

# Building projects: how to

Whether you're building projects from *Modern Electronics* or loading up your junk box, parts can empty your wallet. Here are tips from a professional experimenter on how insiders save big money when they buy components cheap.

by Jeff Sandler  
Contributing Editor

**B**ack in those good old days we always seem to be reminiscing about, you could buy all the electronics parts you needed. In New York City, for instance, there was Radio Row—two blocks of electronics stores, some dealing in new brand name parts, others in surplus goods.

Resistors, capacitors, inductors, transformers, tubes, sockets, gears, dials, controls, chassis, cabinets, test equipment, radios, tvs, tuners, turntables . . . if it was related to electronics you could get it on Radio Row.

It's a far different story today. There's Radio Shack with a limited supply of parts. And most cities have at least one electronics parts distributor. But, you'll have to pay top dollar for parts from these sources—if you can get the ones you need!

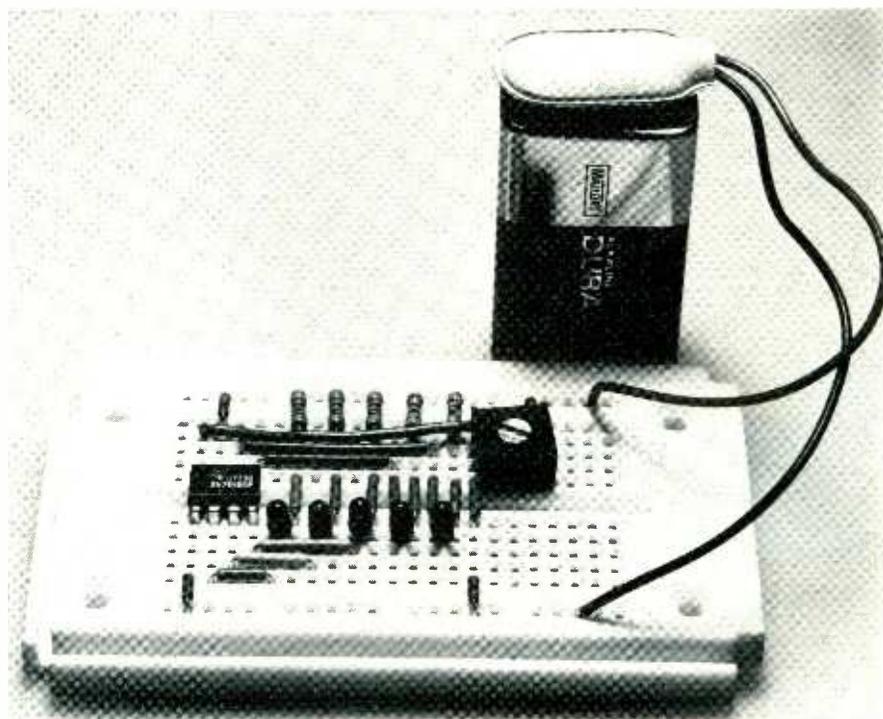
Your problems in obtaining the right parts at the right price when you need them are multiplied if you're really into construction because of the large number you need. Fortunately, there are ways you can get what you need, when you need them, and at a price you can afford.

## Impossible triad

In the world of economics, there is something called the *impossible triad*. The triad is composed of three elements: price, quality, and availability. According to the triad, it is impossible to get top quality and low cost on an "I need it now basis."

Unfortunately, the impossible triad applies to the electronics parts market. So, you'll have to make your buying decisions based on which of the three criteria is most important to you. Put another way, if you need a part right now, you may have to pay two or three times as much as you would under other circumstances. And, if you need it now, but have only a very limited budget, you may have to settle for seconds or culls.

Parts sources can be divided into four general categories: brand name distributors, Radio Shack, mail order parts houses, and salvage. Brand name parts



are first quality branded parts sold on a one piece at a time basis. They're usually obtained over the counter at electronics parts distributors.

Parts distributors specialize in selling electronic parts, usually to radio and tv repairmen and small manufacturers. Although some also sell CB and audio equipment, many do not. Generally, these firms are listed in the Yellow Pages under "Electronic Equipment and Supplies."

## Blister packs

Back in the good old days, resistors, capacitors, sockets and most other small parts were stored in drawers behind the counter. You either handed the counterman a list or told him what you needed.

Today, virtually all small parts are sold from racks in sealed blister packs. The racks are generally off to one side of the counter, or in a far corner. Each pack lists the part's value and price. Generally, resistors, capacitors and other inexpen-

sive items are sold two or three to the package.

