



MMC4000LV MMC4000HV

EV Fluid Heater User Manual

Version 0.9 - Preliminary



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Updates	MMC reserves right to periodically update user manual with new information or error corrections. All changes will be documented in the revisions section of this manual.

Disclaimer

The hardware described in this manual is not a consumer product. It is OEM part meant for installation and service by qualified personnel. Operation involves high temperature, poisonous liquid and lethal voltages. UNDER NO CIRCUMSTANCES, EXPRESSED OR IMPLIED, MMC WILL BE HELD LIABLE FOR ANY DIRECT OR CONSEQUENTIAL DAMAGES TO LIFE, PROPERTY OR HARDWARE, OR LOSS OF BUSINESS OR PROFITS RESULTING FROM USAGE OF THIS PRODUCT. USER ASSUMES ALL THE RISK ASSOCIATED WITH USE OF THIS PRODUCT.

REVISIONS

REV	DATE	NAME	COMMENT
01	Nov 15 2014	Victor Tikhonov	Initial Release

Warning and Caution labeling

The following internationally recognized icons are used in this manual to indicate danger, warning and caution conditions. Paying attention, observing and following safety rules is sole responsibility of the user.

	General Prohibition		General Warning
	Do Not Turn On		Warning - High Voltage
	Disconnect or Turn Off		Warning - Magnetic Field
	Do Not Touch - High Voltage		Warning – hot liquids
	Relevant Information		Hint



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1 Foreword

Dear Customer!

You have acquired one of the most capable and sophisticated hardware capable to fulfill your performance demands. Please keep in mind that its operation involves high temperatures (near water boiling point 100°C), poisonous liquids (ethylene glycol, aka "antifreeze") and high voltages (your traction battery voltage). Therefore it is critical to observe safety and warning instructions and have this product installed and serviced by qualified personnel. The MMC4000 is NOT a consumer product and thus it is not designed to be "consumer friendly". It is a specialized OEM sub-system meant to be part of electric or a hybrid vehicle, conventional vehicles (usually commercial trucks) requiring running heating subsystem but restricted in idling its engine just for that purpose, or a stationary infrastructure. Please read and understand this manual. Contact Metric Mind Corporation technical support if you have any questions not addressed in this manual.

2 List of Abbreviations

Throughout this manual, some specific technical abbreviations are used. Their meaning is shown in the table below.

AUX	Auxiliary
BMS	Battery Management System
CAN	Controller Area Network
EMI	Electromagnetic Interference
GND	Ground
HV	High Voltage
LV	Low Voltage*



*Throughout this manual the term "HV" or "high voltage" is used to refer to the voltage applied to the power connector whether heater model is "low" voltage range (200...500 VDC) or high voltage range (450...900 VDC). This is often referred to as "traction battery voltage". Unless specifically mentioned, "low" voltage range is still considered high voltage as far as safety context, in contrast with auxiliary 12VDC or 24VDC voltages powering internal control logic, which is referred to as "AUX", the same voltage running lights, wipers, radio and other such subsystems.

3 Safety and Warning Instructions

In this chapter you will find safety instructions which apply to this device and refer to assembly, start-up and running operation in the vehicle. These instructions mostly apply to stationary application as well. Always read and observe them in order to maintain personal safety and avoid damage to the device and other property!

The following generally applicable safety measures have been developed based on the knowledge



of the manufacturer. They are not complete, they can be supplemented by local and/or country-specific safety instructions and guidelines for accident prevention. The system integrator and/or distributor of the device must therefore supplement the present general safety instructions by country-specific and local guidelines.

3.1 Safety Instructions for Electrical Systems



High voltage! Danger to life!



- ☞ Do not touch any HV wiring unless you're assured there is no high voltage applied to the heater!
- ☞ The device may only be connected by a qualified electrician!



Potential Damage to the traction battery or power source!

- ☞ Make sure the battery or other power source supplying heater (fuel cell, solar panel, generator and such) has enough power and current capability to sustain prolonged operation. While the heater has low voltage lockout feature, it will not prevent your battery from overdischarging if left unattended.
- ☞ You must make sure that the battery voltage is within working voltage range of chosen device. If your battery voltage falls in overlapping range (450VDC to 500VDC) LV or HV model can be used with identical outcome.

Potential Damage to infrastructure:



- ☞ Only use compatible and high-quality power cable and connector!
- ☞ Make sure the power leads are of sufficient cross-section area to continuously carry max. working current.
- ☞ Make sure crimp terminals in power connector are secured - loose crimp will cause local overheating and arcing resulting in melting near by plastic parts and potentially causing fire.
- ☞ Make sure to protect optical interface parts in case heater is washed from outside. Avoid direct contact with road debris, salt or corrosive liquids.
- ☞ The heater features galvanic isolation between AUX voltage and HV. Connecting traction battery to device's Ground terminal will not damage the MMC4000 but may destroy other control circuits in the vehicle relying on the isolation between HV and AUX (chassis).

