# Peltier Cooled Thermal Management System
# User's Guide

For use with StellaCam II, StellaCam3 and Wat-120N astro-video cameras


Developed and maintained by
CosmoLogic Systems, Inc.

Thank you for purchasing the Peltier Cooled Thermal Management System upgrade to your StellaCam II, StellaCam$^3$ or Wat-120N astronomy video camera. This upgrade will provide you with a dramatic improvement in your images by reducing the thermal noise associated with an excessively warm CCD sensor. This improvement is accomplished by cooling and regulating the temperature of your camera's CCD sensor.

# I. System Description

## A. Regulated CCD Cooling

A significant advantage provided by the upgrade is precise regulation of the CCD sensor's temperature. Changes in ambient temperature will not affect the temperature of the CCD because the CCD is maintained at a constant temperature. This regulation is accomplished by incorporating temperature sensors which feedback the CCD sensor temperature along with the camera's enclosure temperature to a microcomputer based control unit (MCU). By monitoring these temperature readings, the MCU is able to maintain the CCD temperature by precisely controlling power being applied to a set of Peltier modules which are thermally bonded to the CCD. The Peltier modules act as a heat pump to draw heat from the CCD sensor and exhaust it through the camera's enclosure, which also has a heat sink and fan attached to it. The enclosure temperature is monitored by the MCU such that if it gets too warm, the MCU will turn on the cooling fan to help remove the heat. The cooling fan will be turned back off if the enclosure temperature drops to an adequate level determined by the MCU.

Since the camera enclosure acts as a heat sink, attaching the camera to your telescope provides additional heat sinking. When attached to a telescope, the system will typically provide about –60 °F of cooling to the CCD sensor compared to an unmodified camera. Even if the cooling system is turned off, there will still be around –20 °F of cooling provided compared to an unmodified camera. This is due to the thermal bonding of the CCD to the enclosure along with the side-mounted heat sink plus the telescope also acting as a heat sink.

An unmodified camera's CCD typically runs at about 110 °F in an ambient environment of 70 °F. Therefore, at this ambient, the cooling system will typically drop the CCD temperature down to 50 °F (10 °C). This is the target temperature for regulation. So in warmer ambient environments, the target temperature of 50 °F may not be reached. In cooler ambient environments, the CCD temperature will be maintained steady at 50 °F unless the environment is so cold that power to the Peltier modules is completely shut off.

An unmodified camera's CCD runs at about 50 °F in an ambient environment of zero °F (not a 1-to-1 temperature correlation). Therefore, this upgrade will give you the equivalent thermal noise level of a zero °F environment while the actual ambient environment may be at 70 °F!

## B. CCD Window Defogger

The design implementation of the Thermal Management System provides a defogger mechanism for the CCD's imaging window. Since the "hot" side of the Peltier modules are mounted to the nose-piece of the camera's enclosure, the warmest part of the enclosure is located just a few thousandth's of an inch above the CCD's window. The heat from this part of the enclosure radiates onto the CCD window, acting as a defogger to keep condensation from forming on the window. In extremely humid environments, the radiant heat may not be adequate to keep condensation from forming. If this occurs, a thermal gasket can be installed to conduct heat directly from the nose-piece to the CCD window, providing enough heat to evaporate the condensation. It should be noted however, that this would reduce the cooling capacity of the system.

## C. User Interface

The user interface to the system consists of a single LED indicator light which also functions as a push-button switch, as well as an optical data port.

The push-button switch is used to toggle between "cool down" and "warm up" operating modes* of the system. The system automatically begins controlling the CCD's temperature when power is first applied to the camera. If the CCD is above 50 °F when power is applied, then the "cool down" mode is activated. If the CCD is below 50 °F, then the "warm up" mode would be active until it reaches 50 °F.

The optical data port is used with an optional Optical Data Cable which can be connected to your computer's COM port or USB port via a Serial-to-USB adapter.

**Cool Down:**
While the system is cooling the CCD, the indicator light flashes at a "fast" rate of four times per second. When either the target temperature has been reached (CCD = 50 °F) or when the Peltier module power reaches 100%, the indicator light dims down and becomes steady "on" to indicate that the "cooled state" has been achieved. The system cools the CCD at a 3 °F per minute rate and will take about 10 minutes (depending on ambient temperature) or less to reach its "cooled state" after power up.

**Warm Up:**
While the system is warming the CCD back up, the indicator light flashes at a "slow" rate of once per second. When the Peltier modules power becomes 0%, the indicator light turns "off" to indicate that cooling is no longer being applied to the CCD sensor. The system allows the CCD to warm up at a 6 °F per minute rate and it typically takes about 10 minutes (depending on ambient temperature) for the CCD sensor to completely warm up.

