GUIDE TO TROUBLESHOOTING LEGACY OPTO 22 PRODUCTS

Solid State Relays
G1 (Standard) I/O
G4 I/O
Pamux™
Optomux™
SNAP I/O™ Modules
Serial B3000-B and B3000 SNAP Brains

Form 1104-191112—November 2019

OPTO 22
The Future of Automation.

Table of Contents

Guide to Troubleshooting Legacy Opto 22 Products

INTRODUCTION

This guide addresses some of the technical issues that come up most often when troubleshooting and specifying legacy Opto 22 products, including SSRs, input/output (I/O) modules, Pamux and Optomux systems, and serial SNAP I/O systems. For Ethernet-based SNAP controllers and brains, consult the device's user's guide for troubleshooting information.

Although the information in this guide is believed to be accurate at the time of publication, Opto 22 is not liable for any loss or damage directly or indirectly caused by the use or abuse of information contained herein. This document is in the public domain and may be freely copied or distributed, providing that this notice accompanies any such reproduction or re-transmission.

About Opto 22 Product Support

Technical support for the life of the product is included with your purchase of any Opto 22 product.
If you cannot find the help you need in this document or on our website (www.opto22.com), contact Opto 22 Product Support:

Phone:	800-TEK-OPTO (800-835-6786 toll-free in the U.S. and Canada) 951-695-3080 Monday through Friday, 7 a.m. to 5 p.m. Pacific Time	*NOTE: Email messages and phone calls to Opto 22 Product Support are grouped together and answered in the order received.*
Fax:	951-695-3017	
Email:	support@opto22.com	
Opto 22 website:	www.opto22.com	

Opto 22 Product Support should be contacted any time an otherwise unresolvable application issue arises in the field, any time clarification of specifications or system performance is required, any time a damaged or defective item needs to be returned for repair, or any time a question comes up that doesn't appear to be addressed in our documentation. Typical response times are within one business day.

Please have the model number of the product you need help with, as well as applicable software and firmware titles and versions when contacting us regarding such issues. Having easy access to any hardware in question while on the phone with our Product Support Group is also desirable.

In general, Opto 22 does not provide field technical support. If you feel that you require this level of service, we recommend that you contact one of our automation distributors or OptoPartners. A list of distributors and partners is available on our website, www.opto22.com.

RETURN AND REPAIR POLICY

In-Warranty Repairs

Most I/O modules and solid-state relays manufactured after January 1996 have a limited lifetime warranty. Other products carry a 30-month warranty. In-warranty units will be repaired or replaced free of charge. See the Opto 22 Limited Warranty on our website for details. The repair does not extend the warranty beyond the original warranty period.

Out-of-Warranty Repairs

Any unit that is out of warranty will be repaired at a cost equal to half the current list price. This applies only to those units that can be repaired. The repaired unit will be given a 30-month repair warranty. The warranty period for out-of-warranty repairs of obsolete products will be 30 months or until repair parts are no longer available—whichever comes first.

Repair Returns

Prior to returning any product for repair or replacement, please contact Opto 22's Product Support Group (see page 1) to request an RMA number. In order to be processed properly, the RMA number must be on the shipping label when the package is received by Opto 22.

If you have any questions about the warranty status of your Opto 22 product, please contact Product Support.

SOLID STATE RELAYS

Opto 22 has been the world's leading manufacturer of solid-state relays for decades. More than 40 years ago, we pioneered the design of the relay that is now almost universally used in the industry.

Our SSR product family spans current and voltage ratings from 1.0 A to 45 A, from 120 VAC to 575 VAC, and from 5 to 200 VDC. Relays are available in five package styles. Control voltage is 3-32 VDC in most models, though selected products are available with 120 VAC nominal control voltage.

All relays feature 4,000 Vrms (1 sec.) optical isolation from field to control, and are, at a minimum, UL and CSA approved. AC switching models also typically feature built-in transient suppression to 0.5 power factor. MTTF rates for these products are typically greater than a million hours.