Potential Damage to the MMV4000:

- ☞ Make sure maximum voltage applied to power input of heater does not exceed specification.
- ☞ Make sure AUX power and control voltages are within specified limits. Exceeding absolute maximum limit will damage heater control electronics.
- ☞ There are no user serviceable parts inside other than power fuse. In case software monitor reports error, contact MMC tech support. Most of these errors can be cleared and issues resolved remotely.
- ☞ If your device is equipped with flow sensor, DO NOT defeat its operation. Doing so may leave heating elements powered up while there is insufficient fluid flow, which may lead to elements burning out before stalled liquid will trigger overtemperature protection.
- ☞ The MMC4000 is internally fused. Under no circumstances should you bypass, upgrade or replace fuse with higher current rating. If power fuse keeps blowing, you must determine root cause of malfunction. The fuse is sized with enough margin not to blow under any normal working condition. In the even of fuse blow the heater software takes a snapshot of the fault condition and stores it in non-volatile memory. This information is user accessible (read only), and helps to determine root cause of the failure. Mere replacing fuse will not fixing underlying problem and the same blow will likely reoccur.

**CAUTION**

- ☞ Overheating of the cables! Fire hazard!
- ☞ Heater enclosure is sealed. Unauthorized opening or attempted repairs will void warranty

Generic rules when servicing any HV hardware:



- ☞ Physically unplug system power. Do not rely on relays or contactors still under software control as any microcontroller glitch may cause inadvertent closure of power relays. Turn off the ignition and remove key. If equipped, remove service disconnect or main power fuse
- ☞ Make sure the system cannot re-apply HV power due to software glitch or unauthorized access.
- ☞ When practical, do HV measurements with one hand - connect/disconnect test leads using spring loaded hooks or alligator clips. Remember the current path from one hand to another lies through your heart, while from any one hand to your feet the heart will be bypassed.

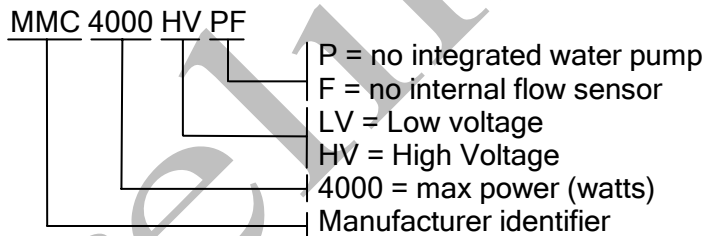
3.2 Safety instructions for fluid heating systems

- ☞ Make sure fittings are tight and fluid hoses are in good condition.
- ☞ Make sure retaining clips are used to secure hoses onto the fittings as high temperature liquid increases pressure of vapors and insecure hoses may slip off fitting during maintenance or inspection causing severe burns by hot ethylene glycol or water. Disassemble, service or open expansion tank for refill only when liquid is cold.



- ☞ Use of expansion tank for safety is required. Aside of convenient point to fill up the system with fluid, it will allow vapor to escape in case of malfunction causing fluid to boil.

4 Model Identification








The MMC4000 can be ordered without integrated fluid pump (P version) and/or without internal flow sensor (F version) or without both (PF version). If external water pump is used, make sure the flow rate does not exceed max 10 l/min to avoid damage to the flow sensor.

Reversing direction of fluid flow will not damage but will disable the MMC4000*.

* This does not apply to MMC4000xx-PF version



5 Scope of Delivery

Pos	Item	Qty	Representative photo
1	MMC4000 series heater fluid heater	1	
2	MMC optic fiber to USB serial interface converter	1	
3	8 circuits Ampseal interface plug	1	
4	Ampseal crimp terminals	8	
5	Fiber Optic cable 1.5m	2	

Optionally items 2-5 can be ordered from the manufacturer as spare parts

6. Manufacturer Contact Information for ordering spare parts

METRIC MIND CORPORATION
 10117 SE Sunnyside Rd., STE F1211
 Clackamas, OR 97015 USA
 Phone: +1(503)477-6071
 Email: tech.support@metricmind.com
 Web: www.metricmind.com

7 Proper Intended Use.

The MMC4000 fluid heaters are designed to maintain set liquid temperature closed circulation loop using a DC power source. In general, MMC4000 is meant to be installed in a battery or fuel cell powered electric vehicle (or a boat) or a hybrid vehicle/boat, equipped with standard heater core. The MMC4000 will replace your engine as a source of heat. It can also be used in semi-stationary applications such as - space heaters in RVs or ground camps. It is especially usable in electric or hybrid vehicles converted from conventional gasoline or diesel powered ones, so that all internal heating system (air ducts, blowers and controls) can remain unchanged and only source of hot liquid replaced. For instance, one such application is heating of the cabin of long haul trucks using on-board DC battery as tighter environmental regulations prohibit idling large diesel engines overnight or during long stay. Also increasing numbers of ocean ports and cargo docs prohibit fossil fuel powered trucks and other vehicles to enter their premises all together and only electric powered ones are allowed to operate within certain radius of the port. Using MMC4000 in such vehicles solves cabin heating issues.

