LED Strip Lighting Upgrade

11 May 2014 – Jim Aspinwall

This article details a do-it-yourself LED lighting upgrade for the 12-volt D.C. lighting fixtures in Airstream and other recreational vehicles that have 12” fluorescent tube lighting fixtures. At least two things inspire such an upgrade – probably the most important is energy efficiency/battery-life when dry-camping. The second, for me, is that I despise replacing light bulbs of any kind, anywhere and anytime.

A third reason is that incandescent and fluorescent lighting emit ultra-violet light as a by-product of how they produce visible light. UV attracts bugs and decays materials. LEDs, unless designed to do so, produce very little or no UV light, attracting few or no bugs, which makes outdoor life a bit more pleasant. Ultimately there is an overall long-term hassle, time, and cost-saving benefit to LED lighting.

Ultimately this is a do-it-yourself project requiring a bit of wire, a few tools, soldering and appropriate care dealing with non-lethal low-voltage electrical circuits.

What We’re Replacing

Our target is replacement of the fluorescent tubes in a typical 12-volt, 12” RV ceiling or cabinet lighting fixture.

Typical 12-volt fluorescent lighting fixture.

Be SURE your fixtures are 12-volt D.C. and NOT 120-volt A.C. fixtures!! How do you know? One might assume that if the lights work when the vehicle is not connected to “shore power” they are running off your internal batteries. To be sure you will need to use a voltmeter to check the power wiring at the fixture.

Options and Costs

There are various options for replacing conventional incandescent and fluorescent lighting with LED lighting:

- Replacing existing fixtures with new LED fixtures at a cost of $60-100 each
- Replacing existing bulbs and tubes with new LED substitutes – at a cost of $18-25 each ‘bulb’
- Innovative do-it-yourself alternatives – $20 per fixture as described below

Our 30 foot 2004 Airstream has 8 dual-12”-tube fluorescent fixtures. The cost of the first two obvious off-the-shelf alternatives would be about $300 to replace 16 tubes if not at least $480 to replace all 8 fixtures. The cost of the D-I-Y replacement of the main “living space” lighting is $140. That leaves a lot of money available for replacing the other conventional bulbs with drop-in LED replacements.

There are two factors to consider with the “tube replacement” option – one replacement product conveniently snaps into the existing fluorescent tube sockets and uses existing wiring, compensates for the fluorescent starter ballast, and since the ballast circuit is left intact, probably does not save a lot of electricity/battery-life. Another tube replacement option requires re-wiring ‘around’ the socket and ballast system, and if you’re going to go that route, it can be done for less cost, as I’ll describe below.

Savings

In terms of bulb cost, over the ‘life’ of the vehicle, considering bulbs may last 2-4 years, perhaps not that much or break-even with the D-I-Y method, and you may ‘lose’ money with the fixture or bulb replacement alternatives. The biggest savings may be in battery life, which you may or may not replace every three years, and with reduced use and proper charging/maintenance may be extend to 4-5 years.

In terms of electrical/battery-life – going from incandescent to LED can drop your power consumption 60-80 percent! There is also considerable reduction in wasted heat which will reduce wear/aging of fixtures, wiring and A/C needs in summer. Going from fluorescent to LED will reduce power consumption 20-50 percent depending on how inefficient the original fluorescent fixture is.

Reducing the costs and hassles of the 3-B’s: Batteries, Bugs and Bad-bulbs make LED replacements fairly attractive.

Where to Start

I continuously shop for LED innovations. I dabble routinely in household bulb replacements with the goal of having NO incandescent, NO halogen, NO CFL and NO fluorescent tube lighting at home. In this quest I watch for new products to appear on-line and in home improvement centers. LED opportunities increase monthly.

There are hundreds of ‘cheap’ sources for CHEAP bulb replacements on eBay and Amazon. Most of those are also too-blue to be useful. For large bayonet ‘1141’ bulb replacements I like the warm-white bulbs available from Out of Doors mart – about $12 each.

I’ve acquired and experimented with the expensive rolls of LEDs with all sorts of color and effect controls, and while novel are not suitable for most normal lighting replacement. One concern is that the ‘white’ light output is significantly blue. For normal life use – dressing, eating, task lighting this is quite annoying.

