Chapter 19 (From V3.0 User's Manual)

Power Supplies

The primary power source required for your C/MRI is a +5Vdc Regulated Power Supply. The term **regulated** is extremely important. It means that the supply's output voltage is controlled, i.e. regulated, to remain at the specified value, in this case +5Vdc, essentially independent of the AC line fluctuations and variations in the load placed on the supply.

Many applications also require a +12Vdc supply to power block occupation detectors and switchmotors. It's desirable, in my book, that this source also be regulated. However, in many situations, you can get buy with a well-filtered but not necessarily regulated +12Vdc. By contrast, the +5Vdc supply **must** be regulated. In certain specific applications, you'll need both +12Vdc and -12Vdc regulated outputs, but we'll deal with that later.

BUILDING YOUR OWN POWER SUPPLIES

In my previous C/MRI related publications, I devoted considerable space describing, "How to build your own power supplies." I showed how to build a +5Vdc regulated power supply, a +12Vdc power supply and a ±12Vdc regulated power supply and all of these with different current capability. That was important at the time, for example, when the original MR series was published in 1985-86. However, times have changed. With a market now flooded by rapid advances of the computer industry, you can obtain a surplus computer power supply for essentially zero, or nearly zero cost. And to top it off, a computer power supply provides all 3 voltages, +5Vdc, +12Vdc and -12Vdc and typically with plenty of power to spare.

The conclusion is that you can now obtain high quality commercially built units that meet all your interfacing needs for less than you would pay for a good power transformer, if you were to build your own supply. Therefore, I have not included any "how to build your own supply" information in this manual. If for some reason, you still want to build your own supplies, you can find the information in: 1) the original C/MRI series in **Model Railroader,** 2) either the First or Second Editions of the book **Build Your Own Universal Computer Interface**, or 3) all editions of the **C/MRI User's Manual** prior to V3.0.

REGULATED VERSUS UNREGULATED POWER SUPPLIES

For those interested in further explanation concerning regulated versus unregulated power supplies, I'll go into more detail in this section. However, if you would rather simply get on with selecting a supply to best meets your needs, I suggest you skip ahead to the next section.

Typical power sources, like a conventional DC power pack used for train control, are not regulated. This is easily demonstrated by connecting a voltmeter across the track and setting the speed control knob to its maximum. This will result, most likely, in a voltage reading in excess of +12Vdc. Now, without changing the knob setting, place a locomotive on the track and you will see the voltage decrease. Now hold the locomotive, but let the wheels slip and you'll observe that the voltage further decreases. Now apply an increasing downward pressure, so the engine represents a greater and greater load to the supply. Each time you increase the load, the voltage decreases an additional amount.

If you happen to have a DC power pack with an amp meter, you will see that the current demand increases each time you apply more downward pressure. Fundamentally, as the current demand increases with an unregulated supply, the output voltage decreases. Fig. 19-1 illustrates the output current/voltage relationship for an unregulated power supply.

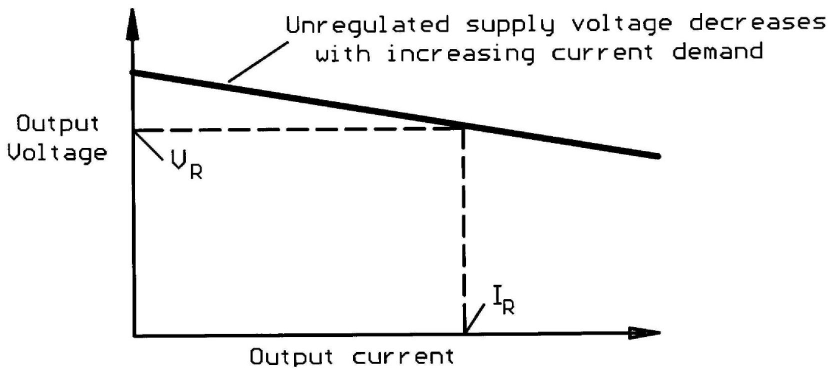

Fig 19-1. Current/voltage relationship for an unregulated power supply

With an unregulated power supply, as the current demand on the supply changes, the supply's output voltage changes. This is an intolerable situation with digital integrated circuits (digital ICs). Solid-state digital-electronic components (such as those used on the C/MRI circuit boards), require a constantly applied +5Vdc that is independent of load fluctuations, as well as being independent of AC input voltage fluctuations. Typically, the maximum allowable voltage swing is +4.85 to +5.25Vdc. This requires a power supply with a regulated output voltage.