SSR Applications

Q: What is a solid-state relay?

A: An SSR is a semiconductor device that can be used in place of a mechanical relay to switch electricity to a load in many applications. Solid-state relays are purely electronic, normally composed of a low current *control* side (equivalent to the coil on an electromechanical relay) and a high-current *load* side (equivalent to the contact on a conventional relay). SSRs typically also feature electrical isolation to several thousand volts between the control and load sides. Because of this isolation, the load side of the relay is actually powered by the switched line; both line voltage and a load (as well as the control signal) must be present for the relay to operate.

Q: What are the advantages of using an SSR over a mechanical relay?

A: Many applications require a moderate amount of power (W to kW) to be switched on and off fairly rapidly. A good example would be the operation of a heater element in a controlled- temperature system. Typically, the amount of heat put into the system is regulated using pulse-width modulation turning a fixed-power heating element on and off for time periods ranging from seconds to minutes. Mechanical relays have a finite cycle life, as their components tend to wear out over thousands to millions of cycles. SSRs do not have this issue; in the proper application, they could be operated almost infinitely.

Q: What are the limitations of using an SSR?

A: SSRs have a few limitations when compared to the capabilities of their mechanical counterparts. First, because the relay is semiconductor-based, it will never turn all the way on or off. This means that in the ON state, the relay still has some internal resistance to the flow of electricity, causing heat to be generated internally. When in the OFF state, the relay will exhibit a small amount of leakage current, typically a few milliamps. This leakage can keep some loads from turning off, especially ones with a high impedance.

Additionally, SSRs are more sensitive to voltage transients; while Opto 22 relays are very well transient protected, if a relay gets hit hard enough a sufficient number of times, it will degrade and eventually fail. This makes SSRs less ideal for driving highly inductive electromechanical loads, such as some solenoids or motors.

SSRs should also never be used for applications such as safety power disconnects, because even in the off state, leakage current is present. Leakage current through an SSR also implies the presence of a potentially high voltage. Even though the relay is not conducting a large amount of current, the switched terminal will still be "hot" and thus dangerous.

Q: Do you make multi-pole or multi-throw SSRs?

A: Opto 22 manufactures only single-pole, single-throw SSRs. If multi-phase operation is required, just use a relay on each phase.

Q: Can I hook up SSRs in parallel to achieve a higher current rating?

A: No. There is no way to guarantee that two or more relays will turn on simultaneously when operated in parallel. Each relay requires a minimum voltage across the output terminals to function; because of the optical isolation feature, the contact part of the SSR is actually powered by the line it switches. One relay turning on before the other will cause the second relay to lose its turn-on voltage, and it won't turn on, or at least not until the first relay fails from carrying too much current.

Q: What does a "zero-crossing" turn-on circuit refer to?

A: *Zero-crossing* turn-on and turn-off refer to the point on the AC waveform when the voltage or current passes through zero. It is at this point that an AC SSR will turn on or off:

- Zero-voltage turn ON occurs when the AC voltage waveform passes through zero.
- Zero-current turn OFF occurs when the AC current waveform passes through zero.

Opto 22 AC relays are designed with a zero-crossing turn-on and turn-off circuit. When the AC waveform crosses zero, transients are minimized. This makes it much easier and safer for the semiconductor device in the relay to be turned on or off. It also generates much less electrical EMI/RFI noise.

Q: Can I use an AC SSR to switch DC?

A: No. Because of the zero-crossing circuit described above, the relay will probably never turn on. And if it is on, it will probably not be possible to turn it off, as DC voltage typically never drops to zero.

Q: Can I use a DC SSR to switch AC?

A: No. The semiconductor device used in Opto 22's DC SSRs is polarized. It may break down and only conduct for half of the AC waveform.

Q: Can a DC SSR be used to switch an analog signal?

A: This is not recommended, for several reasons. First, the voltage drop across the relay will cause signal loss. Second, the conduction characteristics of the SSR are very non-linear at low operating voltages and currents. Use a mechanical relay; it will work much better.

