INSTALLATION GUIDE and USER MANUAL

Maxwell Technologies, Inc.®
12V Ultracapacitor Engine Start Module (ESM)

Models:

- ESM123000-31
- ESM ULTRA 31/1800
- ESM ULTRA 31/900

Document #1017462 Rev. 5

Maxwell TECHNOLOGIES
Enabling Energy's Future™

Contents

1 Safety

The **Ultracapacitor Engine Start Module** **is not a battery** and must be treated differently than a battery. Please review these important safety warnings.

WARNING

DANGER – HIGH CURRENT HAZARD!
Power terminals pose an extreme arcing hazard when ESM is charged.
Always discharge the ESM prior to removal or handling.
For information about the discharge procedure, refer to Section 7.

Do not operate (charge) unit above specified voltage (18V continuous / 24V momentary).

Do not operate unit above specified temperature rating of +149°F (+65°C).

Protect terminals from accidental shorting.

If jump start is required use the external jump post if the vehicle is equipped with one, or jump across any Battery Positive (+) and Battery Negative (-) Terminal.

WARNING

DO NOT CONNECT IN REVERSE POLARITY!
Do not connect the terminals in reverse (+ to – and/or – to +). Sparks and arcing will occur on a charged ESM creating a shock and/or burn hazard. Permanent damage to the ESM will also occur.

WARNING

DANGER
DO NOT CONNECT CABLES FROM THE BATTERY
TO THE STARTER + TERMINAL OF THE ESM.
This will short the battery and cause arcing.

WARNING

WARNING – THIS IS NOT A BATTERY!
DO NOT JUMP START
Do not connect battery across the STARTER + 'S+' and BATTERY – 'B-' terminals.

Chance of arcing or damage to battery.

2 Introduction

The Engine Start Module (ESM) by Maxwell Technologies, Inc. is intended to provide years of reliable starting for high compression gas or diesel engines up to 16L in displacement. The ESM replaces one battery for starting of engines with a 12V starting system. It is designed to recharge from an existing system battery(s) and provides starting power across a broad temperature range even when batteries would not have sufficient power. There are two products in the ESM family, the ESM ULTRA 31/900, and the original ESM123000-31. Please make sure you install the correct ESM product for the type and class of vehicle as shown in the specification table below.

Specification	ESM ULTRA 31/900	ESM123000-31 or ESM ULTRA 31/1800
Vehicle Type	Medium Duty (Class 3-6)	Heavy Duty (Class 7-8)
Diesel Engine Size (displacement)	4L to 9.9L	10L to 16L
Cold Cranking Amps	900 A (3 second crank)	1800 A (3 second crank)
Peak Power	16.4 kW	32.8 kW
Input Voltage (B+ Terminal)	9V – 18 V	
Output Voltage	15.0V – 16.2V (temperature dependent)	
Operating Temperature	-40°F to +149°F (-40°C to +65°C)	
Current Draw (from batteries)	25A (max. during charging), < 10 mA when charged (sleep mode)	
Recharge Time	8 minutes	15 minutes
Weight	16 lbs (7.3kg)	21 lbs (9.5 kg)

3 Unpacking

Inspect the shipping box for signs of damage prior to unpacking the ESM. Damage to the shipping box or ESM should be reported to the carrier immediately. Retain the shipping materials until the unit has been inspected and is determined to be operational. Remove the ESM from the shipping box by lifting the ESM straight up. The ESM only weighs 16 lbs. (ESM ULTRA 31/900) or 21 lbs. (ESM123000-31) and is significantly lighter than a similarly sized lead-acid/AGM battery. DO NOT lift the ESM from the box or carry using the provided jumper wire from the Starter (+) to the Battery (–) posts. Discard jumper wire before installation.

If the unit is found to be defective or any parts are missing, contact **your original Point of Purchase** or **Maxwell Technologies, Inc. at (858) 503-3300, or toll-free at (877) 511-4324.** A Return Material Authorization (RMA) number must be issued prior to returning the unit for repair or replacement.

4 Accessories

Additional materials that may be needed for installation (see step 3 in Section 5.2.2, below) are shown below. These items are not included with ESM, but may be necessary to isolate other vehicle electronic non-starting loads from the starter system.