Such a regulated supply actually monitors its output voltage and automatically, continuously and nearly instantaneously, varies parameters internal to the supply to keep the output voltage constant. Fig. 19-2 shows the corresponding current/voltage relationship for a typical +5Vdc output voltage Regulated Power Supply.

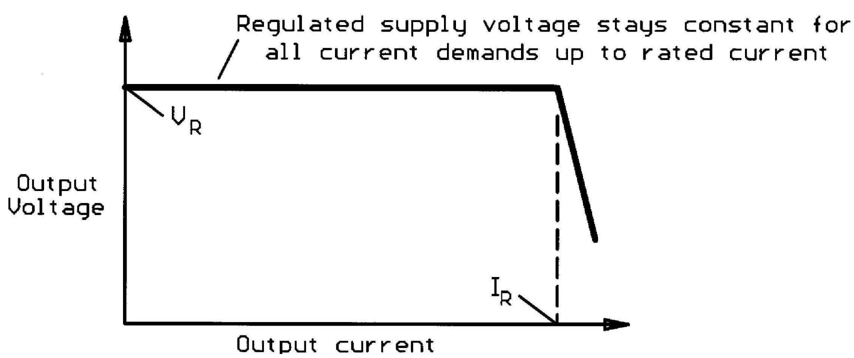

Fig 19-2. Current/voltage relationship for a typical +5Vdc output regulated power supply

Fundamentally, the output voltage stays constant, within a very narrow tolerance range, such as plus or minus one tenth of a volt (±0.1Vdc), over a current demand range from near 0A up to some maximum rated value, of say 20A.

The result is that a well-regulated power supply will maintain constant output voltage over a wide variety of conditions presented by the C/MRI system. These include varying node sizes in terms of the number of I/O cards installed, current surges as I/O lines turn on and off and a continually changing current demand as hundreds of signal LEDs turn on and off, just to name a few. In spite of all these changing levels of current demand, the voltage output of the supply, and thus the voltage correspondingly applied to all the C/MRI circuit boards, stays rock steady at +5Vdc.

LINEAR VERSUS SWITCHING POWER SUPPLIES

There are two basic types of output voltage regulated power supplies, linear and switching. You can think of a linear supply as one where the internal resistance of the supply is varied electronically to keep the output voltage constant. They operate like the old train control rheostats whereby the resistance setting, if desired, could be varied to keep output voltage constant under changing load conditions. However, the required setting-changes are accomplished automatically, electronically, within milliseconds. Linear regulated supplies dissipate excess power as heat, just like the old rheostat, and are typically limited to lower current output supplies – say less than about 3A.

Switching supplies are a relatively newer approach to achieving output voltage regulation. They use electronics effectively to turn the supply on and off at a high frequency and then to control the on-off duty-cycle to keep the output voltage at a constant level. Filtering is built into the design so that the on and off durations are seen as only an averaged “on” state, at the supply output. Switching supplies have a much higher efficiency, produce relatively little heat and therefore can more easily handle much higher current outputs – up to 20A is very common and many provide even higher current capability.

Both types of supplies work just fine for our C/MRI applications. However, in most applications a switching type supply is preferred the main reasons being their higher current capacity and typically lower price.

SUPPLY VOLTAGES USED FOR RAILROAD INTERFACING

As introduced earlier, two different voltages are typically needed for interfacing electronics to a model railroad, +5Vdc and +12Vdc. The +5Vdc powers all the basic C/MRI cards, such as the SMINI, SUSIC, IOMBX, DIN32 and DOUT32. Also, in the majority of applications, the +5Vdc powers the signal and panel LEDs. Typically, the current demand from +5Vdc is relatively high – usually on the order of several amps up to 10A or more.

The +12Vdc is used to power block occupation detectors, such as the JLC provided DCCOD, stall-type switchmotors, such as the Tortoise, the Switch Motor Control (SMC) cards, if used, and Cab Relay Cards (CRCs) if using Computer Cab Control. Sometimes, the +12Vdc is also used for driving incandescent-type signal and panel lamps and even LEDs. The current demand for the +12Vdc is generally somewhat lower than that required for +5Vdc but can still range up to several amps or more.

If conventional block occupation detectors are used, such as the JLC provided Optimized Detector (OD), which uses current sensing diodes, the 12Vdc supply needs to provide both positive and negative 12Vdc outputs. Such supplies are referred to as bi-polar ±12Vdc Power

Supplies and they provide 3 output connections, +12Vdc, ground and -12Vdc. For optimized performance, the magnitude of the plus and minus outputs must be held to the same value, thereby dictating they be regulated. However, if the JLC provided DCC Optimized Detector (DCCOD) is used, only +12Vdc is required.

