



CM-813

Product Description & Troubleshooting Manual

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1. CM813 Functional Description

The CM813 is an electronic, micro-controller based device that implements the functions of the APADS™ (Air-conditioning Protection and Diagnostics System) control system. It is part of a family of APADS™ controller products specifically designed to reduce air conditioning maintenance costs in vehicular HVAC systems by increasing the life of system components and aiding in the diagnosis of system faults. With APADS™, air conditioning reliability is improved by actively monitoring system conditions and controlling the refrigerant compressor and the on-off fan drive. When used in a functional and properly maintained vehicular HVAC system, the CM813 is transparent to the vehicle operator. The salient feature of the CM813 is that it protects AC system components from unstable and self destructive modes by placing limits on the dynamic response of the system under certain environmental and suboptimal conditions. Additionally, diagnostics aid technicians in the servicing of systems by communicating specific fault codes that warn of existing or impending problems.

The APADS™ control system is composed of an electronic control module (CM813), two "semi-smart" pressure switches and a conventional evaporator thermostat (TSTAT). The input signals are interpreted by control and diagnostic algorithms which drive outputs to the AC clutch coil, fan actuator circuit and diagnostic LED's. In the APADS™ system, the CM813 controller becomes the only device through which power is switched to the AC clutch coil. The CM813 fan output is designed to interface with electronically controlled diesel engines, but it can be used on mechanical engines with the addition of an appropriate engine fan temperature control.

The CM813 is an Index standard product designed for installation in the commercial vehicle underhood environment. It is packaged in a rugged housing designed to withstand severe environmental conditions.

2. Electrical I/O Definition

Name	Function	Description
AC Drive	Output	AC compressor clutch coil drive
Fan	Output	Fan actuator circuit
GND (3)	Power	Module ground, Pressure Switch Returns (2)
HPx	Input	High pressure switch
LPx	Input	Low pressure switch
TSTAT	Input	Evaporator thermostat and AC on/off input
VIGN	Power	Module supply voltage, ignition switched

2.1 Inputs: The module receives inputs from the following sensors:

Index PM-700 series pressure switches:

HPx, High pressure switch, normally closed

LPx, Low pressure switch, normally closed

2.1 Inputs - continued

These "semi-smart" devices have an internal resistor installed in parallel with the electrical contacts to allow diagnosing of sensor, wiring and connector faults. Both switches are configured to provide a current path to ground when they are closed. (Reference PM-700 Technical Data Sheet.)

Note: Actual set and reset pressures are application specific.

TStat (Evaporator Thermostat)

The evaporator thermostat is the main AC system control. The TSTAT is wired in series with the AC system on/off switch. These switches are configured to switch to battery voltage when AC compressor operation is desired.

2.2 Outputs: The module produces the following output signals:

ACDrive (Compressor Clutch Drive)

A high side relay switch that provides battery voltage to the AC compressor clutch coil when activated.

Fan (Fan Actuator)

A low side switch (sinking to ground) that is used to signal the fan actuator circuit to activate the on/off fan drive. A fan "on" state is signified by the switch being in the open (nonconducting) condition.

Diagnostic LEDs:

Red and green diagnostic LEDs on the module are used to communicate fault diagnostics and indicate system status.

3. Control & Diagnostic Functions

3.1 A/C Compressor Control Rules

1. The AC compressor is absolutely kept off for the first 15 seconds after ignition switch engagement (module powerup).
2. The thermostat input is ignored and the AC compressor is turned on for 15 seconds directly after the 15 second ignition engagement timer (rule 1) times out. If the high or low pressure switches indicate out of bound or fault conditions, the compressor is turned off.
3. All three inputs (TStat, HPx, LPx) that can control the AC compressor are governed by control logic that limits the maximum cycle rate to once every 15 seconds.
4. The evaporator thermostat is the primary control. The AC compressor will cycle at the frequency governed by the thermostat but is limited to a maximum of one cycle per 15 seconds (rule 3)
5. When the high pressure switch indicates a high pressure condition, the AC compressor is allowed to stay on for an algorithmically determined variable period, limited to 10 seconds. The compressor is allowed to turn on after the high pressure switch resets and rule 3 is satisfied.

