

A Brighter Dimmer

Build this full-featured panel light dimmer

There have been numerous articles dedicated to do-it-yourself aircraft light dimmers, so why this one? The answer is features – a few key added capabilities that may be very useful compared to previous designs. So, while I was at it, I decided to go about it with a design approach that reflects my ideas about appropriate ways to do electronics in the home-building aviation environment.

So, let's begin with a summary of feature/functionality and goals. As a baseline, the simple goal is a positive variable lighting supply capable of at least 2.5 amps. That should easily be enough, by a factor of two, but just in case, this design will be capable of up to 5 amps per channel. Additionally, there are a number of others goals. They are:

- Multiple outputs with tracking capability
- Day time full brightness over-ride capability
- Reliability
- Current limiting/short circuit protection
- Thermal protection
- Low drop-out voltage (ability to adjust the dimmer bus up as close to the battery voltage as possible)
- Photocell light sensor automatic control capability
- Low cost

The general approach chosen is a multi-channel linear design – linear to eliminate chances of generating radio interference, even though a switching design would have been more efficient. Now, let's examine what some of these goals mean and how we expect to meet them:

Multiple outputs with tracking capability – Most dimmers are single output, or multiple output with individual controls. With a single output, invariably there are some instruments or items that dim out of proportion to others. For example, in my plane when the instrument lights are at the right level, the Vision Microsystems VM-1000 is way too bright. The solution here is to provide multiple dimmer outputs that can operate at different levels, and track each other. This is accomplished with a master output, and multiple slaves, in this case two (you can add more if you wish), which can be set at any desired level at or below the master, and then will track the master. For example, a slave can be set to always be a settable number of volts (say, for example, 2 volts) below the master.

Day time full brightness over-ride is a feature where a dimmer output reverts to full brightness when the dimmer is turned off (i.e. during daylight). This is useful for items like a GPS annunciator, which needs to be full-on in the daytime, but dimmed at night.

Obviously, we want our design to be reliable. My approach to this is to minimize parts count, use industrial grade components, and assemble it in a rugged manner. A key ingredient in this approach, which also addresses the next three goals, is the choice of an integrated circuit three terminal adjustable voltage regulator device from Linear Technologies as the workhorse of the design. Though perhaps a bit more expensive than cobbling together a collection of cheaper discrete (and perhaps obsolete) components, far less parts are needed, all-around performance is better, and a lot of features come automatically. For example, the specified LT1804 parts include inherent fold-back over-current protection, and over temperature sensing for automatic thermal shut-down. Additionally, they are low drop-out designs, that can bring the output to within one volt of the input. Not to be too opinionated, but LT sure makes some nice parts!

Another feature we would like to have is photocell automatic sensing and control capability. This will be provided by an optional replacement of the external adjustment potentiometer with a simple cadmium sulfide photocell circuit.

Finally, a basic premise of do-it-yourself is to save money (if not also to learn something and have fun!). We will do that, as this design will come in at a small fraction of a purchased finished product that has less feature functionality. It is again, however, not the absolute penny-pinching cheapest approach, rather one that favors simplicity and reliability in exchange for a few bucks.

Design Overview

Figure 1 is a block diagram of the dimmer. The core is a set of channels built around the LT1084 series three terminal adjustable regulators. Three channels are shown – the master and two slaves - although you can build it with as many or few slaves as you want. Figure 2 shows the essentials of how a three terminal adjustable regulator works. The device generates and maintains a precisely regulated voltage (about 1.2 volts) across the Output and Adj terminals. Therefore, if a resistor, R2, is placed across these terminals, a constant current is generated, which then flows through R1, and the output voltage is determined by the ratio of R1 to R2, as per the formula shown in Figure 2. This is exactly how the master channel is operated, with the R1 potentiometer being the panel mounted dimming control.

The slave channels track the master via an offset adjustment. The Daylight Over-ride Circuit monitors the dimmer's on/off status and will supply a full output when the dimmer is off. Finally, the Light Sensor circuit can be substituted for R1 for automatic control with a photocell.

Design Details

Check out the details of the design in schematic diagram Figure 3: IC1 is the regulator for the master channel. R1 adjusts its output by the conventional mechanism described above, and C1 and C2 provide the necessary filtering for device stability.