Radio Shack is very much like an electronic parts distributor. It too sells small parts in sealed blister packs, usually in groups of two per package. Although Radio Shack does sell its parts through 6,000 stores across the country, it has only a limited selection of goods. Radio Shack parts cost less than brand name items.

The main advantage of both the electronics distributor and Radio Shack is availability. If you need a part in a hurry, all you have to do is make a trip to the store. If you're more interested in price than delivery date, mail order parts houses can save you a bundle.

Most mail order houses don't deal in one-at-a-time parts. Instead, they sell by the package. The only exception to this is transistors and ICs, which are sold by the piece.

Most mail order parts houses prefer to sell by the package, which contains one

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# buy and substitute parts

Ever dig into your junk box for just the right capacitor and come up empty handed even though you have lots of wrong values? Here's the inside story on how pros make do with parts values they have on hand.

by David Heiserman

**T**here is no doubt about it: the most rewarding way to participate in the wacky and wonderful world of *Modern Electronics* is by building your own circuits from scratch. So one day you find a circuit in the magazine you'd like to build. You are turned on to the idea and you start gathering parts shown on the schematic diagram or the parts list.

Things progress smoothly until you get to that 4.7  $\mu\text{F}$  capacitor with a voltage rating of 35v. You can't find one of them around town to save your life. Maybe you can find one at a premium price of \$3 or \$4 in an industrial electronics catalog; but then you see the company won't accept orders for less than \$100.

The whole job comes to a grinding halt just because you can't get that confounded capacitor. Discouragement sets in, you throw the parts you have already gathered into a junk box and seriously consider taking up fishing for a hobby.

## Getting easier

All this trouble is unnecessary today. It is unfortunate that beginners in hobby electronics feel they must take every part specification so seriously. But, in reality, there is a very good chance that the engineer who designed the circuit using that weird 4.7  $\mu\text{F}$ , 35v capacitor merely pulled it out of his own box of spare parts. Who knows where he got it?

There is a very good chance that any capacitor in the 1  $\mu\text{F}$  to 10  $\mu\text{F}$  range would do the job equally well. And, as far as the voltage rating is concerned, it could be anything more than about twice the circuit's supply voltage.

Parts specifications aren't etched in stone in many instances. There is nearly always a wide range of tolerances that allow the builder to substitute freely. Of course there are exceptions in critical timing circuits and in high-performance audio and rf circuitry. But, as a general rule, no one should be stopped cold by a mere set of numbers someone has assigned, often in a rather arbitrary fashion.

So the next time you want to build a circuit described in a book or magazine,

try to match the parts specifications as closely as possible. But when you run into trouble finding a part with the exact specifications, try making some substitutions of your own.

## Breadboards

You should always breadboard a circuit—build it up in a temporary fashion—before making a commitment to the final design. Breadboarding is especially important if you are making any parts substitutions because it gives you a chance to doublecheck your choices before investing a lot of time and money in the final product.

The accompanying tables list some ideas for substituting parts that play non-critical roles in any sort of circuit. You might not have the know-how and experience to determine whether or not you can get away with the substitutions recommended here, but you'll never know unless you try. You have nothing

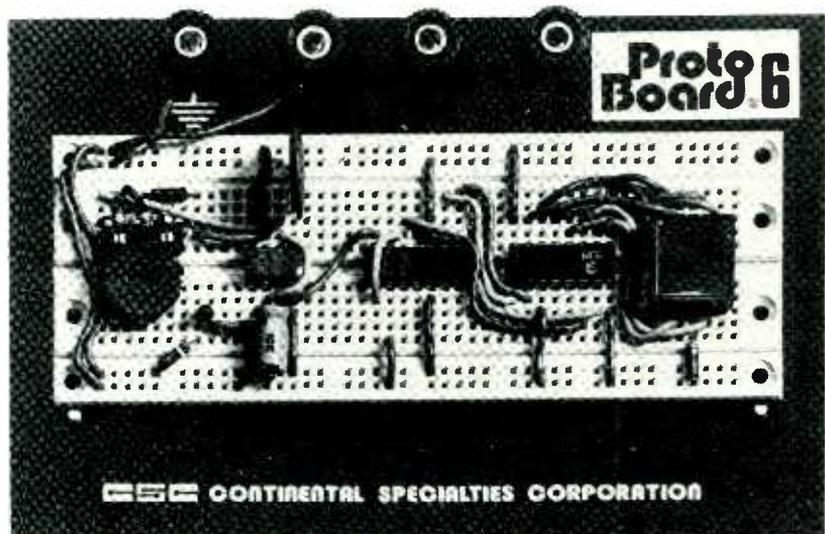
to lose and everything to gain by trying your own parts substitutions where necessary.