I should point out that block occupation detectors (both the JLC provided OD and the DCCOD as well as, other brands) are covered in detail in the **Railroader's C/MRI Applications Handbook.** The handbook also provides in depth coverage of the SMC and CRC cards, the latter being used with Computer Cab Control (CCC) applications.

It's important to note that a bi-polar ±12Vdc supply is also required if the Classic USIC (with the 68701 Microcontroller) configured for RS232, is used, or for the original RS422 Conversion Card. For added clarity, only +12Vdc is required for the SUSIC and/or the newer RS485 Conversion Card.

Please don't be concerned if the above sounds confusing at this point. Actually, obtaining a suitable power supply to meet your interfacing requirements is quite straightforward and easy to accomplish, once you understand a few basics. Also, what's nice is that there is an abundance of supplies available – and many at bargain-basement prices.

****Important Point****

Make certain that your +5Vdc Power Supply is REGULATED. Do not use a conventional RR power pack set for 5 volts. Do not use a Wall-Mart or Radio Shack plug-in-the-wall type power supply unless it specifically states that the +5Vdc is a REGULATED output. Regulated means that the output voltage stays constant, in this case at +5Vdc, independent of the load, up to the rated supply current.

Before we take a look at a sampling of readily available supplies, let's see how to go about calculating the needed power requirements. This information can help to insure that a supply with sufficient capacity will be selected.

CALCULATING POWER SUPPLY CURRENT REQUIREMENTS

Because large capacity computer power supplies are available at bargain-basement prices, a common approach is simply to skip making any calculations and to obtain a large capacity supply, such as +5Vdc at 20A or more, and +12Vdc at say 8A. Because the price is cheap, and because such a supply can easily handle almost any size setup, even for a large railroad, this approach is valid. If this is your approach, you may skip ahead to the sub-section, ***Using Surplus Computer Power Supplies.***

Because current requirements can vary greatly from application to application, I recommend that you make a rough calculation of what to expect. Ball-parking your expected needs for current requires only a few simple calculations. Table 19-1 provides a worksheet for calculating the +5Vdc current need. It lists the typical +5Vdc powered C/MRI circuit boards and their current draw per board. Signal and panel LEDs typically contribute significant current requirements, so I've added them to the list, along with blank lines where you can add other +5Vdc powered devices unique to your application. An example might well be a special circuit board for driving flashing lights, gates and a bell to protect a grade crossing.

Table 19-1. Current loading calculations for 5Vdc supply

Load (device)	Current (A) (per device)	Quantity Used	Total Amps
SMINI	.35		
SUSIC	.09		
USIC	.15		
DIN32	.18		
DIN	.16		
CIN24	.18		
DOUT32	.12		
DOUT	.25		
COUT24	.35		
CRC	.05		
Signal LEDs	.02		
		TOTAL	

Table 19-2 provides a worksheet for calculating the +12Vdc current need. It lists the typical +12Vdc powered C/MRI circuit boards and their current requirements per board. Also listed is the possibility of using incandescent signal and panel lamps, but in this case you'll need to fill in the current value. Blank rows are provided for adding in other unique +12Vdc powered devices unique to your application. An example might be 12Vdc relays for automatically handling reversing loops or for turning off staging tracks.

Table 19-2. Current loading calculations for +12Vdc Supply

Load (device)	Current (A) (per device)	Quantity Used	Total Amps
DCCOD	.02		
OD	.02		
Tortoise[1]	.04		
CRC	.06		
SSD[2]	.25		
Signal LEDs[2]	.02		
Signal lamps			
		TOTAL	

Notes: [1] Tortoise includes portioned part of SMC card, if used.
[2] Current for SSD card includes signal LEDs so don't double count if SSD cards are used.

The actual current drawn by each type of circuit card varies dependent upon such factors as inputs open-circuited or grounded and whether or not outputs are activated. Also, with the DCCOD and OD, the current drawn with a clear block is about 1 milliamp and with the block occupied, LED turned on, is about 20 milliamps (.02A). The Tortoise value shown assumes direct drive from two C/MRI output pins and using the two 500Ω pull-up resistors (per Fig. 3-8). If you are using SMC cards, as shown also in Fig. 3-9, you can lower the number to .03A per Tortoise, which includes the current overhead of the card itself.

The design approach I've taken is to use what I call "ball-park toward-worst-case values" in both tables. Because the numbers shown are on the high side, using them to determine your supply requirements results in some spare capacity – which is a good thing.

