BUILDING YOUR OWN

CONTROL BOARD

BY

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COMPILED BY JEFF MORRISON APRIL 17, 2015

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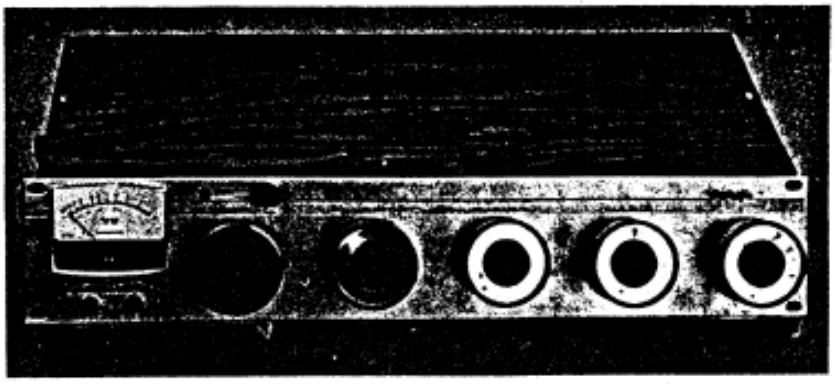

By Ronald Pesha

You can build a complete control board, achieve excellent sound quality and good appearance, and save money. Modern ICs have made the job enormously simpler than in the days of vacuum tubes or even the days of discrete transistors. I know; I have built boards since the days of tubes.

My early attempts were embarrassing disasters, but then I had no instructions. The suggestions in this article should get you started, and keep you going without too many pitfalls. Study the basic design, then modify it to meet the unique needs of your own station.

During seventeen years in commercial broadcasting I built numerous control boards, including two full-size stereo boards for a high power FM station. I also deejayed at stations ranging from the very small to a leading station in the nation's second market, so I know how a board should "feel." This is important; if you are not an announcer, get input from those who are. I am now broadcast instructor at a small college, and our ten-watter uses two boards of the design suggested in this article.

Basic Design

Basically a control board consists of a large number of inputs, each with a pot, mixed together on a common wire called a "mixing buss" and feeding a program amplifier. Refer to the Overall Schematic, (Figure 1) which shows one microphone input, one turntable input and one "high level" input. Preamplifiers for microphone are built into the control board, but turntable or phono preamplifiers are external. The "high level" inputs require no preamplification; these inputs are used for various types of tape players, telephone lines, etc.

All pots except the microphone pots are provided with cue positions. When in cue, the input is switched to feed a cue amplifier via a common "cue buss." (Figure 2). As a cue amplifier need be neither high power nor high fidelity, a small amplifier is built into the control board. Its output feeds a small speaker which can be mounted externally.

The main microphone switch shorts the microphone preamp output when off, and shorts the audio to the monitor amplifier when on. This mutes the monitor. Additional contacts can control a warning light.

It is easy to fabricate a very small "remote" amplifier by simply providing a few microphone preamplifiers feeding pots which mix via a mixing buss and feed a program amplifier. Such an amplifier may be built in a very small case, provided with a suitable headphone output, and powered with flashlight cells. The LM386 IC amplifier which is suggested for use in a large control board is ideally suited for this application, as it will function fine on six volts (four flashlight cells). Six volts will not allow sufficient output to drive a speaker for a cue amplifier, but is adequate for program-level output (a few milliwatts) in a remote amplifier.