3.1 A/C Compressor Control Rules - continued

6. When the low pressure switch indicates a low pressure condition, the compressor is turned off. The compressor is allowed to turn on after the low pressure switch resets and rule 3 is satisfied.
7. If the supply voltage drops below 11.0 volts, the compressor is turned off. It is allowed to turn on again after there has been sufficient rise in system voltage, and rule 3 is satisfied.
8. The AC compressor is latched off until the next ignition cycle if any of the following faults occur:

- Open Clutch

3.2 Fan Control

1. Fan control is adaptive, dependent upon the frequency of request for operation. Fan timing has a minimum duration of 45 seconds and a maximum duration of three (3) minutes. When the fan is requested, the fan control output is in the "open" state.

3.3 Diagnostic Fault Descriptions

1. *Static Low Pressure:* When the system exhibits states and conditions that are indicative of complete loss of refrigerant, the Static Low Pressure fault is asserted.
2. *Dynamic Low Pressure:* Detected by rapid low pressure switch cycling, this behavior is symptomatic of a partial loss of refrigerant. If the low pressure switch dominates control and tries to cycle the compressor, displaying certain dynamic characteristics, the Dynamic Low Pressure fault is asserted.
3. *High Pressure:* This is detected by monitoring the High Pressure switch activity after the fan has been engaged. This fault can be caused by fan drive failure, debris on the condenser or refrigerant overcharging. If the high pressure switch controls the system with a certain dynamic behavior, the High Pressure fault is asserted.
4. *Open Clutch:* This is detected by sensing the current flow to the AC clutch. If no current flow is sensed when the AC DRIVE is turned on, an open connection to the clutch coil is inferred.
5. *Shorted Clutch:* This is detected by sensing excessive current flowing to the AC clutch coil. This is indicative of either a short in the clutch coil or the wiring from the module to the AC clutch.
6. *Low Psw open:* Indicates that the wiring to the low pressure switch is defective. This can be caused by an unseated connector, break in the wiring harness or moisture intrusion into the connectors or switch.
7. *High Psw open:* Indicates that the wiring to the high pressure switch is defective. This can be caused by an unseated connector, break in the wiring harness or moisture intrusion into the connectors or switch.
8. *Low Voltage:* Indicates a low supply voltage condition. This can be caused by a defective alternator, discharged batteries or excessive electrical loads. This diagnostic is self clearing; the blink code is displayed only while low voltage is present.

3.4 Blink Codes

Communication of diagnostic information is provided by a blinking red LED (Light Emitting Diode) built into the module. When a fault occurs, the corresponding fault code is stored in nonvolatile memory. The module always broadcasts the appropriate blink code until it is cleared.

Since only one blink code can be displayed at time, the fault of highest priority always takes precedence. The Fault Code Table displays the order of priority, name, description and number of blinks associated with each fault. Only the highest priority fault is held in memory. Once the fault is cleared, a new fault must occur to initiate a new blink code. A "blink" is approximately 1/4 second in duration. Once the number of blinks have been broadcast, there is a delay time of two seconds before the blink code is repeated.

The blink code is cleared by two methods:

- Cycle the ignition switch (One second on, one second off) for *four* (4) consecutive cycles.
- Self clearing based on the persistence of the fault. If a fault condition occurs once and does not repeat, the fault code is held for an extended period of time and then cleared. If the fault is repetitive, it will always be retained in memory until the problem is rectified.

Fault Code Table

Priority	Fault Code Name	Fault Description	LED Blinks
1	Static Low Pressure	Full loss of charge	1
2	Dynamic Low Pressure	Partial loss of charge	1
3	High Pressure	Overcharge, blocked condenser	2
4	Open Clutch	Clutch wire open	3
5	Shorted Clutch	Shorted Clutch Coil	3
6	Low Psw open	Cut wire to Low Psw	4
7	High Psw open	Cut wire to High Psw	4
8	Low Voltage	Low battery voltage	Rapid Green
9	NO FAULTS	No faults, module functional	Red off, Green slow blink

4. Mechanical Specifications

General Description:

The module is designed to be mechanically rugged for survival in the underhood heavy duty commercial vehicle environment. The unit is potted in an epoxy compound that provides a thorough environmental seal and enhanced heat sinking for electrical components.

