

MOV Backseat Relay P/N 201602

User's Manual

Rev 9.1 for firmware version 2.4 & 2.4.1

1 INTRODUCTION

This device is used to backseat motor operated valves (MOV) to stop packing leaks while minimizing stress on the valve. It is connected at the motor control center to bypass the open limit switch. Three clamp-on current sensors are used to measure three phase current to the valve motor. By sensing an increase in current, it detects the valve at the backseat and opens a contact to remove power from the valve motor.

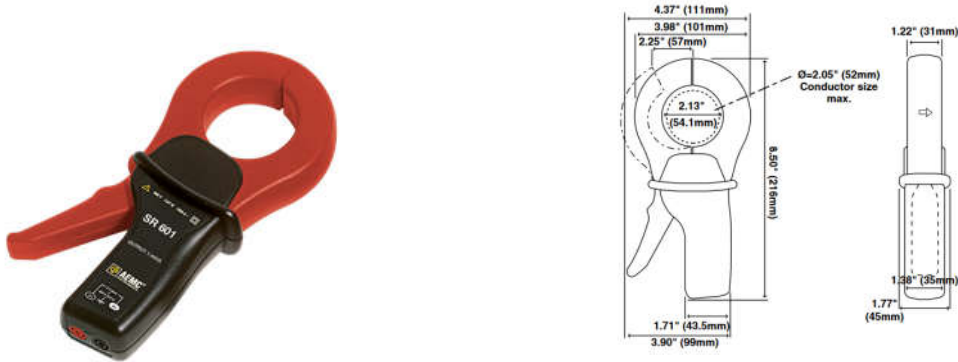
2 SPECIFICATIONS

Inputs:	Three phase AC, 60 Hz, from split transformer 1000:1 ratio AC current probes
Input Range:	0 to 1A (RMS) from current probes, corresponding to 0 to 1000 Amps sensed by the 1 mA/A (1000:1) probes. Auto scaling is used to measure current in ranges of approximately 20, 150, and greater amps.
Input Impedance:	1 ohm
Accuracy:	5% absolute RMS current, 10 bit (1/1024) sensor resolution
Output:	MOSFET solid state relays rated for 400 volts AC/DC, 2 amps continuous duty. Dual MOSFET relays are used in series for the output contact, along with an independent permit logic circuit controlled by the panel buttons, to reduce the possibility of a single failure keeping the motor running.
Logging:	Text file to Micro SD memory card
Connectors:	4mm safety banana jacks
Response Time:	< 8 milliseconds trip current sensing
Display:	2 lines x 20 characters LCD, backlit
Indications:	LEDs, green (contact open) and red (contact closed)
Controls:	POWER turn on or turn off the unit OPERATE MOV close contact and begin a test sequence STOP stop a test sequence and open contact SETUP view and step through settings [+], [-] change a setting
Power:	6 volts DC from four AA alkaline (supplied) or lithium batteries, 46 mA, good for up to 50 hours of operation.
Auto Shutoff:	After 30 minutes with no key press
Size:	195mm x 101mm x 44mm
Weight:	0.5 kg

3 CURRENT PROBES

AC current probes are passive clip-on transformer types having a current ratio of 1000:1. Probes from any manufacturer meeting this spec may be used. The following probe made by AEMC Instruments has been evaluated as suitable for this application. Other models and manufacturers may also be used. Ensure that specifications are compatible with a load impedance of 1 ohm, unless restricted as described below.

AEMC Model SR601 has a nominal current range of 1000 Amps RMS. It is supplied with banana jacks for use with longer leads (10 foot leads are included standard with the backseat relay) to give a safe distance from an open MCC. It is suitable for the full range of the MOV relay.



Other AEMC probes, all having 1 mA/A sensitivity (1000:1 ratio):

- SR600, no diode protection (not needed in this application)
- MN185, 125A range, small size

Refer to AEMC Instruments web site <https://www.aemc.com/> for specifications and other probes.