In a typical installation the MMC4000 is plumbed to the same fittings on a firewall the coolant hoses from the engine used to be connected to. This is by far the simplest modification, unlike major system redesign if ceramic elements or heat pumps are deployed.

Though not optimized, the MMC4000 can be used as portable space heater in buildings or garages. However, note that the MMC4000 cannot accept AC power or pulsating DC power resulting from direct



rectifying AC mains power and will require external radiator as a heat exchanger.

The MMC400 fluid heater CANNOT be used in open loop application such as on-demand residential or commercial running water heaters where hot liquid is not returned to the inlet of heater.

The following absolute limits are set for the operation of the MMC4000 heater. Operating outside these limits can lead to shut down or damage to the heater:

- ☞ Max. DC input voltage 500 VDC for LV version and 900 VDC for HV version
- ☞ Max AUX supply voltage 32 VDC
- ☞ Max temp control DC voltage 5VDC
- ☞ Max Enable control voltage < AUX supply voltage
- ☞ Maximum pressure cooling water system 1.0 bar

8 Technical specifications

Parameter	MMC4000LVx	MMC4000HVx	Unit
Min. input voltage (PWR)	200	450	VDC
Max. input voltage (PWR)	500	900	VDC
Min. AUX voltage	8		VDC
Max. AUX voltage	32		VDC
Max. temp control voltage (analog input)	5		VDC
Max. DC input power (adjustable)	4000		W
CAN 2b 11 bit identifier, comm. speed (default)	125/250/500/1000		kbps
Power - control isolation resistance min (initial)	1		GOhm
Fluid flow rate*	600		l/hr
Reverse polarity (HV power) protection	Yes (fuse)		---
Dry Weight LV and HV version	1.2		kg
Dry Weight LVP and HVP version	1.0		kg
Overtemperature protection	Yes		-
Insufficient fluid flow protection	Yes (optional)		-
AUX power voltage	8...32		VDC
IP protection	IP54		---
Enclosure Body Height	88		mm
Enclosure Body Width	334		mm
Enclosure Body Length	250		mm
Insulation testing (AC input / DC output)	2		kV
Power inlet over-voltage protection	264		V

* parameter does not apply to LVP or HVP version

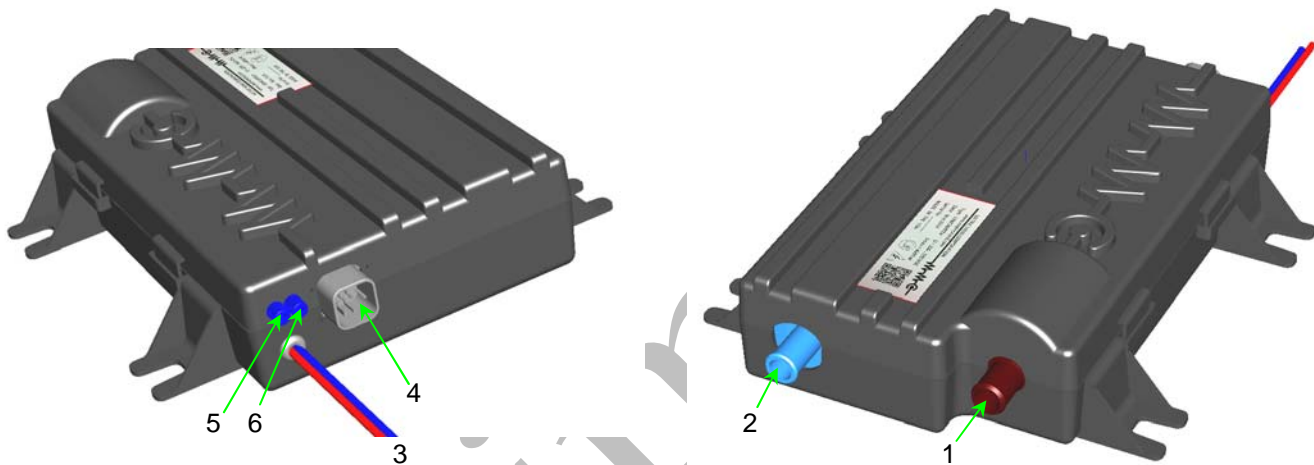
8.1 Special features and options

- ☞ Fiber Optic cable isolation between a PC and heater circuit



- ☞ Field upgradeable firmware via fiber optic interface (hardware included)
- ☞ External output for diagnostic LED
- ☞ No internal fluid pump option
- ☞ No flow sensor option
- ☞ Vibration-resistant construction for automotive use
- ☞ Reverse HV polarity protected (internal fuse)
- ☞ 5 way controllable (user programmable modes):
 - By simple ON/OFF via ENABLE input (MES RM3/4 series compatible mode)
 - By external analog voltage
 - By external potentiometer
 - By external PWM signal
 - By CAN from external control unit

9 Major mechanical and interface components



1. Cooling water inlet (Ø 19 mm or 3/4")	2. Cooling water outlet (Ø 19 mm or 3/4")
3. HV battery power connector (input)	4. Interface connector (input/output)
5. Fiber optic interface transmit port	6. Fiber optic interface receive port

10 Electrical interface

Electrical interface and pinout of connectors is the same regardless of the model.

