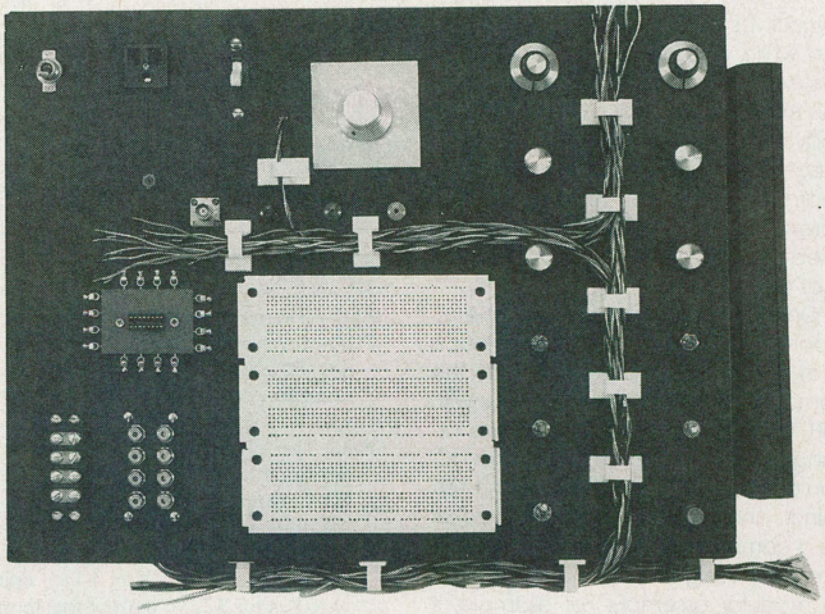
Build the ProtoMax Design Station



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Designing electronics circuits is much easier with this breadboarding system. It puts everything you need at your finger tips.

Quite often when you're working on one project, you have to start working on a second project to help speed the completion of the first one. That's exactly the scenario that lead to the creation of the *ProtoMax* prototyping station described in this article. While assembling and testing a bunch of power-supply filter boards, it seemed that a custom test fixture was needed to speed up the test procedures.

However, on second thought, it seemed more worthwhile to build a "generic" test fixture. It could contain everything needed to test the filters, in addition to many other components that could come in handy.

You've all seen the usual kind of prototyping board, containing a power supply and maybe some switches, but very little else. And even though an ordinary protoboard (for short) is helpful when testing a new circuit design, you always end up having to solder leads to a potentiometer, a switch, a jack, etc. And when you get down to it, you can never find the jumper leads that you had cut, stripped, and tinned the last time you used your breadboard. Well, no matter what devices you commonly use, you can permanently install them on the ProtoMax and have them always available.

With that in mind, let's take a closer look at the ProtoMax, and explore the ways that such a device can help save you a lot of time and aggravation. By the way, all of the components to be discussed have wire braids already attached to them, so they can simply be plugged into the prototyping board whenever needed.

An Overview of Features. Believe it or not, the most electrically "active" part of the ProtoMax is the AC-power section. It's located in the upper-left corner of the unit. It consists of an AC power cord, a circuit breaker, a toggle switch, and an AC socket, all connected in series (see Fig. 1). That section is used to provide safe, switchable current for either a test instrument or an AC adapter used to power a prototyped circuit. By the way, buying a universal AC adapter (like a wall-transformer type) will keep you from having to build a power supply for each circuit that you just want to try out.

An interesting section of the unit is the variable attenuator (located in the upper-middle section of the ProtoMax chassis). For what it does, it's very easy to build. Its purpose is to allow the user to tap current off of a resistor network (see Fig. 2). The switch allows you to select one of several voltage dividers in the network. If the input and common leads were connected to a power supply (or some other signal source) the power available to the output lead is halved each time you switch to a lower position in the network.

If you decide to build one for yourself, keep in mind that the values of resistance you use and the number of switch positions is up to you. In fact, the resistor labeled R_{min} can be omitted if you don't want a minimum value of resistance between the input and the output. Its usefulness depends on the limits of your imagination. I've used it to tap a desired voltage from power supplies while providing them with a continuous load (which is mandatory for transformerless supplies), and to attenuate signals to determine certain circuit characteristics; output impedance, for example.