To utilize the tables, simply write in how many boards, or devices, of each type you expect to utilize, multiply each by the applicable current and add up the total. Don't be concerned if you don't know the exact quantity of each board you'll be using. What you're after is a rough estimate, so simply estimate on the high side.

Many users employ a single supply to handle their whole railroad and others use a separate supply per node or for group of nodes. I tend to favor a separate supply per node which minimizes the need for having heavy power-bus wiring between nodes. You can go either way. Just base your current requirement calculations on the planned distribution of your power supplies.

As an example, let's assume a setup with 1 SMINI, 32 LEDs, 15 DCCODs and 8 Tortoise switchmotors. Using Tables 16-1 and 16-2, you should arrive at .99A required at +5Vdc and .62A required at +12Vdc. This could be for the total railroad or for a single node, all dependents upon the setup.

Now lets look at a larger setup using 1 SUSIC, 5 DIN32s, 14 DOUT32s, 400 LEDs, 150 DCCODs and 20 Tortoise switchmotors. Using Tables 16-1 and 16-2, you should arrive at 10.7A required at +5Vdc and 3.8A required at +12Vdc.

It should be noted that in the last example with 400 LEDs, the LED current alone multiplies out to be 8A (calculated as 400 x .02). Thus, when your number of LEDs reaches a high number, it is common practice to make some assumption such as, only 1/3 will be turned on at any given time then use that reduced number in your calculations. This would reduce the total +5Vdc requirement to 4.4A.

Whatever numbers you come up with, it's still a good idea to purchase a supply that exceeds your "ball-park" calculations by a considerable amount. Having spare capacity is a desirable trait. In order to get an idea of what's available, let's take a look starting with supply types having lower current capacity and working our way up to those supplying greater current capability.

AC-DC REGULATED WALL ADAPTERS

Probably the easiest and quickest way to power a small startup system, such as a single SMINI-based node, is to use a Wall-Mart or Radio Shack type plug-in-the-wall-outlet style power adapters. However, be very wary of those offered by Wall-Mart and Radio Shack, because from what I've observed, most of their offerings are not regulated supplies.

Table 19-3 illustrates a sampling of such supplies that are regulated, and listed in the current Jameco catalog (see Appendix A for a lists of recommended parts suppliers and their contact information) at the time this is being written.

Table 19-3. Example regulated DC output voltage wall-adapter power supplies

Jameco part number	Rated voltage and current outputs	Cost
164101CF	+5Vdc @ .5A	$8.95
168604CF	+5Vdc @ 1A	10.95
210892CF	+5Vdc @ 2A	12.95
228937CF	+5Vdc @ 3A	13.95
220898CF	+12vdc @ .2A	7.39
162996CF	+12vdc @ .5A	8.95
220687CF	+12vdc @ 1.25A	12.29
210809CF	+12vdc @ 1.5A	14.95

Current capacity of this type of supply is typically limited to the range of values listed and to the best of my knowledge each supply only provides a single voltage. All those listed in Table 19-3 are advertised as being regulated which is a requirement – especially for the +5Vdc. Besides being lower current outputs, the other disadvantage is that you typically need to purchase two supplies – one for +5Vdc and one for +12Vdc.

These supplies come with varied output plugs, both male and female type. The best approach is usually to cut off the plug, or jack, and use your VOM to determine which conductor is positive and which is ground and then make the proper connections to your hardware. Also, the ground connections from the +5Vdc and the +12Vdc supplies must be connected together for a common ground to your C/MRI.

CHECKING POWER SUPPLY VOLTAGE, POLARITY AND REGULATION

It's an extremely good idea to always check power supply voltage before making power connections to C/MRI circuit board. Connecting the wrong voltage, or reverse polarity, to any circuit board can cause severe damage to all the ICs and polarity sensitivity capacitors resulting in a very costly error!

To check voltage level and polarity, for example with a +5Vdc supply, follow these steps:

1. Set your VOM to read DC voltage.
2. Use a clip lead to connect the meter's negative, black lead, to the ground output of your power supply.
3. With your power supply turned on, touch the meter's positive, red lead, to the power supply output labeled +5Vdc.
4. The meter should read almost exactly 5Vdc. The maximum acceptable tolerance range is 4.8 to 5.2Vdc.

If your meter reading appears backwards, or displays a negative number, your supply connections need to be reversed.

Be wary of any power supply you may find laying around, or on a store shelf, where it doesn't clearly state that the output is DC voltage and that it is a regulated. To help verify that your supply is adequately regulated, connect a resistor across the supply so that it draws about 80 percent of the rated current. If the measured voltage outputs, with and without the resistor, remain very nearly identical then you have a regulated supply. Additionally, the measured output voltage of a +5Vdc supply should absolutely never fall outside of the range 4.75 to 5.25 volts.