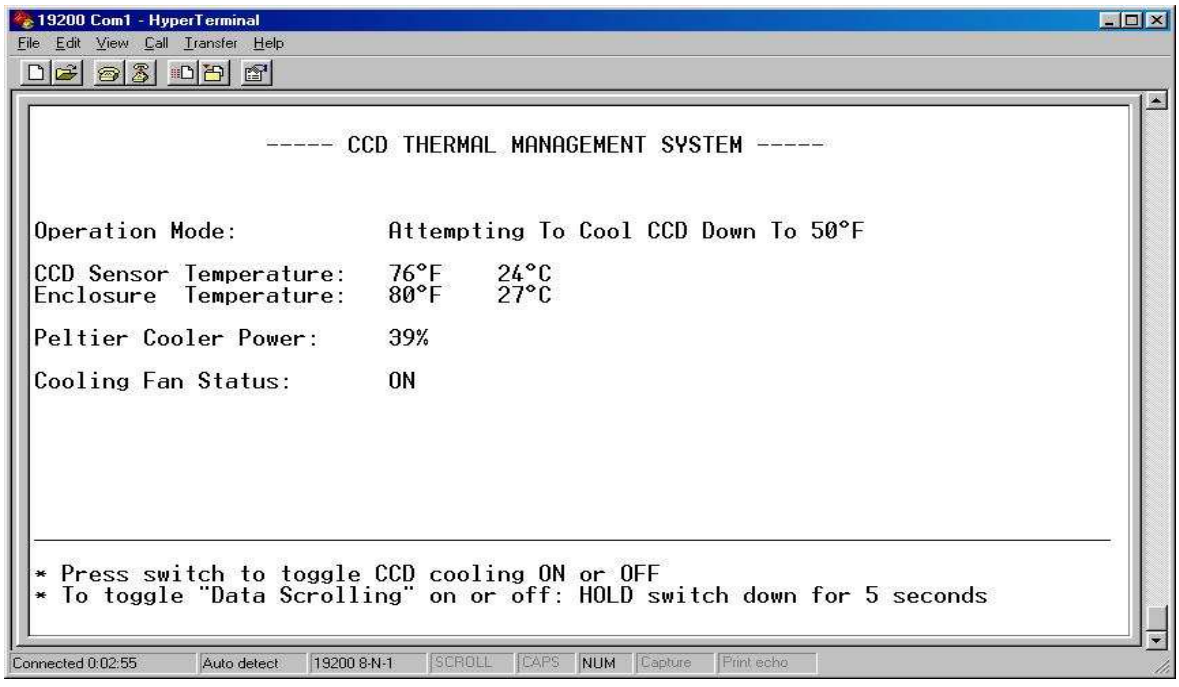
If power is removed from the camera while the CCD is in a "cooled state", the Thermal Management System will not be operating electronically and therefore will not be actively controlling the warm up rate of the CCD. Due to the thermal resistive elements within the system, the CCD will not be subjected to a severe warm up rate so this will not damage the camera, however it will place unnecessary thermal stresses on the CCD. Therefore**, WE STRONGLY RECOMMEND THAT YOU ALLOW THE SYSTEM TO WARM UP THE CCD BEFORE DISCONNECTING POWER TO THE CAMERA**. By allowing the system to control the "cool down" and "warm up" rates of your camera's CCD, you will actually be inducing less thermal stress on the CCD than it was exposed to before the modification was installed – leading to an improved life expectancy of your camera.

* Note: If the CCD is already below 50 °F, you cannot toggle to the "cool down" mode – it can only "warm up" to 50 °F.

## User Interface (cont.)

**Self-Diagnosis:**
The Thermal Management System constantly performs a self-diagnosis and is able to detect and report a number of potential failures. In the unlikely event that a failure occurs, the system will indicate the failure by strobing the indicator light. The light will flash at a high rate for one second, then go off for one second and continuously repeat this cycle. You will need to use the Optical Data Interface to view the failure report (see below). Possible component failures are: bad temperature sensor, out-of-tolerance temperature sensor, Peltier module failure, or power driver failure. Some failures, such as an "enclosure temp sensor failure" will not adversely affect the operation of the cooling system – but may reduce its efficiency in cooling the CCD. Other failures, such as "CCD temperature sensor failure" will cause the system to slowly shut off power to the Peltier modules – inhibiting its ability to cool the CCD. Of course, any failure within the Thermal Management System will not affect the operation of your camera – just the benefits that come from cooling it.

