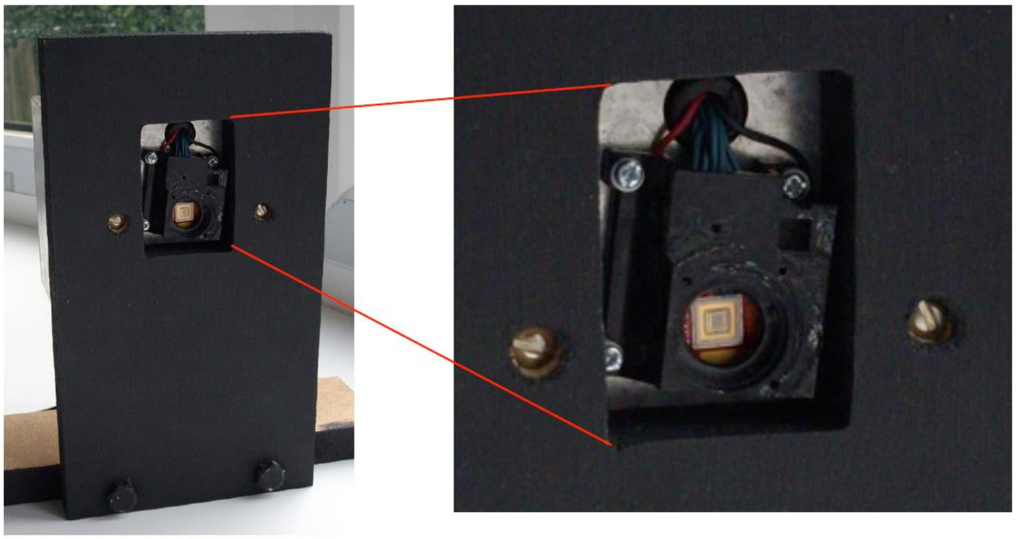
Nanowaves

A simple Phlatlight LED driver for optical communications

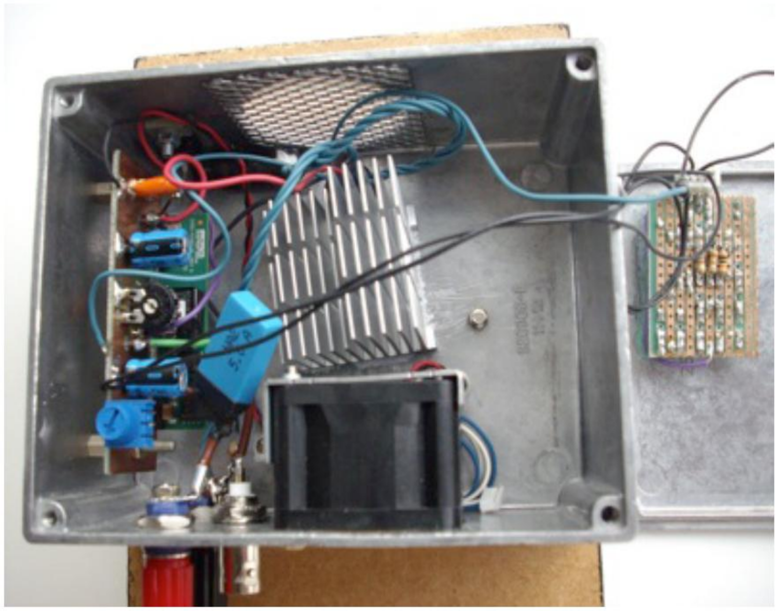
By Stuart Wisher G8CYW



A number of Nanowavers have recently obtained a very powerful LED, heatsink, Peltier effect cooler and even also a suitable fan from sellers on e-bay. The LED, a Phlatlight (photonic lattice) CBT-54 can run at up to 9.1A continuous and 13.5A at 50% duty cycle according to its data sheet. Startling for an LED! Even more interesting was the news from Clint Turner, KA7OEI, in the US who has been using these for some time that the LED will actually survive at over 20A for a few seconds! This article details how I have implemented a simple design to run my CBT-54 for all its worth. Some of this that follows is rather idiosyncratic and other bits are simply "because I can", but I have ended up with a design that simply connects straight to my transverter with no modification to the transverter itself required (thanks for this Russ, G4PBP), and will run the LED at up to 20A peak current. Whilst designed for sub-carrier operation, the design is equally suited to baseband AM with an easy adjustment of FET bias as this circuit will operate in class A for AM as well as class B for SSB.