Off to the left of the protoboard is a curious device built around an IC socket. It can fill a variety of needs. It is a piece of printed-circuit board with traces that run between the socket and the terminals that surround it. The terminals can be used to grab onto wire or the tip of a test probe. (You know how difficult it is to hold a test probe on an IC pin while also doing other things!) It's also very easy to put an alligator clip on the terminals. Another neat benefit that may not be apparent is that the entire assembly can be detached from the main unit with the removal of two screws. That way the IC board can be used all by itself if it's more convenient that way.

One of the niftiest uses for the IC board is to test DIP headers in projects that require multiple copies of the same header. For those unfamiliar with DIP headers, they're just terminals arranged exactly like the pins on an IC. You can solder components to the terminals and plug them into an IC socket as a complete assembly. They're really great for designs that lend themselves to modular assembly. For example, if you have a series of display boards on a project, all requiring the same signal-conditioning circuit, noise filter, or pull-up resistors. If one of the displays fails, you simply have to swap DIP headers between display circuits to find the culprit.

When making-up a batch of headers, the builder need only hook the small board up to either the prototyped circuit on the protoboard or the actual circuit and test header after header.

It also provides you with a means of transferring support components from the protoboard to a header. Assuming your prototype is already working, you would start by plugging an empty header into the little board. Remove a component from the protoboard and replace its leads with wires on the board. Install the component into the header, and attach the leads you put in the protoboard to the appropriate terminals on the little board. Do that for each component to be moved to the header, test the system and you're done. Now all you have to do is make copies of that header. Not only have you prototyped a header, but you've made a test fixture for them as well!

One use for the socket (and perhaps an obvious one) is to permit you to try different pin-compatible IC's in the

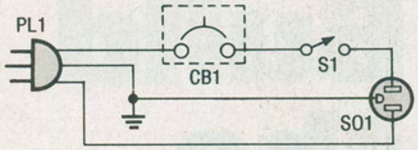


Fig. 1. The AC-power section consists of an AC power cord, a circuit breaker, a toggle switch, and an AC socket all connected in series.

PARTS LIST FOR THE PROTOMAX

R_A, R_B—See text
PL1—3-terminal molded AC power plug with line cord
CB1—Circuit breaker
S1—SPST switch
S2—Rotary switch
SO1—3-terminal 117-volt AC outlet
Perfboard materials; enclosure; IC socket; assorted potentiometers, switches, connectors; wire; hardware; etc.

Note: The following items are available post paid from John Yacono, P.O. Box 4042, Farmingdale, NY 11735. An assortment of three control potentiometers (10k, 250k, and 2-megohm) for $5.00; fifty 4-inch nylon wire ties for $2.00; both of the above and 20 feet of industrial-grade Teflon-coated twisted pair for $9.00. Send a SASE for a list of other available parts (list is included with all orders). All payments in U.S. funds only; NY residents add applicable sales tax.

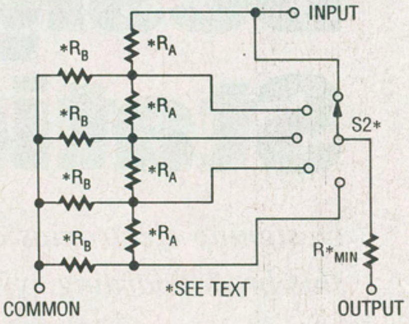


Fig. 2. A switchable attenuator is easy to build. The switch allows you to select one of several voltage dividers in the network.

same application. I was designing a circuit one time, only to find out (after burying an LM239 quad comparator under tons of wire) that a different IC (an LM339) was needed to provide enough source current. (My eloquence for profanity was elevated beyond all human stature that day.)

Kidding aside, it can also be used as a mini break-out box for computer-interface projects. The incoming signals can first be sent to one side of the board (going to the pins on one side of the IC socket). They will leave the little board and go to the protoboard from the other side. Bus wire can be used to connect and cross-connect pins on one side of the IC socket to the pins on the other side, allowing you to change connections (and thus hardware protocol) without touching the circuit on the protoboard. That provides you with the ability to organize your work clearly and keeps things from looking like a rat's nest. As a variation on the same idea, you can put a DIP switch in the socket and switch between different protocols.

