

# Temperature Sensor for a Meade DSI-I Camera with Software for Auto Dark File Selection

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Updated July 27, 2006

Updated September 24, 2006

## Updates July 27, 2006, software version 1.1

- 1) USB to 1-wire adapter DS9490R tested, works ok.
- 2) Button "Force new dark" added to force selection of a new dark file corresponding to the present temperature
- 3) the time interval for the log file can now be set in 5 second steps
- 4) specific error messages for missing sensor or missing interface
- 5) Review and/or edit the exposure time setting and the temperature stamp added to the filename

## Updates September 24, 2006, software version 1.1.1

- 1) better error handling for missing or empty directories etc.
- 2) Option added to save *all* dark files taken at a specific temperature (i.e. series of darks with different exposure times) to the library, with prompts

This is a description of a project which adds a temperature sensor to a Meade DSI-I camera and software which automatically selects a dark file corresponding to the CCD temperature, similar to the DSI-II series camera which has an integrated temperature sensor. After dark file selection, the Envisage imaging session has to be restarted (my program cannot control Envisage by itself). Hardware costs are between about \$10 or \$25 depending on the interface solution.

Warning: adding the temperature sensor to the camera means opening the camera housing and doing modifications which may terminate your warranty for the camera. I take no responsibility whatsoever with regard to damage done to your camera, should you use this description to reproduce my project. In addition, I am not responsible for any damage that the software described below might cause to your computer soft- or hardware.

## I. Introduction

The temperature sensor used in this project is a DS18S20 sensor manufactured by Dallas Semiconductor, now Maxim-Dallas. It costs about 5 \$ and should be available in any electronics store. Detailed information about this sensor can be found under [http://www.maxim-ic.com/quick\\_view2.cfm/qv\\_pk/2815](http://www.maxim-ic.com/quick_view2.cfm/qv_pk/2815) and the links in that document, including a full pdf data sheet. The following is an excerpt of the above document:

"The DS18S20 Digital thermometer provides 9-bit centigrade temperature measurements and has an alarm function with nonvolatile user-programmable upper and lower trigger points. The DS18S20 communicates over a 1-Wire® bus that by definition requires only one data line (and ground) for communication with a central microprocessor. It has an operating temperature range of -55°C to +125°C and is accurate to ±0.5°C over the range of -10°C to +85°C. In addition, the DS18S20 can derive power directly from the data line ("parasite power"), eliminating the need for an external power supply."

The temperature readout precision can be increased to 0.06 degrees centigrade by software. I used that increased precision in my software

The DS18S22 sensor comes in a TO-92 housing (like a small transistor) which can easily be mounted directly in contact with the DSI-I CCD chip. There are only two wires (signal and ground) between the sensor and the host computer and no extra power supply.

For communication with a host computer, you need just a few components soldered to a serial interface connector (9-pin sub-D, see below) and a serial port of your PC or laptop. A more convenient alternative, especially for laptops, is a USB interface which is available as DS9490R and costs about 20\$. The present project is only tested with the serial interface version, as I am still waiting for the USB interface to arrive. The software is prepared for the USB interface, but not tested. **Update July 27, 2006** tested with DS9490R USB interface.

There is full software driver support for the sensor (and all other 1-wire devices) available under <http://www.maxim-ic.com/products/ibutton/software/tmex/index.cfm>

This includes support for the Microsoft .NET environment. I used these drivers to write a small Windows program in VisualBasic.NET (using Visual Studio .NET 2003 and the .NET framework version 1.1 that Meade Envisage uses as well). This program periodically reads out the CCD temperature in a predetermined time interval (5 sec) and displays it. Optionally, the program selects an appropriate dark file from a dark file library corresponding to the current CCD temperature and copies it into the dark file directory selected in Envisage. The program recognizes (or sets) the "Delta Temperature" setting in Envisage, which otherwise has no function for a DSI-I camera. If no fitting dark file is found, the program asks you to take a new dark file (or files) at the given temperature, to be stored in the dark library.

As the program cannot control Envisage directly, you are asked to manually stop and restart the imaging process as soon as the dark file has changed. Envisage does not automatically use a new dark file when you just replace the file in the dark directory. You need to do a Preview and then start imaging again.

To use my program, you need to install the 1-wire drivers, one dll (Dynamic Link Library) the Visual J# Redistributable Package 1.1 from Microsoft (required by the dll) and my application. It is assumed that you have installed Meade Envisage, which in turn requires that you have the .NET Framework version 1.1 installed on your computer. This is all described in detail below.

## **II. Hardware**

### A) Sensor

In this description, the task sounds more difficult than it is in reality. I did it in one evening. Writing this report took much longer. It should not be your very first electronics project, however.

Warning! The DSI-I camera contains components that are sensitive to static discharge. Take the same precautions as if you were working on components of your PC. You are not going to make any connections to the camera circuit, however.

To open the DSI housing, loosen the 4 hex socket screws in the corners of the front (CCD) side. Attention! Lo and behold, these are *metric* M3 screws, to the delight of this European

citizen. To open, put the camera face up and lift the front piece off. There is a rubber ring between the two halves. Be careful not to damage it.



Fig.1 This is how the CCD-side of the DS1-Pro looks like. The sensor is mounted to the lower edge of the CCD

You can now lift the circuit board out of the lower housing part. Whenever you do that, be very careful when you put the board face down. Never put it on the desk with the CCD face down because you might scratch the CCD window. You should always put it back into the upper housing part where the CCD is sitting on a rubber pad.