Using a Conventional Pot Switch as a Cue Switch

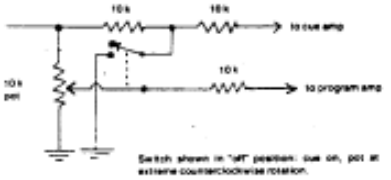

Figure 2

Overall Schematic

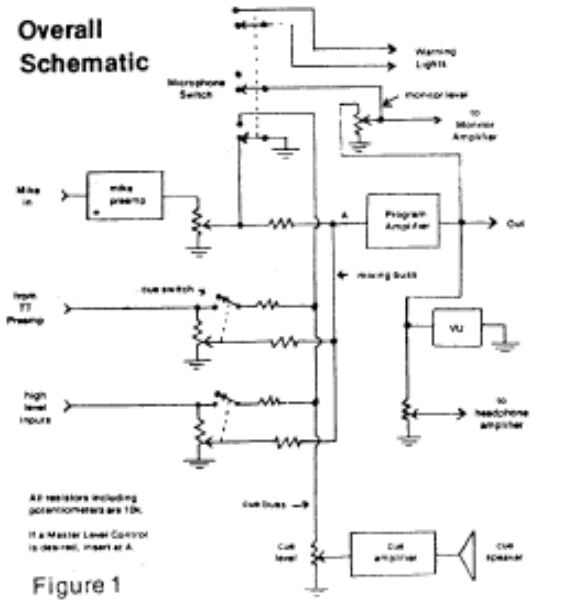

Figure 1

Microphone Preamplifier

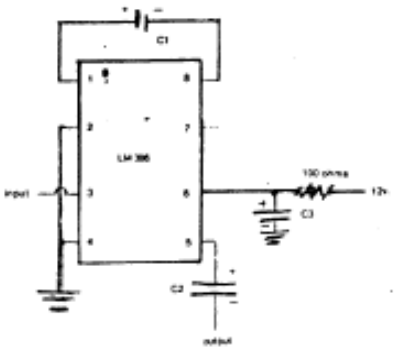

Figure 3

Cue Amplifier
Headphone Amplifier
Program Amplifier
Monitor Amplifier

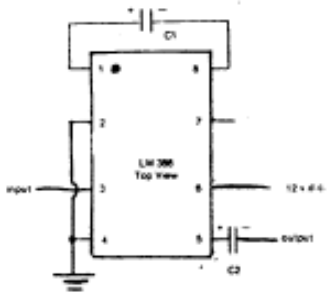

Figure 4

The Amplifiers

While this control board may be built with opamp type ICs for superior performance, I recommend using the LM386 (Figures 3 and 4). It's cheap, versatile, simple, and readily available at Radio Shack stores (no, I have no connection with Radio Shack). In the control board in the photographs, the 386 is used for microphone preamplifier, program amplifier, cue amplifier, headphone amplifier, and even low power monitor amplifier purposes. Using a single-ended 12-volt power supply, this IC needs a minimum of parts and provides sufficient output to drive 8-ohm speakers and headphones directly.

This low-impedance output is also used to drive "500 ohm" program lines. Now the subject of "impedance matching" is often misunderstood, and a full discussion would require much space. In this instance we are using the contemporary approach of feeding relatively high impedance loads with a low impedance source. The 500 ohm program line is effectively merely "bridging" the IC output, at such a higher impedance that its characteristics have no significant effect on the IC output.

Transformers often fail to function properly if the impedances are not closely matched, but we use no transformers here. For short runs, they aren't necessary. If the control board feeds nearby tape recorders, etc., just use single conductor shielded cable. If you do have a long audio run, such as to a carrier-current transmitter in another building, you will need a transformer. In this case, you can use a 500 ohm to 8 ohm transformer with the 8 ohm side wired across the control board's output.

The 386 is also recommended for microphone preamplifier service. While not designed as a low level device, I find that its hiss level is inaudible when used as an announcer's microphone preamplifier with the usual close talking. Note that the high input impedance of the 386 is bridged across the microphone's output, with no transformer. Again, if you have no microphone runs over 30 or 40 feet, you will probably experience no difficulty in using single conductor shielded microphone cable. The 386 wired in this manner can handle microphones from a very low impedance up to at least 10,000 ohms impedance.

I find that the overall distortion of the control board at program-level output (the milliwatt range) is well under 0.5%.

Using Opamp Amplifiers

If you prefer to use conventional opamps, I am including suggested amplifier designs (Figures 5 and 6) using a type 301 or 748 IC. Again, the very high impedance input merely bridges a microphone output and uses no input transformer. The output impedance of this type of amplifier is considerably higher than the output impedance of the 386, but it can also feed a program line directly without use of a transformer. If a transformer is necessary, for feeding a long audio line, use a 1:1 ratio transformer, rated at 500 to 500 ohms or 600 to 600 ohms.

An opamp requires a dual power supply, often called a split or center tapped power supply. I have found regulated power supplies unnecessary for this application, although it is often necessary to connect a large value non-electrolytic capacitor to ground from the + and — terminals of each IC. .05 uf or 0.1 uf capacitors are suggested.