**Optical Data Interface:**
In addition to the LED acting as a status indicator, it may also be used as a data port to connect the Thermal Management System to your computer. An Optical Data Cable is available as an option that interfaces the cooling system to your computer. The "TMS Optical Data Cable" consists of an optical coupler on one end that simply plugs onto the LED. The other end of the cable contains a 9-pin female "RS232" com port connector. This connector plugs into either your computer's com port or into a Serial-to-USB adapter and then to your computer's USB port. When the Thermal Management System detects a "cable connection", it begins transmitting data optically through the LED. The optical data is converted to an RS232 format, so your computer receives standard text data. To view the data you need to run a communications program such as Procomm or Hyperterminal. Hyperterminal is a communications accessory that comes standard with all Windows operating systems. With Hyperterminal running, you will get a display showing the current mode of operation, the CCD sensor temperature, the enclosure temperature, the power level being applied to the Peltier modules, the cooling fan status, and some basic instructions. In the unlikely event that a failure occurs, a message describing the nature of the failure would also be displayed.




Thermal Management System display using Hyperterminal

## D. Thermal Management Advantages

**Dark-Frame Stability:**
Since the CCD sensor is regulated at a constant temperature, any thermal noise that may still be present will now be constant. This simplifies image calibration with respect to dark-frame subtraction. Any noise present in the dark-frame is not going to change as the ambient temperature changes. So as long as you operate within an ambient between around 0-to-70 °F, your dark-frame is going to be the same. Even at 80 °F, the dark-frame is going to be so close that you probably won't see any difference. This means that you'll be able take a single dark-frame and use it to compensate (remove hot pixels) any image you process later on! And very likely any time of the year as well - depending on your climate.

**No Condensation:**
Another advantage to using the camera's enclosure as a heat sink is the avoidance of condensation within your camera's body. Anytime a surface is colder than the air next to it, moisture in that air can condense onto the surface – especially in a high humidity environment. With this design modification, the enclosure will always be warmer than the air inside or outside of your camera, therefore condensation cannot form on the walls of the enclosure. The electronics within your camera will always be protected from the hazard of condensation droplets falling on sensitive components.

**Deeper Cooling / Better Noise Reduction:**
Since the CCD temperature is regulated, you get the maximum amount of cooling required to achieve the best noise reduction results over a wide operating range of ambient temperature. A non-regulated system would not be able to achieve –60 °F of cooling and operate over such a wide range. With such a system operating in colder ambient temperatures, you would risk damaging the CCD by exceeding it's minimum operating temperature specification – thus, it would be up to the operator to remember to turn the system off during cooler weather. With active thermal management, you get the full benefits of deep cooling without having to worry about damaging your camera's CCD sensor.

The following diagrams show the effects of cooling a "thermally noisy" Stellacam II camera by –45 °F. The dark frames were taken in an ambient environment of 65 °F with the stacking set to 256, gain set to Hi, and gamma turned off. The camera was mounted on a telescope.

Cooling Off, CCD = 95 °F

Cooling On, CCD = 50 °F

# II. Operating Your Cooling System

The Peltier Cooled Thermal Management System was designed to be as simple to use as possible. When you apply power to your camera the system automatically begins to monitor and control the temperature of your camera's CCD sensor - just let it run.

Normally the system will enter the "cool down" mode* at power up. This will be indicated by the flashing of the LED light at a "fast" rate of four times per second. In a warm ambient environment (>60 °F), it will typically take about 10 minutes for the CCD sensor will reach its "cooled state". When this occurs, the LED will become constant "ON". From this point on, the CCD temperature will automatically be regulated "steady" through out the night – even as the ambient temperature drops.

When you are finished with your observing session, simply press on the LED and release. This will place the cooling system into its "warm up" mode. The "warm up" mode will be indicated by the flashing of the LED light at a "slow" rate of once per second. After about 10 minutes the LED will turn "OFF", indicating that the cooling system is no longer activated. You can now remove power from the camera and "pack it up" for the night.

At any time while power is applied to your camera, you can monitor your CCD temperature along with other cooling system parameters by attaching the (optional) TMS Optical Data Cable between the LED on your camera and your computer's data port. Refer to "Optical Data Interface" in the "User Interface" section of this guide.

* Note: If the CCD is below 50 °F at power up, it will enter into the "warm up" mode until the CCD reaches 50 °F.

# III. Power Considerations

**Recommended Power Supply:**
With the Peltier Cooled Thermal Management System installed in your camera, you may need a larger capacity power source to run it. An unmodified camera only requires about 160mA at 12vdc, however with the cooling system installed, it will now require about 610mA at 12vdc. If you were using the power adapter supplied with your camera, it will not be adequate to power your modified camera. We recommend that you use a regulated 12vdc supply with a capacity of 700mA or greater.