With motor run currents of less than one amp, resolution of the backseat relay may require selecting a higher operating trip setpoint. One approach to avoid this is to use a probe with greater sensitivity. A relay SETUP option allows use of probes with sensitivity of 1, 5, 10, or 20 mA/A. A 10 mA/A probe will work fine for small MOVs. The problem is that 10 mA/A probes permitting a 1 ohm input impedance are hard to find; however, using a nonconforming probe over a restricted range is acceptable.

The AEMC SR634 has three ranges: 1000 amps at 5 mA/A, 500 amps at 10 mA/A, and 250 amps at 20 mA/A. Specifications show a maximum load impedance of 0.4 ohms. Exceeding this load specification can result in out of tolerance (low) at high current levels. However, by restricting the current range, this can be avoided. A calibration report provided by AEMC shows that output remains within probe specifications at and below the following measured currents with a one ohm load:

- 5 mA/A range (1000:5) 1000A
- 10 mA/A range (500:5) 100 A
- 20 mA/A range (250:5) 1 A

In practice, we can tolerate significant error during the inrush peak as long as the operating current is well within the restricted range. Don't use higher sensitivity probes for large MOVs (>10A operating current) because that could over-range the backseat relay and possibly give a maximum current trip.

4 DESCRIPTION OF OPERATION

- 4.1 The purpose of the relay is to sense the increased current drawn by the valve motor when the load increases as the valve backseats against the packing. The relay contact is connected into the Motor Control Center (MCC) and is closed to start operation of the motor. Upon sensing increased current, the relay contact is opened, thereby removing power from the valve motor.
- 4.2 Current from each probe is passed through a one ohm shunt resistor to produce a voltage. The absolute value of each AC phase voltage is calculated and the three voltages are added together to obtain the measured current. A digital filter is applied to reduce noise.
- 4.3 When the relay contact is closed, there will be a current inrush surge as the motor starts up. An inrush delay is specified to prevent tripping during this surge.
- 4.4 The input amplifiers have three gain settings. The gain is reduced automatically to keep the inrush surge in range. This improves resolution for smaller motors.
- 4.5 At the end of the inrush delay, current is measured and a trip setpoint is established as a percentage of this current. The motor will continue to run at a constant current until the backseat is reached and motor current increases. When the current increases above the setpoint, the relay opens to stop the motor.
- 4.6 A second maximum current setpoint is specified as a safety backup in case the valve is already against the backseat. It is established as a percentage of the maximum current detected during the inrush surge. If the current exceeds this setpoint after the inrush delay, the relay opens to stop the motor.