Q: What agency approvals do your SSRs carry?

A: In general, Opto 22 relays carry UL, CSA, and CE approval. See our website for approval documents.

SSR Troubleshooting

Q: My SSR does not function anymore. What happened?

A: Solid state relays (SSRs) are simple, reliable devices. If one stops working, typically it just refuses to turn on or off.

If you have a failed SSR, take a close look at the normal operating parameters of that relay within the larger system. Make sure that the relay you're using is appropriate to the application and that it is properly installed.

The three most common reasons for an SSR to fail are:

- **SSR improperly matched to load.** The relay can be damaged by overheating from carrying too much current, too long. Be sure to review the thermal de-rating curves in form 859, the *Solid State Relays Data Sheet.*
- **SSR improperly installed.** If the SSR was not mounted to a large enough heat sink, or no thermal compound was used, the relay will overheat. Improper torque of the load terminal screws can also cause issues. Not tight enough will result in heat at the terminal; too tight can cause internal physical damage, resulting in increased resistance and increased heat. See torque specifications in form 859, the *Solid State Relays Data Sheet*.

Similar failures have also been attributed to the use of crimp-on terminals or spade lugs. Make sure these terminals are tightly crimped, and even drip some solder into the joint to ensure good electrical contact and protection from corrosion.

- **SSR insufficiently protected.** Remember that a semiconductor isn't as tough as a simple metal contact. Repetitive voltages exceeding the peak repetitive voltage (PRV) rating of the relay will cause damage.

  On highly inductive loads, make sure you use snubbers, transorbs, MOVs, and/or commutating diodes.

Q: How can I test my SSR?

A: If you're used to testing mechanical relays, you'll find an SSR requires a different testing method: it requires a load.

A typical SSR always shows an infinite impedance to a resistance meter placed across the output terminals. That's because:

- An SSR requires a small amount of power to operate, derived from whatever voltage source is placed on the load terminals. A typical multimeter does not supply sufficient voltage to cause the relay to change state.

- AC SSRs contain a zero-crossing circuit (more info on). This circuit does not allow the SSR to turn on unless the field terminals see a transition through zero volts. Since most test equipment supplies a DC voltage to the relay, the relay will never see the zero it requires to turn on.

To test an AC solid state relay, then, you'll need some sort of AC load. It's best to operate it at the actual line voltage at which it's used, driving a load such as a standard incandescent light bulb.

Q: I have an SSR driving a load. The load turns on but never seems to turn off, unless I remove power from the relay entirely. What might be happening?

A: This is normally an issue when using an SSR with a high-impedance load, such as a neon lamp or a small solenoid. Loads like these often have relatively large initial currents but relatively small "hold-in" currents. The result is that the off-state leakage current through the relay is sufficient to keep the load on, once it has been turned on. See .

The solution to this issue is to place a power resistor, sized for 8–10 times the rated maximum leakage current for the SSR, in parallel with the load. Make sure that this resistor has a high enough power rating for the application.

For example, for a 5 mA leakage current at 120 VAC, a resistor drawing 50 mA would be desirable.

0.005 * 10 = 0.050
V = I*R can also be expressed as R = V/I
So R = 120/0.050 = 2400 ohms
And P = I*V = 0.050 A * 120 V = 6 watts

Using Ohm's law, the resistor value becomes 2,400 Ohms. The resistor will dissipate 6 watts, so a 7.5 or 10 watt power resistor should be used.

The equations are:

Ohm's Law: V = I*R
Power: P = I*V

Because V = I*R, the power equation can be changed to either of these:

P = I*V = I*I*R (I squared times R)
P = I*V = V*V/R (V squared over R)

Q: I have a new AC SSR driving a solenoid. It turns on once but will not turn on again. What is going on?

A: Some loads, like certain solenoids, some types of halogen lights, and some types of strobe lights incorporate a diode in series with the coil or filament. This causes the load to behave as a half-wave rectifier. Opto 22 SSRs have a built-in R-C snubber circuit in parallel with the output. The capacitor in this circuit charges up but cannot discharge through the series diode, causing a voltage to appear across the SSR terminals. Because the SSR must see a zero voltage across the terminals to turn on, it can't turn on again in this situation.