Dimensions:	
<i>Housing</i>	Refer to CM813 Specification Drawing
<i>Material/finish:</i>	Refer to CM813 Specification Drawing
<i>Mounting:</i>	Dual fasteners, .375" diameter; mounting torque 37 ft-lbs., maximum
<i>Encapsulation:</i>	Epoxy Resin
<i>Wires:</i>	18 gauge, color coded, SXL insulation
<i>Connectors:</i>	Customer specified, refer to CM813 Specification Drawing
<i>Marking:</i>	Part/Model number, traceable to date of manufacture
<i>Weight:</i>	0.55 lb. (8.8oz.)

5. Electrical Specifications

The module must be wired into the ignition circuit (NOT continuously powered) and must have a 7.5 amp fuse in series with the power lead of the module.

5.1 Parametric Specifications

Applicable over full operating temperature range: -40 to 212°F (-40 to 100°C)

Parameter	Min	Typ	Max	Units
Supply Voltage note 1	10.0	13.5	16.0	Volts
Supply Voltage note 2			24.0	Volts
Supply Current (no load)			50.0	mAmps
Load (AC clutch drive)	3.0	4.0		Ohms
Load (AC clutch drive)		0.1	0.20	Henries
Load energy $\frac{1}{2} L I^2$			1.5	Joules
Relay contact voltage drop		0.04	0.10	Volts
Load (Fan actuator circuit)	13.0			Ohms
Load (Fan actuator circuit)			80.0	mHenries
Input Debounce delay	0.3		1.1	Seconds
Open Clutch sense current	0.15	0.5	1.27	Amps
Shorted Clutch cut out resistance	1.7		2.4	Ohms
Voltage Cutout off threshold	10.8	11.0	11.2	Volts
TSTAT on range	5.0		VIGN	Volts
TSTAT off range	0		1.0	Volts

Notes: (1) Continuous operation, (2) Absolute maximum; two minute duration, (3) All voltages referenced to ground lead of device.

6. Environmental Specifications

Operating Temperature: -40 TO 212°F (-40 TO 100°C)
 Exposure Temperature: -40 TO 230°F (-40 TO 110°C)

6.1 Electrical Design Compliance

The CM813 will withstand, without permanent damage or subsequent degradation to performance, the following conditions:

- Reverse polarity; 16 VDC indefinitely
- Load Dump, 120 V peak
- Overvoltage; 24 VDC for two minutes
- ESD: 15k human body model

The device will not suffer any permanent damage and will be functional during the application of the following stimuli:

- RFI: 20V/m 1MHz to 1Ghz
- RFI: 50V/m 25 to 30 Mhz
- EMI: Power supply noise, mutual coupling

6.2 Mechanical Design Compliance

<i>Shock:</i>	Drop test onto concrete, six feet onto each of three mutually orthogonal surfaces.
<i>Vibration:</i>	Swept sine wave, three orthogonal planes, 10 to 2,000 Hz, 1 inch peak displacement, 6G maximum.
<i>Pressure Wash Immunity:</i>	1,100 psi, temperature of 140°F, spray nozzle 6-10 inches from unit.
<i>Chemical Immersion:</i>	Unit will be resistant to external or operational damage from 24 hour immersion into the following: Water Transmission Fluid Antifreeze/Water solution Windshield Washer Fluid Diesel Fuel Degreaser Brake Fluid Engine Oil Gasoline Kerosene
<i>Corrosion Resistance:</i>	Sprayed with the following substances: Salt Water, Battery Acid

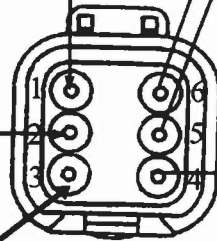
7. Product Life

The design service life for the CM813 is five years. Typical life will be in excess of five years, based on module "on" time of 4,100 hours per year. Product warranty for the CM813 and PM-700 pressure switches will be established through the Index sales and marketing department.