- Terminal block, SS 3/8"–16 thread or equivalent. Examples are shown below:



- In place of a terminal block, a simple SS 3/8" bolt, washer and nut may be used to connect non-starter vehicle loads to the batteries. Electrical insulation material (Heat Shrink) is also required for proper isolation.


- 0 AWG – 6 AWG (or appropriately size cable for the load) Cable with 3/8" ring lugs to connect other vehicle electronic non-starting loads to a Positive (+) battery post.

Tools Required: (not supplied)
Klein Tools KLE2006 Large Compound-Action Crimp Tool (or similar)

5 Installation

5.1 Mounting Location

The ESM is designed to mount in the same space as a Group 31 battery. The typical location is in the battery box of a Class 3-8 truck. If there is adequate space, the ESM should be installed in addition to batteries. If batteries fill the battery box, one battery must be removed and replaced with the ESM. An installation video is available at the Maxwell Technologies, Inc. ® Website for additional installation instructions. Please visit http://www.maxwell.com/esm and click on the Engine Start Module (ESM) Installation Video.

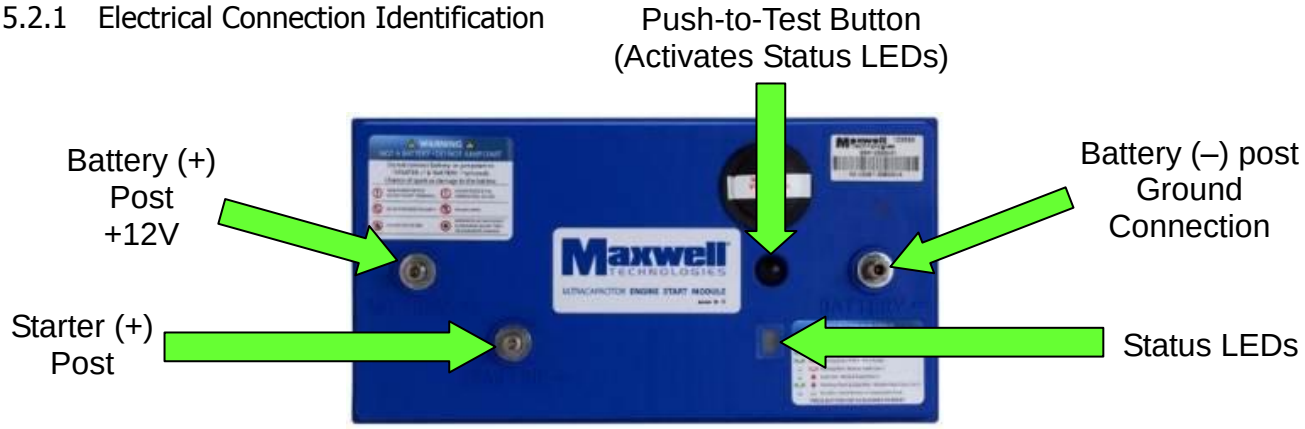
On some truck models, the Diesel Particulate Filter (DPF) After-Treatment System (ATS) may be located near the vehicle battery box. These systems typically generate very high temperatures during the regeneration process which may cause the Engine Start Module to experience an Over-Temperature Fault (>149° F/ 65° C). If possible, mount the ESM far away from the DPF. Refer to Section 6, below for additional diagnostic and trouble-shooting information.