Recently I returned to a Lowe’s store to acquire a few wedge-base LED ‘bulbs’ (typically used for landscape lighting replacement) to use in place of the #193 and similar bulbs in the Airstream dining table and bedroom side lamps. They are not cheap at $10 each but they are fantastically bright and pretty true white. Having acquired the appropriate ration of these I explored other LED options, found a similar bi-pin replacement for other fixtures, which are also suitable for some wiring/socket modifications if so inclined.

I then found the household LED fixture section and the ‘answer’ for the fluorescent replacement became apparent. They have kits of LED strip lighting, starter and expansion packs. I’d found and dabbled with similar components from Ikea so things were “looking brighter” for this project. The two-strip expansion pack for $20 is just what I needed.

Utilitech LED expansion kit.

I anticipated some “electrical work” to accomplish the goal, but $20 per fixture versus $50 seems more than ‘fair.’

Additional Supplies

Yes, there is a “tricky part” – this is a D-I-Y project! You need some “hook-up” wire, little blue wire nuts or crimp connectors, a few tools, and be able to solder. If you are familiar with your vehicle’s electrical wiring you may be able to get away with not having a voltmeter – to determine power source and wire polarity (positive/+ and negative/-.) “Measure twice, cut/wire once” is always prudent advice.

- Stranded hook-up wire – 20 gauge, two colors, 5 inches of each color per LED strip
- Small gauge (blue) wire nuts
- 40-60 watt soldering iron and 60/40 or 63/37 electronic solder

If you don’t have or are not familiar with these items, or soldering, you may wish to seek out a local amateur radio operator, electronic enthusiast or someone at a “Maker Fair” to help you tackle the preparation of the LED strips.

On to the bench and trailer…

How To

There are five main steps to this upgrade process:

- Remove the covers and fluorescent tubes from the existing fixture to access the power wiring to the ballast circuit. This also gives you some idea of how much wire you'll need and where to make the new connections.
- Prepare the LED strips with enough wire to connect them to the power source – this is where the soldering comes into play.
- Identify and disconnect (cut the wires) to the ballast circuit – the wiring from the power source and light switch will be your connection point for the new LED strips.
- Connect the wires from the LED strips to the power source wires.
- Mount (stick-on) the LED strips, place the wiring within and replace the covers.

Assessing the Work Space

For safety, or if you are simply timid about dealing with electrical circuits turn off the light fixture and turn off the main battery switch in the vehicle. I'm quite familiar with the guts of wiring and most fixtures and feel comfortable "working live" in this situation.

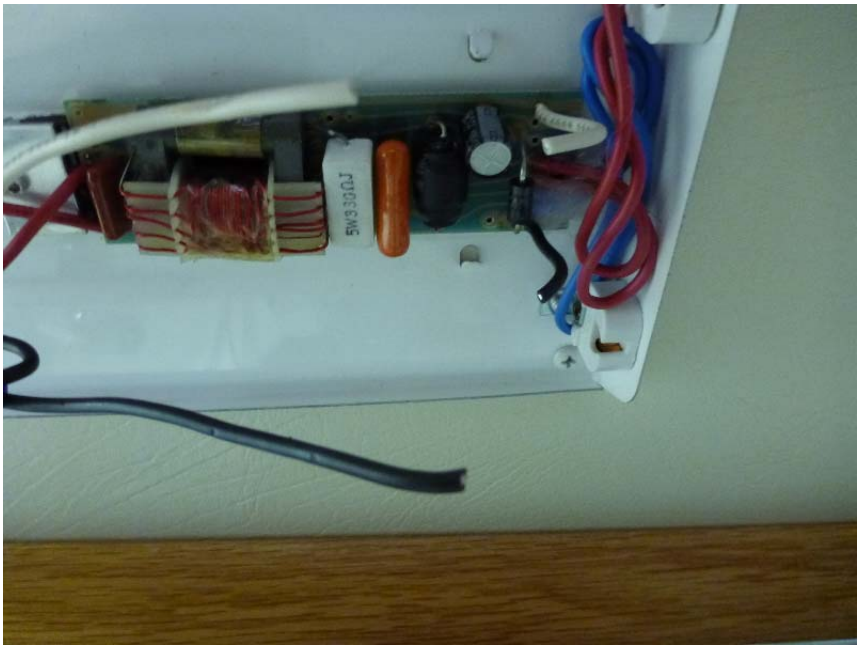
I suggest you start with an easiest to reach (under counter) light fixture, to save your arms and eyes from strain and dropping/losing any parts.