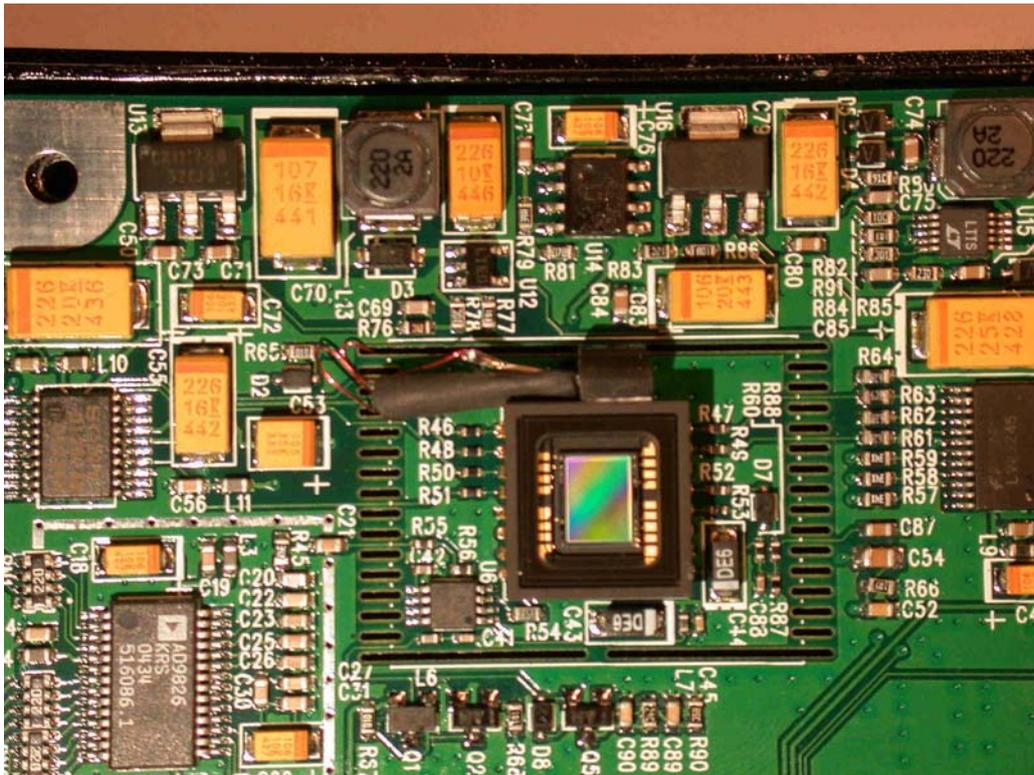


Fig.2 Sensor with wires

To prepare the sensor, bend the pins 1 and 3 (the outer ones) such that you can solder them together. Solder a very thin insulated wire to pin 1/3 and one to the center pin 2. I used ~20 cm long pieces of a 0.1mm copper wire that is insulated by a Formvar varnish. This is the wire that is used e.g. for winding inductors or wiring up experimental circuit boards. Most PVC insulated wires will be too thick. Of course, you cannot use bare copper wires. The insulating varnish can either be scraped off before soldering, or just heat the wire ends up long enough until the varnish is burned away and the wire end is pre-tinned. Use shrink tubing to insulate the pins.

The TO-92 has a large flat face which is the one that will be in contact with the CCD. One of the side faces will be glued to the DSI-I circuit board. When mounted that way, I had the feeling that the TO-92 housing of the sensor would be just flush with the CCD surface, which was a little to close for my taste. I carefully sandpapered the sensor housing on the side that is glued to the board so that the sensor remains clearly below the CCD surface. I guess that I took off half of a millimeter. Be careful not to exaggerate here. Once you can see the chip inside, you've lost a sensor!

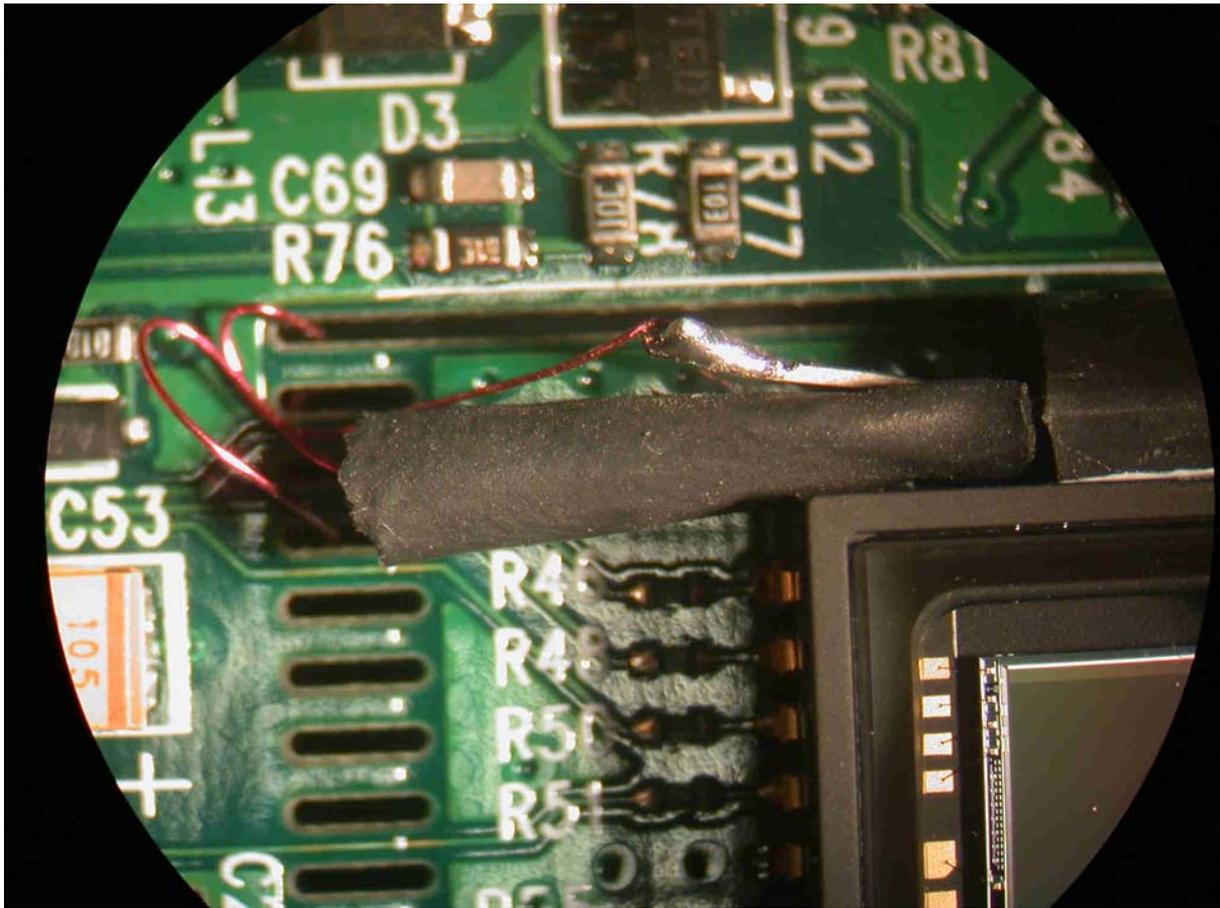


Fig. 3 Sensor closeup with wires going to the backside of the DSI board

In Fig. 3 you can see the wires with the red varnish insulation. Before gluing the sensor in place, thread the two wires to the backside through the slots in the DSI board (Fig. 4).