IC2 and 3 are the slave regulators. What we need now is a way to make them track at or below the master output, and with a simple adjustment capability. This is accomplished with the tracking circuit composed of Q1-Q4 and associated components. Q1, R8, and D1 create a current source that supplies about 8 milliamps to current mirror Q2, Q3, and Q4. These 8 milliamps flowing into Q2's collector also flow through R5, generating a voltage, which in addition to an emitter-base drop appears at the bases of Q3 and Q4. Q3 and Q4 emitter-follow this voltage across R6 and R7, causing a current of 8 milliamps to flow into each of their collectors. For Q3 and IC2, this current comes from R3, the Adj terminal, and offset adjustment potentiometer R10. The current from the Adj terminal is miniscule, while the current from R3 is fixed at about 5.5 milliamps, due to the 1.2 volts across R3. This leaves about 2.5 milliamps drawn from R10, which will generate a voltage of from 0 to 12 volts, depending on the setting of R10, which then is the offset for IC2 relative to IC1. The IC2 output will track below the master channel by the voltage across R10 + 1.2 volts. The second slave channel works the same way.

Now that we have our tracking slave channels in place, what about the daytime over-ride? The approach I've taken here is to provide a circuit that can be optionally connected to a specific load, which can be supplied by any of the dimmer channels and will then drive that output or load full-on if the dimmer is not powered (i.e. "daytime"). What we want, then, is to detect if power is applied to the dimmer. This is accomplished by the D3/R3 connection to the gate of Field Effect Transistor Q5. The way Q5 works is that it will be an "open circuit" from Source to Drain (the upper and lower terminals) if the voltage from source to gate is below about 3 or 4 volts, and a "short" if it is above about 6 or 7 volts. Thus, we are using this clever little device as a power switch. If the dimmer is on, the gate to source voltage will be around .6 volts, well into the "open circuit" region of Q5, and power will be supplied to the over-ride output from a chosen dimmer output via D4 (via jumper JMPR1, 2, or 3). When the dimmer is off, resistor R12 will bring the

gate to source voltage to about 8.2 volts, limited by zener diode D2. Q5 turns on, providing a direct power feed to the load attached to the Over-Ride Output.

Lastly, the photocell controlled automatic feature – The photocell (or Light Dependant Resistor) R 14 changes its resistance over a range of several hundred ohms to the 10's of thousands of ohms from sunlight to darkness. As it does, it varies the voltage across Q6. R15 allows you to adjust the sensitivity of the automatic dimming function. The Q6 circuit is substituted for R1 (via jumper JMPR4), controlling IC1 and the tracking dimmer outputs in proportion to the ambient light level.

Construction

Physical layout for this design is not critical. You may chose to mount the small components on perforated board or make a printed circuit board. A layout is provided on my web site, where finished boards are also available. The most important aspect of construction is proper heat sinking of the regulator chips, IC1-3, which can generate a substantial amount of heat. The design intent is to supply up to 2.5 continuous amps per output, although the LT1084 is good for 5 amps. Mount IC1-3 carefully, using insulators and heat sink grease.

Table 1 lists the parts and manufacturer's identification. Potentiometer R1 gets mounted remotely on your panel, where you want your main adjustment to be. Be sure to mount R10 and R11 and the unit in such a way that you can reach them for set-up adjustment. Everything else is “just hook it up”.

If you are using the automatic control feature, remotely mount and connect the photocell, R14, leave out the external potentiometer R1, and connect in the photocell circuit via jumper JMPR4.

As mentioned before, you can add or delete slave channels as you wish. The components to replicate or delete, using the second slave channel as an example, are IC3, C4, R4, Q4, R7, and R11. The common connections are at the output of the master, the base of Q2, and ground.

The over-ride circuit may also be omitted. If you include it, jumper the dimmer output of choice to the over-ride circuit with jumper JMPR1, 2, or 3.

Using the dimmer in the automatic photocell controlled mode may be appropriate for only some loads. For these, you may wish to build a dedicated simple single channel unit without slaves or any of the associated circuitry.

If you plan to operate in a 24 volt environment, all you need to do is change the value of R 1 to 5K, and R10 and R11 to 10K. In fact, the unit can be built with these values for both 24 and 12 volt operation, with the side effect that in 12 volt mode the potentiometers will complete their action within half their rotational range.

Figure 4 shows a completed unit built according to the schematic, featuring a printed circuit board and DB15 connector. If you would like to simplify the construction of this project, you can visit the website listed at the end of the article, where you will find the circuit board layout and connector information.

Installation

Mount the unit in a location that allows adequate air flow over the heat sink. Connect the switched and un-switched power and any loads that require the over-ride output.

It will take some experimentation to determine which loads to supply from which output. Start with all connected to the master output, and then decide which are the outliers - too bright (or too dim), relative to the majority. Then, move those that are too bright to slave outputs, in groups, according to their level compatibility. In most cases, there will be only a few items that are out of

line. If there are some particular loads that require higher levels, rather than lower, put these on the master output, and the remainder on slaves. Then, adjust the slave offsets, R10 and R11, until you are satisfied with the overall tracking.