Suggested amplifier designs include a necessary bypass capacitor, which should be as small in value as possible without resulting in oscillation or instability. Typical values range from about 4.7 pf to about 30 pf.

The Etched Circuit Board

The major hobbyist-type electronics parts dealers sell etched-circuit or printed-circuit boards which match DIP ICs such as the 386 and the 301/748 opamp. These boards include copper pads for mounting components. As each amplifier is so simple, with so few components, this approach is far easier than etching your own boards.

I mount the components on the same side of the board with the etched copper "wiring." This allows me to mount the board flat in the bottom of the case rather than on edge, and it makes for easy circuit tracing. I drill holes through the copper pads at ground points so that the 4-36 or 4-40 size machine screws used to secure the etched circuit boards in place also make the ground connections. I include internal tooth lockwashers under the nuts to be sure of a solid ground. Obscure problems have been traced to high-resistance grounds. In one case, an apparently tight and secure nut was loosened to reveal corrosion beneath. Once this bad ground was eliminated, the equipment functioned properly.

The Mixing Pots

If you're building a board, you're probably doing it to save money. Expensive constant impedance attenuators are out, unless a commercial station has given you an ancient vacuum-tube board with tar leaking from transformers but good pots. I salvaged pots from such a board and junked the rest (the case could have been stripped and repainted, but it was just too large). At other times I have used ordinary carbon pots, even when building boards for small commercial stations. True, they wear out rapidly. But they are cheap to replace and, if the board has been fabricated in an accessible manner, easy to replace.

By using inexpensive carbon pots, you can select a convenient mixing resistance. I suggest 10,000 ohm pots. This value is high enough not to "load" most sources to excess, but low enough to keep noise pickup low. You may locate the higher quality Ohmite "AB" brand pots at a bargain price on the surplus market. If only linear-taper pots are available, they can be converted to audio taper by connecting a resistor from wiper to ground. This resistor should be about 15 to 20 per cent of the resistance of the pot.

Pot Spacing and Knob Size

By all means, space the pots widely and use large knobs. Disc jockeys cannot work easily with tiny, close-spaced knobs. Furthermore, excessively small and narrow control boards with tiny knobs look

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Use of IC Opamp Type 301 or 748

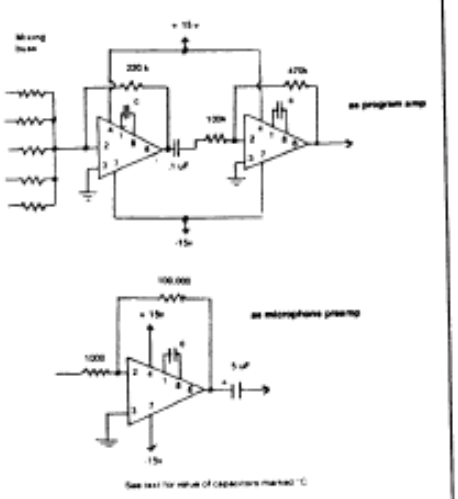


Figure 5

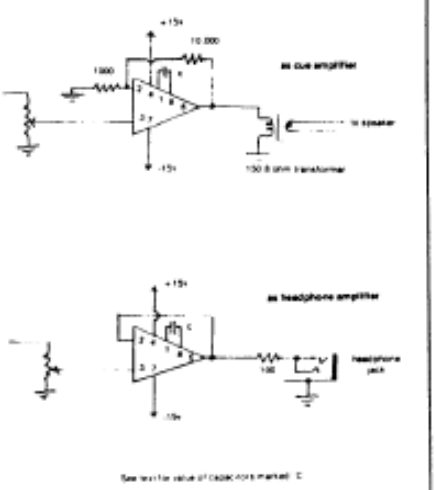


Figure 6

building your own control board . . .

(Continued from Page 8)

toylike. Really large knobs on a dramatically wide board will make your project look very impressive.

Large knobs are not commonly available from the usual electronics supply houses. The knobs used on some commercial control boards such as Harris (Gates) are available as replacement parts from the manufacturer. The knobs shown on the control board in the photographs are 2-1/8 inches in diameter and feature an attractive chrome insert and two set screws. These were purchased for $1.32 plus shipping from National Radio Corporation, 89 Washington, Melrose, Massachusetts. They are available in either black or gray, and are known as "HRT" knobs.