Basically, the design uses a Murata dc-dc converter to efficiently obtain a low voltage for the LED from the more usual 12V vehicle supply or gel battery. The advantage here is that 5A at 12V from the battery is converted into 12A at 5V for the LED, and the Murata chip is rated at 16A maximum output with no heatsink required due to its greater than 90% efficiency. A low ESR capacitor is used to comfortably obtain peak output currents for SSB use in excess of this current level.

The next element of the design uses a suitably rated MOSFET to drive the LED in a source-follower circuit. One feels a little strange using a series resistor of just 0.05 Ohms to limit the LED current, but it is all a matter of proportion and working at the level of current involved. This is a simple circuit that uses the properties of the MOSFET to bias the LED to provide whatever standing current is decided upon by the user and a modulating signal is capacitively coupled to the gate which then appears superimposed on the source. The proof of the pudding it is often said is in the eating. In this case a spectrum analysis is rather more useful, and the distortion products, even in class B, second and third harmonics are well below significance at minus 30dB or (much) better. Since this test was done by



analysing emitted light from the LED, the linearity of the LED output with current is also in the loop, and indicates the suitability of the whole system for communication, not that the band is occupied very much by other users! The MOSFET is bolted and thermally well connected to the diecast box, the low value resistor is Araldited in to a corner of the box giving it plenty of thermal contact. Lead lengths are intentionally short in this area so as not to lose too much voltage at high currents. The bias arrangement makes use of a 78L08 regulator to make sure the MOSFET bias is stabilised against variations in battery voltage, the 5V output of the Murata device is insufficient here. The net result is that this system will keep going at a stable level until the nominal 12V supply is well exhausted at below 11V. It is interesting to see the current demand going up as the battery voltage reduces, as the Murata device compensates for the drop in input voltage

It could well be argued that the overall thermal aspect of my design is rather "belt and braces" with the Peltier effect cooler, heatsink and fan, but there is a point to this. The LED seems to be characterised for light output at 40 degrees Celsius and the light output increases slightly as the temperature is reduced, this effect is particularly noticeable for red leds rather than blue or green. The implication is that up to another 20% light output is obtained by running at 20 degrees rather than 40 degrees. The Peltier device is run from the 5V supply and consumes 1.5A at this level. This translates to about an extra half amp from the 12V battery, and since my favourite mode of operating is from the back of a vehicle with its 100Ah battery, of no consequence. There are no markings on the Peltier device and it has proved hard to obtain any information on it, but it is likely that it was run at this level in the equipment the LEDs were intended for. This could be missed out if you wish but as I said, part of this project is "because I can"! The result of my efforts in cooling is that when tested in a room at

just over 20 degrees, the LED temperature as indicated by its integrated thermistor, is minus 6 degrees when the LED runs at the 1A quiescent level I run for class B SSB, and when "talked up", the temperature hardly goes over 10 degrees.

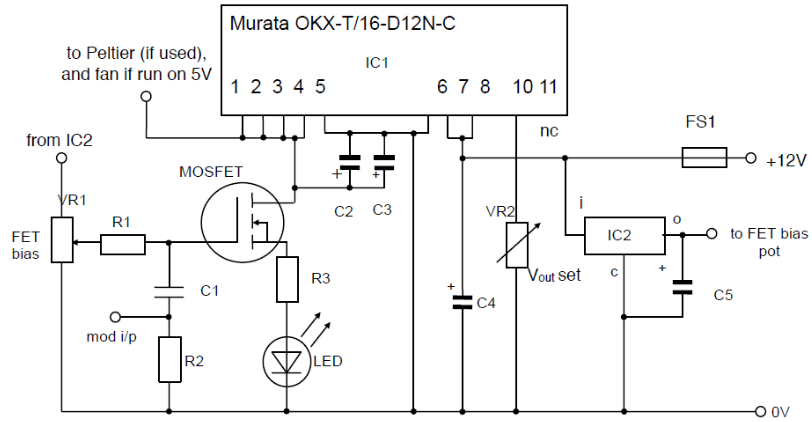
I am aware that this design runs somewhat "on the edge", but to date, my spare Phlatlight remains unused. A 5A resettable circuit breaker limits the total input power to the whole driver to 60-odd watts averaged by another low ESR capacitor on the 12V side of the circuit. And anyway, what is the point of using such a high power device without utilising it to the max? It might equally be said that I am using the Phlatlight "phlat out!"