Remove outer cover and fluorescent tubes.

There isn't much to see under the outer cover but it allows you to size-up how and where you'll place the LED strips. Inside dimensions of the lighting 'box' from edge to edge are just over 12" – just enough room for the length of the strip and the wires we'll use. As you'll see later I found the best place for the strips are along a line from each of the mounting screws.

Squeeze and remove the cover over the ballast circuit and wiring.

The ballast circuit module is necessary only to provide a short burst of high-voltage to start the fluorescent tubes. We'll leave it in place but cut and use the power wires that go to it for our LED strips. Depending on the arrangement of the fixture you'll need 4-6 inches of wire attached to the LED strips to connect to the 12-volt D.C. power wires.



The 12-volts power wires from the vehicle 'ground' and power switch to the ballast circuit are the ones we'll cut and use for the LED strips.

This is a good opportunity to get familiar with the wiring behind and inside the fixture. The wires that come into the fixture may 'hot' all the time when your main battery switch is ON, or be controlled from a wall switch. We won't use the 'hot' or switched wire at this point, but the wiring to ballast circuit that also goes through the switch on the fixture. *Your fixture and light switching may vary – you decide.*

The LED strips are polarity-sensitive, which means you need to know which wire is positive/- and which one is negative/- in your vehicle system and on the LED strip in order to match them up properly. In most Airstreams the WHITE wire is the 'ground'/chassis/common or negative wire that is also connected to the vehicle frame. (This seems to mimic normal household wiring in which the white wire is 'cold'.)

The positive/+ or ‘hot’ wire in this Airstream is the black wire (which also seems to mimic household wiring) but I have seen blue, red, orange, yellow and other colors used for the ‘hot wire’, which is often switched at a wall plate or in the fixture.

This is a good time to have access to a voltmeter or at least a DC test light to determine which wire is which, which one is ‘switched’ on and off. Most analog (needle) and digital meters have a 15 or 20 volt scale appropriate to use for measuring 12-volts DC.

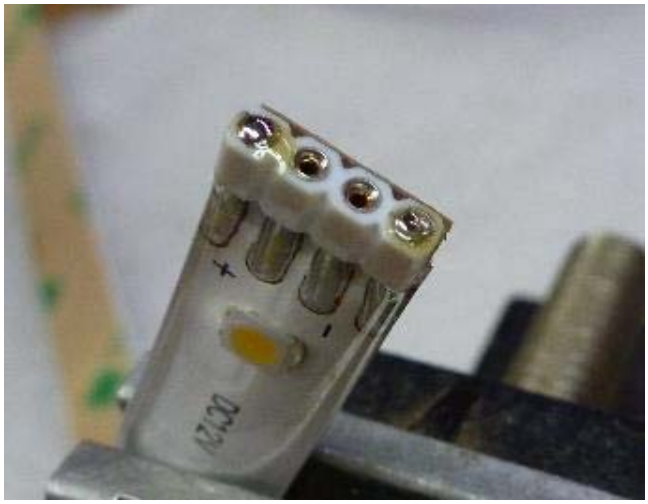
If you’re confident in the steps to this point and preparing the LED strips you could cut the wires to the ballast circuit now, leaving enough wire from the ballast circuit to re-connect it if you or someone will want to un-do this modification later.

