HOW TO REDUCE UNSTABLE or BOILING IMAGES

- Understanding what causes the problems
- How can materials and finishes help
- Temperature control of telescope components
- Modifications to the telescope
- The environment

AWR Technology have put in a lot of work investigating these issues and have produced a guide and a **Temperature Management System** to install.

Control of thermal characteristics of the telescope components by measurement and application of heat or forced cooling to correct differentials will cause images to be much more stable.

The environment is something we may not be able to do anything about but knowing what is happening will indicate the best time to do observing.

When the sun is shining it is also radiating and most materials will absorb this energy, reaching temperatures much higher than ambient. Thermal mass means there will be heat conduction internally and so building up a store which needs to be got rid of at night before the induced thermals stop.

Radiation from slabs of concrete, tarmac or buildings will be strong at night and eventually their temperature will dip below the air. At that point there are no thermals.

DEW 3 Handbook

V1.0

Materials change temperature by CONDUCTION, CONVECTION or RADIATION.

For astronomers, RADIATION is the prominent heat loss mechanism at night and the surface property (emissivity) is important.

The lower the emissivity the less heat loss in that surface.

At night the temperature of the surface can be much colder than the surrounding air because of radiation.

MATERIAL	EMISSIVITY
Aluminium Foil	0.04
Aluminium Anodised	0.77
Aluminium Black Anodised	0.88
Paint	0.9 to 0.98
Glass	0.85 to 0.95
Brass Polished	0.03
Brass Dull	0.2
Stainless Steel Polished	0.07
Stainless Steel Weathered	0.75
GRP plastic tube	0.8 to 0.9

TELESCOPE COMPONENTS

We need to consider the main elements of a telescope separately to work out the heat losses and what can be done to mitigate their effects. So we will consider the front element, the tube, the rear elements and ‘other’ separately.

Front Element

This will radiate strongly and can have large thermal mass (conduction is poor) so it needs time to cool to reach air temperature but it will continue cooling below ambient. It needs gentle warming with a heater band half a tube diameter downwards and by convection warm air will rise to the secondary. A fierce setting will make tube currents worse. Measurement is needed to control the temperature. This applies to the object glass, front correcting elements and the secondary in a Newtonian.

Note - A front position heater around the rim of the element is not the way to go. Its effect will be to warm the edge at the expense of the centre and produce a large temperature gradient from centre to edge.

TELESCOPE COMPONENTS

The TUBE

A thin tube with large surface area and little thermal mass will quickly reach the temperature of the air by conduction – the average of the inside and outside. But it has a large effect on tube current if not at ambient.

However, the radiation loss is strong with its large surface area but balanced by conduction with the air so the tube temperature should stay reasonably in equilibrium with the air.

A plastic tube is thick and a very poor conductor so the outside may get much colder than the air and dew can form on this component first. The inside surface will also stay hotter for longer so there will be tube currents.

We can and should wrap an aluminium foil blanket around to stop the external radiation loss. AWR can supply this material.

TELESCOPE COMPONENTS

Rear Element

A glass mirror has a large thermal mass and low thermal conductivity so it takes a long time for the heat to diffuse out of it to reach ambient temperature. There is little radiation loss – the aluminium coating has very low emissivity. So conduction to the air and convection is going to be the way it loses heat. This poses a big problem as it causes tube currents and light passing through this is bent in all directions (diffraction) – the boiling we see.

We are told to let our telescope stabilise for an hour but mirrors above a certain size can cool at a lower rate than the air is cooling during the night, so never reaches equilibrium. A FAN is needed to supply forced cooling. How long should it be on?

The boundary layer of air on the mirror can also be blown away with a fan blowing sideways across the tube but do not introduce vibration from the fan.

OTHER parts of the telescope

Tube Rings – usually have a layer of felt and are clamped to the tube. The felt acts as a heat insulating material so reducing conductivity from the large mass of the tube rings and its support.