5.2 Electrical Installation

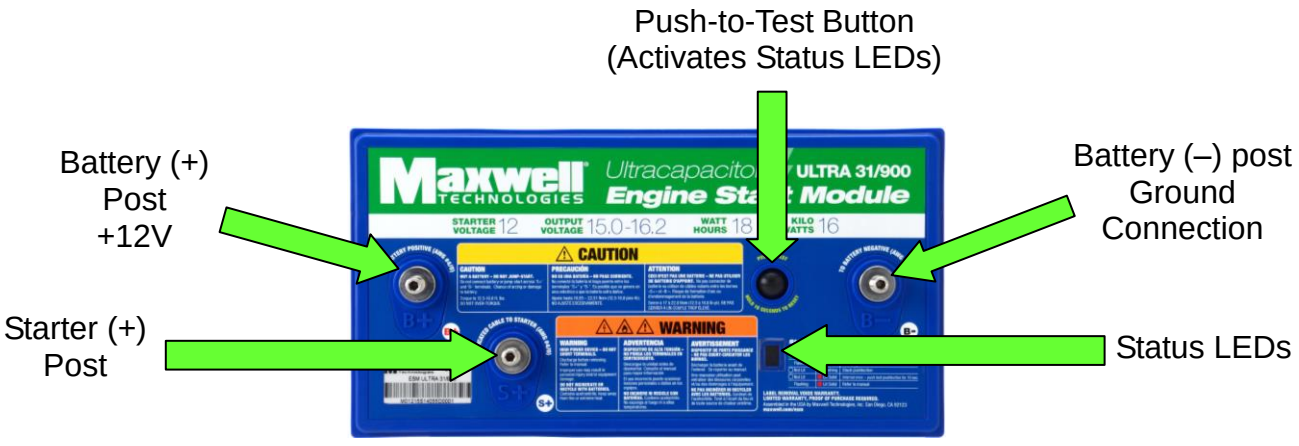
WARNING

DANGER
DO NOT CONNECT BATTERY CABLES FROM THE BATTERY TO THE STARTER + POST OF THE ESM.
This will short the battery and cause arcing.

5.2.1 Electrical Connection Identification



ESM123000-31 and ESM ULTRA 31/1800



ESM ULTRA 31/900

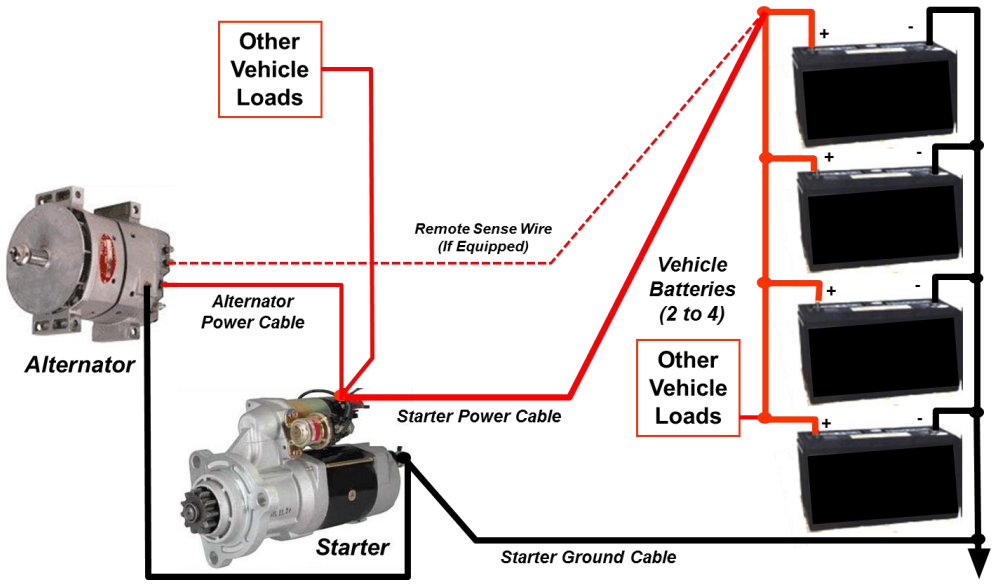
5.2.2 Wiring Instructions (*refer to the "before and after" installation diagrams*)