Just below the header-prototyping area are a barrier strip and eight RCA phone jacks. The barrier strip allows you to connect external circuits that have either lugged or bare, stranded ends to circuits on the protoboard. The RCA jacks perform the same function for external devices sporting RCA plugs.

Eight jacks might seem excessive, but what if you need to set up some kind of audio/video A/B switch? If the circuit must condition one signal based upon another (handling the audio and video separately), you'll need two audio inputs and two composite-video inputs (for A/B operation), two modulating-signal inputs (one audio and the other video), and two outputs (again audio and video). There go the eight jacks! Now imagine even a simple surround-sound project and all its possibilities.

All the knobs and switches on the right side of ProtoMax allow the user to control all the various parameters in your prototyped circuit. The potentiometers include many of the standard values in use by most hobbyists: 10k, 50k, 250k, 500k, 1-megohm, and 2-megohm. They, like the RCA jacks, can be connected to a prototype circuit using the leads already soldered to them.

Various types of switches are used on the ProtoMax. However, there are no single-pole single-throw toggle switches—that would be a waste of the unit's surface area. Why install an SPST when a DPDT can do the same job...and then some? Among the switches are two center-off DPDT's (again because they are more versatile than normal DPDT's), one locking DPDT (for sensitive circuits you don't want to switch accidentally), and three momentary-contact switches of various configurations.

The last area of interest (besides the

breadboard itself, which is self explanatory) lies between the attenuator and the prototyping board. Located there is a row of inputs and outputs: one BNC connector, and a series of pin jacks. They can be used to provide power and allow the user to connect an oscilloscope or other instrumentation (signal generators, DMM's, etc.) to the prototype via the pre-tinned twisted pairs.

But enough about the features of our ProtoMax, let's talk about what features you should put in yours.

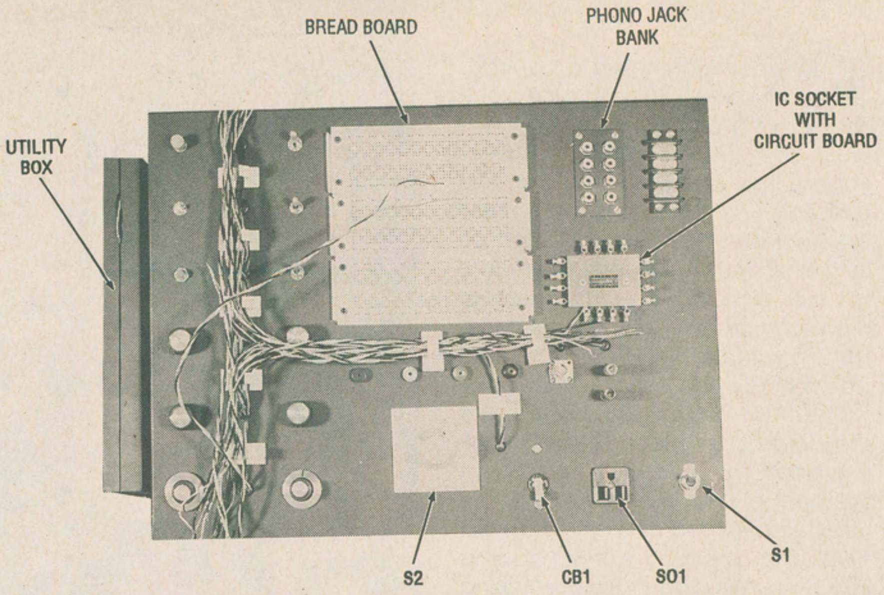
Build What You Need. To begin with, you must first determine what immediate needs you have. That's because, even though it's a good idea to have a ProtoMax, you probably won't build one project until you have a definite need for one. You may need anything: a speaker, a switch, whatever. Then try to remember what components might have come in handy in the past, had you had them around with leads attached. Last, consider the things that are likely to be needed, such as common jacks, connectors, power supplies, perhaps a voltmeter, and, of course, the breadboards. Then all you need is a cabinet that is suitably sized.