Rigid Bar fitting – The telescope tube can be bolted onto a rigid bar which then goes into a dovetail or bolted directly onto the DEC axis head. If there is no felt pad then it is easy to put one in, that will stop the tube getting locally warm at the mechanical joins. Convection from the bar will not be a problem because of the small surface area.

Finderscope – is usually attached to the side of the tube near the eyepiece, so some reflective bubble wrap can be used around its support.

Another physical phenomena we have to contend with is **DEW**. When air cools, the water content remains the same but when at 100% saturation temperature (the dew point) water will condense. Reducing the temperature still further just increases the amount of dew forming to keep the air just fully saturated.

So, we need to monitor humidity and temperatures around the telescope to control temperature differentials and not let the telescope components go below the dew point. It is also possible to stop condensation forming with forced air flow up to about 5 degrees below the dew point.

The equipment you need is a multi channel temperature monitor and humidity meter for logging all the important points around the telescope. You need to characterise what is going on in order to provide the correct treatment. The AWR Temperature Management system will do all this. Logging gives you cooling curves and with comparison to the air temperature you can figure out what needs improved thermally. You can also measure temperatures in the environment.

Telescope Temperature Management

- Measures 6 temperatures plus the air temperature
- Controls 4 heater bands
- Measures relative humidity, calculates the dew point
- Controls power to heaters via relay
- Control fan cooling via relay
- Logging for 24 hours
- 12V power needed for the bands
- USB and WiFi connectivity
- Simple setup menus

DEW 3 INSTALLATION

The electronics box needs to be mounted on the optical tube assembly as the sensors and heater bands will be there. It has plugs and sockets for the various wires apart from the incoming 12V supply cord. The humidity sensor is in a separate box

The box will generate less than 1 watt when operating 4 bands at maximum power due to the current sensing resistors so will not contribute significantly to the temperature profile around the telescope.

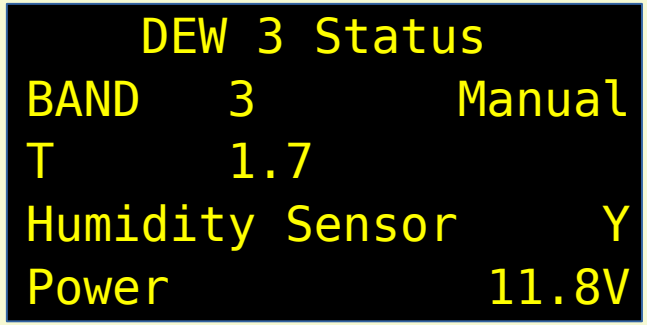
It would be usual to use Velcro to attach it, allowing removal from the tube when it is not needed. All electronics suffer from being left in unheated spaces for long periods.

All sensor and heater band wiring should be tidied into looms and fixed to the telescope tube with tiewraps or other clips.