10.1 HV connector Pin Assignment (if present)

Pin number	Function
1	High voltage power input positive (always RED wire)
2	High voltage power input negative (always BLUE wire)

10.2 Signal Interface Connector Pin Assignment



Pin	Name	Function	Pin	Name	Function
1	FLT	Fault out (LED)	2	CL31	AUX power return (GND)
3	CL15	AUX power input	4	CANL	CAN Low
5	CANH	CAN High	6	EN	Heater ENABLE
7	ANA	Analog control input	8	POT+	Potentiometer bias

10.3 Description of interface signals and functions

Pin 1 FLT. Diagnostic and visual indication interface - configured as 10mA current sink. Connect cathode of external LED to this output. Connect anode of the LED to C15 AUX power.

Pin 2 CL31. Connect to the vehicle chassis (neg. of AUX power)

Pin 3 CL15. Connect to AUX power source (12...24VDC), typically after ignition key.

Pin 4 CANL. Connect to CAN low of controlling CAN bus.

Pin 5 CANH. Connect to CAN high of controlling CAN bus.

Pin 6 EN. Connect normally open switch to this input. Connect the other terminal of the switch to CL15.

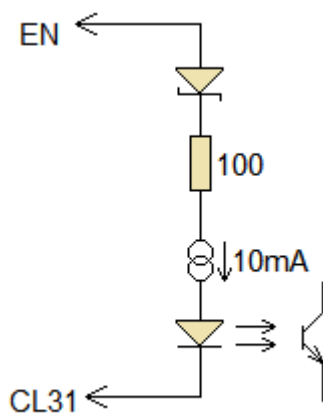
Pin 7 ANA. Connect to external control voltage. 0...5V corresponds to 0...100% of output power.

Pin 8 POT+ Connect external 5k pot to this input. Connect other side of the pot to ANA. 0...5k resistance corresponds to 100...0% of the output power.

 If a particular control function is not used, leave corresponding interface pins unconnected.

10.4 Vehicle interface internal circuits

10.4.1 Enable signal



The MMC4000 is enabled by connecting EN to +12...+24 VDC auxiliary vehicle net. Leaving EN unconnected or connecting EN to CL31 disables the MMC4000.

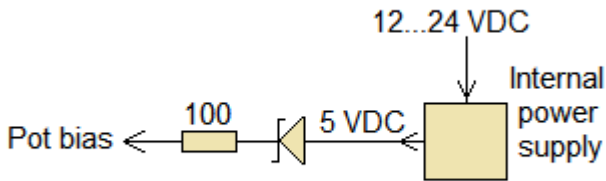


In CAN mode EN signal is not monitored and CAN control takes priority. You can leave EN unconnected if the MMC4000 is configured for CAN control.

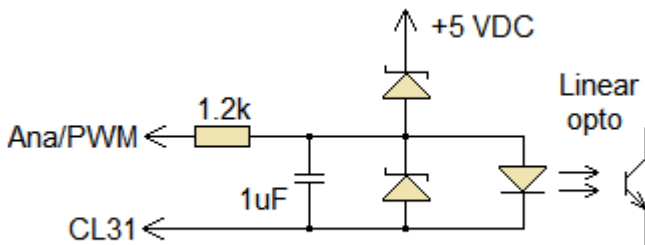
10.4.2 Analog / PWM control

Analog power control is accomplished by applying analog voltage to Ana/PWM input. This can be implemented two ways: if your vehicle controlled has DAC output with 0...5 VDC output voltage range, you can directly apply it to the MMC4000 Ana/PWM input. 0...5VDC corresponds to 0...100% of preconfigured max power. To improve noise immunity there are ~0.7V dead zones designed to the analog control circuitry, e.g. MMC4000 will not start outputting power when analog voltage reach 0.7 VDC, and will output 100% power when analog voltage is at ~4.3 VDC or above. If you don't have any analog voltage source, there is special output (POT+) to bias external 5k variable resistor. You can use any linear potentiometer by connecting one fixed end to the bias power and wiper to the ANA input. Leave the other fixed end of the potentiometer unconnected. Reducing resistance from 5k to 0k (with some dead zone margins) increases MMC4000 power from 0% to 100%. This way in case of broken control pot connection output power is reduced to zero.

ANA input can also receive 0...5 VDC PWM signal within 150...5000 Hz frequency range. The low pass RC filter on the input has -3dB cutoff frequency of ~130 Hz.