Stereo Mixing Pots

If you're building a stereo board, you will need "ganged" pots, two pots on a single shaft. Inexpensive carbon dual pots suffer from poor "tracking." That is, resistances do not change exactly the same from section to section. The result is changing balance in the stereo sound as the pot is turned up and down.

To avoid this problem with inexpensive dual pots, follow the suggestion about wiring a fixed resistor from wiper to ground. The exact value of the resistor is not important, but use an ohmmeter to choose two resistors which match as closely as possible, and wire these from wipers to ground on a dual pot. Matched resistors of 20 per cent or less of the resistance of the pot sections will tend to "swamp out" variations in the pot "tracking" and greatly improve the balance. This works best with linear-taper pots. Perhaps you can locate dual Ohmite "AB" brand pots (which come only in linear taper) of suitable resistance. Just be sure the resistance of each section is the same.

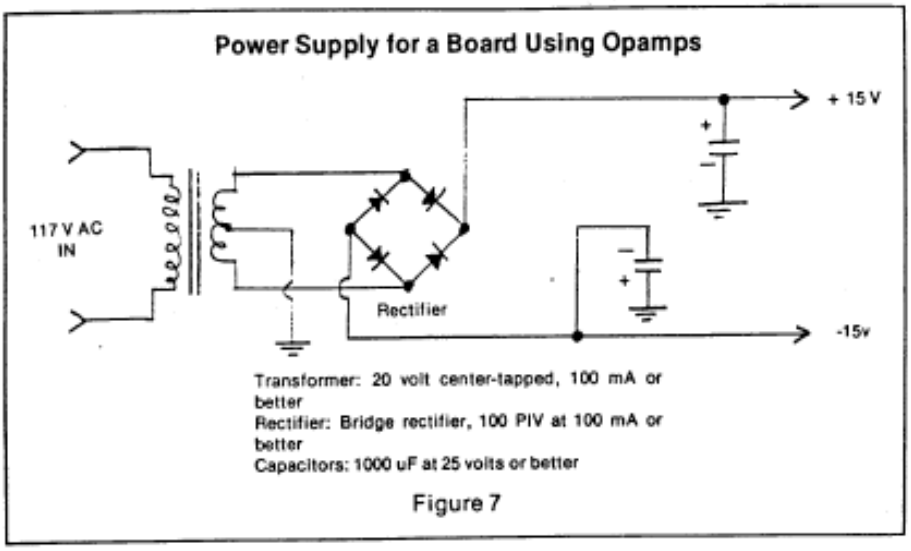


Figure 7

The Power Supply

A simple control board deserves a simple power supply. I have found for non-critical use that opamps such as the LM301 do **not** require a regulated supply. They do require the usual dual or split supply, but a single transformer, bridge rectifier, and two **large** filter capacitors are adequate. See Figure 7. It may be necessary to wire capacitors of about 0.1 uF value directly from the + and — inputs of each amplifier to ground to avoid oscillation, but this is a characteristic of the opamp rather than a fault of the power supply.

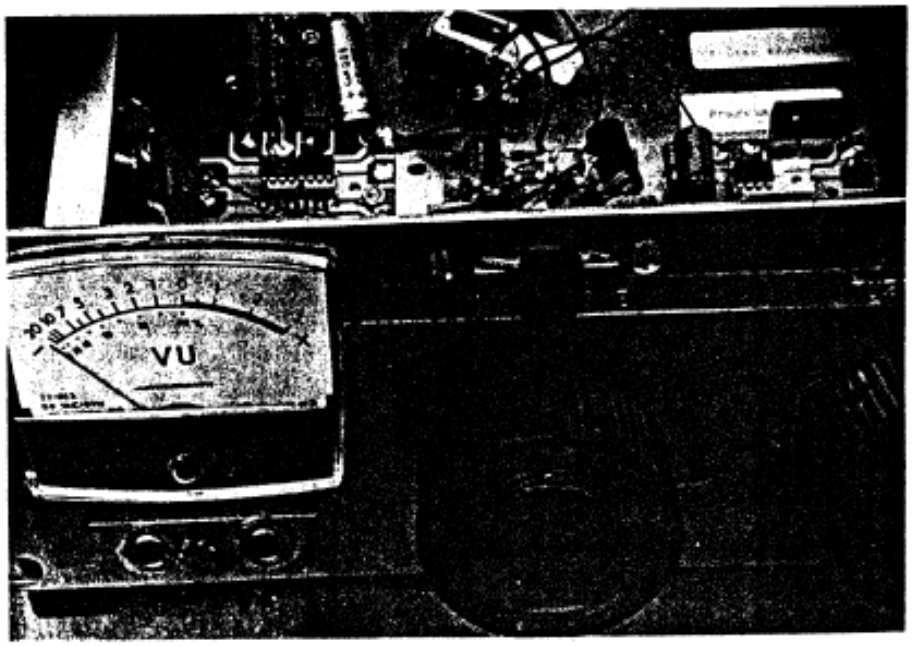
Opamps are generally rated at plus or minus 18 volts maximum. A power transformer rated at 24 volts or more center-tapped is too high. Though harder to locate, try to use a transformer rated at 20 volts center-tapped.