Keep in mind that the ProtoMax doesn't have to win any beauty contests. You can mount everything on a wooden board if you have to, just as long as any hazardous voltages are safely concealed. All that matters is that you effectively transform your "junkbox" parts into something that is very useful, and at your fingertips when you need it.

Construction. Since the ProtoMax is pretty much a "generic" test fixture, let's talk about building it from a generic point of view. We'll tell you how to build any kind of fixture from the ground up, and include examples of how the ProtoMax itself was assembled.

To start off, gather up everything that you think you would like to include in your unit. Then decide which things will be wired directly together, if any; you may want to have everything independently available. For example, you could hook up a power supply directly to a terminal strip, or just have leads coming from the supply ready to be hooked up to whatever you like, whenever you like. If a number of the devices in your unit are to be interconnected, it's a good idea to draw a schematic.

Now you must choose some sort of cabinet for the unit. Our ProtoMax was installed inside a large aluminum project box. Holes for the various attachments were made in different ways. Round holes were simply drilled out, while square holes were cut out with a nibbling tool and filed to a perfect fit.



ProtoMax contains a step-variable attenuator, consisting of S2 (a multi-position rotary switch) and several series connected fixed resistors; there's also a bank of RCA phono jacks, a breadboard, several potentiometers and assorted switches, and an IC socket.

Other types of cabinets are just fine; plastic, wood, etc. You can even mount everything on a piece of wood, although it's hard to mount panel-mount items on a board—but if you can find a way to mount everything, do it.

The next thing to do is plan how you are going to position everything on the front panel. While laying out your unit, it's best if you make a template for the front panel out of a piece of paper, with the components evenly spaced. If you use a ruler to do the job right, the final result will be neat in its appearance.

Like our ProtoMax, you should group similar items together. For example, all of the switches should be grouped together, output jacks together, etc. Another thing to keep in mind when positioning some items is whether you're right handed or left handed. Controls are easier, and safer to use when you don't have to reach across the board to get to them. Also, try to keep controls that are easily knocked out of whack (like potentiometers) further away from you than more stable ones. For the same reason, place toggle switches closer to the protoboard than pushbuttons.

If you must attach leads to, say, a potentiometer, and they must come through the panel to the front, prepare a spot for an oversized hole to accept a rubber grommet. A grommet will prevent the rough edge of the cabinet's material from harming the wire's insulation. Note you can reduce the number of grommet holes you must drill if you use some kind of color scheme in your wiring. Also, don't forget to mark holes for mounting hardware as required.

After you have your template just how you want it, either transfer the markings to the front panel or tape the paper to the panel and drill right through it. (By the way, if the cabinet you use is metal, center-punching is recommended. Misaligned controls and connectors are easy to spot and, if you like symmetry, can make you wince each time you use the unit.)

After all of the holes are drilled, test fit all of the components before continuing. If all is well, now is the time to paint the cabinet if you are going to do so. It's not necessary, but it does add a nice touch to the project without adding too much extra work.

The ProtoMax was painted with a flat-black spray paint that dries with a peble-grain texture. You can simulate that kind of test-equipment finish with any flat black spray paint, although it takes more time and paint. Start by applying a very light (barely complete) coat of spray paint to all surfaces from a distance of at least two feet. Use broad sweeping stokes, first left and right, and then up and down to fill in any unevenly covered areas. For this kind of finish