The solution here would be to put a high-value resistor (several tens of kilohms) across the terminals of the SSR, to allow the capacitor to drain.

NOTES FOR ALL OPTO 22 ANALOG I/O FAMILIES

About Transformer Isolation

Transformer isolation is important with analog signals to prevent ground loop issues (also referred to as common mode noise). Most analog signals are floating; that is, the signal common is not tied to earth ground. With these types of signals, transformer isolation is not necessary. However, if you have two analog signals and both are grounded—that is, their signal commons are tied to earth ground—then you may need transformer isolation.

Without transformer isolation, the signal commons for both analog channels are tied together at the rack through the analog modules (assuming the two channels are on the same rack). If each signal has its common tied to earth ground in different locations, and if earth ground is at a different voltage at these locations (which is normal), then there is a voltage difference between the two signal commons. This potential (or voltage) difference causes a *ground loop* current to flow between the two ground points and through the analog modules, which may interfere with the analog signal being measured.

Transformer isolation breaks the connection between the two analog modules and eliminates the path for the ground loop current to flow.

If you're not familiar with this potential issue you may spend hours of troubleshooting time during or after startup, trying to figure out why the system is not working correctly. Even if you are familiar with this issue, you might not realize that your ungrounded analog sensor is inadvertently grounded.

Isolation in Opto 22 I/O Families

SNAP analog I/O modules include from 1 to 32 channels, depending on the module. Most offer transformer isolation between modules but not between channels on the same module. However, other SNAP analog input modules are available with channel-to-channel isolation. Be sure to choose the module with the isolation needed for your application.

G4 analog I/O offers transformer isolation between each single-channel module.

High-density G4 analog I/O offers transformer isolation between the two interface cards but not between channels on the interface card and not between groups of channels on the interface card.

G1 (Standard) analog I/O modules offer transformer isolation only with the modules that have a "T" in the part number. G1 analog modules with a T at the end of the part number have isolation between each module.

Notes on Sourcing Current Loops (4–20 mA)

A few **SNAP** analog modules, such as the SNAP-AIMA-iSRC input and the SNAP-AOA-23-iSRC output, provide built-in isolated loop sourcing for both channels with the connection of a single 24 V power supply, such as the SNAP-PS-24 or SNAP-PS24U power supplies.

Most SNAP analog modules, however, do not have a built-in isolated loop excitation power supply, nor do they provide for a shared loop power supply. An external loop power supply (SNAP-PS-24 or SNAP-PS24U) is required. If one power supply is used for multiple loops, then the power supply will bypass any transformer isolation. The only way to maintain the isolation in this case is to use separate, isolated power supplies, one per loop.

G4 single-channel I/O modules G4AD3 and G4DA3 provide both transformer isolation and a built-in isolated power supply to source current loops.

High-density G4 analog I/O cards do not have a built-in isolated loop excitation power supply and do not provide for a shared loop power supply. An external loop power supply is required. There is no provision for transformer isolation except between the two I/O cards on the I/O unit.

G1 (Standard) analog mounting racks allow for a shared loop source power supply. Although this can be used with "T" modules, it defeats the purpose of having transformer isolation, because G1 analog "T" modules provide transformer isolation only for the analog signal and not for the loop power supply. The only way to maintain the isolation in this case is to use separate, isolated power supplies, one per loop.

G1 AND G4 DIGITAL I/O FAMILIES

In addition to our multichannel SNAP I/O modules, Opto 22 still makes two families of single-channel digital I/O products: the Standard (or G1 series), and the Generation 4, or G4 series. Opto 22 invented the first modular, optically isolated I/O product meant for use with computerized control systems. These G1 I/O modules introduced the familiar white-yellow-red-black color scheme and were emulated by many other industrial automation manufacturers.