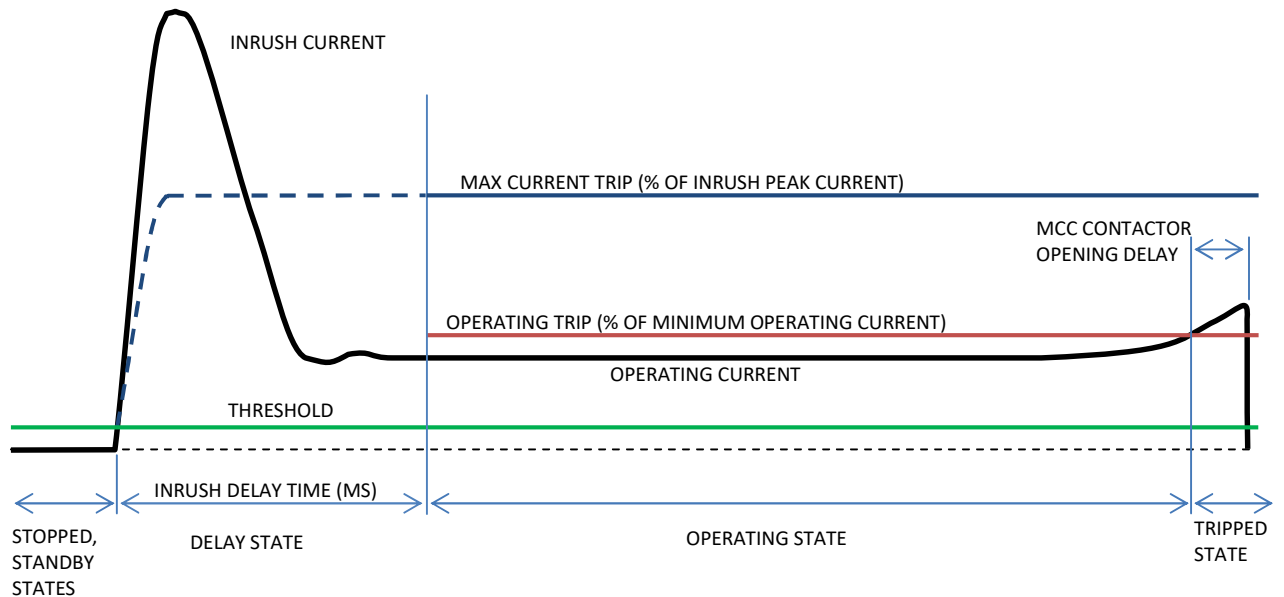


Figure 1: Typical Test Sequence

- 4.7 Figure 1 shows a hypothetical current trace (not to scale) for a run. The relay progresses through various states according to the sensed current.

- 4.8 In the STOPPED state, the relay contact is open and the current sensed must be zero. During this time, a self-calibration of the zero current level is performed for use in later calculations. If current or excessive noise is detected, an error message will display.
- 4.9 When OPERATE MOV is pressed, the STANDBY state is entered. The relay contact is closed and the inputs are compared to a threshold current. When input exceeds threshold, the INRUSH DELAY state is entered.
- 4.10 The maximum current setpoint is initialized and continuously recalculated as the specified percentage of the measured current during the delay. It begins lower than the current during the delay state and follows the current, but only increasing.
- 4.11 The operating and maximum current trips are not enabled during the delay state.
- 4.12 A lost phase trip is enabled during the delay and operating states. It trips if loss of current is sensed on any phase for 1/2 cycle.
- 4.13 OPERATING state is entered when the inrush delay time ends.
- 4.14 The initial operating current trip setpoint is determined by multiplying the measured current at start of operating state by the specified setpoint percentage.
- 4.15 The actual inrush surge time is determined by scanning the readings taken during the delay and determining the time at which the current dropped to a level close to the operating current.
- 4.16 If enabled, phase balance compensation is determined by averaging the phase currents during the last two cycles (33 ms) of the delay state. A gain adjustment is calculated to bring each phase to the average. Compensation is only performed if at least two cycles have elapsed between the calculated inrush surge end time and end of the delay state.
- 4.17 The operating current trip setpoint will continue to follow the current down, but not up.
- 4.18 In the operating state, the operating trip, maximum trip, and lost phase trip will all be enabled.
- 4.19 If the motor is stalled or if the delay is specified too small, current may be above the maximum current setpoint when operating state is entered. The MAX CURRENT TRIP will result.
- 4.20 When the valve reaches the backseat, current will increase until the operating trip setpoint is reached. The OPER CURRENT TRIP will occur.
- 4.21 After the relay contact opens, current may continue to increase until the motor controller mechanical contacts have opened. This is normally a few milliseconds. This is recorded as post trip current.
- 4.22 When any trip occurs, the relay contact opens and the display shows Review Results and the cause of trip. The [+] or [-] buttons may be pressed to show recorded readings of trip current, post trip current, inrush peak current, inrush time, and run time. Data points at 1 millisecond intervals are also shown for the first two seconds and last two seconds of the run. These results and data points are retained until the next run or until the device is turned off.
- 4.23 If a memory card is inserted prior to start of the run, data points and results will be logged to file.