1. Prior to installing the ESM test the starting and charging system to isolate any pre-existing problems. Refer to the Technology and Maintenance Council (TMC) of the American Trucking Associations (ATA) Recommended Practice 129A (RP-129A) for procedures to test the cable interconnects between all the starting and charging system components for maximum voltage drop.
2. Remove all cables from the vehicle batteries, noting where they were originally connected.
3. All cable lug terminations and battery posts should be thoroughly cleaned to remove grease and oxidation.
4. Test the vehicle batteries individually and ensure they are properly charged to avoid issues later. Remove and replace any batteries that are discharged below their specified voltage or Cold Crank Amp (CCA) rating.
5. Place ESM in the desired location being careful to align the (+) and (-) posts in line with the existing Vehicle Battery(s) (+) and (-) posts; remove a Battery (if needed). DO NOT CONNECT THE ESM UNTIL INSTRUCTED.
6. Identify the cable(s) connecting Battery Positive (+) post to the Starter Solenoid at the Battery(s).
7. Inspect connection of Battery + (Red) cable(s) at the Starter. If the Starter Solenoid is used as a junction point for other vehicle electronic loads (i.e., more than just the Starter (+) cable is connected to the Starter), proceed with the following steps, otherwise skip to step 7.
    a. Remove ALL cables from the Starter Solenoid.
    b. Re-attach the main Battery (+) cable that connects the Battery (+) post to the Starter Solenoid. Identify the other end of this cable as "STARTER +" in the battery box. This will be the only connection to the "Starter +" post on the ESM, and should be identified as the "ESM Starter (+) Power Cable".
    c. Construct or obtain an additional red Battery (+) cable (of appropriate AWG gage to carry other vehicle electrical loads that were previously attached to the Starter Solenoid) with ring lugs for 3/8" dia. post and with sufficient length to run to the Vehicle Battery Box.
    d. Using a Terminal Block, Stainless Steel bolt or other appropriate junction point, connect the newly constructed cable in step C above to the other vehicle electronic load cables just removed from the Starter Solenoid (Refer to Section 4, above for recommended accessories).
    e. Mount the Terminal Block or other junction point to a secure location and make sure it is properly isolated from all vehicle grounds. Securely insulate, tie wrap and/or bundle all loose cables to minimize damage from vibration, potential grounds, abrasion and corrosion.
8. At the batteries, connect the primary 12V Battery Negative (-) Terminal to the "BATTERY –" post of the ESM.
9. Connect an appropriate AWG gauge cable from the primary 12V Battery Positive (+) Terminal to the "BATTERY (+)" post of the ESM. The ESM will now begin its initial charging once connected to the vehicle batteries. Reconnect all previous cables removed from the vehicle batteries.
10. Connect the new cable constructed in step 6, above, to any primary Battery Positive (+) Terminal.

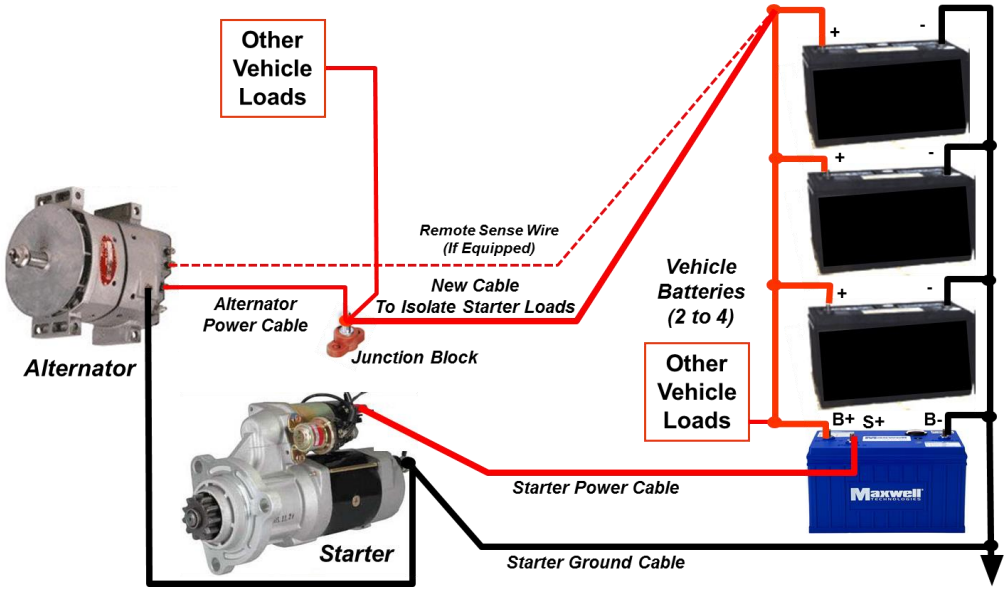
11. Before connecting the cable from the Starter Solenoid to the Starter (+) Terminal of the ESM measure the voltage from the cable lug to both Battery Positive (+) and Battery Negative (-) Terminals. The voltage should read 0V for both. A voltage reading on either test indicates the Starter Solenoid may be bad or there is another wiring path from the Starter Solenoid to the batteries. This will result in improper ESM operation and must be corrected before continuing with the installation.
12. Connect the ESM Starter (+) Power Cable from the Starter Solenoid (+) to the "STARTER+" terminal of the ESM.
13. Press the "Push-to-Test Button" on top of the ESM. The status LED's should display a Flashing Green light. This indicates the ESM is charging.
    Note: The ESM will take up to 30 minutes for an initial charge drawing approximately 10 amps from the batteries. After 30 minutes, press the Push-to-Test button again the light should be Solid Green.
14. Make sure all cables are adequately isolated and secured to original or existing cable bundles to minimize damage from vibration, potential grounds, abrasion and corrosion.