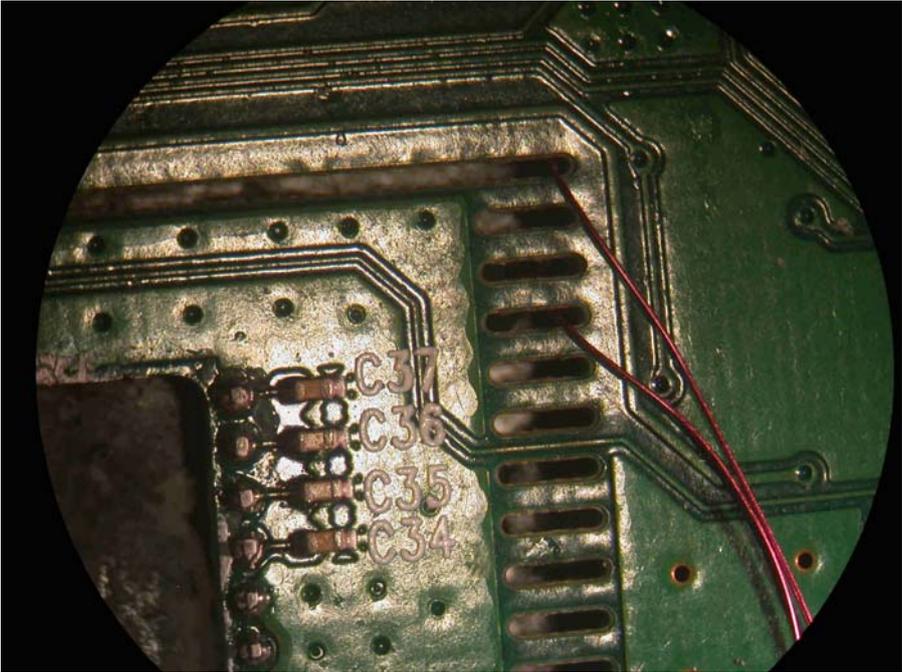


Fig. 4 insulated wires coming out of the slots on backside of CCD board

Now comes the dangerous part: apply a small amount of thermal grease to the flat face of the sensor. Apply a small amount of epoxy adhesive to the circuit board close to the CCD. You should take epoxy with a short curing time (10 min). Be very careful not to come even close to the front window of the CCD with either epoxy or thermal grease. Press the sensor with the sandpapered face into the epoxy adhesive and at the same time make sure that it is pressed against the CCD to make good contact with the CCD housing.

***Never, ever let thermal grease or Epoxy get in contact with the CCD front glass!*** You might be able to wash off the thermal grease, but you will definitely spoil your day with Epoxy on the CCD.

I was anxious enough to hold the sensor in its position for 10 minutes until the epoxy was cured. Yes, that is a similar feeling to doing a manually guided exposure with your eye glued (no pun intended) to the guiding eyepiece.

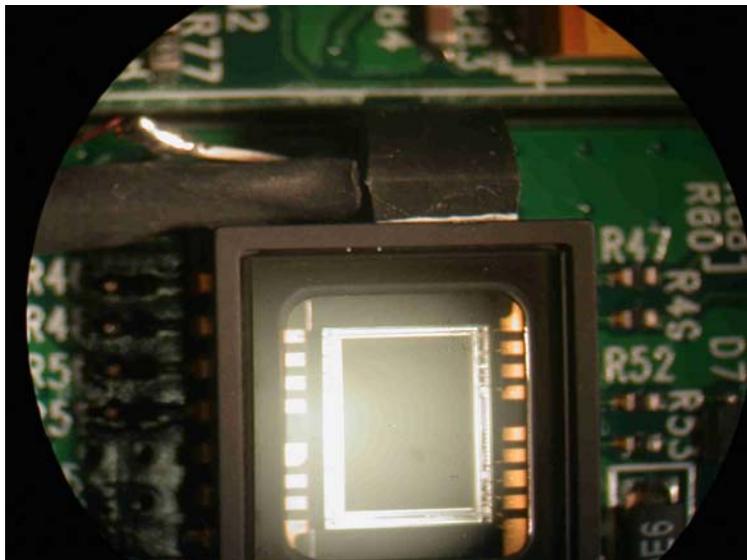


Fig. 5 Sensor glued in place. You can see the thermal grease on the flat face of the sensor

For connecting to the outside world, I drilled a small hole into the heatsink part of the housing for a 2.5mm mono-plug (Fig. 6 and 7)