5 TEST PROCEDURE

- 5.1 If the batteries were replaced, turn on the device and step through the SETUP options to set the date and time.
- 5.2 If a recorded log of the test and results is desired, insert a Micro-SD memory card into the small slot on the right side of the case, near the [+] button. Insert with SD card contacts facing the front.
- 5.3 Connect test leads from the yellow relay contact jacks to parallel with the limit switches in the motor control cabinet. Typical connection points are shown in Figure 2. Option A gives full control to the relay. With option B, the relay just bypasses the limit switches.

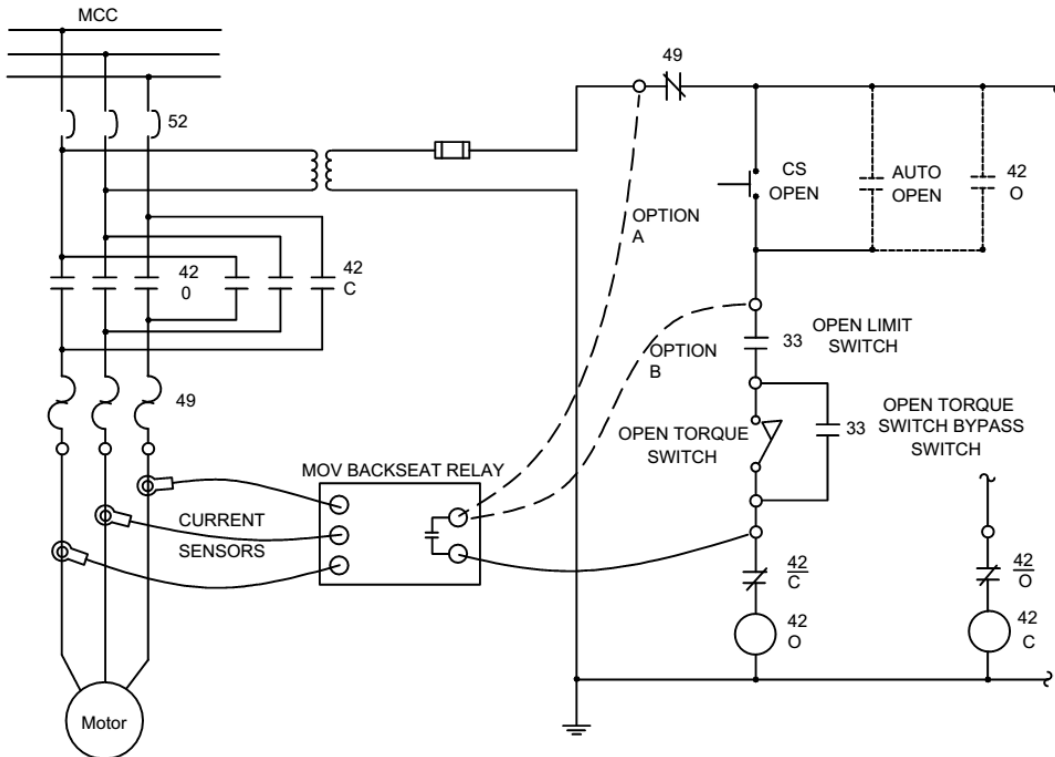



Figure 2: Typical Connection Diagram

- 5.4 Clip the current sensors across the wires to the motor. Phase sequence and sensor orientation do not matter for operability.
- 5.5 Press the power button  to turn on device. The display will show PREREQ to prompt you to press the SETUP button and verify settings are appropriate for the motor and valve.
- 5.6 Repeatedly press SETUP to cycle through the settings. Press the [+] or [-] button to make changes to settings.
 - Review Results – This will only appear in the SETUP menu if a run has already been made. See paragraph 5.13.
 - Operating Trip - the operating trip setpoint is set as a percent of the operating current, with 100% being the minimum steady state motor operating current. Thus, a 150% setting for a 10 amp current will give a trip at 15 amps. Default value is 110%. Range is 101% to 500%.