As indicated in Table 1, substituting resistors, capacitors and inductors is largely a matter of hitting the basic value within 20 percent. A 4.7  $\mu\text{F}$  capacitor specified on a circuit diagram can be replaced with a more common 5  $\mu\text{F}$  version without creating any noticeable difference in the operation of the circuit.

Of course, it is also possible to make up combinations of series and parallel circuits to yield equivalent values. You can mimic the operation of a 1.5k resistor, for example, by connecting a 1k resistor in series with a 470-ohm resistor.

Resistors, capacitors and inductors have other ratings that are important to observe, namely power, maximum voltage and current ratings respectively. These ratings ought to be equal or greater than those specified for the proj-

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Here's what a breadboard looks like. It has many holes into which the experimenter plugs parts to hook them together, eliminating soldering. Avid electronic builders for years have stashed soldering irons, pliers and other paraphernalia in desk drawers at work so they can play with their hobby over coffee and lunch breaks. This pocket-sized solderless breadboard eliminates a lot of the trouble and makes desk-top experimentation even easier. This board, from Continental Specialties Corp., 70 Fulton Terrace, New Haven, CT 06509, is about the size of an audio tape cassette. Now you can fit a breadboard alongside the bologna and cookies in your brown bag.

## how to buy

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or two dollars worth of the part. There are some houses that do sell by the piece, however. A recent ad from one of these listed .01 mfd disc ceramic capacitors at 5¢ each, and 10,000 ohm potentiometers at 65¢ each.

In most cases, mail order houses sell manufacturer's overruns and parts inventories bought from companies discontinuing a product. These surplus parts are generally first quality, equal to the brand name parts costing much more at electronic parts distributors.

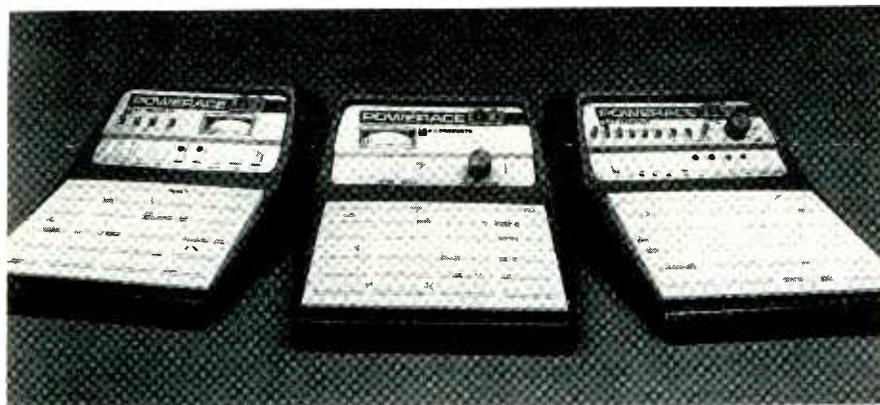
As good a deal as the mail order houses offer, there are some disadvantages in getting your parts this way. For

assortment of parts. This accumulation, called a *junk box*, gives you the parts you need, when you need them. Using your junk box as a parts source, you can build when you want to, then restock in leisure at the best prices available.

### Brand-name transistors

Assembling a good junk box involves more than just buying one of everything. Looking through the construction projects in *Modern Electronics*, you see that some parts are used more frequently than others. Once you get a feel for the kind of parts you'll need, it's just a matter of finding the right source.

Resistors and capacitors can be obtained from all four sources discussed.



**Powerace is the name for these breadboards by AP Products, Painesville, OH. All three models have built-in power supplies so you won't have to use outside batteries or supplies to power your projects.**

one thing, you'll have to wait several days or weeks for the parts to arrive. And, if you only need a few parts, you'll be faced with meeting the house's minimum order, usually around \$5. But, if you use a large volume of parts, the mail order house is the best source.

Mail order houses tend to specialize in the kind of parts they handle. Some, for example, are primarily in the transistor and IC market. Others concentrate on resistors, capacitors and inductors. Fortunately, there are some that sell everything. Most advertise their goods in electronics magazines.

### Modern electronics

Without question, the least expensive source of parts is old electronic equipment you can salvage. Many experimenters make a habit of visiting the town dump once a week or so to pick up old radio and tv sets for salvage.