The resistance value required to achieve an 80 percent rated current is defined by the equation:

$$\text{Calculated Resistance (in } \Omega) = V_R / (.8 * I_R)$$

The power rating required for the resistor is defined by the equation:

$$\text{Wattage (in watts)} = (V_R)^2 / (\text{Resistance Selected})$$

In the above equations, V_R is the rated supply voltage and I_R is the rated supply current (in amps). Suitable resistors can be found in the DigiKey and Mouser catalogs and also possibly at Radio Shack. Because most resistors you find will not exactly match your calculations, select a resistor with the closest resistance value. Use that resistance value to recalculate the wattage so that it reflects the actual power to be dissipated by the resistor. Then, for the selected resistor value, pick one with a wattage rating that lies above the value you calculated.

TABLE-TOP POWER SUPPLIES

The next step up in capability is typically referred to as Table-top power supplies. Instead of plugging directly into a wall outlet, they sit on a "table-top" with an AC line cord reaching to the outlet. In some instances, the AC line cord is an integral part of the supply while other times it is not and frequently you need to purchase the cord separately. Therefore, it's a good idea to check out this feature before obtaining one of these supplies. Otherwise, you may end up with a nice looking supply, but without a suitable AC line cord with which it can be connected.

Typically, table-top modules are somewhat larger and heavier than wall-adapter types with resulting higher output capability. Table 19-4 illustrates a sampling of such regulated supplies as listed in the current Jameco catalog at the time this is being written.

Table 19-4. Example regulated DC output voltage for table-top power supplies

Jameco Part number	Rated voltage and current outputs	Type supply	Cost
196146CF	+5Vdc @ .9A and +12Vdc @ .8A	Switching	$8.95 ($4.95)
155651CD	+5Vdc @ 1A and ±12Vdc @ .3A	Linear	$9.69
196138CF	+5Vdc @ 1A and +12Vdc@ 1.49A	Switching	$17.95
189561CF	+5Vdc @ 4A and +12Vdc @ .5A	switching	$12.95 ($6.25)

The cost data shown in parenthesis, at the time of this writing, is a listed "on sale" price. I mainly included it to illustrate that you might want to shop around for power supplies. Frequently they are an “on sale” item and you can often obtain very good buys. An advantage of the table-top supply is that multi-voltage outputs are readily available.

Although the current capacity of table-top supplies can range higher than those listed in Table 19-4, their corresponding prices seem to rise to the point where using a surplus computer power supply definitely offers a more attractive approach. All the supplies listed in Table 19-4 are advertised as being regulated which is an absolute requirement – especially for the +5Vdc.

These supplies come with varied output plugs, both male and female type. The best approach is usually to cut off the plug, or jack, and use your VOM to determine which conductors are positive for the various voltages and which is ground and then make the proper connections to your C/MRI hardware. If the grounds are separate for the two voltages, they need to be connected together for a common ground to your C/MRI.

USING SURPLUS COMPUTER POWER SUPPLIES

Typically, the most cost effective approach to meet railroad interfacing needs, especially when substantial current is required, is to make use of a surplus computer power supply. With the rapid manner in which the world replaces “old” computers with newer ones, surplus computers, and therefore surplus computer power supplies are available at bargain-basement prices – and often available free.

It takes appreciable effort to get a surplus computer supply ready to be connected to your railroad and the C/MRI, but the end results coupled with the cost savings, are usually more than worth the effort. Frequently, the most difficult task is figuring out which wires are which from the maze of multi-colored wires emanating from the box which usually exhibit no defined color code. The next complexity is figuring out what special “trick” is required to get the supply to “turn on.” Later in this chapter, I’ll explain how to overcome both of these challenges.

Although it takes a little work, like adding one, or more, load resistor(s) to get the supply to turn on and a little more effort to figure out which output wires are which voltages, you just cannot beat the cost/capability tradeoff provided by using surplus computer power supplies. Even if you decide to purchase your surplus supply, rather than scrounge for one, the result still can be a very good buy. For example, Table 19-5 illustrates a sampling of such purchased supplies as listed in the current Jameco catalog at the time this is being written.