- Inrush Delay Time - this time, in milliseconds, is the delay to allow for the inrush current spike to settle out before determining the operating current. Recommended is at least 50 ms longer than the measured inrush time. Default is 250ms. Range is 40 to 2000 milliseconds.
 - Max Current Trip – the maximum trip setpoint is set as a percentage of the inrush current during the delay. It is set to less than 100% with 100% being the peak inrush current detected during the delay. Default is 50%. Range is 10% to 95%.
 - Sample Filter - This numerical value defines a noise filter applied to the incoming signals. It computes a running average with older readings fading in importance. A larger value will give better noise filtering at the expense of slower response. Default value is 10. Range is 1 to 50.
 - Current Probe – Standard probe is 1 mA/A (1000:1). If another probe sensitivity is used, select here. Options are 1 mA/A, 5 mA/A, 10 mA/A, and 20 mA/A.
- 5.7 After the setup pages have been reviewed, you will enter the STOPPED state.
- 5.8 Press OPERATE MOV to start the run and close the relay contacts. The red LED will come on.
- If an SD memory card is inserted, there will be a notice and momentary delay while a new log file is opened. The delay will get longer as the number of log files on the card increases.
 - After the file is opened (if applicable), the red LED will come on and the relay contact will close to start the MOV.
 - STOP may be pressed at any time to halt the test and open relay contacts.
- 5.9 If connection option B is used, initiate valve operation using the control panel OPEN switch.
- 5.10 If control circuit power is being supplied by a secondary device (such as a variable AC unit), initiate opening of the valve from this secondary device.
- 5.11 Display may briefly show STANDBY until current is detected, then DELAY and then OPERATING.
- 5.12 When the motor current reaches a trip condition, the relay contact will open and the display will show Review Results (+,-) and the type of trip:
- OPER CURRENT TRIP will occur when current exceeds the operating trip setpoint (operating state only).
 - MAX CURRENT TRIP will occur if current exceeds the maximum trip setpoint (operating state only), possibly caused by valve already against backseat or insufficient inrush delay time.
 - LOST PHASE TRIP will occur if any phase is not detecting current.
 - MANUAL STOP if you pressed the STOP button to end run.
- 5.13 With Review Results (+,-) displayed, press [+] or [-] to review various measurements taken during the test. These are useful for establishing setup values for a given valve without having to read the log file on the SD memory card.
- Type of trip
 - Trip current
 - Operating current

- Post trip current (maximum current due to motor contactor delay)
 - Inrush peak current
 - Inrush time (peak width)
 - Run time (inrush + operating)
 - Lost phase identification (if applicable)
 - Log file name (if logging to SD card)
 - Data points, at 1 millisecond intervals, showing time (ms), current, and state (delay, operating, or tripped). Up to 2000 points at the start of the run (2 seconds worth) and up to 2000 additional points at the end of the run will be available. Hold down the [+] or [-] key to accelerate the scan of points.
- 5.14 The run results will be retained until the relay is turned off or until another run is made. Review Results will now be available when stepping through the SETUP menus.
- 5.15 Press STOP to reset to the home state.
- 5.16 The SD memory card may be removed to transfer the log file to a computer for analysis.

6 SETUP MENUS

Two levels of setup menu are provided, standard and advanced. At power-up when the PREREQ screen is shown, the standard menu is enabled. At this time, you may press the [+] and [-] keys to change to advanced, or leave them alone to remain in standard. When in the STOPPED state, you may also press the keys to change menu level. If the wrong number of key presses is made, press STOP to reset the key counts and then try again.