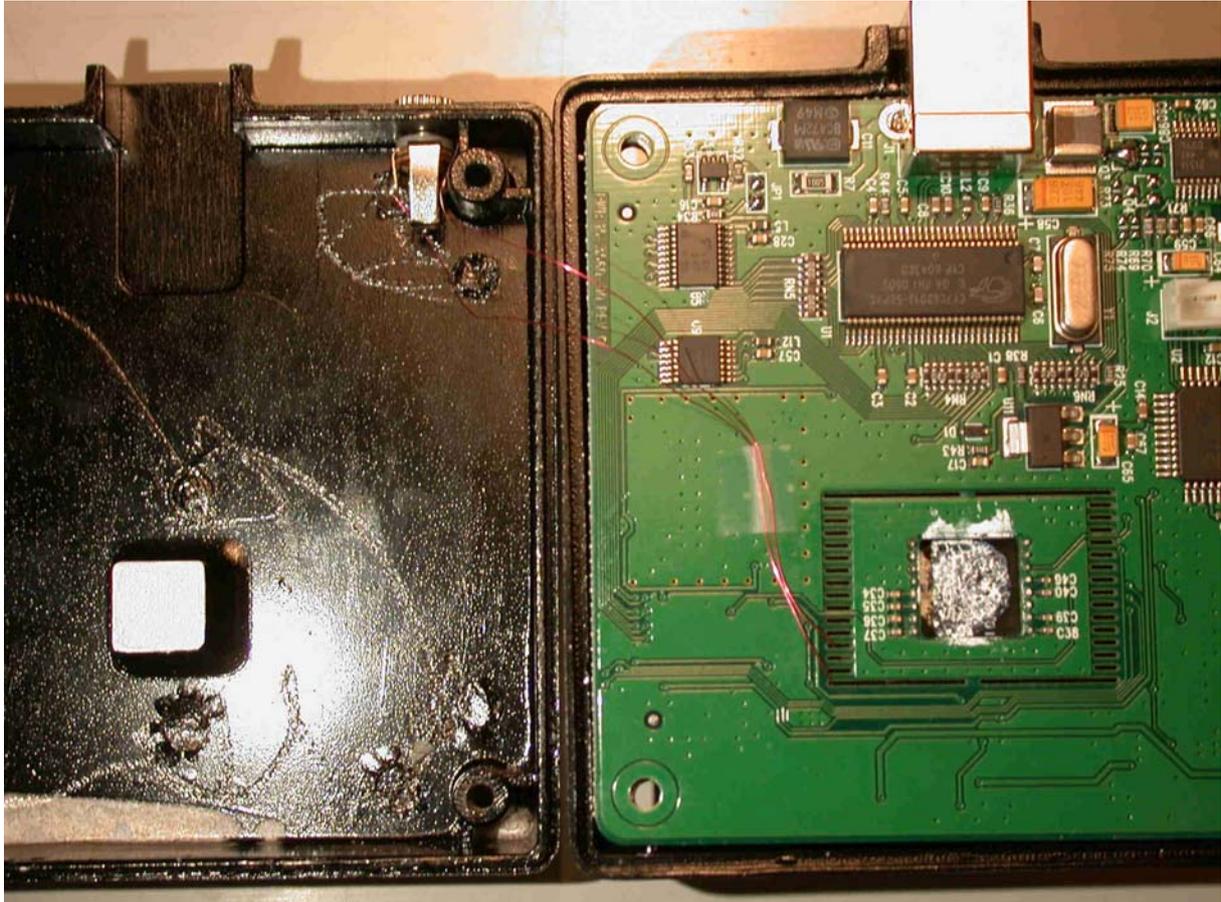


Fig. 6 Wiring to the outside world. You can see the heat sink covered with thermal grease and the backside of the CCD with thermal grease

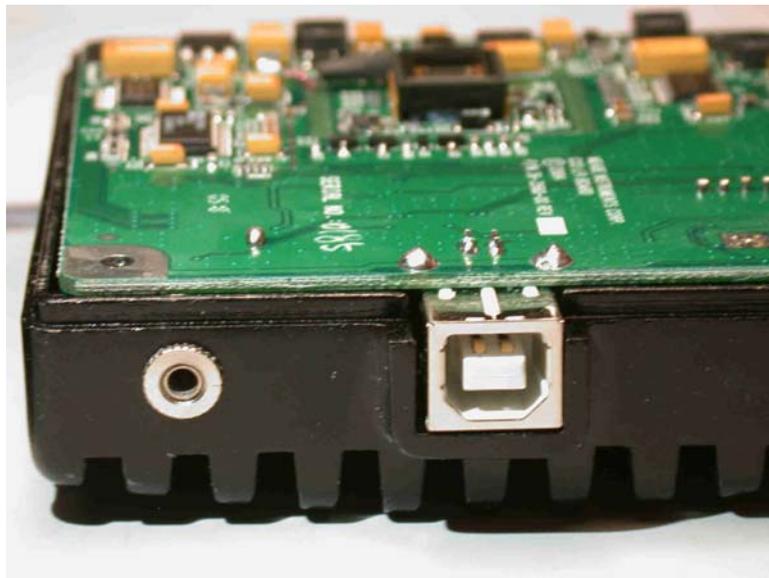


Fig. 7 2.5 mm mono plug mounting to the left of the USB plug

You need to mount the connector as close to the corner and as close as possible to the bottom of the housing so it does not interfere with the components on the CCD board. To the right side of the USB plug, there are larger components on the board close to the edge, so you should not mount the connector there. Be aware that one of the contacts of the connector is on ground potential now (connected to the camera housing). You need to solder the ground wire

(connected to pins 1 and 3 of the sensor) to this contact. If you use a stereo plug, you could have the sensor wires floating, i.e. without contact to the DSI ground. This would enable you to use a simpler serial interface (see below).

Check the wiring again and be sure that nothing shorts out anything. You might have to put some insulating tape around the connector. Carefully reassemble the camera housing. It may take you a while until you have the rubber seal exactly back where you want it. Do not squeeze it in the wrong place. The difficult part is over!

### B) Serial Interface

If you want to know all details about the serial interface to a 1-wire device like the DS18S22, have a look at