Parts list

Where to get parts: All of the parts (except the photocell) are available from Digi-Key. I've shown a complete list in Table 1, along with part numbers. The board, regulator ICs, and complete kits are also available on my website at www.a-and-t-labs.com/K11_Dimmer/index.htm

Also, if you have any questions or comments, you can contact the author at n49ex@aol.com or Rmetz@a-and-t-labs.com

Table 1

Part	Specification	Part number
IC1, 2, 3	LT1084CP	LT1084CP (Linear Technology)
Q1-Q3, Q6	2N3704	2N3704
Q4	2N3906	2N3906
Q5	IRF5305	IRF5305
D1	5.6V, 1W. zener	1N4734A
D2	8.2V, 1W. zener	1N4738A
D3	Signal diode	1N4748A
D4	8A, 40 V. diode	SBL845DI
C1	100uF, 35V	P10294 (Panasonic)
C2-C4	22uF, 35V	P11230 (Panasonic)
R1	5K Potentiometer	91A1A-B24-B13
R2-R4	232	232RXBK
R5-R7, R13	100	100RXBK
R8	604	604RXBK
R9	5.11K	5.11KXBK
R10, R11	5K Potentiometer	5AG53BK
R12	10K	10.0KXBK
R14	CDS 500 – 500K photo cell	338-76C348 (Mouser)
R15	10K Potentiometer	5AG14BK
Heat Sink		
Insulators		
Knob		