Key codes

Advanced menu: Press [+] exactly one time, press [-] exactly three times

Standard menu: Press [+] exactly one time, press [-] exactly one time

The standard menu items are described in Section 5.6. The advanced menu includes those items plus these additional items:

- Year, Month, Day, Hour, Minute – Use to set the internal clock/calendar that identifies the log files with the date and time of the test. These settings will also appear in standard menu if the clock has not been set following battery replacement.
- Phase Balance – Enables or disables the phase balance compensation described previously in paragraph 4.16. Default is Off. This setting is temporary and reverts to off when the unit is powered off.
- Threshold – The number of ADC Units (analog/digital converter decimal counts above background) at which the inrush surge is detected to begin the DELAY state. An input exceeding this during STOPPED will give an error message indicating current or noise is present on the input. Default value is 40 with 10 to 200 allowed. It should not need to be changed unless there is a high level of background electrical noise. 40 corresponds to approximately 0.8 amps with a 1 mA/A probe.
- Log File Contents – *Standard* setting will log the test setup, results, and current and state at one millisecond intervals. *Diagnostic* setting provides additional details of program variables that can be used by the factory for troubleshooting. These details are not meaningful to the user. Default value is Standard.

- **Restore Defaults** – This item only appears if any item in the standard or advanced menu, other than the clock/calendar or phase balance settings, differs from the default value. Press [+] to restore or [-], SETUP, or STOP to keep your existing settings.

For both the normal and advance settings, any changes except clock and phase balance will be stored in non-volatile memory and retained when power is turned off or batteries removed. Battery removal will require clock reset. Run results data are not saved.

7 LOG FILE

Data logging of MOV runs is recorded using a Micro SD card. The card is inserted into a small slot on the right side of the case. Orient the card with contacts towards the front. After insertion, a portion of the card will extend outside the case. Remove by gripping and pulling.

When OPERATE MOV is pressed to start a test, a new log file will be opened. The file name will contain the serial number, date and time of the test. For example,

```
MOV Backseat 003 Log 2019-09-01_1819.txt
```

Contents start with an identification of relay and date/time, followed by various settings. Next, current readings are recorded from the start of the inrush current until current drops after the contact is opened. Finally, results are recorded.

```
MOV Backseat Relay S/N 003
09/01/2019 18:19:39
Firmware Version 2.4
Operating Trip Setting = 110 %
Max Current Trip Setting = 50 %
Inrush Delay Time Setting = 250 ms
Sample Filter = 10
Probe = 1 mA/A
Phase Balance Compensation = Off
Threshold = 40 ADC Units
```

time (ms)	amps	state
-----	----	-----
0	0.83	Delay
1	5.74	Delay
2	22.98	Delay
3	47.13	Delay
4	68.76	Delay
5	38.74	Delay
6	73.17	Delay
7	108.32	Delay
8	131.99	Delay
.		
.		
.		
3188	21.53	Operate
3189	21.83	Operate
3190	21.57	Operate
3191	21.84	Operate
3192	21.98	Operate
3193	22.65	Tripped
3194	22.96	Tripped
3195	22.95	Tripped
3196	23.14	Tripped
3197	23.66	Tripped
3198	5.22	Tripped

```

Operating Current Trip

Inrush Peak Current = 154.9A
Inrush Time = 42 ms
Operating Current = 20.52A
Trip Current = 22.65A
Post Trip Current = 23.66A
Run Time = 3.193 sec

```

The logged current readings are tab delineated, making them easy to copy and paste into an Excel spreadsheet for plotting and analysis.

No provisions are made for SD card formatting, file renaming, or file deletion. This must be done on an external computer. Card format is FAT32. Micro-SD to USB adapters are commercially available if needed.

8 SETPOINT CONSIDERATIONS

Proper operation depends upon the selected operating trip setpoint. Too small a value can result in premature trip before the valve reaches the backseat. A large value will allow correspondingly larger stress on the valve. Other factors that may come into play are electrical noise from nearby equipment and uneven friction force during the valve stroke. The default values of operating trip and sample filter were determined by bench testing of a particular valve and operator. Valves in field conditions may require different values.

When logging, current is recorded to file at 1 millisecond intervals during the valve stroke. The readings in the log file may be copied and pasted into an Excel spreadsheet for plotting to a chart. The following chart represents a simulated valve stroke produced using a 3 phase signal generator. At 3000 milliseconds, the current begins a ramp up to simulate reaching the backseat. Two runs were made. The blue trace is with 110% trip and sample filter of 10. The red trace is 110% trip with sample filter of 50.