Table 19-5. Examples of commercially available computer power supplies

Jameco part number	Rated voltage and current outputs	Cost
190094CF	+5Vdc @ 20A, +12Vdc @ 8A, -12Vdc @ .5A, +3.3V @ 20A	$8.95
190115CF	+5Vdc @ 20A, +12Vdc @ 8A, -12Vdc @ .5A, +3.3V @ 20A	9.59
200694CF	+5Vdc @ 22A, +12Vdc @ 7A, -12Vdc @ .15A	19.95
205938CF	+5Vdc @ 25A, +12Vdc @ 10A, -12Vdc @ 1A, +3.3V @ 14A	21.95

Current capacity runs 10 to 20 times higher than table-tops and the prices are very much the same. I’ve seen even lower prices elsewhere from time to time and if you work it right you can usually pick up surplus computer power supplies basically free – as I’ll explain shortly.

WIRING A SURPLUS COMPUTER POWER SUPPLY

There are several questions that frequently arise when trying to apply surplus computer power supplies. I'll list the most frequently asked questions in bold type and then provide some answers.

How do I connect up the 120Vac power? Almost every, if not all, computer power supplies in the United States, use a standard 3-wire power cord, with a 3-connection female socket that plugs into a male socket in the computer supply and a 3-prong male plug that plugs into a standard 3-wire wall outlet. Sometimes the power cord is supplied with the supply, but many times you need to purchase the cord separately. The Jameco part number for such a recommended cord is 38050CF.

****Important Point****

Very few, if any, computer power supplies provide transformer isolation from the AC input lines. If you use two or more supplies on your layout, it's critical that each use 3-wire power cords to ensure that the cases are at earth ground. **No not use any cheater plugs.** Note also that it is recommended to use the 3-wire cord even if you are using only one supply. Also, if your home has only the older 2-wire outlets, and you are using more than one supply, you MUST provide a reliable earth ground for the third wire. If you are unsure how to do this, consult a qualified electrician.

Some supplies have an AC input ON-OFF switch built right into the case. Others have a separate switch that is wired directly to the supply. Other supplies do not have any type of AC line power switch provided. If not, then you will have to add your own, or as a possible alternative, which is impractical and not recommended, plug and unplug your supply each time it's used.

I personally have my railroad area wired with dedicated 120Vac outlets, which are controlled by separate wall mounted switches. Multiple outlets are provided at each of the 7-node locations. A computer power supply is plugged into one of the outlets at each node as are DCC power boosters, unfiltered uncoupling magnet supplies, scenic lighting supplies which are tied into the C/MRI and other similar type power supplies. By simply turning on 3 wall switches, I power up the whole railroad including the computer supplies. I really recommend this approach and even if not prewired, the wiring can be added by a qualified electrician.

What output wires perform what function? This undoubtedly is the most frequently asked question. Computer supplies typically have up to 30, or sometimes even more wires utilizing an assortment of different colors and connector types, emanating from the case. In most cases, zero information is provided on what colored wires provide what function.

Firstly, I need to qualify all the following comments by stating that I have zero personal experience with the relatively newer computer power supplies, which typically provide +3.3V in addition to the +5Vdc. Although I would expect that the general approach to setting up such a supply probably doesn't change much, strictly speaking, the details presented in this section are based on experience gained from supplies not providing the added +3.3Vdc.

Although there is no guarantee that the color codes are the same from one manufacturer's model number to another, I've found that all of the different supplies I've worked with employ the same basic color code. Here it is, including the typical number of wires provided per color, Black (with 8 to 14 wires) is common ground, Red (with 5 to 7 wires) is +5Vdc and Yellow (with 2 to 3 wires) is +12Vdc. I can't tell you if the supplies you acquire will be the same and I don't know if the newer type supplies providing the added +3.3Vdc create any differences. Also, I didn't need the negative 12Vdc, but if you do (e.g. for the DC version of the Optimized Detector) its color is quite easy to locate, using your VOM, once you have the other colors sorted out.

What you can be quite confident about, however, is that the number of wires used per color is closely related to the current rating per voltage. Thus to get a handle on what color codes your supply might be using, simply make a list of how many wires are provided per color. The color with the most wires is most likely to be the common ground. The color with the next to the highest wire count will likely be your +5Vdc (or possibly the +3.3Vdc if it has a higher rated current capacity than the +5Vdc). The color with the next highest number of wires will probably be the +12Vdc, etc. Once you get the first few voltages figured out, that's as far as you need to go for two reasons: 1) they are the only voltages we'll be using and 2) they are the only voltages we'll need to know about in order to be able to turn on the supply.

From the last comment, you might be inclined to ask the question, why can't we simply turn on the supply and measure the voltages between the different wires? That's a good question but simply plugging in a computer power supply and turning on the supply switch provided, seldom, if ever, will "turn on" the power supply! Solving this perplexing question is provided in the answer to our next question.