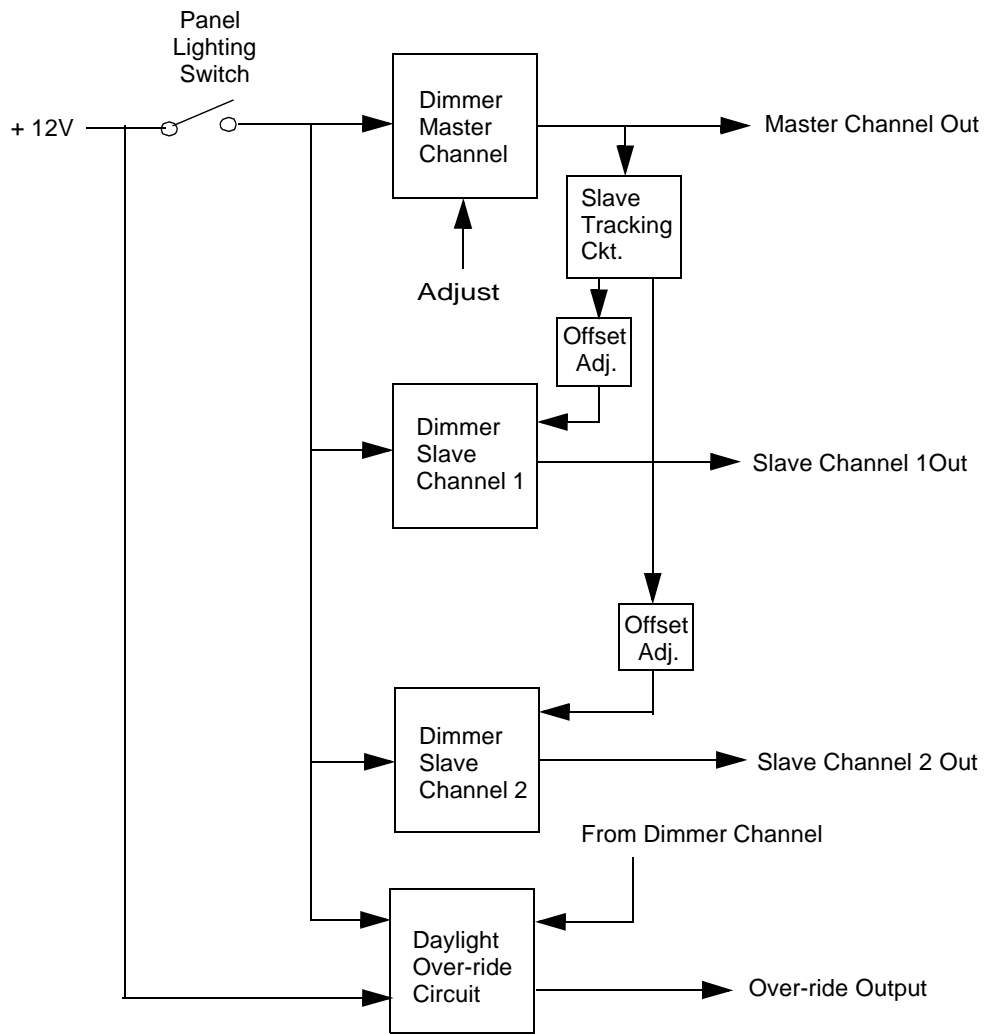


Figure 1: Block Diagram

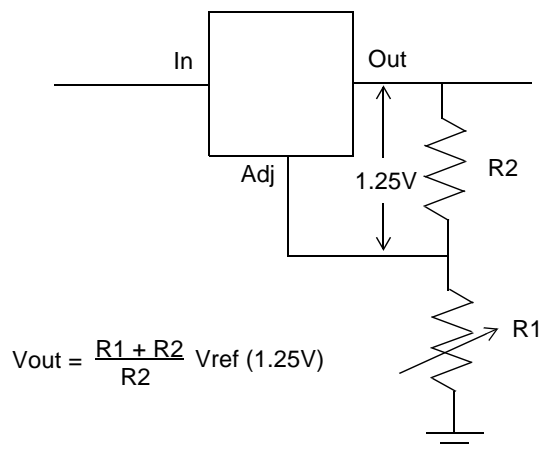
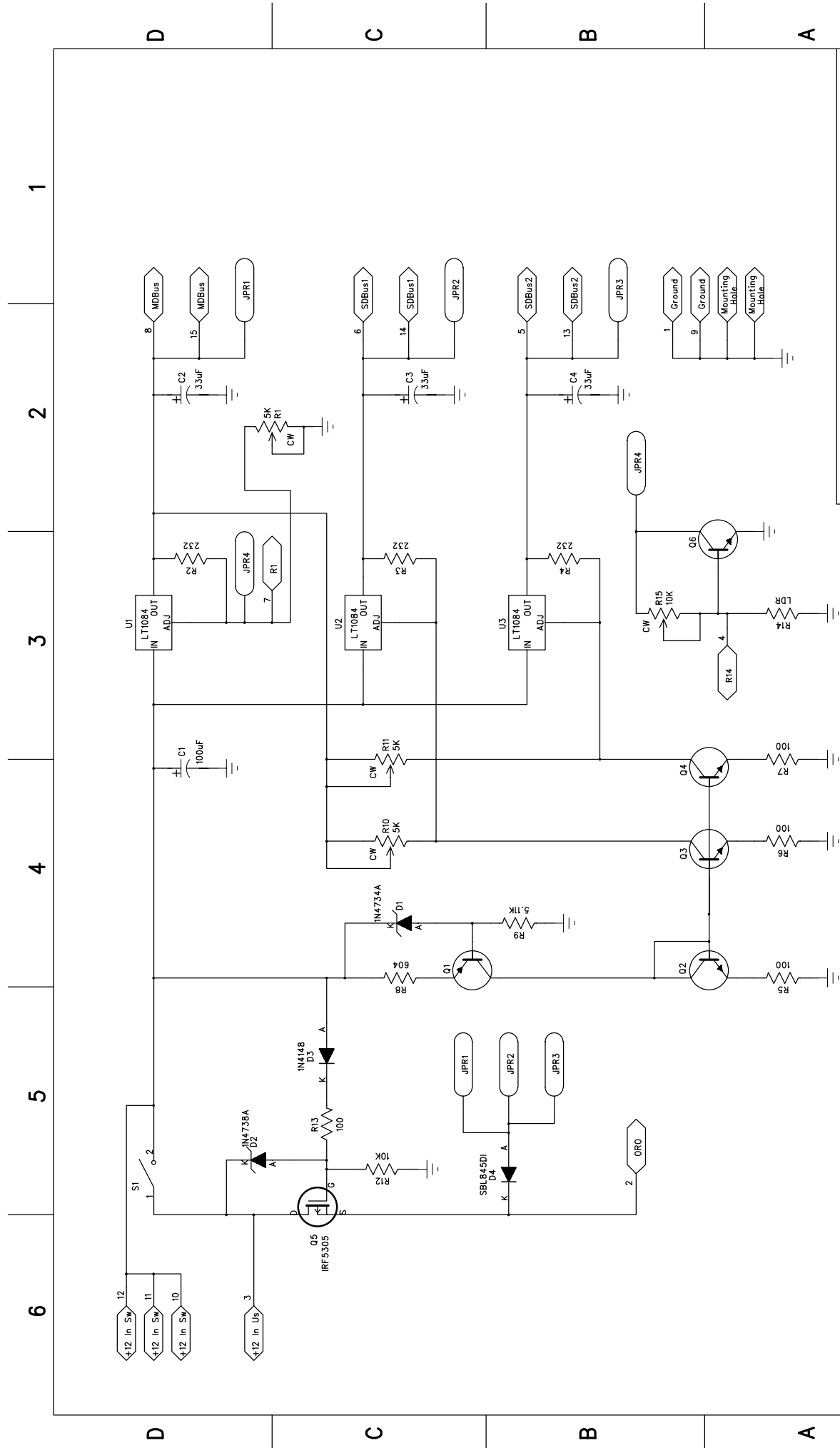


Figure 2: Basic Three Terminal Regulator



TITLE: PANEL DIMMER