Control pot bias supply

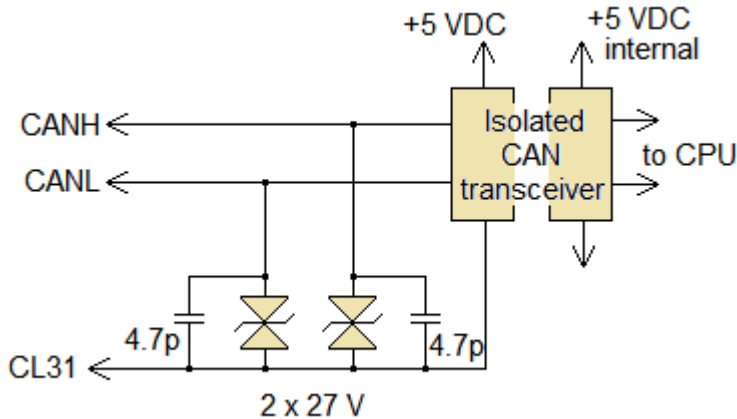


Analog input circuit

10.4.3 CAN control



When MMC4000 is configured for CAN control, no other interface signal need to be connected. You only need to apply +12...+24V power to the heater, and connect the CAN bus. CAN interface is isolated from the HV. To avoid high voltage spikes on the transceiver input and output, make sure CL31 is connected to the vehicle chassis, otherwise overvoltage suppressors will not function for high common mode noise.



i The CAN transceiver is not internally terminated by default, allowing MMC4000 to be a middle node on the CAN bus. However, there is provision on the PCB for the node termination. If the MMC4000 is last node on the bus used must short two SMT pads on the PCB labeled "CAN TERM."

10.5 CAN interface specifications.

- ☞ CAN 2.0B comm. protocol, 11 bit identifier. CAN speed default is preset to 125kbps and can be user set to (125 / 250 / 500 / 1000 kbps).
- ☞ No bus termination installed.

10.5.1 CAN Messaging

	Byte# ->	7	6	5	4	3	2	1	0
7C1h Control	DLC=3						Battery PWR request		EN
7C2h Vars	DLC=6			Temp computed	Ana % Req.	PWR computed		HV computed	
7C3h Fixed	DLC=8	Access counter	Model type	SW version	Main Fuse	MFG Week	MFG Year	Serial number	
7C4h Status	DLC=3						Limits 2	Limits 1	Limits 0

Limits 0

7C4H	
------	--



byte 0	
Bit 7	IGBT status
Bit 6	
Bit 5	ANA pot status
Bit 4	
Bit 3	Limitation status
Bit 2	
Bit 1	Temp. sensor status
Bit 0	

Limits 1

7C4H byte 1	
Bit 7	CAN comm. status
Bit 6	
Bit 5	HV limits
Bit 4	
Bit 3	PWM limits
Bit 2	
Bit 1	elements status
Bit 0	