How do I get the supply to turn on its outputs? Switching type power supplies typically require a minimum load before they turn on. Simply plugging in a supply, and turning on the AC power input, most often results in zero output. You'll sometimes observe the fan trying to start for a fraction of a second, and maybe a brief transient movement on a VOM meter, if connected to outputs, but usually nothing more. What do you need to do? You need to hook up a load to the output(s). For sure, don't hook up any C/MRI components, or other electronic components, because at this point we are totally unsure of which outputs provide which voltages.

Most supplies require somewhere around a 10 percent load to effectively turn on. It's best then, to calculate what corresponding value of resistance is required and then attach that as the load. Some articles, concerning using computer surplus power supplies, state that you need to place a load on every output voltage. I have never found that to be necessary. I've always found that if I place an appropriate load on the +5Vdc output, that all voltage outputs turn on and operate correctly. Although I have no experience with supplies providing the added +3.3Vdc output, I would expect that because it is rated at very high current, as is the +5Vdc, that with such supplies you would need to use separate resistors to load both the +3.3Vdc and the +5.5Vdc.

The resistance value required to achieve a 10 percent rated current is defined by the equation:

$$\text{Calculated Resistance (in } \Omega) = V_R / (.1 * I_R)$$

The power rating required for the resistor is defined by the equation:

$$\text{Wattage (in watts)} = (V_R)^2 / (\text{Resistance Selected})$$

In the above equations, V_R is the rated supply voltage and I_R is the rated supply current (in amps). Suitable resistors can be found in the DigiKey and Mouser catalogs and also possibly at Radio Shack. Because most resistors you find will not exactly match your calculations, select a resistor with the closest resistance value. Use that resistance value to recalculate the wattage so that it reflects the actual power to be dissipated by the resistor. Then select a resistor with the next highest wattage rating.

To ball-park typical needs, lets assume a supply with the +5Vdc output rated at 20A. Using the first equation calculated resistance value is 2.5Ω and, with that value resistance, a power rating of 10W is required.

An excellent source for locating suitable resistors is Mouser Electronics (See Appendix A). Table 19-6 illustrates the selection available in the range most suitable to our power supply loading application.

Table 19-6. Example cement power resistor selection

Resistance (Ω)	10 Watt	15 Watt	20 Watt
2.0	280-CR10-2.0	280-CR15-2.0	280-CR20-2.0
2.2	280-CR10-2.2	280-CR15-2.2	280-CR20-2.2
2.4	280-CR10-2.4	280-CR15-2.4	280-CR20-2.4
2.7	280-CR10-2.7	280-CR15-2.7	280-CR20-2.7
3.0	280-CR10-3.0	280-CR15-3.0	280-CR20-3.0
3.6	280-CR10-3.6	280-CR15-3.6	280-CR20-3.6
3.9	280-CR10-3.9	280-CR15-3.9	280-CR20-3.0
4.0	280-CR10-4.0	280-CR15-4.0	280-CR20-4.0

(Note: Part numbers shown are for Mouser Electronics)

There's quite a selection to choose from. Because I don't like to dissipate any more power than is really required, I rounded the 2.5 up to 3.0Ω and found that it worked just fine. The corresponding power rating is then calculated, using the second equation, as 8.33W. Picking the next highest standard wattage I went with the 3.0Ω at 10W resistor, Mouser part number 280-CR10-3.0. Actually, I ended using this same resistor on the +5Vdc outputs on all of my power supplies and everything worked even though the rated currents were somewhat different. Fundamentally, you need a load that's in the right "ball-park" – the value need not be precise.

Once you have a supply loaded correctly so that it turns on, use your VOM to check the various output wires to see which provide what voltages. The wires for the voltages not needed should be cut short and electrical tape applied to the ends so as not to cause problems.

What fuse protection is recommended? Computer power supplies have built-in electronic circuit breakers to protect against shorting of outputs. However, I still like to provide additional fuse protection on all used outputs. With a low-voltage power supply capable of 20 to 30A, or more output, you are basically looking at an arc welder.

Just as an added safety measure, and to possibly help prevent damage to C/MRI circuit boards, I insert fuse protection on all outputs. In fact, where there is +5Vdc going to multiple areas, such as different nodes, different IOMBXs, different bunches of trackside signals and such, I use a separate fuse for each area. I seldom ever blow a fuse, but if one should, it surely helps me to quickly track down where a problem exists.