8. Testing the CM-813 Module

Pin number one (blue): A/C compressor clutch coil drive. An open, shorted wire, or shorted compressor clutch in this circuit causes the control module to disengage the A/C clutch and activate the red LED to blink three consecutive times. The A/C compressor will be latched off until the next ignition cycle, if open clutch is detected. (This diagnostic is not self clearing. You must cycle the ignition switch four times to clear the fault.)

Pin number two (red): Control module supply voltage, ignition switched. If voltage drops below 10.0 volts, LED will not illuminate. Low voltage signal is also detected in this circuit. This can be caused by a defective alternator, discharged batteries or excessive electrical loads. This diagnostic is self clearing, the blink code is displayed only while low voltage is present. If wire is disconnected or has an opened circuit, system will not function.



Six pin connector:

Pin number six: Not used.

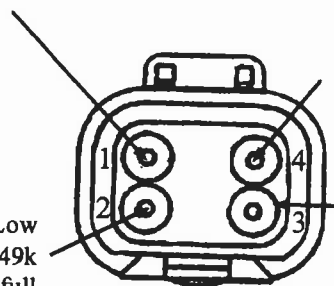
Pin number five (green): Evaporator thermostat and A/C on/off input. The evaporator thermostat is main A/C system control. The t-stat is wired in series with the A/C system on/off switch. These switches are configured to switch battery voltage when A/C operation is requested. If wire is disconnected or opened, system will not function. Control module will not know there is a problem.

Pin number four (black): Control module ground. All voltage checks must be grounded at this pin. If wire is disconnected or opened, system will not function.

Pin number three (orange): Engine fan actuator circuit. A ground signal is provided in this circuit to either a engine ECM or a fan solenoid valve to keep the engine fan off. When the high pressure switch switches to an open state, (pressure rising above 300psi) it will remove the ground from this circuit causing the engine fan to engage. Depending on the control module, the fan control is adaptive, depending upon the frequency of the request for operation. Fan timing has a minimum duration of 45 seconds and a maximum of three minutes. When the fan is requested, the fan control output removes the ground going to either the ECM or the fan solenoid. If wire is disconnected or opened, engine fan runs continuously.

Pin number one (white): Low pressure switch. The switch has a 2.49k ohm resister built into the header, with a full charge of refrigerant the switch is in the open position. If the pressure switch closes due to the pressure dropping below 10psi or a loss of refrigerant, the A/C clutch will disengage. If wire is disconnected or opened, the control module will disengage the A/C clutch and will activate the red LED to blink four consecutive times.

Pin number two (white/black): Low pressure switch return. The switch has a 2.49k ohm resister built into the header, with a full charge of refrigerant the switch is in the open position. If the pressure switch closes due to the pressure dropping below 10psi or a loss of refrigerant, the A/C clutch will disengage. If wire is disconnected or opened, the control module will disengage the A/C clutch and will activate the red LED to blink four consecutive times.



Four pin connector:

Pin number four (yellow/black): High pressure switch return. The switch has a 2.49k ohm resister built into the header, the switch is normally in the closed position. When pressure rises above 300psi the switch will activate the engine fan.. If wire is disconnected or opened, the control module will disengage the A/C clutch and will activate the red LED to blink four consecutive times.

Pin number three (yellow): High pressure switch. The switch has a 2.49k ohm resister built into the header, the switch is normally in the closed position. When pressure rises above 300psi the switch will activate the engine fan.. If wire is disconnected or opened, the control module will disengage the A/C clutch and will activate the red LED to blink four consecutive times.