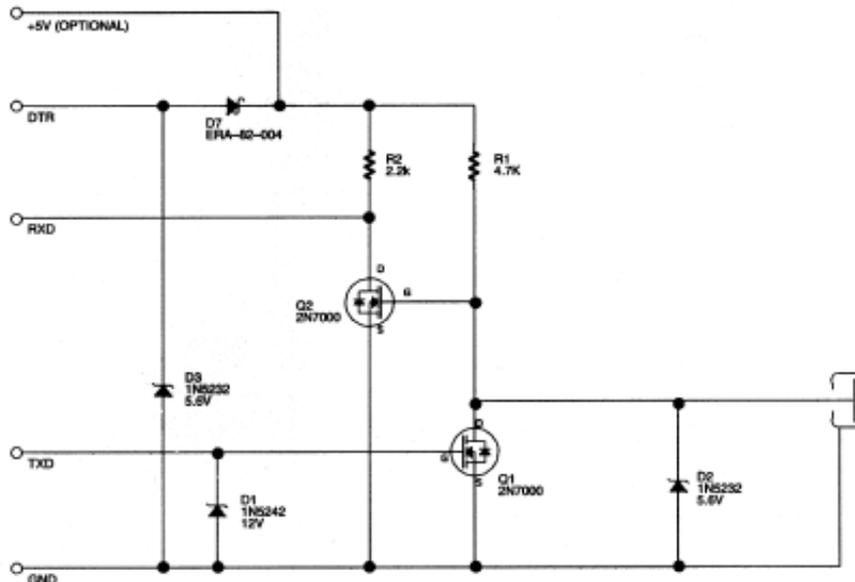
<http://pdfserv.maxim-ic.com/en/an/app74.pdf>

The following information is from that document:

**Table 2**

SIGNAL	9-PIN CONNECTOR	25-PIN CONNECTOR	DESCRIPTION	FUNCTION
RXD	2	3	Receive Data	input
TXD	3	2	Transmit Data	output
DTR	4	20	Data Terminal Ready	output
RTS	7	4	Request to Send	output
GND	5	7	Ground	(reference)
DSR	6	6	Data Set Ready	input
CTS	8	5	Clear to Send	input

**5V RS232 READ ALL CIRCUIT Figure 10**



The parts you need are one Zener diode 12 Volts, two Zener diodes 5.6V, one Schottky-diode (I used a BAT46 in place of the ERA-82-004) a 2.2 kOhm and a 4.7kOhm resistor and two 2N7000 transistors (which I replaced with BS170, a run-of-the-mill N-channel enhancement FET). You do not need the optional 5V supply. There is a simpler interface in the same document with only a few diodes which however needs a floating connection to the sensor.

You cannot use that interface with the mono plug because with that connector one end of the sensor is connected to ground at the camera. If you use a stereo plug and have the sensor connected floating, you could use the simpler interface as well.

You can solder the components directly to the 9-pin D-Type connector for the serial line (needs a female connector). They easily fit into a standard connector housing. I used a very flexible ~1,5 m long cable taken from a defective headphone for the connection between this plug and the mono plug at the camera. Any other shielded cable will do as well. Connect the shield to the ground side.

The interface was tested with the serial interface of an IBM X4 UltraBase (docking station for an IBM X41 Thinkpad which has no serial interface built in) and an USB to RS-232 adapter, a Quatech QSU-100 in my case. An IBM USB Serial Parallel Adapter did not work.

There is also a commercial serial interface for 1-wire devices available (DS9097U), see <http://para.maxim-ic.com/cache/en/results/4872.html> My software has provisions to use this interface as well, but is not tested with it.

Another option is the USB interface DS9490R which has a RJ11 output connector that connects to the 1-wire sensor. The software is again prepared to use the USB interface but not yet tested with it as I am still waiting for my sample.



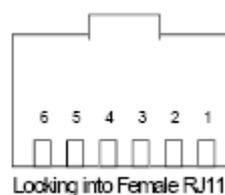
Fig. 7 USB to 1-wire adapter DS9490R

**Update July 27, 2006** The USB to 1-wire adapter DS9490R works perfectly well with my program. To connect the sensor, connect the ground wire (pin 1 and 3 of the sensor, 1-Wire return) to pin 4 of a RJ11 phone plug, the data line (pin 2 of the sensor) to pin 3 of the RJ11 connector. I used a discarded phone cord for the connection from the DS9490R to the sensor plug. In Setup, select DS9490R and the appropriate USB1...USB4.

The following table and schematic is taken from the data sheet of the USB adapter at <http://pdfserv.maxim-ic.com/en/ds/DS9490-DS9490R.pdf>

**Figure 4. 1-WIRE RJ11 SOCKET FOR DS9490R**

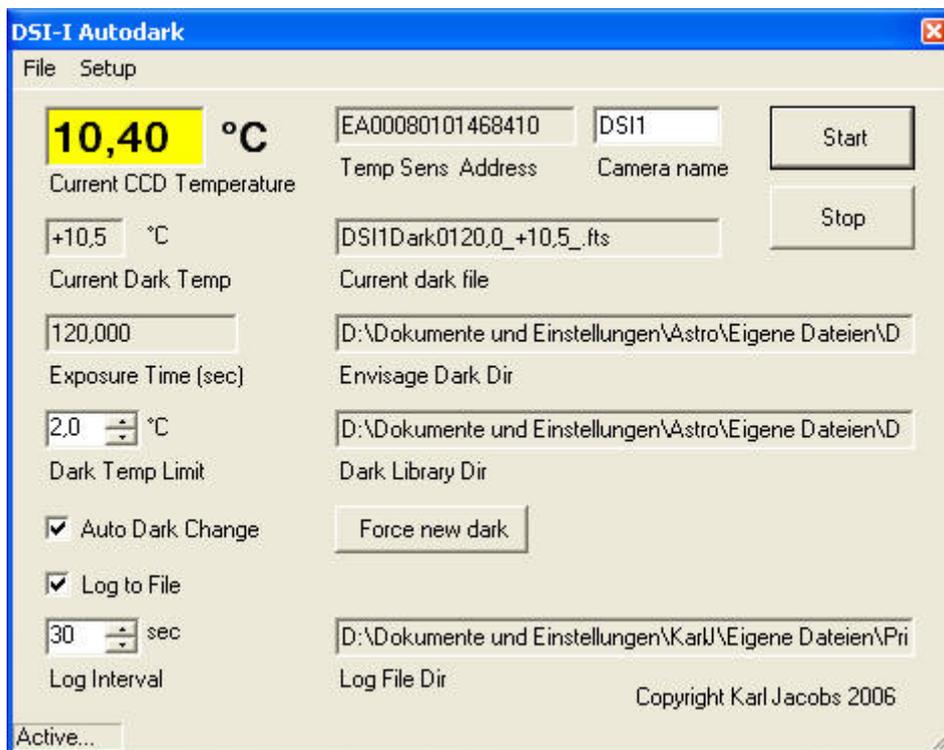
PIN	SIGNAL NAME	DESCRIPTION
1	V <sub>DD</sub>	5VDC Output
2	GND	Power Ground
3	OW	1-Wire Data
4	GND_OW	1-Wire Return
5, 6	N.C.	No Connection
6	N.C.	No Connection



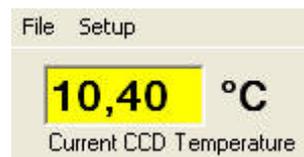
This ends the hardware chapter.