15. The ESM is now ready to start your engine!

Typical vehicle wiring diagram before ESM installation



Typical vehicle wiring diagram after ESM installation



A note about jump starts: **Do NOT Jump Start on the STARTER + terminal of the ESM!** If required, REMOVE the ESM "STARTER +" lead and connect it to the jumping battery. If the starter does not function there is some other vehicle problem.

6 Diagnostics

The ESM includes two Light Emitting Diodes (LEDs) that display status of the unit when the Push-to-Test button is pressed. To activate the LEDs, simply press and release the Push-to-Test button on the top of the ESM. The red and green LEDs will illuminate and/or flash for 10 seconds as shown in the following diagram to display the status of the ESM. Holding the Push-to-Test button down for 12 seconds will reset the internal computer. Note that the LEDs are only active for 10 seconds when the button is pressed, and then they automatically turn off.

Fault Class Descriptions:

There are six different fault classes incorporated in the ESM. While some may be redundant these diagnostic codes help customer service personnel diagnose any problems with the ESM.

Fault Class	Green LED	Red LED	Description / Example	Recovery
1	Green Off	Red Flashing	Stuck or jammed Push-to-Test Button.	Recovers automatically when fault condition is corrected.
2	Green Off	Red On	Internal electronics errors and/or internal temperature sensor errors. Not serviceable by user.	Recovers with Manual Reset.
3	Green Flashing	Red On	Internal electronics failure and/or internal temperature sensor failure. Not serviceable by user.	Recovers with Manual Reset.
4	Green Flashing	Red On	Battery under-voltage error, battery over-voltage error, or over-temperature error.	Recovers automatically when fault condition is corrected. Allows continued use with maximum 12V output.
5	Green Flashing or Green Off	Red On	Internal electronics failure. Not serviceable by user.	Recovers with Manual Reset. Allows continued use with maximum 12V output.
6	Off	Off	No response from unit and loss of functionality.	Non-recoverable fault.

Normal Operating Conditions: The ESM LEDs will display two types of normal status:

1. A flashing Green LED indicates the ESM is charging, and may or may not have sufficient power to start the vehicle. The initial charge cycle will take up to 30 minutes; subsequent charge cycles will take up to 15 minutes.
2. A solid Green LED indicates the ESM is charged and ready to start the vehicle.

Abnormal Fault Conditions:

1. Module Class 1 Fault. Indicated by a flashing Red LED means the Push-to-Test Button is stuck or jammed. Check the Push-to-Test Button to see if it is depressed or if something is obstructing its operation. You should feel a tactile 'click' when the button is pressed and released. The ESM will recover automatically when this fault condition is corrected.
2. Module Class 2 Fault. Indicated by a solid Red LED means there is an internal electronics or temperature sensor error. If a module Class 2 fault condition exists, press and hold the Push-to-Test button for 12 seconds. This will reset the internal electronics and attempt to clear the fault.
3. Module Class 3 Fault. Indicated by a solid Red LED and flashing Green LED, indicates an internal electronics or temperature sensor failure. Press and hold the Push-to-Test button for 12 seconds. This will reset the internal electronics and attempt to clear the fault.
4. Module Class 4 Fault. Also indicated by a solid Red LED and flashing Green LED indicates either an over-temperature fault, or under-voltage or over-voltage fault has occurred.
    a. When the internal temperature of the ESM exceeds 65°C (149°F) an over-temperature fault will occur. If an over-temperature fault exists the ESM must be allowed to cool down to below 60°C (140°F). The internal charging electronics are disabled during an over temperature condition, and the ESM may not start the vehicle. The ESM will automatically reset when the internal temperature falls below 60°C (140°F) and continue to operate normally without user intervention.
    b. If the battery voltage is below 9.0V or above 24.5V an under-voltage or over-voltage fault will occur. Correct the problem by repairing the vehicle batteries or charging system to ensure the voltage is greater than 9.5V or less than 24V. The ESM will automatically reset when the Battery + voltage is between 9.5V and 24V and continue to operate normally without user intervention.
5. Module Class 5 Faults. Indicated by a solid Red LED, or a solid Red LED and a flashing Green LED indicates that some other minor internal electronics error has been detected. The ESM will still operate but in a degraded power or 'limp home' mode where the output voltage is limited to 12V instead of 15V. The vehicle should still start, but you may notice a longer cranking time. Press and hold the Push-to-Test button for 12 seconds. This will reset the internal electronics to clear the fault. If the fault condition still exists and the temperature and voltage to the Battery (+) terminal are within normal operating ranges then there is some other internal fault that requires ESM replacement. Please contact your Point of Purchase or Maxwell Technologies, Inc. for a Return Material Authorization (RMA) number. An RMA number must be issued prior to returning the unit for repair or replacement.
6. Module Class 6 Faults. Indicated by no response from the Status Indicators and the ESM does not seem to be functioning at all (Note, there must be 12V power to the ESM for these indicators to function). Please contact your Point of Purchase or Maxwell

Technologies, Inc. for a Return Material Authorization (RMA) number. An RMA number must be issued prior to returning the unit for repair or replacement.

Note: The Diagnostic status indicators work ONLY when there is a battery connected to the ESM BATTERY (+) and (-) posts.

7 ESM Discharge

Prior to packing the ESM for return on an authorized RMA please discharge the ESM as follows:

1) If the ESM voltage is above 2V:
   a. Disconnect the "BATTERY +" cable from the ESM.
   b. Connect a 12V load, such as a headlight, across the "STARTER +" and "BATTERY -" posts this will discharge the voltage stored in the ESM.
   c. Verify voltage is 2V or less.
   d. DO NOT use a cable, bare wire or low/no resistance conductor to discharge ESM!
2) Using a voltmeter, measure the voltage between the "STARTER +" and "BATTERY -" terminals. If the voltage is under 2V, the ESM is now considered safe for handling.

8 Maintenance

Terminals should be periodically checked for oxidation or lose connections and cleaned or tightened as necessary. Poor electrical connections account for the majority of ESM problems. Prior to removal or system maintenance, ensure that the ESM is discharged (See section 7). No other regular maintenance is required.

9 Storage

The ESM can be stored in the original package, discharged, in a dry place. Observe the maximum storage temperature as stated in the product specifications below. Discharge a used ESM prior to storing or shipment.

10 Disposal

Do not incinerate or recycle with batteries. Do not crush. Do not dispose in trash. Dispose in accordance with local regulations for electronic waste.

11 Specifications

ESM Specifications		ESM ULTRA 31/900	ESM123000-31 or ESM ULTRA 31/1800
Cranking Amps (S+ Terminal)		**900 CCA** (3 sec. crank) [1]	**1,800 CCA** (3 sec. crank) [1]
Input voltage		**9 V to 18 V** (on B+ to B- Terminals)	
Output voltage	**Max.**	**16.2 V** (for 32°F (0°C) or lower)	
	Nom.	**15.0 V** (for 77°F (25°C) or higher)	
Recharge	**Nom.**	**5 minutes** (after one start if voltage drops below 14.5V)	
	Max.	**8 minutes** (from 7.5V to 15V)	**15 minutes** (from 7.5V to 15V)
	Initial	**15 minutes**	**30 minutes**
Current draw (from battery)	**Sleep Mode**	**< 10 mA**	**< 10 mA**
	Charge Mode	**25 A** (max)	**25 A** (max)
Electrical	**Cap.**	**500 F** (min, initial)	**1000 F** (min, initial)
	ESR	**4 mOhm** (max, initial)	**2 mOhm** (max, initial)
	Peak Power	**16.4 kW** [2]	**32.8 kW** [2]
	Loss	**0.15 volts/day** (self-discharge) [3]	
Package	**Type**	**BCI Group 31**	
	Dim.	**13" L x 6-13/16" W x 9-7/16" H** (330mm L x 173mm W x 240mm H)	
	Weight	**16 lbs** (7.3 kg)	**21 lbs** (9.5 kg)
Terminals	**Type**	**SAE Type A post**	
	Thread	**3/8" – 16 UNC**	
	Torque	**150 to 200 in-lb, 12.5 to 16.6 ft-lb** (17 to 22.5 N-m)	
Temperature	**Operation**	**-40 to +149 °F** (-40 to +65 °C)	
	Storage	**-40 to +158 °F** (-40 to +70 °C)	
Shock and Vibration		**SAE J1455, Mid-frame**	
Designed for heavy duty truck battery box environments			