DEW 3 Handbook

V1.0

SPLASH SCREEN then
STATUS SCREEN

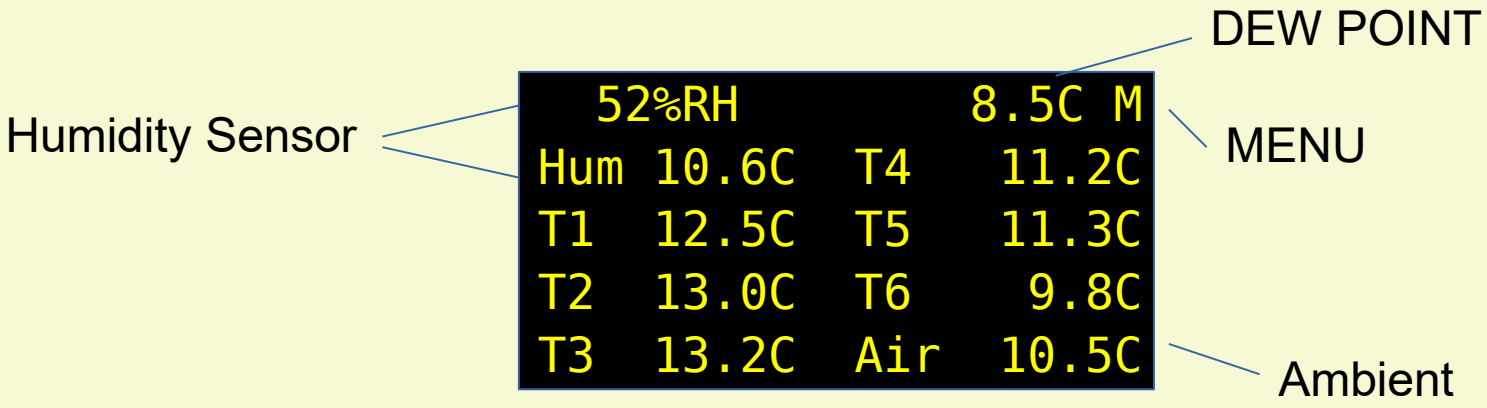


BANDS 3 detected
SENSORS 1,7 detected

AUTO or MANUAL
temperature control

HOME SCREEN 1

LIVE DATA SCREEN - TEMPERATURES



UP / DOWN keys to next screen

HOME SCREEN 2

LIVE DATA - BANDS

HIGHLIGHT is the FOCUS
Press ENTER to ADJUST

No power – band open cct

```
  52%RH          8.5C M
B1   5%   -W dT1   -0.5C
B2  10%    2W dT2     -C
B3  25%   15W dT6   -0.2C
B4  60%    3W dT4    2.5C
```

No diff T – sensor open cct

Band, Actual Percent, Actual Power, Sensor and Differential Temperatures (ambient - sensor)

UP / DOWN keys to next screen

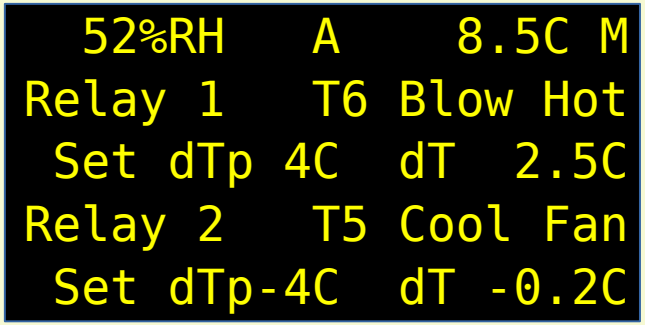
DEW 3 Handbook

V1.0

HOME SCREEN 3 (Auto)

INFORMATION SCREEN

Relay Actions



dT differentials are live and with respect to air temperature.

Set is target differential to the dew point.

UP / DOWN / ENTER keys

Highlighted text at any point goes to sub menu by pressing ENTER

A = AUTO

CANCEL key returns to the previous menu without saving data.

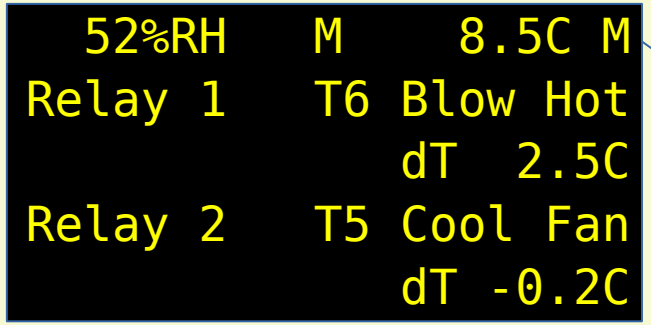
DEW 3 Handbook

V1.0

HOME SCREEN 3 (Manual)

INFORMATION SCREEN

Relay Actions



menu

Relay and the temperature channel being monitored.

dT differentials are live and with respect to air temperature.