Limits 2

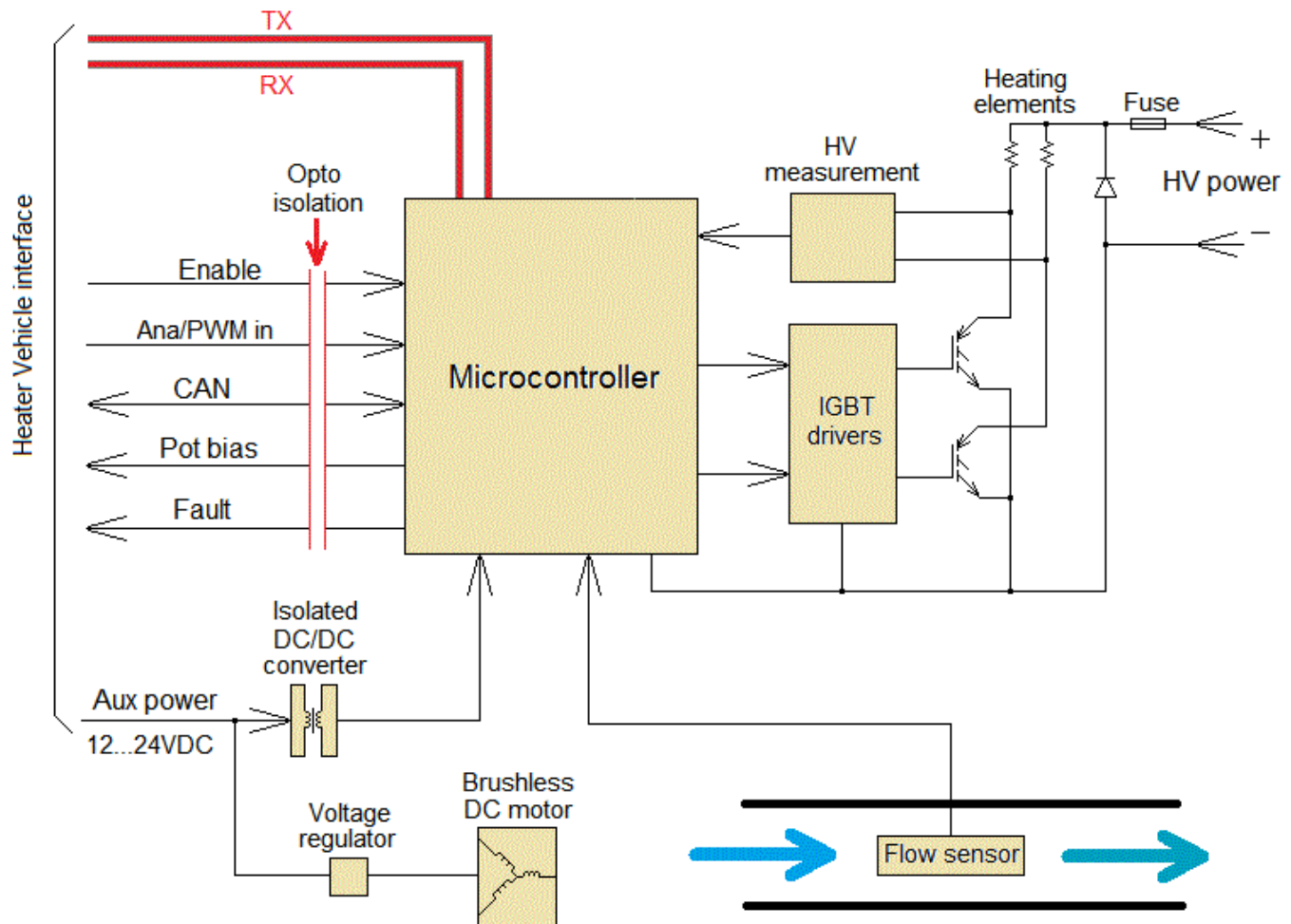
7C4H byte 2	
Bit 7	Crow bar source
Bit 6	
Bit 5	Fluid flow
Bit 4	Temp reached
Bit 3	Pump EN
Bit 2	3.3V power
Bit 1	FLT status
Bit 0	EN status

CANdb database is available for download from the MMC web site.

10.5.2 Changing the CAN Parameters (Options)



11 Block Diagram of the MMC4000



12 Dimensions and Installation Information

For installation of the heater, the following points must be strictly adhered to:

- ☞ All models featuring fluid flow sensor must be installed in correct orientation according to the arrows molded on the enclosure. Installing heater at wrong angle will prevent sensor from detecting the flow and disable the heater*.
- ☞ The air-cooled version must be installed so that a constant fresh air supply is guaranteed. This has a direct influence on the power of the device (de-rating).
- ☞ The mechanical fixings must be arranged so that the device is fitted firmly and in a way that is as vibration-proof as possible.
- ☞ The cable feeds and cooling water tubes should have sufficient space for routing and plumbing, and may under no circumstances sit in contact with sharp-edged components.



12.1 Installing and Connecting the Heater

The MMC4000 heater is intended to be installed on a firewall in the engine compartment, but can be installed on any vertical surface or supporting brackets providing upright position, Tilt up to 15° in any direction is allowed*.



The MMC4000xx heaters are equipped with flow rate sensor which is operational only if the heater is installed in correct vertical position. Heater should not be installed in horizontal or any other orientation than vertical. It is allowed to install MMC4000xx heater in any position if the fluid flow rate sensor is disabled in the software. In such configuration is a responsibility of the user to make sure fluid chamber is always filled with fluid, and there is sufficient fluid flow while heater is electrically enabled.

Note that integrated fluid pump is not self-priming. Make sure the air is removed from the coolant loop before operating heater.



Be aware that in case of loss of liquid heating elements exposed to the air will burn up within a few seconds. With liquid present but not moving, heater may protect itself from burning out, but depending on the ethylene glycol and water mixture ratio the fluid might boil before temp protection kicks in, this will cause rapid pressure increase and unless expansion tank is used - burst of hot liquid, damage to the seals and water pump. In case of internal leak due to increased vapor pressure, controller circuit may get damaged.

Rapid temperature increase due to this condition will be detected and stored in memory for service and troubleshooting purposes and damaged heating elements or control circuit due to insufficient fluid flow or absence of fluid is not covered by warranty. For this reason running heater with its flow sensor disabled is not recommended, regardless whether internal or external water pump is used.

* If a flow sensor is disabled or not present, the MMC4000 will work in any position. However, care must be taken to ensure sufficient fluid flow. Keep in mind that in case of clogged or kinked tubes or loss of liquid and no external means to disable heater due to insufficient flow rate, the heating elements may burn out.

12.2 Using USB/Fiber Optic Cable interface dongle to configure the heater

Because heater is installed near hot liquid, to avoid corrosion of the serial interface contacts used very rarely and increase safety by complete galvanic isolation the heater is equipped with fiber optic interface to a PC.