Observe that the blue trace has much greater fluctuation than the red. The larger the filter value, the more the historical average of previous readings come into play. This smoothes out the trace but it also adds some delay.

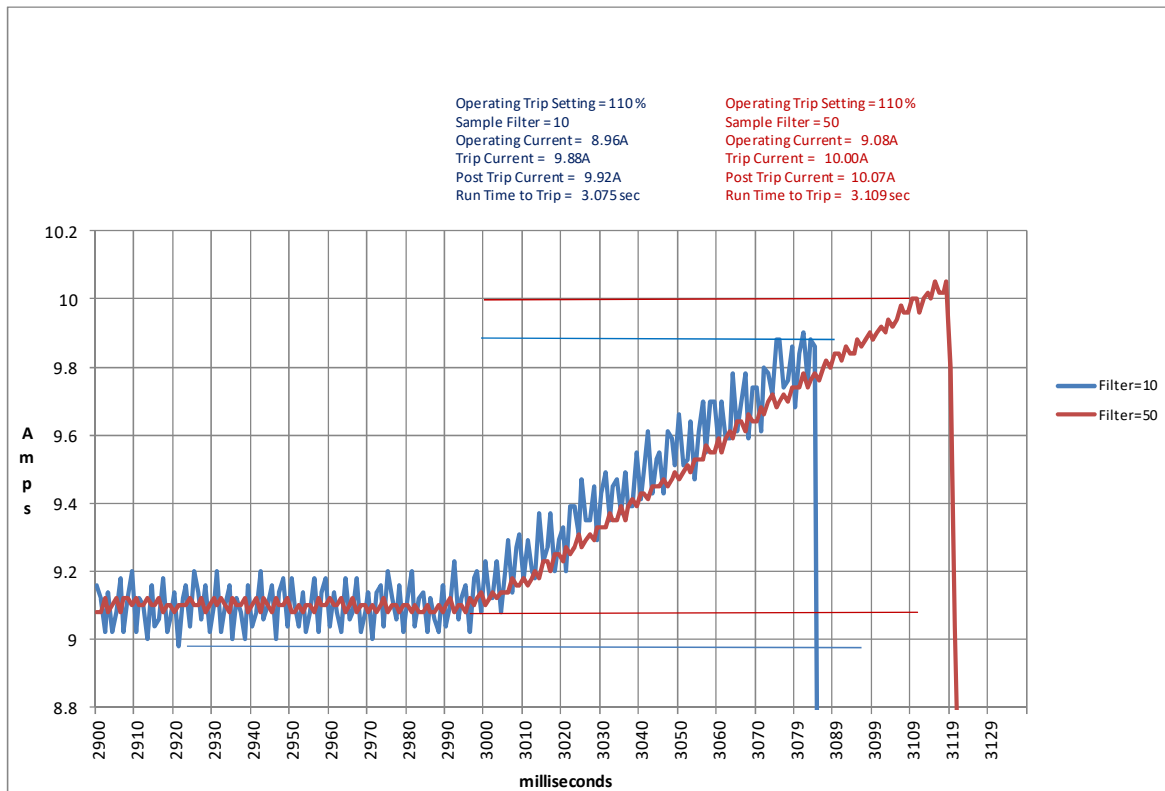
The operating current setpoint is determined as the percentage of current during the operating state. Since it tracks current downwards, the most negative spike will define the setpoint. For this reason, the red trace shows a higher operating current trip setpoint than the blue. The trip will occur on a positive going spike, so the greater the noise, the sooner the trip will occur (possibly premature). In this example, the 50 filter caused a longer time to trip; however, the smoother trace can allow the trip setpoint percentage to be decreased to give a faster trip. Field conditions may be noisier than this simulation.