Although not as inexpensive as the free parts in junked radios and tvs, another source of inexpensive parts is the surplus PC board. Sold mail order in the same way as parts, and sometimes by the same firms, these boards are usually obsolete computer boards. Many contain several dozen ICs along with hundreds of resistors, diodes, and capacitors.

If you're just starting out in electronics, you'll want to accumulate a large

Brand name resistors will cost about 25¢ each, usually being sold in a blister pack at two for 49¢. Radio Shack sells the same resistors at two for 19¢. But, you can also buy assortments of 100 or more resistors for between one and two dollars mail order, and for \$3 at Radio Shack.

Capacitors are priced in the same general way as resistors, with brand name blister packs costing as much as ten times more than capacitors sold in 100 piece assortments. The actual cost of a capacitor depends on the kind of construction used. Disc ceramics are about the least expensive capacitor available, and work well in most circuits.

If you decide to buy resistors and capacitors in quantity, make sure you know what you're buying. Most assortments are sold in plastic bags labeled as so many resistors or capacitors for so many dollars. Although the bags may all look the same, there is a big difference in what they contain.

Some dealers sell bags containing so many pieces of the same value. Others sell only assortments. Some of these assortments are unselected; just a random sampling of the dealer's stock. Still others contain a specified number of each value. If you're just beginning to put together a junk box, the selected assortments are best. Once you know your use rate for each value, buying a

bag of the same value resistors is the most economical way to go.

Transistors are sold pretty much the same way as resistors and capacitors. You can buy a brand name transistor for \$1.69 in a blister pack, or 79¢ from Radio Shack, or for less than ten cents each in assortments. Most simple projects, such as ours in *Modern Electronics*, will work with just about any small signal transistor of the same sex—NPN or PNP. So, a stock of 2N2222 or 2N3904 NPN and 2N3906 PNP transistors should cover most of your needs. You'll probably need a few NPN and PNP power transistors too.

You'll also need a selection of diodes, both small signal and rectifier. For most small signal applications, the 1N4148 is ideal. Available in brand name blister packs for less than a dollar, you can get ten of them from Radio Shack, for 99¢. The best source is mail order where you can get 50 for a dollar.

Rectifier diodes cost a little more than signal diodes, but the basic relationship between brand name, Radio Shack and mail order prices is the same. You should be able to get rectifiers mail order for less than a nickel each in quantity.

With each passing day, the use of ICs to replace hand-wired circuitry increases. There are literally thousands of ICs on the market today. And to further complicate matters, you'll have to choose between the CMOS and the TTL family of ICs—they're generally not compatible.

### Integrated circuits

Looking through the pages of *Modern Electronics*, you'll see that no more than a half-dozen different digital ICs are used. Add a few op-amps and 555 timer or two and you'll have an IC stock covering 95 percent of your needs.

Buying ICs is a little different than buying other components. Many local distributors are really parts depots for tv and radio servicemen. They carry only those small parts used by the service industry. Because of this, you may have some trouble getting a particular IC, especially digital ICs, over the counter. Even Radio Shack carries only a limited selection.

Your best bet for ICs is the mail order parts house. Most will sell by the piece, and at very attractive prices. Recent ads have offered 4001 and 4011 CMOS gate ICs at 23¢ each. But, you'll have to observe the minimum order requirement—usually \$5.

### Junk box

Another recent innovation in electronics is the light emitting diode, or LED. Although you can get LEDs from mail order houses and from distributors, probably the best source for you is your local Radio Shack. They have a good selection priced at two for 69¢. If you do plan to use large numbers of LEDs,

Radio Shack will sell you an assortment of 25 for \$2.

In addition to individual LEDs, you may need some seven-segment digital displays. Although Radio Shack has a good selection at reasonable prices, you can get all the displays you need for about a dollar a digit from mail order houses.

Although LEDs are great for use as indicators, they really don't provide illumination. For that you'll need incandescent lamps. Although some mail order houses do carry lamps, few list them in the advertisements or catalogs. Your best bet is Radio Shack or your local parts distributor. You might try your local hardware store or the hardware department of large general merchandise stores. They carry a small selection of lamps, at least some of which you can use.

Today, many experimenters prefer to build their projects on printed circuit board. You can usually get a supply from your local parts distributor and Radio Shack. Some of the mail order parts

houses also sell boards and supplies. If you use a lot of printed circuit boards, look for scrap board sold in plastic bags. Each bag usually contains several pieces of board of various sizes, priced about a dollar a square foot.

### Printed circuits

If you hand wire, you'll need a good supply of wire and cable. Radio Shack and most parts distributors have a good selection of wire and cable. Mail order houses often have special sales. If you need large quantities, you may be able to make a special deal with a mail order house.

