MOV Backseat Relay
P/N 201602

User's Manual
Rev 7 for firmware version 2.3

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.

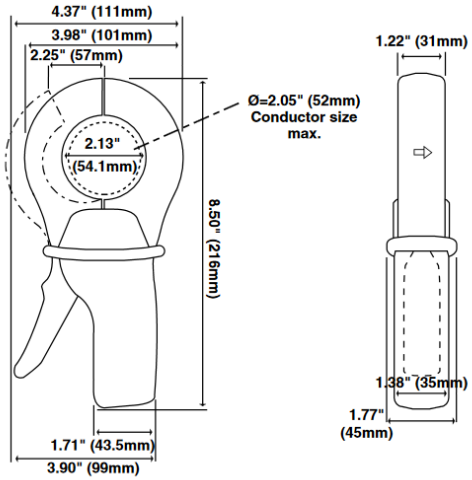
2 SPECIFICATIONS

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 1000:1 probes. Auto scaling is used to measure peak 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, 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.

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 similar and suitable AEMC probes, all having 1000:1 ratio:

- SR600, no diode protection (not needed in this application)
- SR604, with 5 foot leads
- SR701, greater accuracy
- SR704, greater accuracy with 5 foot leads
- MN106, 150A range, with 5 foot leads
- MN312, 200A range

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

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 susceptibility to 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 selected 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.

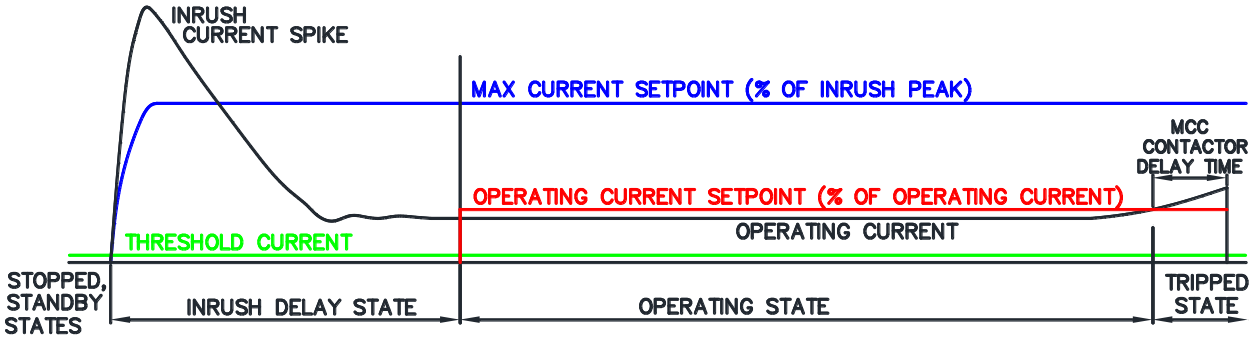


Figure 1: Typical Test Sequence

4.7 Figure 1 shows a hypothetical current trace for a test. 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 is detected or excessive noise is present, 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 current threshold. 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 state. It detects if no current is sensed over a period of ½ cycle on any phase.

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 historic 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 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 In any tripped state, the relay contact opens and the display shows the cause of trip and the amperage at time of trip. The [+] and [-] buttons may be pressed to show recorded readings of trip current, post trip current, inrush peak current, inrush time, and run time.

4.23 These recorded readings are no longer available after the Stop button is pressed.

5 TEST PROCEDURE

5.1 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.