To upgrade heater's firmware in the field, you can use any serial terminal utility allowing sending external ASCII files such as RealTerm (also available from MMC web site).

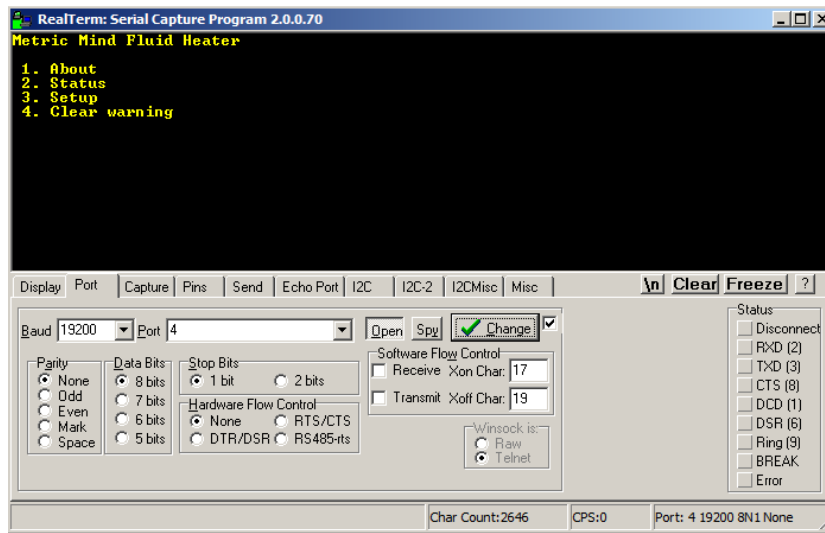
13 Serial communication

The MMC4000 is equipped with serial port for diagnostics and field upgrades of the firmware. To prevent contact corrosion in close proximity to hot corrosive liquid, assure absolute electrical safety and immunity to EMI, no physical connectors or any metal parts are present, and communication is implemented via fiber optic cables. Operation is transparent to the user, as special supplied USB/optical transceiver dongle converts serial transmitted data to modulated optical transmission which is demodulated on the receiving end. For full duplex operation two fiber optic cables are used.

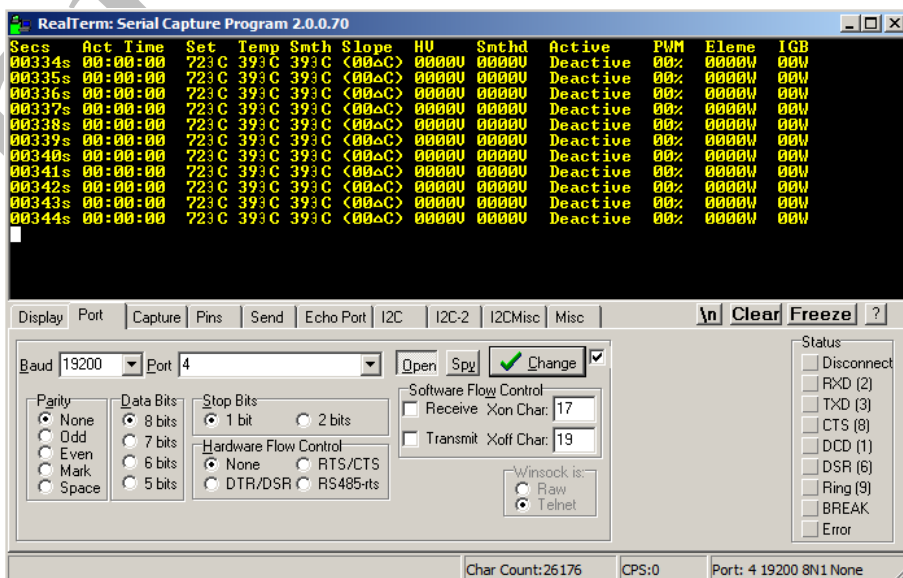


The firmware is supplied as ASCII file and the latest revision along with comments specifying changes is always available for download from the MMC web site. Any serial terminal utility capable of sending and receiving external ASCII files can be used to communicate with heater controller. Examples below depict one of such utilities - free terminal program RealTerm for PC, provided by Sourceforge (sourceforge.net).

Supplied serial to optical converter has USB interface. It is recognized by operating system as serial port and automatically installs appropriate virtual port driver. The port number assigned to the adapter by windows when USB connector is plugged in has to be selected in the terminal utility. On the screen capture below the port number is set to COM4. Other communication parameters are: 19200 Baud rate, 8 data bits, no parity, 1 stop bit, no flow control.