### III. Software

I wrote a Windows application program that has the following functions:

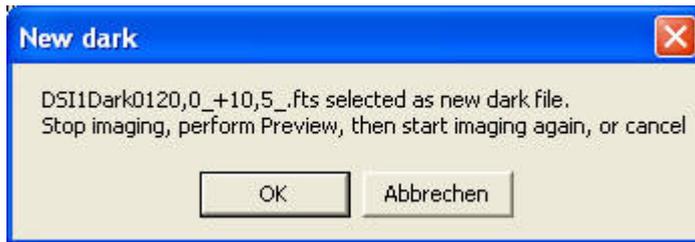


- 1) After hitting Start, reads the temperature of the CCD chip (DS18S20 sensor) and displays it. The Envisage camera name (default: DSI1) has to be entered in the Camera name field, so that settings like Exposure Time and the Envisage dark directory can be copied from the present Envisage settings. If you change the camera name field, you need to exit the program and restart it to be effective.



A temperature reading of 85°C is an error indication. Wait 5 sec for the first reading. The status bar at the lower left tells you whether the program is in its “stopped mode” (waiting for response to a message box or stopped with the Stop button or not started yet with the Start button) or in its “Active” mode where it takes readings. If stopped, no temperature readings are performed nor any log file entries are made.

- 2) enters the temperature into the temperature control of the Envisage “Setting” page
- 3) If the temperature has changed more than the Dark Temp Limit, looks for a dark file (matching the current exposure time set in Envisage) in a library of dark files which has been taken at a temperature close enough (i.e. within the given dark temp limit) to the present temperature of the CCD.
- 4) If existing, copy that dark file to the present dark directory of Envisage and ask the user to stop and restart imaging or cancel



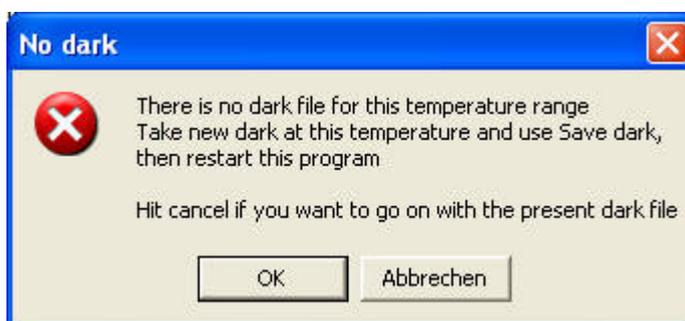
If you hit Cancel, Auto Dark Change will be unchecked. Envisage will continue using the previous dark file.

### Update July 27, 2006

you can force the selection of a new dark file corresponding to the present temperature by hitting the “Force new dark” button.



If there is no matching dark file, asks the user to take a new set of darks at this temperature, store it in the library (see below) and restart imaging thereafter.



If you hit cancel, “Auto Dark Change” will be unchecked!

- 5) Optionally, log date, time, temperature, dark file temperature etc. to a file. The filename is [Camera name]\_Log.txt. All data is appended to the end of the file. If it does not exist, it will be created.

The format is Time;Date;Envisage file name;current CCD temp.;dark temp limit;current dark file name;exposure time

Example entry:

01:11:25;12.07.2006;test exposure;36,20;2,0;DSI1Dark0120,0\_36,0\_.fts;120,00000  
(Note that the German decimal separator is a comma, the US version has a period).

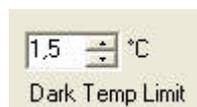
**Update July 27, 2006** the time interval for the log file can now be set in 5 second steps in the Log Interval spin box.



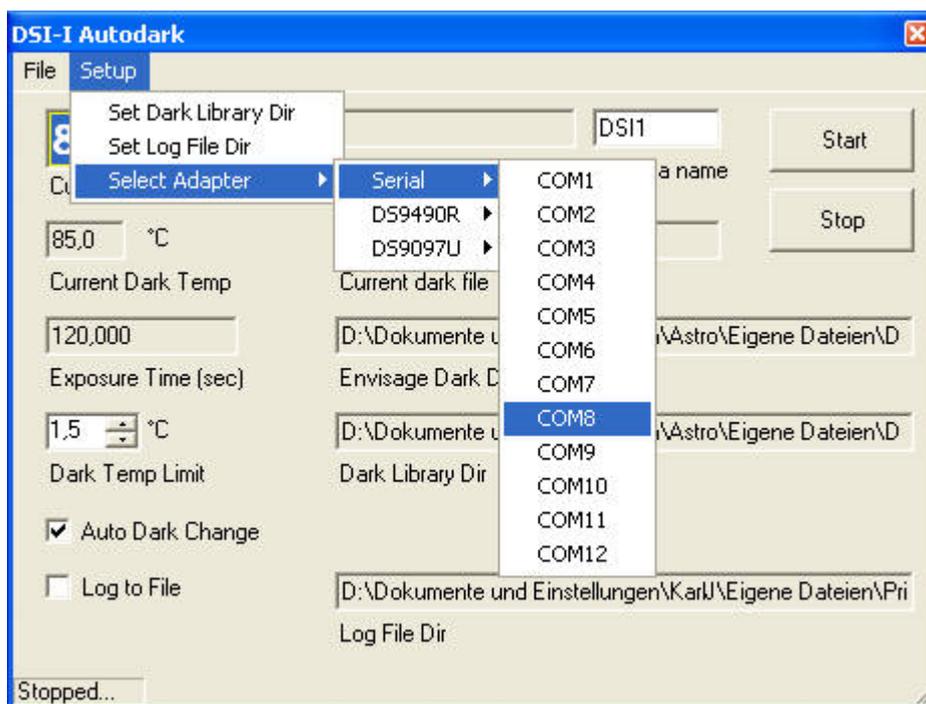
Steps 1 to 4 are repeated periodically, until the stop button is pressed or the program is exited.