The power supply diagram for a control board using the suggested LM386 amplifier includes a 3-terminal 12-volt voltage regulator. (Figure 8). Such regulators are cheap and easy to use, and the power supply remains simple. Furthermore, the single-ended 386 is more sensitive to power-supply hum than opamps and require better filtering.

Be sure to include a fuse of suitable current rating in the primary of the power transformer. In the unlikely event of a failure, you don't want to blow the circuit breaker for the whole Student Center.

Normally, I wire all components of the power supply inside the control board's case, except for the power transformer. Mounting it externally avoids possible magnetic hum problems, and it also keeps the 117 volts A.C. completely out of the board itself. However, with care it is possible to mount the transformer internally and fabricate a fully self-contained control board.

I do not use a power switch. It's another control for disc jockeys to forget to operate. The integrated circuits use very little power when idling. An old tube-type board which draws upwards of 200 watts continuously when on is a different matter, but a small modern IC board certainly requires no power switch of its own.



Two standard jacks are mounted below the VU meter. The "output" jack feeds earphones, and the "input" jack allows direct access to the mixing buss for patching in a portable cassette recorder for playback. Removing the top exposes components and wiring for maintenance and service.

Phono Preamplifiers

Traditionally, the turntable preamplifier has been external from the control board and mounted near the turntable itself. While I have built solid-state preamps with proper equalization inside control boards, it is difficult to beat the price and convenience of the plug-in-to-the-wall phono preamps sold by dealers such as Radio Shack and Lafayette. These units are very inexpensive and while they may not have equalization as precise or noise level as low as a commercial broadcast-quality preamp, remember that we're doing this all on a tiny budget.

Remember, too, that broadcast-quality preamps usually come with expensive output transformers and sufficient power to feed into a 600-ohm (or even 150-ohm) load, traditional for old-time control boards. On our board, the preamp feeds into the much lighter load of the 10,000 ohm pot.

Note that these consumer-grade preamps are stereo units, and the separation between channels may not be sufficient for two different turntables in a mono control room. However, they are still inexpensive if only one channel is used.

The Case

The small 5-pot production board shown in the photographs was built inside a standard aluminum chassis, 17" x 13" x 3" high, with the top open rather than the bottom. This results in a low control board with great accessibility. Just lift off the top and all of the wiring is exposed.

For the front panel I used 1/8" thick aluminum in the form of a standard 19" wide relay rack panel. Both the rack panel and the large chassis are available from the large electronics parts houses. Be sure to get aluminum, not steel. The heavy front panel gives a solid look and feel to the project.

I cut pieces of wood to fit the ends of the chassis, stained them, and secured them with wood screws driven from inside the case. A sheet of wood cut to fit the top finishes the control board, while retaining the accessibility. The combination of wooden case and aluminum front panel results in a control board as attractive as it is functional. If you need a control board wider than 17 inches, mount two chassis side by side. A long low control board, three feet wide but only inches high, can be very impressive in appearance.

Or you can have a suitable case made to order. Virtually any community has sheet metal shops. While they specialize in ductwork for heating and air conditioning, most will have the necessary shearing machine and sheet metal bending brake to fabricate a case for you. Draw the case indicating the dimensions, and incorporate a sloping front panel if you like. I suggest keeping it only a few inches high but wide enough for all your pots and a VU meter.