Although some references to using surplus computer power supplies for railroading recommend fusing the 120Vac input line, I personally find it more desirable to use the intended 3-wire power cord without disruption. My reasoning is, if that approach is good enough to connect a computer it certainly is good enough to connect to my surplus computer power supply.

How should I set up the power supply for making connections to the C/MRI and railroad? I find it best to mount each power supply, along with associated fuse holders and screw terminal strips I'll cover shortly, on a nicely painted piece of ¾-in plywood about 14-in square. Painting, sanding and filling the edges you can make it look really nice. For some supplies, you may need to make up small metal angle brackets to hold the supply to the plywood while other supplies come with angle corner brackets or some sort of tabs ready for mounting.

I then cut off and discard all the varied output wiring connectors that come with the supply. I group all the common ground wires together (black in my case) and terminate them using a grounding-bar (such as used within a 120Vac breaker box and available separately at hardware or home building supply stores). I then group the wires of common color for each of the other voltages being used, and connect each color group to one or more fuse holders. The latter typically come in groupings of 1, 2, 3 or 4 fuses per holder. Table 19-7 illustrates the corresponding part numbers as listed in the current Mouser catalog.

Table 19-7. Recommended fuse holders

Number of fuses held per holder	Mouser Electronics (part number)
1	534-3536
2	534-3537
3	534-3538
4	534-3539

Note: Open type - Use only for low voltage, e.g. 5Vdc & 12Vdc

To keep wiring neat and well separated, I use a separate fuse holder for each voltage. Typically I make use of one holder with 1 or 2 fuses for the +12Vdc and another holder with 2, 3 or 4 fuses for the +5Vdc. If you happen to be using the Classic Optimized Detector (OD) which also requires the negative 12Vdc output, then I'd recommend adding in another holder with 1 fuse for the -12Vdc. Using an appropriate spade lug, I then wire from each of the fuse holders directly to a screw terminal on a barrier-type terminal strip as listed in Table 19-8.

Table 19-8. Recommended screw terminal strips

Number of terminals	Mouser Electronics (part number)
2	15BB002
4	15BB004
6	15BB006
8	15BB008
10	15BB010

The railroad and C/MRI grounds then terminate directly into the grounding-bar noted above and the various areas requiring +5Vdc, +12Vdc, and if used -12Vdc, connect directly into the appropriate screw terminal on the barrier-type terminal strip. Properly documenting each connection is important. Place a fast-blow fuse, of appropriate current rating, in each of the fuse holder positions and you are all set, **once you use your VOM to make a final check that each output is the correct voltage**, to connect up your railroad and the C/MRI!

OBTAINING SURPLUS COMPUTER POWER SUPPLIES FREE

I indicated some fairly good prices for surplus computer power supplies back in Table 19-5 and I've often seen them available even cheaper. However, if you work it right, you can very likely obtain surplus computer power supplies for zero, or very nearly zero cost. I've done this for all 8 of the surplus computer power supplies used on the new SV Oregon System and most of my friends and two local Grand Rapids railroad clubs using the C/MRI, have done the same.

Where to look? Second hand, "Old" and discarded computers can frequently be found in many, many places. Check with members of your extended family; check out where you work or with your friends where you work. You are bound to find discarded computers you can have for the asking. To explore additional opportunities, check out any place that repairs computers and/or takes in used computers for upgrades. There are also many individuals that work at "sideline-type" businesses that take in junk computers to swap parts around to create working computers that are frequently sold at bargain prices. These operations typically end up with more left over power supplies than they can ever possibly use. I've found that, with a little explanation that you want the supply for a model railroad, they will give you their unneeded supplies free. However, even if they want a payment, going with a couple dollars is more than they will obtain at typical computer scrap prices.

Because computer power supplies come all enclosed within their own metal case that fits within the computer case, it's a relatively easy task to remove the supply from the computer. Typically, all you need to do is remove a few screws and unplug a few connectors, and that's it. Once in a "lifetime" you may end up with a computer supply that you can't get to function. However, I find that situation very rare. The power supply is essentially the most rugged portion of a computer, so you'll find that they operate flawlessly nearly forever.

In the preceding paragraphs, I've just talked about obtaining power supplies free, or practically free. Actually, if you are happy with using a dedicated computer for your railroad, such as a lower end Pentium, then all the above ideas and suggestions are about as applicable to obtaining a computer as they are to obtaining just the power supply.

Basically, if you like the idea, obtaining the computer end of a C/MRI as well as whatever number of surplus supplies you may require, can be very close to a non-investment.

Happy interfacing on your Model Railroad,

Dr. Bruce A. Chubb, MMR