In addition the following settings can be made or functions performed:

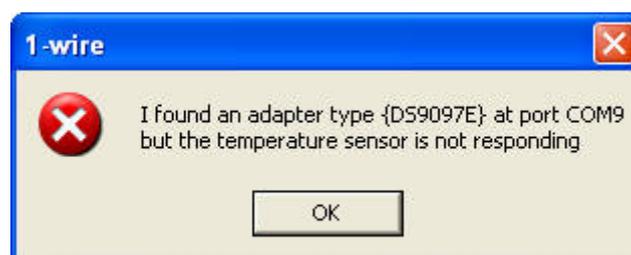
- 1) Set the dark temp limit, i.e. the allowed difference in temperature between the present CCD temperature and the temperature at which the presently used dark file was taken. Note: this setting is immediately transferred to the corresponding Envisage setting.



- 2) Choose the 1-wire interface adapter (Serial, Port No., USB)



if there is no device connected, you will get e.g. **Updated July 27, 2006** either

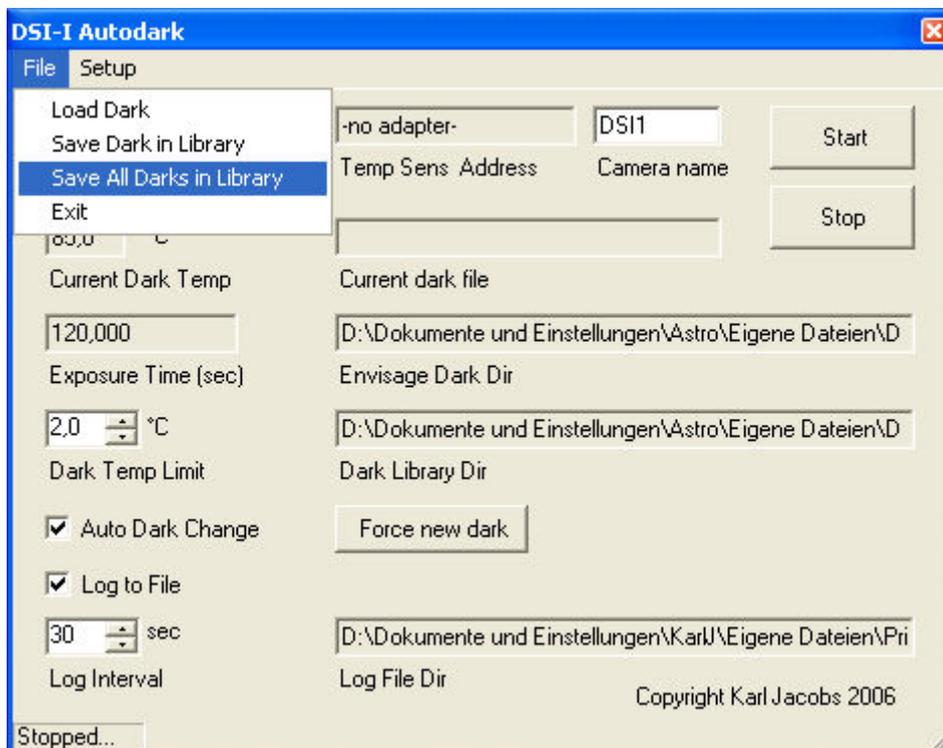


or you get



which could mean that you just chose the wrong COM port or there was no adapter at the COM port remembered from last time you started the program.

- 3) Set the dark library directory
- 4) Set the log file directory



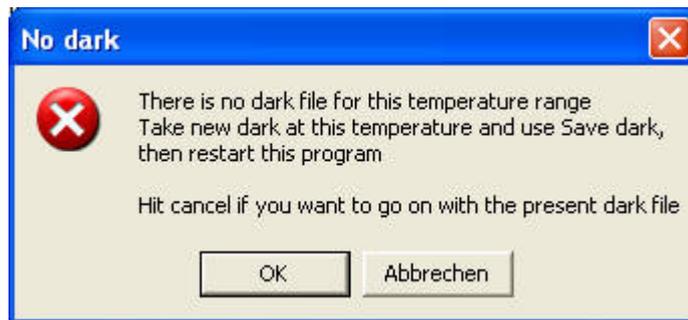
- 5) Save the present dark file to the library (Menu item “Save Dark in Library”)
 

This copies the present dark file in the Envisage dark directory (if there is one with the exposure time shown) and stores it in the library, adding the temperature reading that was measured before you got this message to the filename:  
(This implies that you take the dark right after you get this message, before the temperature changes further substantially)

**Update September 24, 2006:**

Use “Save All Darks in Library” to save the complete series of darks in the Envisage dark directory to the library. This is useful if you have taken a series of darks with different exposure times at a specific temperature (this is the Envisage default setting). You will be prompted once to review/edit the temperature stamp given to the library filenames (see below) and prompted for every file to save (see below). The caveat for

this function is that you should not have “old” dark files in the directory, so you should consider taking the darks with the “delete old darks” option in Envisage.



There is a prompting message before the file is actually stored in the library which you should check carefully before giving a yes to it:

**Updated July 27, 2006:** There is now a dialog box that allows you to review and edit the exposure time setting and the temperature stamp added to the filename. I found this necessary because after taking the darks, Envisage writes the live mode exposure time back to the registry and not the preview long exposure time. This is what my program uses to look for the right dark file to store, so there is confusion. The safest thing is to make a preview first, which writes back the long exposure time. This dialog gives you the possibility to restore things manually.



**Update September 24, 2006:** for the “Save All Darks in Library” case, the exposure time in this edit box is displayed as “-all-“, as you are saving files with different exposure times, so there is no sense in editing the exposure time box. You can still edit the “temperature stamp” value which then is used for all files to be saved.