Sheet metal workers customarily work with galvanized iron. You may have to wait while a shop obtains sheet aluminum. While you're at it, ask the shop to get a piece of 1/8" thick aluminum for the front panel, cut to exact size. Get a quote first.

You'll need an electric drill to prepare front panel holes for the pots (use a 3/8" drill bit) and to prepare the rear panel for the necessary external connections . . . jacks, barrier strips, etc. You'll need a large round hole to mount most VU meters. I mark the hole, drill a series of small holes inside the mark, and finish with a coarse half-round file. It's slow, but cheap.

The Monitor Amplifier

I always use a monitor amplifier separate from the control board itself. To feed the control room speakers, any amplifier of reasonable quality and a few watts output should be satisfactory. If you need to feed speakers in other studios, office, etc., use a separate amplifier. The monitor amplifier for the control room should be dedicated to that purpose, as its level and muting are controlled within the control board. Place this amplifier in an inaccessible location, setting its volume control for a reasonable range on the control board's monitor level control.

Warning Lights

The microphone switch should provide contacts to control a warning light. Do **not** wire 110 volts a.c. directly to this switch! If it controls a relay, use d.c. for the relay, and don't ground the relay power supply to the board or you will have clicks in your audio. I have used a flashing LED mounted at eye level as a warning light, and found that it attracted more attention than a 100 watt red bulb burning steadily **over** a door.

Headphones

I use a separate 386 integrated circuit amplifier to drive headphones. An opamp amplifier may also be used. This makes it easy to provide a level control for headphones, wiring it at the input to the headphone amplifier.

The output of the headphone amplifier is wired in parallel to both sides of a three-way jack. Thus, standard low-impedance stereo headphones may be plugged in without alteration. Operators may bring their own headphones. In fact, to avoid the problem of excessive wear and pilferage, my station now no longer provides headphones, but allows operators to use their own. This has reduced strain on the budget.

The 386 IC makes a fine headphone amplifier used by itself, for any location in your station where you need to feed low impedance headphones. Just build one 386 circuit and provide a level control and a power supply. For power, obtain one of those transistor radio or cassette recorder "battery eliminator" power supplies, add at least 1000 uf of additional filtering capacitance across the output, and you're all set. 6 volts is adequate, or you can use 9 or 12 volt units.

Keep It Simple

Fabricating your own control board is a big project, but it can be handled if you keep it simple. Don't get carried away and make it as complicated as possible, which may delight technical people but will confuse inexperienced non-technical announcers. Build the facilities you need, and no more. You don't need to allow extra controls "for the future." The future is nearly always different from expected, but a home-fabricated control board is inexpensive enough to warrant a new control board in a few years. Conversely, a commercial control board may also become outdated in this era of high technology, but its thousands of dollars of capital investment make it difficult to replace.

By all means, build a single-output board . . . at least for your first board. The possibilities of crosstalk in a board designed to handle two different programs simultaneously are astronomical. You will have bugs, no matter how carefully you plan, so keep it simple and allow plenty of time. And if you have specific questions, please write to me: Mr. Ronald Pesha, Adirondack Community College, Glens Falls, NY 12801.

Power Supply for a Board Using LM386 Amplifiers

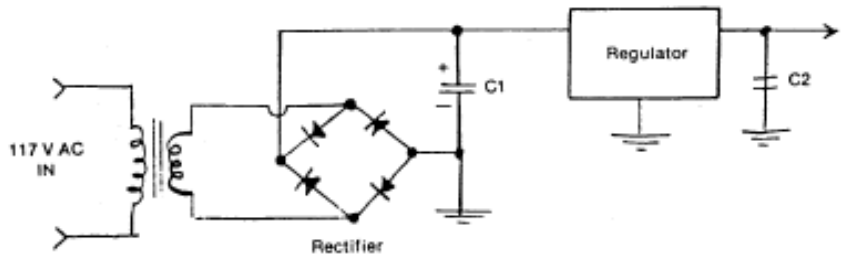


Figure 8

Transformer: 12.6-volt, 100 mA or better
Rectifier: Bridge rectifier, 100 PIV at 100 mA or better
Regulator: 12-volt three-terminal regulator, 100 mA or better (usually available in 1-Amp size)
C1: 500 uF at 25 volts or better
C2: 0.1 uF