UP / DOWN / ENTER keys

Highlighted text at any point goes to sub menu by pressing ENTER

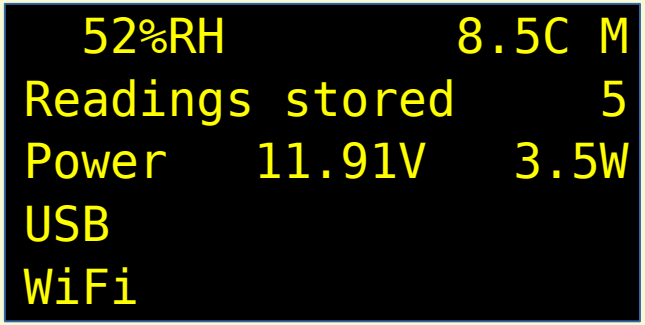
M = MANUAL

CANCEL key returns to the previous menu without saving data.

HOME SCREEN 4

OPERATIONAL STATE

Total Power, voltage and connectivity



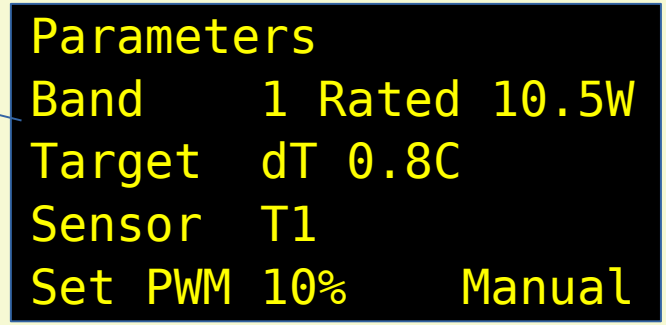
Live band power usage

UP / DOWN / ENTER keys

All BAND parameters

Scrolling this field goes through all the bands.

Target differential with respect to air.



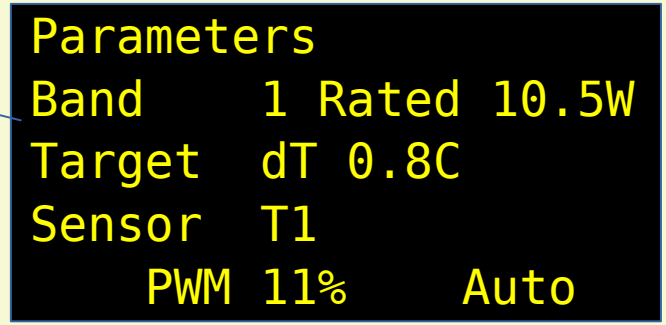
Band rating at full power

UP / DOWN / ENTER keys

All BAND parameters

Scrolling this field goes through all the bands.

Target differential with respect to air.



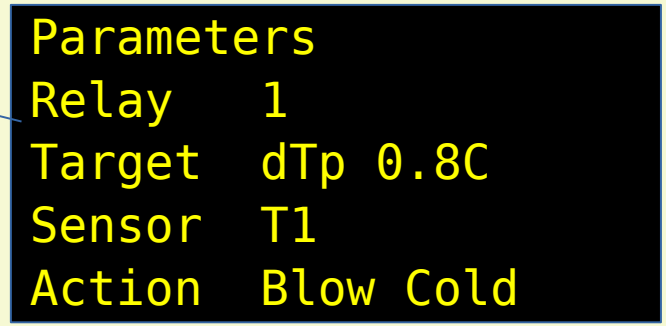
Band rating at full power

Actual PWM in Auto mode.

UP / DOWN / ENTER keys

All RELAY parameters

Scrolling this field goes through both relays



Set association

Differential with respect to dew point

UP / DOWN / ENTER keys

MENU for ADJUSTMENT…
FIRST SCREEN

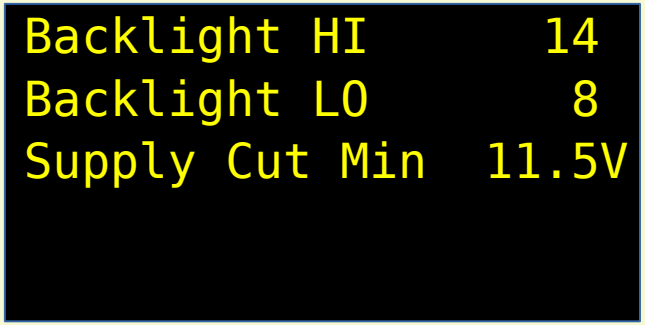
Use UP / DOWN to scroll the highlight to the field then press ENTER

That takes you to the Parameter Adjust.