We recommend that you use a regulated supply (either AC adapter or DC-to-DC converter) to power your camera because the load current changes as the power to the Peltier modules change. With an unregulated supply or direct-to-battery connection, the supply voltage will not be constant. As the load current increases, the supply voltage will drop and this may affect the system performance. Therefore, we highly recommend using a regulated supply.

A regulated AC-to-12vdc, 830mA power supply adapter or a 12v DC-to-DC converter are both available as optional accessories.

**Ground Loop Interference:**
If you are using the same power supply source for both your camera and your monitor (battery or adapter), you may experience interference on your video display. This interference is due to switching currents from the Thermal Management System through a ground loop that this configuration creates. The ground loop exists because there are two parallel ground connections between the camera and the monitor – one from the video cable and one from the power supply. The longer the cable runs, the larger the ground loop is, and the greater the interference will be. For short cable runs, the interference may not be noticeable.

If you experience interference, eliminating the ground loop will eliminate the interference. This is done by simply isolating the power sources between the camera and the monitor, which removes the "power supply ground" connection between the camera and the monitor. Using separate isolated power supplies will accomplish this.

If you desire to use a single battery for both camera and monitor, you can either power the camera with a DC-to-DC converter connected to the battery or an AC-to-12vdc adapter plugged into an inverter connected to the battery. You can then run the monitor directly from the battery or use another DC-to-DC converter or inverter/adapter between the monitor and battery. If using a single battery, you may also try using a "Composite Video Isolator" in-line with the video cable. This will break the ground loop through the video cable to eliminate the interference – however it may not be as effective as isolating the power supplies.

# IV. System Specifications

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| Operating Ambient Temperature Range: | -40 °F to +145 °F<br>(note: camera operating range is +14 °F to +104 °F) |
| Regulation Ambient Temperature Range: | 0 °F to ~ +70 °F |
| CCD Cooling Capacity: | -55 °F typically<br>-60 °F with scope assisted heat sinking |
| CCD Regulation Temperature: | +50 °F when Peltier module power is less than 100% |
| Cooling Regulation Accuracy: | ±1 °F (± ½ °C) |
| CCD Cool-Down Rate: | -3 °F per minute |
| CCD Warm-Up Rate: | +6 °F per minute |
| CCD Cool-Down / Warm-Up Time Period: | 10 minutes typically (depending on ambient temp.) |
| Power Requirement (cooling system only): | 9.5vdc to 15vdc @ 450mA max |
| Total Power Requirement (including camera): | 9.5vdc to 15vdc @ 610mA max |
| Recommended Power Supply: | 12vdc, Regulated @ 700mA or greater |
| Weight (cooling system only): | 1.6 oz (45 g) |
| Weight (including camera): | Approximately 7.1 oz (200 g) |

Optional Accessories:

- TMS Optical Data Cable for Computer Interface
- Serial-to-USB Adapter
- AC-to-DC Power Supply Adapter: AC input, Regulated 12vdc, 830mA output
- DC-to-DC Converter: 9-18vdc input, Regulated 12vdc, 1250mA output

# IV. Warranty Statement

The manufacturer warrants the original purchaser of the PELTIER COOLED THERMAL MANAGEMENT SYSTEM (PCTMS) Upgrade that it shall be free of defects resulting from faulty manufacturer of the product or its components for a period of one year from the date of sale. Defects covered by this warranty shall, at the option of the manufacturer, be corrected either by repair or by replacement. The replaced components will be warranted for the remainder of the original one year period.

The sole obligation of the manufacturer under this warranty is limited to repair or replacement of products pertaining to the PCTMS upgrade only, which prove to be defective within one year of purchase. The manufacturer shall not, in any event, be liable for any consequential damages or loss of profits of any kind resulting from the use of the PCTMS upgrade or the technical information enclosed in this document.

Please fill out the Product Registration Form and fax or mail it to CosmoLogic Systems, Inc. This product must be registered within thirty (30) days from the date of purchase in order to activate your warranty coverage.

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## Product Registration Form

Please fill out the following information and send it to:

CosmoLogic Systems, Inc.
11112 204th Ave Ct. East
Bonney Lake, WA 98391
Ph: (253) 862-4863
Fax: (253) 863-1689
Email: CosmoLogic@timemachine.org

By sending this form back to us, we can let you know of additional products and upgrades as they become available. This form is also used to activate your warranty coverage.

| | | |
|---|---|---|
| Name | Address | |
| Camera Type | City | |
| Camera Serial Number | State | Zip |
| Phone | Email | |
| Purchased From | | Date Purchased |