. When configured the power steer speed and delay may be programmed:

Power Steer Personalities:

Power Steer Speed			Immediate
Calibrator Menu Reference:			10.01
Minimum	Maximum	Step Size	Default
0%	100%	1%	100%

Power Steer Delay			Immediate
Calibrator Menu Reference:			10.02
Minimum	Maximum	Step Size	Default
0s	60s	1s	2S

Power Steer Compensation			Immediate
Calibrator Menu Reference:			10.03
Minimum	Maximum	Step Size	Default
0%	200%	1%	0%

The power steer delay is the length of time the demand will remain active after the trigger signal is removed.

Lift Inhibit Input

One of the digital inputs may be configured as Lift Inhibit. When the inhibit input is active then no lift functions are allowed to start. Any lift functions already active will not be affected.

Cooling Fan

There is a facility provided on the standard MillipaK Pump controller which allows a traction motor cooling fan to be activated via a contactor drive output. The output is activated when the *Seat Switch* input is active. The seat switch input must be configured using the digital i/o configuration item. The cooling fan drive is deactivated when the seat switch input is deactivated.

Pump Hours Meter

The MillipaK maintains a log of the number of hours during which the controller is providing Pump functionality. The Pump Hours Meter runs whenever the pump motor speed is greater than zero. The current number of logged Pump 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.

If you wanted 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.

Safety Features

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

Fail-safe

The controller's safety system includes a microprocessor watchdog which can detect software failure, and a hardware fail-safe system. 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.

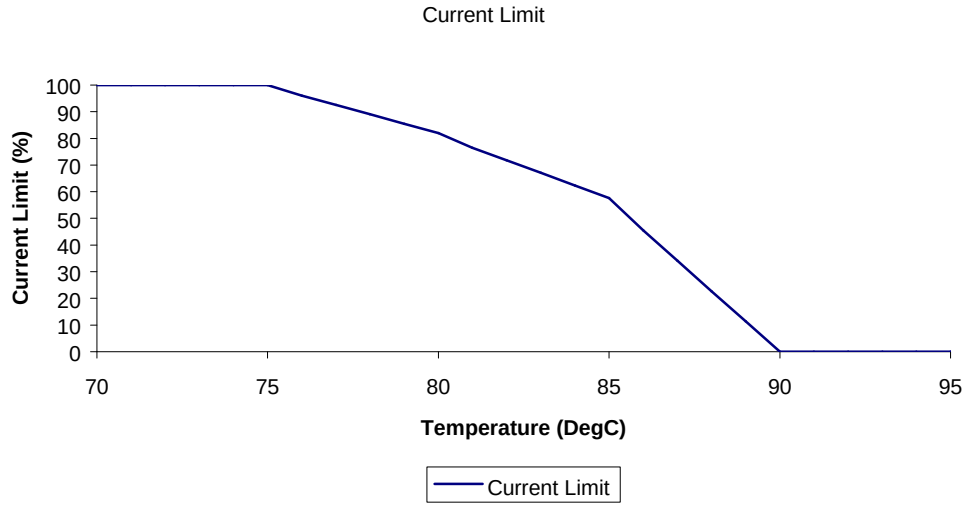
Controller Protection Features

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 the 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 heatsink temperature is limited to 90°C (See Graph). When actual cutback occurs the diagnostic LED will flash 8 times.

Thermal Cutback Characteristic



Maximum Temperature Logging

The system maintains a log of the maximum heatsink temperature measured by the controller. The Maximum Temperature logged is displayed on the Calibrator next to Heatsink 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 heatsink 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 heatsink 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 heatsink 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 the table below.

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%

CBR - Is the Controller Block Rating.

