Re: night sky meter project needs SX programmer

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From: Dan McKenna (*mckenna_at_as.arizona.edu*)
Date: 08/16/04

Date: Mon, 16 Aug 2004 09:44:19 −0700

Hi Stuart, Thanks for your thoughts.
Please find my comments in−line

Stuart Levy wrote:

> In article <4106988E.CBDC990D@as.arizona.edu>, Dan McKenna wrote:
> [in response to Stuart's amazement]
> >Yes, no problem at 21.5 sq arc second
> >the resolution is better than 0.1 Mag
> >
*> >The current to voltage converter on the TSL237 is 2.5*10^−12 amp/Hz*
> >and the photodiode is about .93 by .93 mm and so it is quite sensitive.
>
> >> Is it very sensitive to temperature? How do you calibrate a detector
> >> like that, e.g. how could you make a stable dim comparison source?
>
> >The detector has a dark frequency temperature coefficient and so the
> >zero will drift. I have used temperature compensation requiring a
> >second channel which seems to work. I am now using the TSL237s and
> >find that it is more stable and lower noise than the TSL320R
>
> This is exciting.
>
> Though I'm not an embedded−systems builder, I used to build little
> electronic gadgets and do assembly−language programming. I've been
> thinking how you might put together a system like this.
> Probably you've already thought it through, but anyway here's
> what I have in mind:
>
> For calibration, it'd be good to have both a dark source (a shutter,
> say a black bag to hide the detector in) to measure the dark current,
> and a known light source, ideally an external one, to compensate for
> detector sensitivity changes (if any) and for optical
> misalignment, dust, haze, etc. An isolated bright star, like Arcturus,
> Vega, Polaris, maybe Aldebaran, etc. might make a better test source than
> one you could build.
>

So far tests of the TSL237 show a wide variation in performance as far as noise, dark offset, and dark frequency temperature coefficient.
Some device have a stable enough dark temp coeff that compensation is not needed.
So far that 2 devices out of 20.

A temperature calibration feature will be used if needed

I have a dark cap over the one I built and the dark frequency of .012 Hz has been stable to
.001 Hz. The meter is light tight enough so that It works during the day.

>
> *You might only need to do the bright−source calibration occasionally,*
> *just to establish an absolute sensitivity measure so that results*
> *from different devices could be compared.*
>

I don't have a lot of data on this, however the devices seem to be vary stable in
light to frequency if you do not include the near IR. I am running my meters with a Hoya cm500 ir blocking filter to produce a broad V band response.

>
> *It'd be nice too to include both a few−digit 7−segment LED display,*
> *for manual readings, and a computer interface −− a serial port*
> *seems simplest −− for easy automated measurement recording.*
>

For now I am using Red Lion cub 5 rate meters for the hand held proto type that read out in frequency, using the period method.

The conversion is close to Mag(sq arc second)= 19−(2.5*log(frequency (Hz−dark))
Using a 50 mm fl f 0.75 lens which gives me a little over a degree field of view

>
> *So in operation you'd do a dark−current measurement*
> *(put bag over optics, press Dark button on device),*
> *then point at mostly−blank sky, and if doing full calibration*
> *also point it at a bright star near the blank sky.*
>

See above

>
> *It seems as though the optical field might need to be surprisingly*
> *small to let bright stars stand out well. If I'm calculating*
> *right, a magnitude−0 star would only amount to mag 21.0/square arc sec*
> *of additional brightness, if spread over a 5−degree field!*

>

Right, The first device used no optics and a field stop producing a 57.3, 1 radian fov.
Now we are build a few models with fov from 1 degree up to 10 degrees.

>
> *The microcontroller should provide at least *two* counter/timers.*
> *One would be driven by the internal clock (best using an external crystal)*
> *to provide an absolute timebase, the other clocked by the photodiode.*
> *Doing it this way, the microcontroller can poll the counters at its*
> *leisure to measure frequency, and do other things like driving the serial*
> *port or display, rather than having to catch every transition of the*
> *photodiode clock.*
>

I find that it is best not to count the frequency, but measure the period.

>
> *It looks as though the SX series controllers have only one*
> *counter−timer, so that might not be the best choice, but lots*
> *of other inexpensive devices have more.*
>

>
> *Poking around on the web, Atmel's AT89S8252 seems handy −− cheap (~$7),*
> *compatible with the ~5V power supply which the TSL237 needs,*
> *has two counters, a UART, and lots of I/O pins for reading buttons and*
> *driving the display, includes nonvolatile memory which the chip itself*
> *can rewrite to save calibration data, and comes in a DIP package*
> *suitable for wirewrap prototyping.*
>
> *It might have about four switches on it. Besides the power switch:*
>
> *"Dark" button, pressed for dark calibration*
>
> *"Mode" button: show output in different forms, e.g.*
> *mag/sq arc sec or raw counts or maybe others*
>
> *"Calibrate" switch: changes the meaning of the two buttons.*
>
> *When calibrate−ing, you'd point at some not−very−starry sky and press*
> *"Dark" to latch that amount of light as the "sky background". The*
> *display would show, instead of the mag/sq arc sec sky brightness,*
> *the *excess* integrated brightness (in magnitudes) above the "sky*
> *background". Point at a nearby bright star to "measure" its brightness.*
> *If you know the actual total brightness of the stars in the detector's*
> *field, pressing Mode will cycle through a series of assumed brightness*
> *values; when that reaches the actual value for the star(s) in view,*
> *holding down Mode and Dark together could save the current calibration*
> *in nonvolatile memory.*

> *If it worked this way, you could also use "Calibrate" to roughly*
> *measure the detector's angular field by sweeping it slowly across a*
> *bright isolated star.*
>
> *So, the whole package might include:*
>
> *the magical photodiode and optics;*
>
> *a prototype box with 6V or 9V battery pack*
> *and a few square inches of perf board;*
>
> *connectors and a 3−pin cable so that the photodiode can be*
> *mounted remotely, out of view of the LED display;*
>
> *a small 4−digit 7−segment LED display (for example the LTC−4727JR,*
> *a 4−digit high−efficiency red display in 16−pin DIP package,*
> *should do);*
>
> *some way to pull up the four display anodes with a few milliamps,*
> *a quad buffer or CD4016 switch or similar;*
>
> *a resistor pack (to limit display current);*
>
> *the microcontroller*
> *(twelve of the microcontroller's I/O pins should be*
> *able to drive the display; with luck the ~3ma−to−ground*
> *capacity of its I/O pins is enough for the display cathodes);*
>
> *an RS−232 driver chip, and DB−9 or similar connector;*
>
> *a few wirewrap sockets (40−pin for the microcontroller,*
> *and four more of 14 or 16 pins for the display, display driver,*
> *resistor pack, and RS−232 driver);*
>
> *a 5V voltage regulator;*
>
> *two slide switches ("On/Off" and "Calibrate")*
> *two pushbuttons ("Dark" and "Mode")*
>
> *I.e. not a whole lot of hardware. It sounds doable to me,*
> *and would probably total under $100 even if the lens and filter cost $40*
> *of that.*
>

Steve Taylor in the UK is working on a model that uses a cell phone display and a 5 button navigator for feature selection.

We are including a GPS interface so that one can drive around as I have done collecting
sky brightness as a function of position and time.

In addition we would like to be able to plug it into the net.
It is possible that the International Dark Sky assoc. might host a web site
for the collection
and display of fixed and mobile data

> *>*
> *> It's been fun thinking about this...*
> *>*
> *> Stuart in sunny Champaign, IL*

It sure is

Dan