Preparing the LED Strips

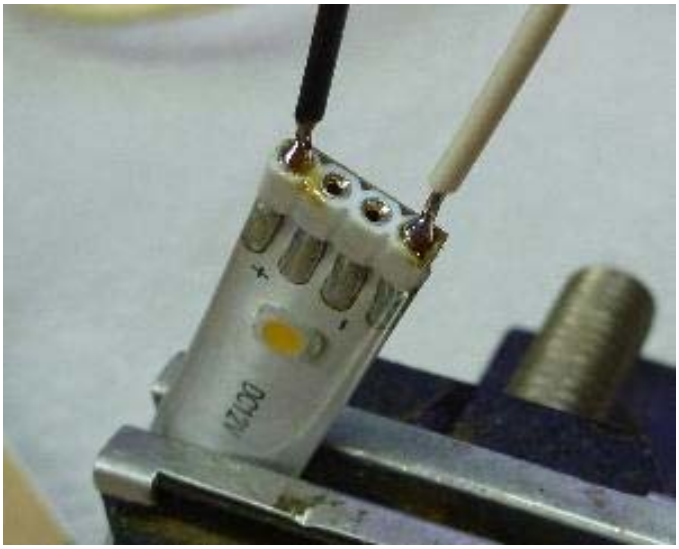
We’ll need to add some custom hook-up wires to the LED strips. The LED strip expansion kit comes with jumper connections to string a series of strips together. The plug-socket arrangement is convenient for most other applications but the plug is too large, making the strip longer than the fixture and difficult to mount evenly. Also the included jumper wire is not long or thick enough to make a convenient connection to the power wires that fed the ballast circuit. For these reasons we have to provide our own wires for the LED strips.

I do the LED preparation is “assembly-line” batch steps:

- Cut enough wires to length for each strip
- Strip 1/8” off one end for attachment to strip
- Solder ‘tin’ the 1/8” wire ends
- Secure the end of an LED strip
- Solder ‘tin’ connection points on only one-end of an LED strip
- Attach different color wires respective to + and – to match the fixture/ballast wires



Solder ‘tin’ two connection points at the end of the LED strip. Note + and -.



Attach 5 inches of wire to each LED strip contact point. Best if the wire color matches the wires/polarity of the fixture/ballast circuit.

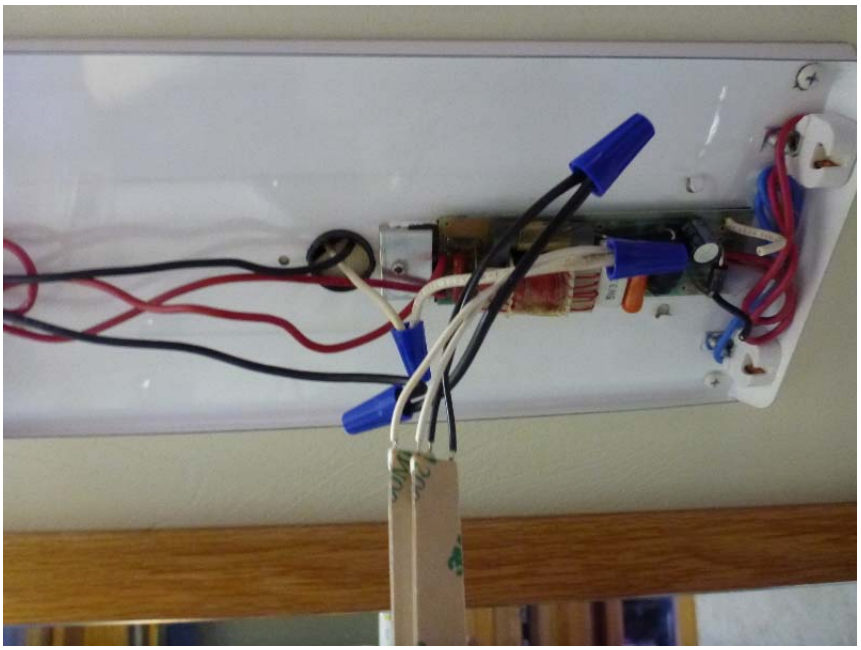
With hook-up wires attached to one end of each LED strip you now have a batch of strips ready to install in the fixtures.

A batch of LED strips ready to install.