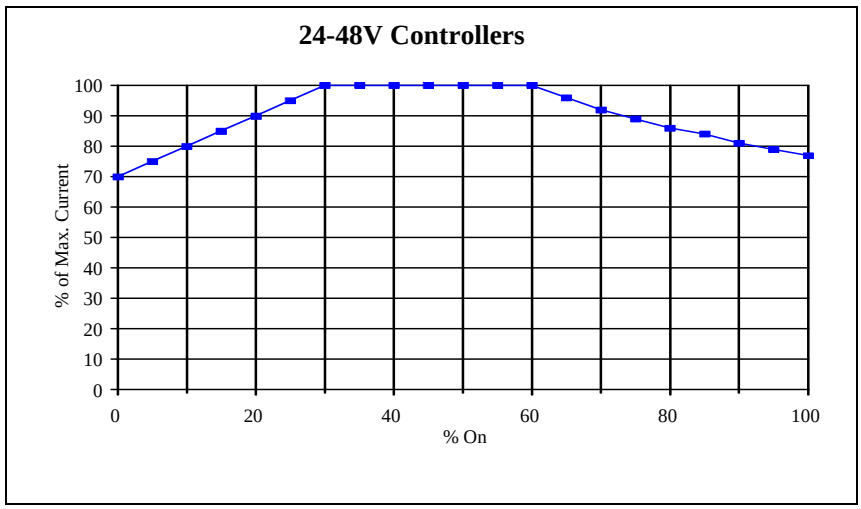
The system will limit the current through the motor to the calculated limit during operation.

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 Graph 2.

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.



Under-voltage protection

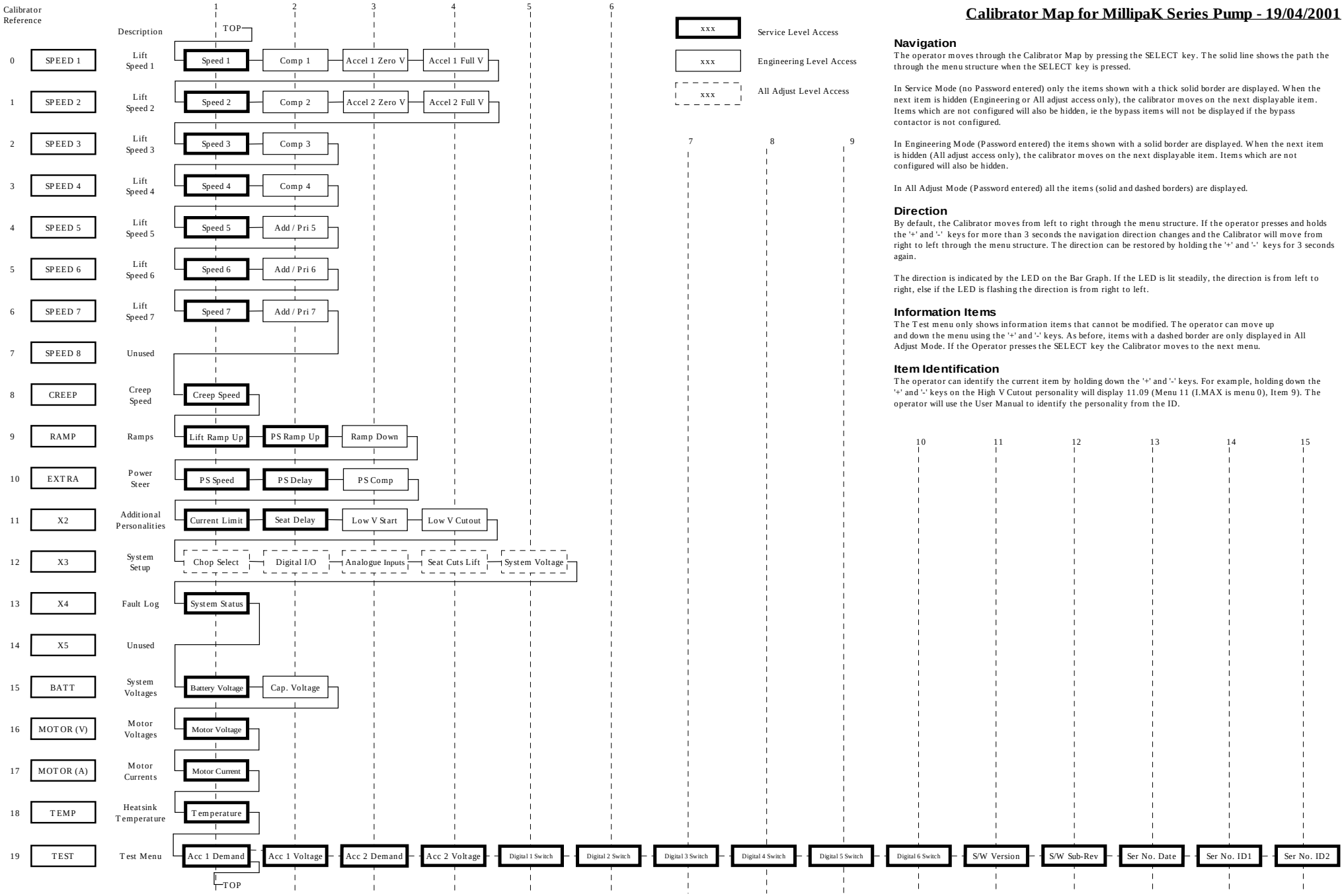
In order to prevent a sudden loss in power, the controller will begin to linearly ramp down the current limit, once the average battery voltage falls below a pre-set under-voltage start level. The current will be ramped down to 0 and a 7 flash fault indicated if the averaged battery voltage falls below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