You'll also need a good supply of connectors. Probably the most useful for the average experimenter is the RCA phono connector. You can get a good stock from Radio Shack for a few dollars. You might also pick up a few power connectors as well. Because of the small quantity involved, Radio Shack or your local parts distributor are the best sources.

After you've built your project, you'll most likely want to mount it in a cabinet of some kind. Again, your local Radio Shack and parts distributor have good selections of cabinets and enclosures at reasonable prices. Although mail order houses don't as a rule carry these items, they occasionally offer surplus cabinets at bargain prices.

Rounding out your junk box, you'll need a few transformers and relays, some perforated board and push-pins, and a handful of sockets. You can get these supplies from Radio Shack, parts distributors, and in some cases, mail order firms. But, a good source for most of what you'll need is salvageable electronic equipment.

Building a useful junk box is one of the prime interests of most electronics experimenters. While you'll probably have to spend a fair amount of money to build the foundation, you can acquire a large assortment of parts very inexpensively if you keep your eyes open for bargains, wherever they can be found. 

## how to substitute

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ect. There is, for instance, nothing really wrong with using a 1/2-watt resistor in place of one specified at 1/4-watt. The 1/2-watt version will be physically larger, but it will do the job.

Rectifier diodes and bridge rectifier assemblies are often specified according to their maximum current and reverse breakdown ratings. It is possible in most instances to come up with a suitable replacement without having to resort to a data book.

### Table 1: resistors, capacitors, inductors and transformers.

#### Resistors

**Ohms value:** within 20% of specification.  
**Ohms tolerance:** equal or better than specified. Generally not critical at all.  
**Power rating:** equal or greater than specified.

#### Capacitors

**Capacitance value:** within 20% of specification (except in critical timing and tuning operations).  
**Voltage rating:** equal or greater than specified; or twice the maximum supply voltage.  
**Type (mylar, ceramic, electrolytic, etc.):** generally not relevant except in critical timing and some vhf and uhf tuner applications.

#### Inductors

**Inductance value:** within 20% of specification.  
**Current rating:** equal or greater than specified.

#### Power transformers

**Voltage rating:** as specified.  
**Current or power rating:** equal or greater than specified.

A lot of people—especially transistor manufacturers and, alas, suppliers—make too much of this matter of substituting transistors. The generally negative attitude must arise from the fact that there are thousands of different transistors listed in transistor substitution manuals.

Quantity does not necessarily imply complexity, though. Perhaps we can all take some comfort from the notion that those who are most afraid to make their own transistor substitutions have never tried it.

Table 2 lists the most relevant specifications for any transistor used in ordinary electronic projects. You will need a transistor data book to determine these specifications. But, once you have the numbers at hand, you can use them for selecting an appropriate substitute.

Unless a circuit builder knows exactly what he is doing, there is little latitude for substituting IC types. A circuit calling for a 7400 digital IC, for example, must use that type of IC.

The IC designations on many parts lists, however, include alphabetical prefixes that merely indicate the device's manufacturer. There is no need to use an IC made by one particular manufacturer if other companies produce the same basic item.

Suffix letters in IC designations aren't really relevant, either. These letters normally indicate a change in the internal mechanisms that do not alter the basic function. There are, however, cases where suffix letters indicate the package style.

Watch out, though! Some IC's have a letter or two inserted between some of the numbers. You can, for example, find

### Table 2: rectifier diodes, bridge assemblies and transistors

#### Rectifier diodes and bridge assemblies

**Current rating:** equal or greater than specified.  
**Reverse breakdown voltage:** equal or greater than specified.

#### Transistors

**A transistor data book must be used for determining most of the specifications for substitution purposes.**

**Type (NPN or PNP):** exact to specifications.  
**Collector current rating (Ic):** equal or greater than specified.  
**Reverse breakdown voltage:** equal or greater than specified.  
**Gain (Beta or h<sub>FE</sub>):** equal or greater than specified.  
**Power rating:** equal or greater than specified.  
**Cut-off frequency:** equal or greater than specified.  
**Case style:** generally not relevant.

a lot of 74C00 quad 2-input NAND gates on the market. That "C" inserted between the 74 and 00 indicates it is a CMOS version of the basic 7400 device, and you will run into a lot of trouble if you try to substitute a 74C00 for a 7400, or vice-versa.

So when contemplating substituting IC's, you can ignore any prefix letters and doublecheck a data book if you think any suffix letters indicate a change in pin numbering. In any event, you must follow the numeric designations and any letters inserted within the basic number pattern. 