The third element in my design is also rather idiosyncratic, rather grandly termed a "thermo chromic indicator", the integrated thermistor on the Phlatlight mentioned earlier is coupled to a quad op-amp circuit that illuminates one of 5 small leds that convey information about the large LED chip temperature by effectively changing the colour of a little dot visible in the dark when out in the countryside at the top of a hill. It seems somehow natural that we associate blue with cold and red with hot, and so a line of 3mm leds is used with blue, green, yellow, orange and red used to indicate below 10 deg, between 10 and 20, between 20 and 30, between 30 and 40, and finally above 40 degrees respectively. The final state of the indicator can also be easily used to switch the Phlatlight off if required via an interlock wire link that needs simply connecting up. I demonstrated this in my recent talk at the RSGB Convention and it seemed to generate as much interest as my attempts not to blind the audience with copious quantities of red light. This circuit on its own may be of interest to anyone wanting an easy way to interpret temperature for any high power device. The interlink would also work by simply grounding any gate/base bias at the final temperature threshold and thereby prolonging the working lifetime of the device.

In starting the design of the indicator, I first of all noticed a simple mathematical relationship between the Phlatlight thermistor resistance and temperature (available on the UKNanowaves Yahoo Group), at the previously mentioned threshold levels, and designed a sort of cascade window comparator that amused me. The circuit is about the nearest electronics ever gets to poetry it has been observed. No setting up is necessary providing the resistor values specified are adhered to and you don't go searching in the junk box for "something that will do" as one of my pals did! It is pleasing on switch-on to hear the fan start up (although rated for 12V, it is run on the 5V supply consuming a negligible 100mA), see the yellow led light initially, rapidly switching to green, and finally after a few more seconds, the blue led comes on, cool!

It will be seen that I have chosen to mount the LED in its original black plastic holder that forms a sort of clamp to hold the LED and cooler tightly together on the outside of a die cast box. Inside the box after removing the little Eddystone lighthouse logo (just my luck, it was exactly where I wanted to locate the heatsink), the heatsink is located inside the box with the fan blowing through the fins, (see photo). Very small amounts of heatsink paste were used just to fill in the valleys in the metal-to-metal contact. The logic of this arrangement is, I know, questionable, but it works, and the spare air from the fan circulates in the box cooling all the other high dissipation components before being vented to outside. It reminds me of the old days with 2C39As in blown cavities (thank heavens for brick amplifiers and LDMOSFETs!).

Optically (or should I refer to the dish feed?) I have removed the two lenses the LED came with as they rather under-illuminate the main reflector (make that refractor, the parallels between microwaves and nanowaves have never been more obvious to me). Here was a piece of luck, the dimensions of the black plastic mount supplied with the LED, after trimming off some projections and filing flat, is close enough to the best distance for mounting the meniscus lens used for optimally illuminating the A4 page magnifier Fresnel lens (sorry, 46 dB gain antenna!). The 28mm focal length 29mm diameter PMN lens from Surplus Shed is glued flat on to the black plastic. Do not use super glue as I did at first, it fell off after the Convention talk, get the Araldite out again. The resultant circular patch of red light produced by the meniscus lens just touches the short sides of the Fresnel lens leaving the corners dark. (Thanks Clint and Barry, G8AGN). It should be added that using no lens at all here over-illuminates the Fresnel and results in some 10dB less focussed output. Another important issue is the size of the resultant LED image at distance, in this case the correct secondary lens keeps this (and the beamwidth) to a minimum of just less than a degree which is what we Nanowavers are used to!