Troubleshooting

BLINK CODES

Slow Green:	Unit is functioning properly
Fast Green:	Low System voltage
One Red Blink:	Loss of refrigerant
Two Red Blinks:	Fan failure or external condenser blockage
Three Red Blinks:	Voltage drop out, open or shorted wire to compressor clutch
Four Red Blinks:	Open wire in pressure switch circuit

Condition	Definition	Possible Cause	Action
Slow flashing green light.	Two seconds on, 1/4 second off.	Unit is functioning properly.	No action needed.
Rapid flashing green light.	Low system voltage, indicates low supply voltage condition. Voltage has dropped below 11.0 volts.	Possibly caused by a defective alternator, discharged batteries, poor ground or an excessive electrical load.	Check voltage at the control harness by probing pins 4 (ground) and 2 (power). If voltage is less than 11.0 volts start checking for voltage drops or a poor ground.
Ignition on, LEDs not flashing on control module or no lights on module.	Control module not receiving battery voltage.	Fuse or circuit breaker blown. Broken power or ground wire to control module. Defective control module.	Repair fuse or reset circuit breaker. Repair wiring. Replace control module.
Red light flashing one blink in sequence.	Low pressure fault. This is detected by monitoring the ambient temperature and switching activity of the low pressure switch.	A partial or total loss of refrigerant. A defective low pressure switch. Bad Schrader valve stem.	Install service gauges and check system for leaks. Disconnect the low side pressure switch connector and measure the resistance value of the switch. If the resistance shows 2.49k ohms, switch is operating properly. If resistance shows less than 5 ohms, replace the switch. Verify with the gauge set. Replace if necessary. <i>NOTE: This check must be done with the switch installed on the vehicle and the ignition in the off position and proper charge.</i>

Troubleshooting (Cont.)

Condition	Definition	Possible Cause	Action
Red light flashing two blinks in sequence.	High pressure fault. The system is exhibiting abnormal high pressure activity.	Fan drive failure. Blocked air flow through condenser.	Inspect proper operation of solenoid valve/relay and/or related components. Remove restriction from condenser.
Red light flashing three in sequence.	Open wire to A/C clutch. Detected by inadequate current through the compressor clutch. If no current is sensed when the A/C drive is turned on, an open connection to the clutch coil is indicated. Shorted wire or shorted A/C clutch. Detected by excessive current through the compressor clutch.	A break in the wiring between the control module and the A/C compressor clutch or a break in the clutch coil. This is indicative of either a shorted coil or shorted wiring to the clutch.	With the use of an ohm meter check the resistance of the clutch coil. If the reading is less than 2.8 ohms, replace the clutch. On the truck harness side of the 6 pin connector verify the resistance between pins one and four is either greater than 5 ohms for an open clutch condition or less than 2 ohms for a shorted clutch condition. Next, check for a bad clutch or bad clutch ground. If clutch resistance is greater than 5 ohms to ground, verify the ground connection before replacing the clutch. If clutch resistance is less than 2 ohms replace the clutch. If the clutch is OK locate the opened, frayed or shorted wiring and repair.
	Fluctuating battery voltage.	Fluctuation greater than one volt caused by a defective voltage regulator.	Replace the alternator / regulator unit.
Red light flashing four blinks in sequence.	Opening in wiring harness to high or low pressure switches.	Unseated connector. Break between wiring harness and pressure switch.	Check both the module and the pressure switch connectors for loose pins. Check connector seals for integrity.

Troubleshooting (Cont.)

Condition	Definition	Possible Cause	Action
		Moisture intrusion into the connectors or switch.	Check pressure switch circuits for continuity. In a properly charged system: Disconnect the high pressure switch and verify the resistance between the switch's two contacts is less than 5 ohms. Disconnect the low pressure switch and verify the resistance between the switch's two contacts is between 2.4K and 2.6K ohms.
		The use of non-Index pressure switch.	Install the correct pressure switch.
A/C clutch not engaging during the first 15 seconds after ignition is turned on.		Unit is functioning properly. Regardless of A/C system state at start up, the A/C clutch is disengaged for the first 15 seconds.	
At ignition turn on with A/C controls set to the on position, compressor is off for 15 seconds, on for 15 seconds, then remains off indefinitely.	No voltage on the A/C ON / Evaporator thermostat circuit. Six way truck harness connector, pin 5.	Defective AC ON / Evaporator thermostat circuit.	With the ignition on and the A/C switch on and the evaporator core temperature above 50 degrees there should be system voltage on the truck harness connector at the A/C ON / Evaporator thermostat pin. Check for bad A/C On switch. Check for break in wiring between A/C On switch and the evaporator thermostat. Check for bad evaporator thermostat. Check for break in wiring between the evaporator thermostat and the APADs module.