Generation 4 was introduced in 1989 as a smaller, more integrated package. The performance of the two module families is essentially identical. The main difference is that G4 has the fuse and module status indicator LED built into the module, while on the G1, the protective fuse and indicator LED are built into the mounting rack.

Because the performance and design of the two families is nearly identical, the following application and troubleshooting sections apply to both, except where noted.

G1 and G4 Digital I/O Applications

Q: Do you recommend one digital I/O family over another?

A: Opto 22 recommends that new users of I/O modules use our SNAP I/O™ (see page 21) unless design constraints do not permit its use. Opto 22 also recommends that current users of G1 and G4 modules take a close look at SNAP I/O for new installations. SNAP is more cost effective than G1 or G4 because it is much higher density; SNAP also offers much greater flexibility in network communications and control software.

If your application requires the use of G1 or G4 modules, unless there are other factors besides electrical performance, both families should perform equally well. Some modules are available in the G4 series that are not available in G1 or SNAP; these include extremely high-speed input modules and modules featuring the equivalent of hand-off-auto switches. The G4 output modules use a fuse type that can be difficult to find in more remote locations if a replacement is needed, but this is not normally an issue with adequate spare-parts planning. Module pricing for G1 and G4 is the same, so cost per point is not typically an issue for single-point modules.

Q: What sort of power supply requirements do these modules have?

A: Each G1 or G4 digital I/O module has two sides which are optically isolated from one another. The logic side requires a positive voltage supply somewhere close to the rated module voltage; a G4IDC5 would require 5 VDC, for instance. Current requirements on the logic side are about 10 mA for all types.

The field side of Opto 22 modules is line powered. This means that for the circuitry to function, there must be a voltage differential across the field side terminals. Of course this is not an issue for input modules, but it is important to keep in mind for the solid-state outputs. These outputs cannot change state without a voltage differential present, so the module cannot be treated as a simple dry contact. To operate properly, one side must be "wet" at all times.

Q: Your literature says that these modules operate in a "negative true" mode. What does this mean?

A: *Negative true* logic is the same as inverting logic. On Opto 22 I/O modules, this means that when the field side is ON, the control side is OFF, and vice versa. Essentially, the module will invert any logical signal that is sent to it. Normally this is not an issue for microprocessor-based control systems, as inverting a logical signal is one of the easiest operations to perform on such a system.

Don't worry about replacing another manufacturer's modules with Opto 22's on this account—we've used negative true logic from the start, and most of the manufacturers who have copied our designs followed our negative-true standard. The reasons behind choosing negative-true logic originally had to do with the performance of various semiconductor components; specifically current ratings of n-channel versus p-channel transistors.

Q: Is there a method by which these modules can be used in a non-inverting mode?

A: Only certain output modules can be used in a non-inverting, positive true logic mode, and only with certain types of module mounting racks. Please contact Opto 22 Product Support for further information.

Q: I need a dry-contact, mechanical output module. Do you make one?

A: Opto 22 manufactures three types of dry-contact output modules in the G1 and G4 series, denoted by an "R" suffix on the part number. These are the ODC5R, G4ODC5R, and G4ODC5R5.
The "R" modules are normally open; the "R5" module is normally closed.

All dry-contact modules are rated 10 VA maximum. They cannot be used in positive true applications and must operate at a 5 V logic level. If other logic levels or higher power handling is needed, Brentek International (www.brentek.com) manufactures dry contact modules almost exclusively; they have several types that are compatible with Opto 22 products.

Q: I currently have several modules made by another company installed in a piece of equipment. Can Opto 22 modules be used to replace them?

A: Typically, yes. Opto 22 makes a very wide variety of modules in both the G1 (0.6 inch-by-1.7 inch footprint) and G4 packages. Opto 22 does not currently make modules in the "M" or "SM" (0.4 inch-by-1.7 inch) style cases, though the G1-series modules are pin-compatible. If there is sufficient lateral space, G1 modules could be used here.