Voltage converter, MOSFET driver, and LED circuit

Component list

R1	10kΩ
R2	1kΩ, only required if connecting to my transverter design (it completes the output circuit in the transverter)
R3	0.05Ω 5W (in addition, the original LED leads add to this)
VR1	100kΩ pot, (MOSFET bias, set to 0V initially)
VR2	10kΩ pot, set output volts
C1	0.1µF modulation coupling capacitor
C2	2.2 µF tantalum (decoupling for IC1, its switching frequency is around 300kHz)
C3	100 µF low ESR (increase this to 1000 µF for baseband use)
C4	100 µF low ESR (increase this to 1000 µF for baseband use)
C5	2.2 µF tantalum (decoupling for IC2)
MOSFET:	I used a HUF 75337P3, but an IRF540 or similar would be ok, just bear in mind I_D max and R_{DS}(on).
IC1	Murata OKX-T/16-D12N-C
IC2	78L08
FS1	5A resettable fuse
LED	CBT54

Construction notes:

Make very solid connections to the voltage converter pins, bearing in mind the current levels increase considerably at its output. The sense input pin 3 is wired directly to the output pins as I used only 1cm of thick wire to the MOSFET drain.

Make sure the MOSFET bias pot is set to 0V before you connect up to the power supply. The original LED leads are used as part of the LED series resistance, do not shorten them (there are three wires in parallel for each LED connection, cut off the wires directly at the plug, strip and twist together before connecting to the resistor and use a common earth point for the LED cathode and all other 0V connections. Wire the MOSFET source directly to the resistor using short direct wiring (I managed a 1cm distance here, cut off the thinner part of the MOSFET leads and connect close to the MOSFET body).

Setting up

Make sure that MOSFET pot is at the 0V end of the track, you have been warned! (again!).

Connect a nominal 12V-13.8V power supply unit via a 10A meter and switch on.

Adjust VR2 until you measure 5V on ICI output (you could be cautious and use 4.5V to start with….).

Check the 78L08 output voltage; it should give its 8V output even when the supply drops to 11V.

Slowly advance the MOSFET bias pot (use one of the nice new enclosed ones with a smooth action) to the point where the LED just lights.

Take a breather here, and just touch the MOSFET gate capacitor with a screwdriver in contact with your hand (the "hum test" for a newly constructed audio amplifier), you should see the LED spring into life and brighten up just on the induced mains hum.

If you have the same Peltier cooler and fan on the 5V side as I have, increase the bias pot for sub-carrier SSB until you get an input current of 1A total, this will result in about 1A or so standing current through the LED. Or for other arrangements, monitor the voltage across the LED series resistor to achieve the same current through the LED.

Operating from the transverter will see the current peak up on speech peaks on SSB. Be aware that you get more drive the lower the sub-carrier frequency. Test on 20 kHz or so, go lower in frequency to increase power, after all, you have the whole band to yourself! At 13 kHz LSB I see 5A into the whole unit (this is averaged by the low ESR capacitors, now go and work out the current that must be coming out of the converter chip and then guess at the peak current through the LED!).

For baseband operations, having fitted the larger capacitors, decide for yourself where you want the “half current” level for class A operation, to be, try 5A if you dare! A volt or so of audio from an op-amp will drive the LED to 10A peak; so I would at least fit a pot on the drive to control it, and probably use a compressor/limiter as well.

If you have a variable supply, you should note that the input current to the whole system goes up as the input voltage goes down, showing the Murata chip is doing its job. This is quite useful when out portable, as the LED output is virtually constant over a battery voltage range from 13.8V down to 11V.

The Murata converter is so efficient that it does not need to be connected to a heatsink, there is no provision for doing so, and it is simply cooled by the circulating air in the box as mentioned earlier. The MOSFET and series resistor are thermally well coupled to the box. Very special cooling arrangements are made for the LED as stated before.

LED temperature indicator

This is driven from the thermistor on the Phlatlight LED substrate. There are eight wires from the substrate, three each for the LED anode and cathode and two for the thermistor that is isolated from the LED.

The thermistor has a resistance close to 6kΩ at 40 degrees Celsius, 8kΩ at 30 degrees Celsius, 12kΩ at 20 degrees Celsius, and 18kΩ at 10 degrees Celsius, it is placed in a voltage divider circuit with a 12kΩ resistor connected between the thermistor and earth which gives a voltage across the fixed resistor of 0.67 (two-thirds), 0.6, 0.5 and 0.4 of the supply voltage at the temperatures given above.