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

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

Low Voltage Start Calibrator Menu Reference:			Immediate 11.03
Minimum	Maximum	Step Size	Typical Value
Low V Cutout	System Voltage	0.5V	18.0V

Low Voltage Cutout Calibrator Menu Reference:			Immediate 11.04
Minimum	Maximum	Step Size	Typical Value
14.5V	Low V Start	0.5V	16.0V



Calibrator Map for MillipaK Series Pump - 19/04/2001

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 (Engineering or All adjust access only), 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 (All adjust access only), the calibrator moves on the next displayable item. Items which are not configured will also be hidden.

In All Adjust Mode (Password entered) all the items (solid and dashed borders) are displayed.

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. For example, holding down the '+' and '-' keys on the High V Cutout personality will display 11.09 (Menu 11 (I.MAX is menu 0), Item 9). The operator will use the User Manual to identify the personality from the ID.

Commissioning Checklist

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

Personality Record

Personality		New Setting	Range		Resolution	Default
			Minimum	Maximum		
0.01	Lift Speed 1		0%	100%	1%	100%
0.02	Lift Comp 1		0	200%	1%	0%
0.03	Accel 1 Zero V		0.00V	4.50V	0.02V	0.00V
0.04	Accel 1 Full V		0.00V	4.50V	0.02V	4.50V
1.01	Lift Speed 2		0%	100%	1%	100%
1.02	Lift Comp 2		0	200%	1%	0%
1.03	Accel 2 Zero V		0.00V	4.50V	0.02V	0.00V
1.04	Accel 2 Full V		0.00V	4.50V	0.02V	4.50V
2.01	Lift Speed 3		0%	100%	1%	100%
2.02	Lift Comp 3		0	200%	1%	0%
3.01	Lift Speed 4		0%	100%	1%	100%
3.02	Lift Comp 4		0	200%	1%	0%
4.01	Lift Speed 5		0%	100%	1%	100%
4.02	Speed 5 (P/A)		Priority/Additive		-	Priority
5.01	Lift Speed 6		0%	100%	1%	100%
5.02	Speed 6 (P/A)		Priority/Additive		-	Priority
6.01	Lift Speed 7		0%	100%	1%	100%
6.02	Speed 7 (P/A)		Priority/Additive		-	Priority
7.01	Creep Speed		0%	25%	1%	0%
9.01	Lift Ramp Up Delay		0.1s	5.0s	0.1s	1.5s
9.02	P Steer Ramp Up Delay		0.1s	5.0s	0.1s	1.5s
9.03	Ramp Down Delay		0.1s	0.5s	0.1s	0.1s
10.01	P Steer Speed		0%	100%	1%	100%
10.02	P Steer Delay		0s	60s	1s	2s
10.03	P Steer Comp		0	200%	1%	0%
11.01	Current Limit		50A	CBR[3]	10A	CBR
11.02	Seat Delay		0.0s	5.0s	0.1s	2.0s
11.03	Low V Start		Low V Cutout	System Voltage	0.5V	Low V Cutout
11.04	Low V Cutout		14.5V	Low V Start	0.5V	14.5V
12.01	Chop Select		Off/On/24V		-	Off
12.02	Digital I/O		1	2	1	1
12.03	Analogue I/P		0	2	1	1
12.04	System Voltage		24V	48V	2V	24V