Our competitor's part numbering schemes are very similar to our own; typically a "standard" package module will have no additional identifier, a G4 package module will have a part number containing the letter "G," and "M" and "SM" packages will also be identified by those letters in the part number. If you want to get an exact cross reference, please call Opto 22 Pre-sales Engineering (800-321-6786 or 1+951-695-3000) and have ready the competitor's part number and a service description, for example, voltage and current rating.

Q: What agency approvals do your modules have?

A: Opto 22's I/O modules are, at a minimum, UL and CSA approved. Most modules are CE compliant. Certain models are also FM approved for use in Class I, Division II hazardous environments. For more information regarding agency approvals for specific models, see the agency approval documents on our website.

G1 and G4 Digital I/O Troubleshooting

Q: I have an I/O module that is not working anymore. What may have happened?

A: As with SSRs, there is no one way in which I/O modules fail. For one, input modules normally fail in a different way than outputs.

Output modules normally fail open, or half-wave for AC, and the failure is usually caused by applying too much current or by degradation of the semiconductor switch by overvoltage. Because the module is separated into two parts by the optical isolator, it is possible to have an output module that behaves properly on the logic side but is broken on the field side. In this case the LED will usually continue to turn on and off as commanded by the driving logic device, even though the module has failed.

Input modules also typically fail on the field side, usually from overvoltage or overcurrent. Unlike output modules, an input module's LED usually will not function as expected when the module has failed. The logic side of Opto 22's I/O modules rarely fails. If it does, it's usually due to using the module at the wrong logic voltage or to miswiring.

The first step to troubleshooting a failed module is to check the fuse. If it is blown, simply replacing it should get the module working again. If the module continues to blow fuses, analyze the load to see if the module is really suited to the application.

Also be aware of polarity. All AC and some DC input modules have a bridge rectifier on the input side of the module, which allows hookup without regard to polarity. (We use a bridge rectifier in some DC input modules to make them also able to handle AC voltages, typically in ranges lower than our AC modules.) Other DC input modules do not have a bridge rectifier, usually for speed (without it, the minimum turn-on and turn-off times are smaller); these modules require the input to be correctly polarized. So if you have a non-working DC module, check the polarity of the input signal.

Q: I have an input module that seems to flicker when a voltage is applied to it. What is happening here?

A: In the Opto 22 input modules that contain bridge rectifiers, it is possible in an AC application to damage one-half of the rectifier and still have the module function for a time. The bridge rectifier turns into a half-wave rectifier, causing the module to turn on and off at the line frequency when an input is applied.

Also, using a DC input module that does not contain a diode bridge on an AC circuit will cause flicker. You may see this as flicker on the status LED, or it may be too fast to see. Digital logic devices, being much faster than the human eye, can cause serious issues with this failure mode.

This failure results most commonly in applications where the input module is placed in parallel with an inductive load. When the load turns off, the back-EMF goes right through the module, damaging one-half of the bridge. To significantly reduce the frequency of this type of failure, place a transorb or large R-C snubber in parallel with both the load and the input module.

Q: I have an output module driving a load. The load turns on but never seems to turn off, unless I remove power from the module entirely. What might be happening?

A: Normally this issue occurs when using an output module with a high-impedance load, such as a neon lamp or a small solenoid. Loads like these often have relatively large initial currents but relatively small "hold-in" currents. The result is that the off-state leakage current through the module is sufficient to keep the load on, once it has been turned on.

The normal solution is to place a power resistor, sized for 8–10 times the rated maximum leakage current for the module, in parallel with the load. Make sure that this resistor has a high enough power (wattage) rating for the application.

See the equations on , which also apply to digital output modules.

Q: I have a new AC output driving a solenoid. It turns on once but will not turn on again. What is going on?

A: Some loads, like certain solenoids, some types of halogen lights, and some types of strobe lights incorporate a diode in series with the coil or filament. This causes the load to behave as a half-wave rectifier. Opto 22 output modules have a built-in R-C snubber circuit in parallel with the output. The capacitor in this circuit charges up but cannot discharge through the series diode, causing a voltage to appear across the output terminals. Because the module must see a zero voltage across the terminals to come on, it can't turn on again in this situation.