An investigation into values of resistance for a reference voltage chain revealed that a series combination of 33kΩ, 6.8kΩ, 10kΩ, 10kΩ, and 39kΩ would give the required threshold voltages to within a small margin of error for the comparators. By running both divider chains from the same supply neatly gives independence from the actual power supply voltage as the whole thing works in proportion. If you want to be fussy, the 33kΩ should be 33.333kΩ, the 6.8kΩ should be 6.666kΩ and the 39kΩ should be 40kΩ.

Finally, the comparators (4 of them in a single LM324N IC) are connected so their outputs go low at the set temperatures which mean that if the +40 degree Celsius limit is reached, the action of the relevant comparator going low can be used to steal the bias on the MOSFET and switch off the LED until things cool down.

I spaced the five small 3mm leds at 0.2 inch centres to match the holes drilled in the back of the box, using a piece of stripboard as a template to get the holes spaced correctly and in a straight line. Stripboard was also used also for the construction of the circuit, unconventionally (surprise surprise!) using both sides of the board to obtain a very compact layout, about the same size as a large postage stamp. The symmetrical pin-out of the LM324N was a help here.

Component list

Th1	on-LED thermistor
R1	12kΩ
R2	33kΩ
R3	6.8kΩ
R4	10kΩ
R5	10kΩ
R6	39kΩ
R7 – 11	all 1kΩ, LED series resistors
IC1	LM324N, pin numbers on circuit diagram
LED1	3mm red
LED2	3mm orange
LED3	3mm yellow
LED4	3mm green
LED5	3mm blue
D1	1N4148 or 1N4001 type

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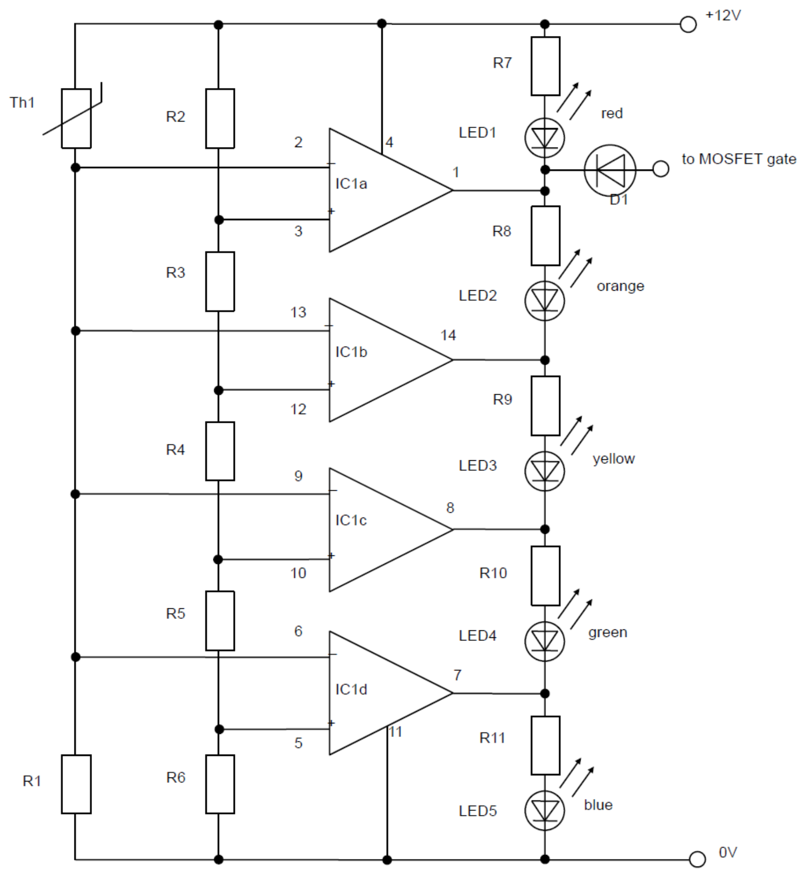

LED temperature indicator