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	Not used
3 flashes	MOSFET Short Circuit
4 flashes	Not used
5 flashes	Not used
6 flashes	Not used
7 flashes	Low battery voltage
8 flashes	Over temperature or timed cutback

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 Heatsink 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	Low Battery Fault	Battery voltage is too low.	7
9	Seat Fault	Seat Switch Fault has occurred	2
4	Configuration Range Fault	A personality is out of range.	1
5	Configuration CRC Fault	The personality CRC is incorrect	1
6	MOSFET On	MOSFETs pulsed during power on failsafe checks (failsafe circuit disabled).	0
7	MOSFET Short Circuit	Short circuit MOSFETs detected.	3
8	MOSFET Short Circuit during Power Up	Short circuit MOSFETs detected during power on failsafe checks.	3
9	Drive 1 Off	Contactor 1 did not pulse during power on failsafe checks (failsafe circuit enabled).	0
10	Drive 1 On	Contactor 1 pulsed during power on failsafe checks (failsafe circuit disabled).	0

Fault Clearance

Any fault indication will be cleared by re-initiating the start sequence after the cause of the fault has been removed. Some faults may only be cleared by re-cycling the key-switch.

Using Status and Test Menus

The status and test menus which are available on the calibrator interface can be used to help pinpoint wiring faults or device failures.

System voltages and currents are available on the following menu items:

Item		Range		Resolution	Display Format
		Minimum	Maximum		
15.01	Battery Voltage	0.0V	63.9V	0.1V	000.0
15.02	Capacitor Voltage	0.0V	63.9V	0.1V	000.0
16.01	Motor Voltage	0.0V	63.9V	0.1V	000.0
17.01	Motor Current	0A	1000A	5A	x000
18.01	Temperature	-30°C	225°C	1°C	x000

Controller analogue and digital input status can be read from the following menu items:

Item		Range		Resolution	Display Format
		Minimum	Maximum		
19.01	Accel 1 Demand	0%	100%	1%	x000
19.02	Accel 1 Voltage	0.00V	5.00V	0.02V	00.00
19.03	Accel 2 Demand	0%	100%	1%	x000
19.04	Accel 2 Voltage	0.00V	5.00V	0.02V	00.00
19.05	Digital 1 (Pin 2)	Open Closed			x1.OP x1.CL
19.06	Digital 2 (Pin 3)	Open Closed			x2.OP x2.CL
19.07	Digital 3 (Pin 4)	Open Closed			x3.OP x3.CL
19.08	Digital 4 (Pin 5)	Open Closed			x4.OP x4.CL
19.09	Digital 5 (Pin 6)	Open Closed			x5.OP x5.CL
19.10	Digital 6 (Pin 7 (switch) or Pin 11 (analogue))[4]	Open Closed			x6.OP x6.CL
19.11	S/W Version	00.00	19.99	0.01	00.00
19.12	S/W Sub-Revision	00	99	1	xx00
19.13	SN Date Code	0100	1299	1	0000
19.14	SN ID 1	00	99	1	xx00
19.15	SN ID 2	00	99	1	xx00

Also available is information regarding the software revision and manufacturing date (serial number) – items 19.11 – 19.15.

Fault Reporting Form

Sevcon is committed to improving the quality of all 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?			

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.

The Software version is shown across two items in the Test menu. The first item is the version and the second is the sub-revision. Both these items need to be used to get the complete software version number. The format is:

Test Item:	S/W Version	S/W Sub-Rev
Version Number:	MM.mm	ss

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

The Serial Number 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

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 use 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 Pump controllers.

Power Configurations

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

Housing	Armature
(CORE) Small	180A
(CORE) Small	300A
(HP) Large	600A
(HP) Large	450A

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

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 minimise 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 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