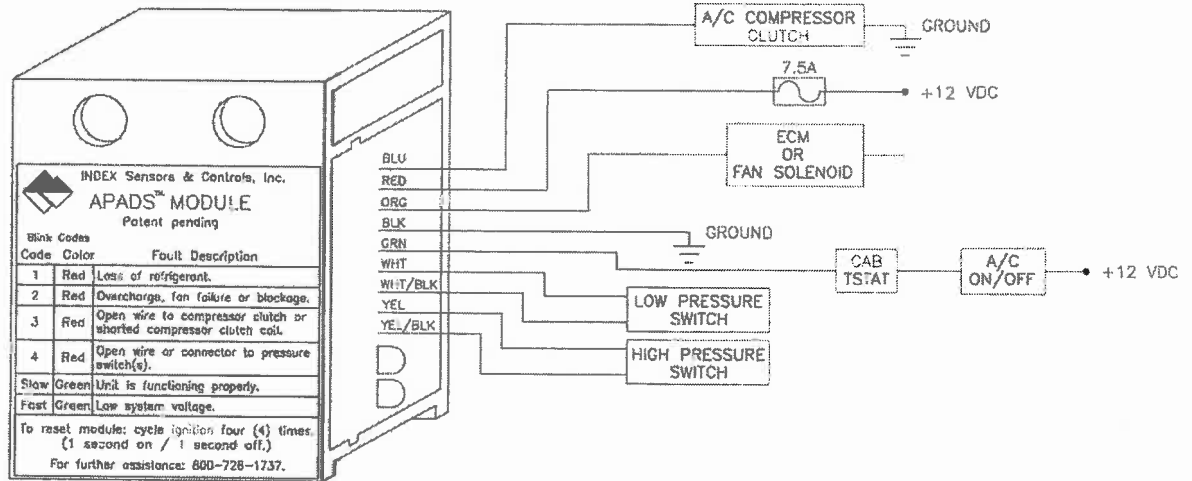
Troubleshooting (Cont.)

Condition	Definition	Possible Cause	Action
			Check for bad A/C relay.
At start up, after 15 seconds, compressor clutch doesn't engage but engine fan engages.	Control module sensing an opening in the high pressure switch circuit.	High side pressure switch failure.	In a normally pressurized system: Disconnect the high pressure switch. A good switch should measure less than 5 ohms. If not, replace the switch.
Slow flashing green, compressor on for a short period of time, off for 15 seconds in a repetitive sequence.		Blockage in the high side of the system or in the condensor.	Repair restriction.
		Partial loss of refrigerant.	Check system for loss of refrigerant.
Slow flashing green light, not engaging in defrost mode or in cold weather.		Unit is more than likely functioning correctly. If the ambient temperature is too low, the compressor clutch is not allowed to engage, because of low system pressure.	
Slow flashing green light, clutch is engaged, A/C not cooling.		Inoperative blower motor.	Check for proper operation of the blower motors.
		Loose or broken compressor belts.	Tighten or replace compressor belts.
Slow flashing green light or poor A/C performance.		A/C drive belt is broken, loose or glazed.	Tighten or replace drive belt.
		Heater valve left open, valve is broken or cable is not operating properly.	Turn valve off or replace valve or cable.
		Moisture in the system.	Check moisture indicator on drier. Replace if necessary.
		Air ducts leaking air flow.	Repair air leak problem.
		Loss of charge before detected.	Check with gauge set, repair leak if necessary.

TO CLEAR FAULT CODES

Clear the fault code by cycling ignition switch four times (one second on/one second off) and the green light will reappear.

APAds® CM-813 I/O



A/C System with APAds®