5.2 Using test leads, connect the output contact in 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.

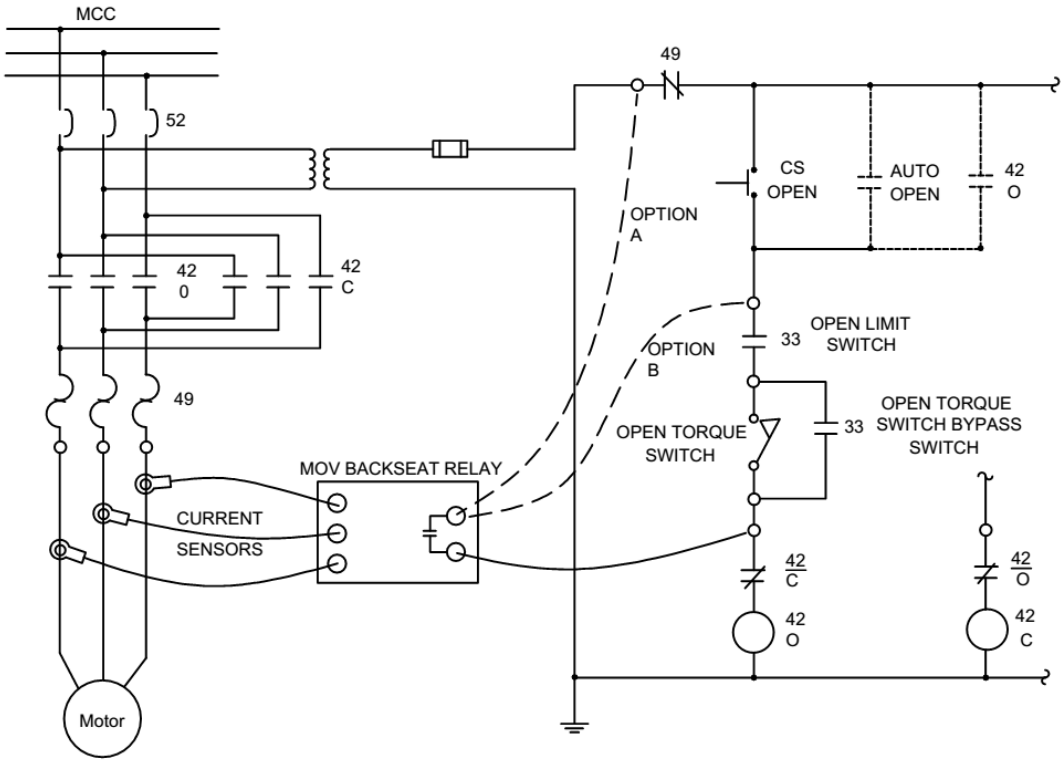


Figure 2: Typical Connection Diagram

5.3 Clip the current sensors across the wires to the motor. Phase sequence and sensor orientation do not matter.

5.4 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.

5.5 Repeatedly press SETUP to cycle through the settings. Press the [+] or [-] button to make changes to settings.

- 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. Allowable values are 101% to 200%. Default value is 110%.
- 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. Allowable values are 50 to 2000 milliseconds. Recommended is at least 50 ms longer than the measured inrush time.

- 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. Allowable values are 10% to 95%. Recommended is 50%.
- 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.

5.6 After the setup pages have been reviewed, you will enter the STOPPED state.

5.7 Press OPERATE MOV to close the relay contacts. The red LED will come on.

NOTES: MOV will start immediately if the MCC breaker is closed and power is being supplied to the control circuit.

STOP may be pressed at any time to halt the test and open relay contacts.

If an SD memory card is inserted, there will be a notice and momentary delay while a new log file is opened.

5.8 If connection option B is used, initiate valve operation using the control panel OPEN switch.

5.9 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.

5.10 Display may briefly show STANDBY until current is detected, then DELAY and then OPERATING.

5.11 When the motor current reaches a trip condition, the relay contact will open and the display will show 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 motor stall or insufficient inrush delay time.
- LOST PHASE TRIP will occur if any phase is not detecting current.

5.12 With the tripped display showing, press [+] or [-] to review various measurements taken during the test. These are useful for establishing setup values for a given valve.

- 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 applicable)

5.13 Press STOP to reset the test.

5.14 The SD memory card may be removed to retrieve the log file.

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 to zero.

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 5.5. 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.
- Threshold – This numerical value (which is not amps) is relative to the input and defines the input at which the inrush surge is detected to begin the DELAY state. An input exceeding this during STOPPED will give and error message indicating current or noise is present on the input. Default value is 6. It should not normally need to be changed unless there is a high level of electrical noise.
- Log File Contents – *Standard* setting will log the test setup, results, and current and state at 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 settings, differs from the default value. Press [+] to restore or [-], SETUP, or STOP to retain your existing settings.