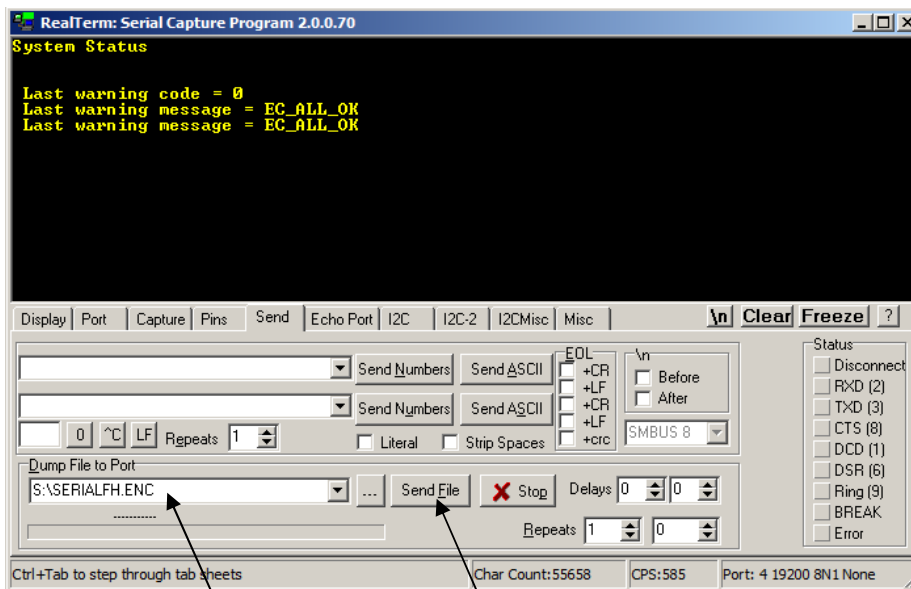


Below is capture of the main status page displaying major running parameters updated every 1s.





To upgrade heater firmware choose "Setup" from the main window and then choose "Firmware download". Navigate to the directory containing firmware file and click "Send File" button.



Select file

Send file

14 Changing internal fuse.

There are no user serviceable parts inside heater other than HV fuse and CAN termination jumper. The fuse will blow in case of excessive power consumption or connecting HV in reverse. Always replace fuse with the same type and ratings. If fuse blows, it indicates internal problem and increasing fuse rating will not make problem go away and will only cause further damage to the power connector HV wiring and external power source or components. Contact the manufacturer for assistance if such situation will occur.

Location of the power fuse is shown on the photo below. Fuse rating depends on the model: it is 25A for LV version and 10A HV version.



The fuse rated for 1000VDC (*Direct Current*) operation. DO NOT install AC rated fuse.



FUSE



If you attempt to replace internal fuse without taking heater out of the vehicle, **ALWAYS** physically unplug main power connector before performing this step. **DO NOT** rely on the power electronics such as relays or contactors to keep high voltage away - in case of software glitch or external interference such components might unexpectedly engage. DC voltage above 36V is considered dangerous and in "right" circumstances such as wet hands of the person subjected to it can be lethal. Traction battery voltage is typically 10...20 times higher than this, thus there is proportionally higher probability that a person subjected to such a high voltage will be killed!

Lethality is virtually guaranteed if electric current passes from one hand to the other through the heart. Note that only 5mA is enough to stop heart of average person. Thus we are stressing again that the user must unplug main power connector before servicing the MMC4000. If the traction battery service disconnect is removed instead, make sure power inverter's capacitors that may still be connected to DC bus and thus to the heater power input do not store charge that can still present danger to the user.

15 Warranty

MMC warrants proper operation of the heater for 24 month from the sale date. Warranty repair or replacement will be provided if uniquely verifiable material and/or assembly workmanship defects are discovered.

Warranty is void if the seal on the housing is damaged or missing or internal diagnostic reveals tampering with the device or its software. Warranty is not transferable.

16 Liability waver and legal disclaimer

THE MMC400 IS NOT A CONSUMER PRODUCT AND AS SUCH IS NOT A SUBJECT TO LAWS AND REGULATIONS APPLIED AND ENFORCED BY A CONSUMER PROTECTION AGENCIES. IT IS OEM HARDWARE SUBSYSTEM, MEANT TO BE INSTALLED AND SERVICES ONLY BY QUALIFIED



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THIS WAIVER IS SUPPLIED TO THE ORIGINAL PURCHASER TOGETHER WITH THE HARDWARE. IN CASE THE HARDWARE IS RE-SOLD, IT IS RESPONSIBILITY OF THE SELLER TO PROVIDE THIS USER MANUAL TO THE NEW USER OR RESPONSIBILITY OF THE NEW USER TO OBTAIN THIS MANUAL BY DOWNLOADING IT FROM THE MMC WEB SITE. LIKE FOR THE ORIGINAL PURCHASER, BY PURCHASING USED OR SECOND HAND UNIT, NEW USER AGREES NOT TO HOLD MANUFACTURER LIABLE FOR ANY PERSONAL INJURY, DEATH OR PROPERTY DAMAGE RESULTING FROM INCORRECT OR IMPROPER HANDLING OF THE MM4000 FLUID HEATER.

preliminary