The sample filter has the form:

$$A_f = A_f - (A_f - A_n) / f$$

Where

A_f = filtered current
 A_n = new current reading
 f = filter constant



9 MAINTENANCE

Calibration of the device may be performed but is not required. Trip setpoints are specified as a percentage of current. As such, the actual current does not matter to meet the intent. Current readings are provided for information. Refer to calibration procedure available at the link below.

A battery icon displays on the STOPPED screen. LOW BATTERY will display when battery drops below 4 volts. No operations are possible under low battery condition.

To replace batteries, remove panel at top rear of case.

For version information, including user's manual, functional test/calibration procedure, and download of the latest firmware version, see <http://campcreektech.com/mov.html>.

Firmware may be easily updated in the field using this procedure:

NOTE: Settings and calibration are not affected by a firmware update

1. Unzip the update file. It will contain these instructions and an image.hex file.
2. Copy the image.hex file to a micro-SD card. The card used for logging may be used for this purpose.
3. Turn relay off.
4. Insert SD card in the slot on the side of the relay.
5. Press the [-] key. While holding it down, press the power key.
6. The screen should show "Bootloader v1.1, Press SETUP to pgm."
7. The [-] key may be released once the bootloader screen displays.
8. If you wish to cancel the update, press the STOP or power key.

9. Press SETUP. The screen will show Erasing for about 3 seconds followed by Programming for about 3 seconds.
10. Once complete, the normal relay startup screen will appear, identifying the version number.
11. The SD card may now be removed.

10 TROUBLESHOOTING

A clean sine wave is required for proper operation. Electronic inverters may not provide this.

The operating current trip is proportional to the minimum current measured during the valve stroke. If shaft friction varies the current, this could affect the trip point.

Small valves with low operating current, less than 1 amp, may require a higher operating trip % to due to limited resolution and background noise. For example, a 130% trip setting may work for a motor with 0.2 amp operating current. See Section 3 for a discussion of probe options.

In general, premature trip can be avoided by increasing the operating trip setpoint or the sample filter. See Section 8 for additional information.

If error-current/noise flashes intermittently while in STOPPED mode, this indicates background electrical noise is being picked up from the environment and exceeds the threshold setting described in Section 6.

11 CONTACT INFORMATION

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12 WARRANTY

Camp Creek Technologies warrants that the product is free from defects in materials and workmanship for a period of one year from date of purchase. If product proves defective during this warranty period, Camp Creek Technologies, at its option, will either repair the defective product without charge for parts or labor, or will provide a replacement in exchange for the defective product.

Revisions

Rev 0, 12/26/2016

Original Issue

Rev 1, 5/26/2017

For prototype firmware version 1.4

Rev 2, 3/3/2018

For production hardware and firmware version 2.0

Rev 3, 3/15/2018

Revised Figure 2 and text to show connection options

Rev 4, 5/4/2018

Firmware Version 2.1

- Sample Filter moved to standard settings menu
- Add threshold setting to advanced settings menu
- Add phase balance compensation
- Allow change of menu level when in stopped state
- Deleted the save changes menu item. Changes are saved automatically.
- Add lost phase test during delay state.
- Add data logging to Micro SD card

Rev 5, 12/24/2018

List other suitable AEMC probes

Rev 6, 5/23/2019

Data logging is now standard rather than an option

Firmware Version 2.2 changes

- Time/date menus now show in standard menu after battery replacement
- Auto zero has been eliminated in favor of fixed calibration

Rev 7, 6/14/2019

Firmware Version 2.3 changes

- Restored auto zero, using improved algorithm for all 3 ranges

Rev 9, 9/16/2019

Firmware Version 2.4 changes

- Data points now viewable on display in SETUP as Review Results.
 - Phase compensation setting is not saved
 - Menu option added to select current probes of different sensitivity
- Expanded current probe information and options

Editorial changes

Rev 9.1, 3/16/2023

Firmware Version 2.4.1 changes

- Perform scale changes at end of peak instead of end of delay, to preventing glitches that could give spurious trip