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PROTOMAX DESIGN STATION
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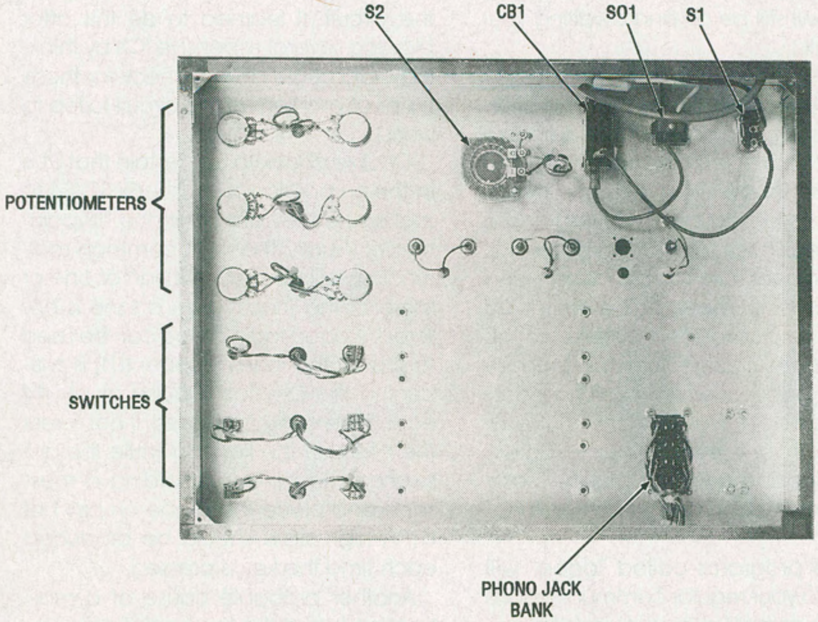

Here's an inside view of ProtoMax, prior to the installation of the multitude of interconnecting wires. Insert a rubber grommet in any hole through which wires are to pass to prevent jagged edges around the hole from stripping the insulation from the wires. To prevent accidental disconnection of any of the connecting wires, be sure to use strain reliefs: Anything that will prevent pressure being exerted on the connection joints themselves is fine.

don't move too slowly. Repeat that procedure every 20 minutes until the cabinet is thoroughly coated.

Just remember though, no matter how you paint your cabinet, be sure to wait at least 24 hours for the paint to dry completely. It may seem dry after an hour or so, but the finish doesn't harden for some time after that.

When the paint is fully dry, mount all of the components in the proper holes and then turn the unit over for wiring. Be careful not to scratch the paint as you install the components. It is a good idea to place the project on a throw rug or an old piece of carpet to prevent marring the finish.

When wiring each component, you should solder a lead to each of their terminals. That way they'll be as versatile as possible. Make sure that the wire that you use can fit in the breadboard sockets after it has been tinned. You can use solid wire, but it has a tendency to break more easily than stranded wire. Try to come up with some sort of color scheme so that you can immediately tell which wire goes where. If you don't have enough different colors for easy identification, you can mark some of the wires with pieces of heat-shrink tubing placed at various places along their length.

Use at least a foot of wire for each lead, so that it will be easy to test-wire your circuits later on. Twist all the wires common to one component together, and pass them through a grommeted hole. Also, it's a good idea to add some kind of strain-relief to the wire coming out of the front panel.

There are two methods of incorporating strain relief to the leads. In one, a self-locking wire-tie larger than the hole itself prevents the wires from tugging on the solder connections. In the other, a loop of wire is fastened behind the panel and performs the same job in places where a large grommet is used. Use whichever method you find to be the easiest.

Turning back to the other side of the unit, each group of wires should be uniformly cut, and the ends of the wires stripped and tinned. The wires can then be plugged right into the breadboard whenever the component they are connected to is needed.

Now let's go over a few of the finishing touches that were done to our ProtoMax. To begin with, adhesive-backed rubber feet were put on the underside of the enclosure at all four corners. That way, the unit will stay put on your workbench.

Also, a neat little metal utility box was attached to the side of the unit using Velcro tape. It is very handy for toting tools that you use all the time (but can never seem to find). Ours contains bus wire for protoboard wiring, an IC extractor, small wire strippers, test-instrument leads, and a full compliment of color-coded alligator clips (which, no matter how many you have, you never seem to have enough of).

As a final touch, adhesive-backed snap clips are used to hold the leads out of the way when not in use. Place them on the front of the unit in positions where they will do the most good. Notice the unused wires for the ProtoMax are a good distance from the protoboard and don't interfere with controls and such.

Now you are ready to tackle the "meanest" of test circuits without even breaking a sweat from running around looking for components. Everything will be all together whenever you need it and at your finger tips. ■