The next message you get is as before: (for “Save All Darks...” there will be a prompt for each file)



- 6) Load a dark file from the library to the Envisage dark directory, detaching the temperature from the filename to make it compatible to the DSI-I format. If Auto Dark Change is checked, the next temperature measurement may ask you for permission to change the dark file again, if it did not match to the current CCD temperature.
- 7) Exit the program

The directory names, camera name and the last choice of adapter and interface are remembered and used as default at the next program start. At the very first start of the program, a serial adapter at COM1 is assumed which may give an error message as shown under 1). In that case, acknowledge the error message box and choose the adapter/port that you actually use.

The filenames in the dark library follow the dark file naming of the DSI-II, which has the temperature at which the dark was taken included in the filename (thanks to Matt for providing this info). A typical dark file in the library would have the filename

DSI1Dark0120,0\_+24,5\_.fts

This is a dark file for an exposure time of 120,0 seconds taken at 24,5 degrees centigrade. As Envisage does not accept this file name as a dark for a DSI-I, my program stores this as DSI1Dark0120,0\_.fts in the Envisage dark directory (as given in the Settings tab of Envisage). If the temperature changes enough, a different file of the library would be copied to the Envisage dark directory, ending up in overwriting the file there. Of course, the library file remains untouched.

Note that my examples are for a German language setting of WindowsXP. In the US version, the filename would be DSI1Dark0120.0\_+24.5\_.fts The program accepts both formats for the dark filenames in the dark library and will also show all numbers in the display according to the language setting of your Windows version.

Information about the present CCD temperature and the full filename of the current dark file (i.e. with the file name including the temperature) is stored in the "User Setup" area of the FITS header (see the settings tab of Envisage) so that it remains stored with each image. I did that because the newest version (5.85) of Envisage does not anymore store the CCD temperature value of the Setting tab in the fits header when using a DSI-I, as did the previous version.

Of course, this all is only useful if you use the Autodark feature of Envisage. If you don't, it might be still a good idea to leave the "Autodark Change" checkbox of my program checked. That is because only if you actually stop the imaging (as requested by my program) and restart imaging, the new header information, including the temperature information produced by my program, will be stored in the fits image files taken by Envisage. If you just keep on collecting more images, the same (old) temperature reading will be stored.

If the "Autodark change" is annoying, switch it off and rely on the log file alone for later postprocessing with the correct dark files.

A word of warning for those who tend to "fall asleep at the wheel": as you need to take action if the dark temperature has changed, not answering the message box stops the temperature monitoring. Your Envisage data taking of course is not affected, but you will not have any temperature monitoring anymore. If you just need temperature monitoring, uncheck the "Auto

dark change” checkbox of my program and rely on the log file for later data reduction. Of course, this makes only sense if you have switched off the Autodark checkbox for Envisage as well. If someone tells me how to “remote control” Envisage by software, this could all change of course. Unfortunately, Envisage does not use keyboard shortcuts for its commands that could be used for this purpose.

#### **IV. Software installation**

##### DEMO Version:

There is a file DSI-I\_Autodark\_DEMO.exe in the same directory that you found this report in. This is a demo version of the program which does not need any drivers or hardware nor Envisage installed and does not write anything to the registry. To use it, download it to an arbitrary directory and start it by double-clicking the filename. For the demo you do not need to perform any of the steps 1-3 described below.

The demo just simulates the operation of the program by producing artificial random temperature readings between -10°C and +28°C and selecting and copying dark files and writing the log file. Start by setting the directories appropriately. You need to fill in the “Envisage Dark Dir” by hand (in the full version, the Envisage dark dir setting is copied here automatically). Put a file with filename DSI1Dark0120.0\_fts (US settings) into the directory chosen as “Envisage Dark Dir” and start the program. The Dark Library Directory will be empty at first. Fill it by using the “Save Dark” feature as described above. The demo version does not enter any of the readings into the Envisage Settings page and does not remember any of the settings from run to run.

To discard the program, just delete the .exe file.

##### Full version

Software installation is in three easy steps. This assumes that you have the .NET framework 1.1 installed on your computer, which is the case if you have installed Envisage or the whole Autostar Suite. (You cannot work with the DSI without having .NET framework 1.1 installed anyway). My program assumes that you have Autostar Envisage installed, which is the Meade DSI control software.

If Envisage is not installed or the dark frames directory in Envisage is empty, the Auto Dark Change checkbox is unchecked and you cannot use this feature. The program might still be useful just for logging the temperatures in this case.

I tested the software in WindowsXP and Windows2000.

##### Step 1

The drivers for the 1-wire devices need the Visual J# Redistributable Package 1.1 downloaded from <http://msdn.microsoft.com/vjsharp/downloads/howtoget/default.aspx>

Download the package (Version 1.1 is needed, not 2.0 nor 1.0) and install it on your computer.

##### Step 2

The drivers for the 1-wire devices can be downloaded from <http://www.maxim-ic.com/products/ibutton/software/tmex/>

(Look for: Download Version 4.00 (includes TMEX and optional OWCOM API and .NET support) and install install\_1\_wire\_drivers\_v400.msi

When installing, uncheck the checkbox for OWCOM API, as you do not need that. After installing the drivers, the installer tries to identify a default interface. You can safely ignore this (it needs a 1-wire device connected to the default interface to work) and continue without identifying the standard interface.

### Step 3

Download DSI-I\_Autodark.exe from the directory that you found this report in. Copy or move the file to a directory of your choice (e.g. C:\Program Files\DSI\_Autodark\). Move a copy of the file OneWireAPI.NET.dll *to the same directory that the DSI-I\_Autodark.exe file is in.* (The standard path to this file, which was installed in step 2, is C:\Program Files\Dallas Semiconductor\1-Wire Drivers Version 4.00\1-Wire.NET) . Either start the program by double-clicking on the DSI-I\_Autodark.exe file or make a link to it, copy the link to the desktop and double-click the link. The program does not make its own entry into the registry, although it uses the Autostar Envisage registry key to store path information etc.

My part of the program (DSI-I\_Autodark.exe) is Freeware for private, non-commercial use. You may distribute it freely with the provision that you acknowledge my authorship. I am grateful for any bug report, suggestion for additional features etc. Mail to karl [dot] jacobs [at] gmx [dot] de

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