For both the normal and advance settings, any changes except clock will be stored in non-volatile memory and retained when power is turned off or batteries removed. Battery removal will require clock reset.

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 on the card. The file name will contain the serial number, date and time of the test. For example,

```
MOV Backseat 003 Log 2019-04-15_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
04/15/2019 18:19:39
Operating Trip Setting = 110 %
```

```
Max Current Trip Setting = 50 %
Inrush Delay Time Setting = 250 ms
Sample Filter = 10
Phase Balance Compensation = Off

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 time current readings are tab delineated, making them easy to copy and paste into an Excel spreadsheet.

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.

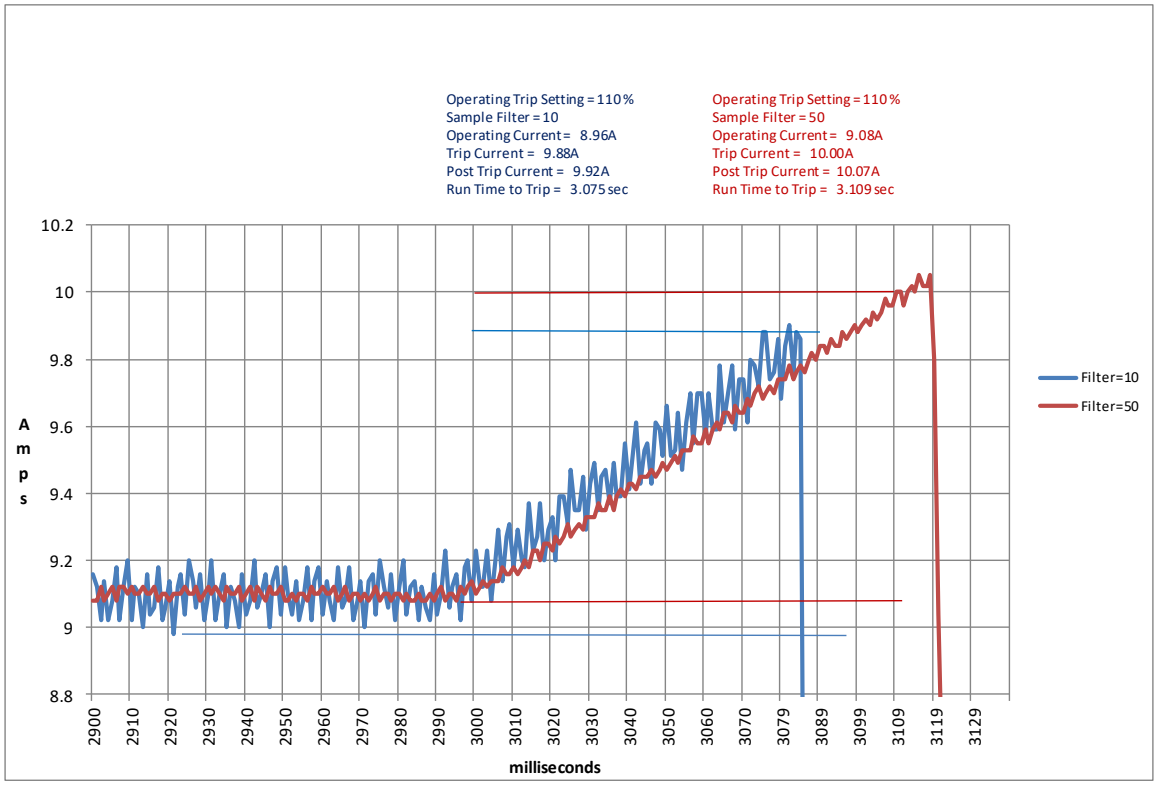
8 SETPOINT CONSIDERATIONS

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.

With the logging option, 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 chart below 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 and 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 allows the trip setpoint percentage to be decreased to give a faster trip. Field conditions may be noisier than this simulation.



9 MAINTENANCE

No calibration is 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.

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.

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. So if friction varies, this could affect the trip point.

Small valves with low operating current, typically less than 1 amp, may require a higher operating trip % to prevent premature trip.

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

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