Installing the LED Strips

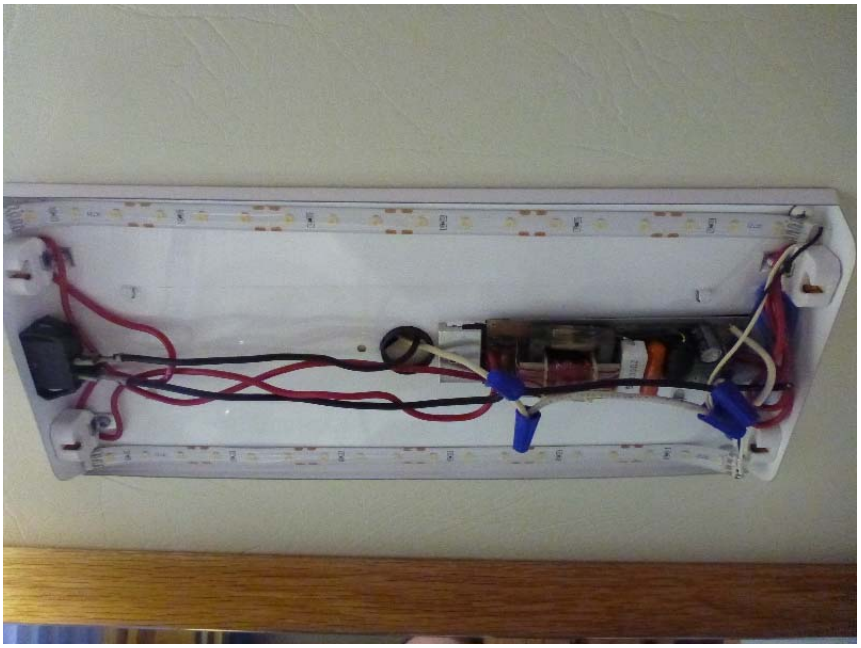
We'll connect the hook-up wires from the LED strips to the wires that were connected to the ballast circuit. In our Airstream the WHITE wire has been identified as the negative/-/ground/common wire and must connect to the negative/- wire attached to the strip, and the BLACK wire has been identified as the switched 12-volt positive/+/hot wire which must connect to the negative/- wire attached to the LED strip. The connection are:

- Strip 3/8 inch of insulation from the ends of the power source wires that were attached to the ballast circuit.
- Strip off 1/2 to 3/4 inch of insulation from the ends of the LED strip hookup wires.
- Twist together the three WHITE (negative/-) wires and secure with a small wire nut or crimp connector.
- Twist together the three BLACK (positive/+) wires and secure with a small wire nut or crimp connector.



Connecting the LED strips to the power wires in the fixture.

This is a perfect time to turn on the power and test the light switches to make sure the LED strip lights up before securing the strips to the fixture and finding out you may have to re-do the wiring. Once the LEDs are verified to light-up properly you're ready to secure the strips, re-assemble the fixture and move on to the next one.



LED strips secured inside the fixture.

Carefully route the hook-up wires along the edge of the fixture to allow clearance for the center cover.

Center cover replaced over the wiring.

Replace the diffusor cover and get ready to enjoy your new light fixtures.

A completed LED strip lighting project.

The time required to experiment with the first fixture was approximately 20-30 minutes. Once the process was established it took about 30 minutes to prepare the remaining batch of LED strips with hookup wires, and approximately 10 minutes per fixture to disassemble, re-wire, test and complete.

I do a lot of electronic bench work, and am quite familiar with the inner workings of two Airstreams mechanically and electrically so this was a “no-brainer” project for me. The biggest challenge is probably not the actual work at each fixture but determining the proper wires and preparing the hook-up wires for the LED strips. I always have a toolbox handy so if you catch me at a site sometime and have the basic parts you might be able to get a little help with this project for your vehicle!

I’ve also done some little custom modifications to fit other LED assemblies into large and small bayonet bulb bases, wedge bases, and solder-in the elongated ‘dome’ lights to various fixtures in order to get my rigs 99.9% LED (except for the oven light – that one needs to be a high-temp conventional bulb – for now.)

Happy battery, bug and bulb-saving! Enjoy the ride!

- Jim