LED options
- ON
- OFF
- Touch
- On error

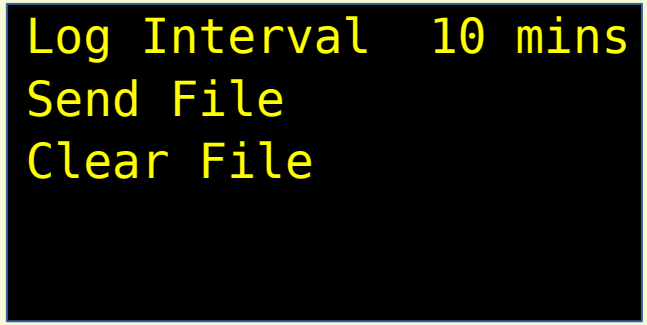
UP / DOWN / ENTER keys

MENU for ADJUSTMENT…
SECOND SCREEN



UP / DOWN / ENTER keys

LOGGING Functions



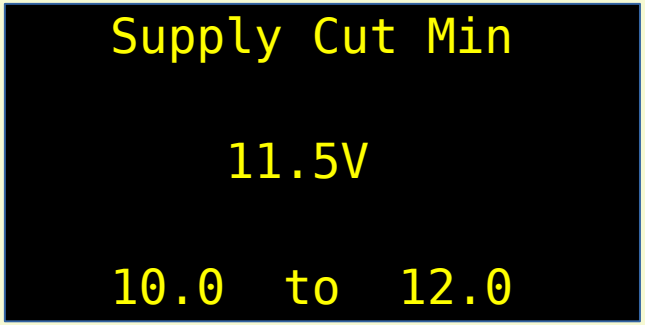
For 144 sets of readings

First reading stored at switch on or at Clear File

UP / DOWN / ENTER keys

SUPPLY CUTOFF

Value scrolls up or down with UP / DOWN keys

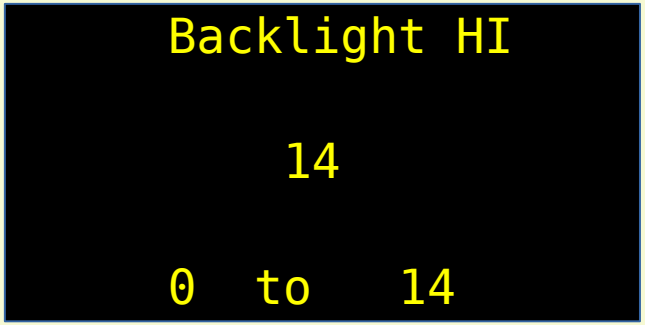


SET Minimum voltage on power battery before it stops the heaters.

UP / DOWN / ENTER / BACK keys

BACKLIGHT HI

Value scrolls up or down with UP / DOWN keys



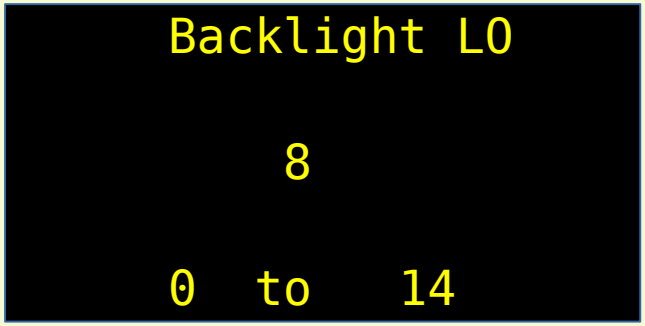
Set HIGH level intensity when you press a key. Useful in daylight when you need to read it.

Set to a lower level at night

UP / DOWN / ENTER / BACK keys

BACKLIGHT LO

Value scrolls up or down with UP / DOWN keys



Set LOW level intensity to the minimum you need to read the display in the dark.

ALL LED’s dim together.

UP / DOWN / ENTER / BACK keys

END