Notes

1. $$CCA = \frac{Cap \cdot (V_{MAX} - V_{MIN})}{Time + Cap \cdot ESR}$$

   Where,
   Cap = 500F (ULTRA 31/900)
   or 1000F (ESM123000-31)
   ESR = 0.002 Ohms
   V_{MAX} = 16.2V
   V_{MIN} = 7.2V (per SAE)
   Time = 3 seconds

2. $$PeakPower = \frac{(V^2_{MAX})}{4 \cdot ESR}$$

3. Nominal open circuit self-discharge rate with no power supplied to the B+ terminal. The first day will be a higher discharge rate.

12 Frequently Asked Questions (FAQ)

1. **[Q]: What can I do if I can't start the truck and the ESM does not appear to work?** *[A]: The simplest action is to disconnect the "STARTER +" cable from the ESM and connect it to any battery (+) positive post. Refer to Section 6 of this guide for diagnostic troubleshooting information.*

2. **[Q]: I installed the ESM but the LED's never turn solid green indicating the ESM is charged. What do I do now?** *[A]: Most likely there is some other vehicle load connected to the ESM "STARTER +" post or on the truck starter that is constantly draining charge from the ESM. All other vehicle loads must be isolated from the ESM "STARTER +" post and Starter. Disconnect the Starter Positive cable from the ESM. With a Digital Volt Ohm Meter (DVOM) put a lead on the Starter Positive cable and the other lead on the negative or positive post of the batteries. The DVOM should read 0V. Put the lead on the opposite battery post and check for voltage. It should also read 0V. If you have any voltage on the display of the DVOM than you have another power source still connected to or bleeding through the starter positive stud.*

3. **[Q]: The ESM displays a Solid Red LED and Flashing Green LED, what does this mean?** *[A]: This indicates one of several faults identified by the ESM. Refer to Section 6 of this guide for diagnostic troubleshooting information.*

4. **[Q]: I had to change a fuel filter and crank the engine several times to prime the fuel lines. Now the truck won't start, what do I do?** *[A]: Cranking the engine several times probably depleted the stored charge on the ESM. Press the Push-to-Test button and the status LEDs should be Flashing Green. This indicates the ESM is charging. When the LEDs turn Solid Green you should be able to start the truck again. If continuous cranking is required during vehicle maintenance disconnect the "STARTER +" cable from the ESM and connect it to any Battery (+) positive post. This allows the truck to run from the batteries. Just be sure to replace the "STARTER +" cable to the ESM when the maintenance is complete. Make sure the fuel filters are full of fuel and prime the system by hand if needed.*

5. **[Q]: How long will the ESM last in my vehicle?** *[A]: warrantied for 4 years; service life estimated at 6+ years.*

6. **[Q]: Where can I find information on RP-129A for voltage drop testing**? *[A]: Contact the Technology & Maintenance Council of the American Trucking Associations, Inc. 950 North Glebe Road, Suite 210, Arlington, VA 22203, Phone: (703) 838-1763, FAX: (703) 838-1701, Email: tmc@trucking.org, Website: http://tmc.trucking.org.*

13 Manufacturer Contact Information:

For Engine Start Module support, contact Maxwell Technologies, Inc. toll-free at:

- ESM Technical Support Line: (888) 890-3337
- ESM Sales Support Line: (877) 511-4324
- Web: www.maxwell.com/esm