The solution is to put a high-value resistor (several tens of kilohms) across the output terminals of the module, to allow the capacitor to drain.

Q: I have an AC output module in a circuit, wired in series (ANDed) with another contact. When that other contact closes, my load turns on momentarily, even though my output module is off. Is my module broken?

A: This situation arises when the output module does not see a voltage across its terminals. This is the case where another contact is wired in series with the module between the module and the "hot" side of the supply. Because the module is totally isolated from field to logic, the field (contact) side of the module must power itself from the attached line. Because of the pilot circuit in the module, the switching semiconductor is in an indeterminate state when there is no voltage across the module. It may turn on for up to a half cycle if it suddenly receives power. The pilot circuit realizes that the module is on but cannot turn it off until the voltage crosses zero again.

There is no easy solution to this issue. Typically a solution involves either maintaining a minimal voltage across the module, pre-wetting it with a low voltage, or absorbing the energy from the half cycle turn-on with an R-C network in parallel with the load.

G1 AND G4 ANALOG I/O FAMILIES

As with digital I/O, Opto 22 still makes two families of single-point analog I/O modules in addition to our multi-point SNAP I/O modules:

- Standard (or G1/Generation 1) analog series, used primarily with Optomux and Pamux
- G4 or Generation 4 analog series, used primarily with our *mistic* analog bricks and legacy M4 I/O controllers

These modules provide a large variety of prepackaged, pre-calibrated analog input and output options for a very large variety of signal types. Analog inputs include everything from standard 4–20 mA and 0–10 V industrial process signal inputs to thermocouples, RTDs, high current, millivolt, and even velocity inputs. Analog outputs are available to handle standard industrial process outputs such as voltage or 4-20 mA loops, as well as more specialized functions, such as time-proportional output for heater control.

The two module families are handled together in this document because they are extremely similar in their method of operation; in many cases, the only differences between a G1 module of a certain type and its G4 counterpart are the package and the fact that all G4 analog modules provide transformer isolation.

Opto 22 analog input modules mount on Opto 22 mounting racks. Unlike our digital module families, the package and interface for our analog modules is essentially proprietary. Several other manufacturers use Opto 22 analog modules on their equipment, but there are no large suppliers of clone products.

Generation 1 modules are typically mounted on G1 analog racks (for example., PB4AH, PB8AH, and PB16AH) and used with Optomux and Pamux brain boards. The B200 *mistic* brain board is also designed for use with these Optomux- and Pamux-compatible G1 racks and analog I/O, effectively giving the entire system the same flexibility and capability as the G4 analog series. G4 analog modules typically mount to analog bricks.

G1 and G4 Analog I/O Applications

Q: Do you recommend one analog module family over the other?

A: Yes, Opto 22 recommends SNAP I/O analog modules (see page 21) over either Standard (G1) or G4 analog. SNAP offers higher density, higher resolution (inputs), lower cost, and additional options for signal types, network communications, and control software.

As far as G1 and G4 modules are concerned, we don't recommend one module family over the other. Usually, the driving force behind the selection is the interface family used—Pamux, Optomux, or *mistic*. The difference between the two module families is primarily physical; G4 may be installed at a 40% greater density but is typically more expensive. Some module types are available in G4 but not G1, including velocity, some thermocouple inputs, and the time-proportional output module.

Q: What type of power supply will I need for these modules?

A: G1 (Standard) analog modules require 5 VDC and ±15 VDC. G1 analog modules manufactured before 1993 may also require a -5 VDC reference. It is important that the 5 VDC supply be isolated (separate "common" terminals) from the ±15 VDC supply for G1 modules. 24–48 VDC may also be required to power current loops connected to G1 analog modules; this will depend on the type of external current loop devices being used.

Generation 4 analog modules require 5 VDC and 24 VDC. In G4 installations, the G4REG regulator on the *mistic* brick (mounting rack) is typically used to supply module power. G4 current loop modules are capable of sourcing 24 VDC for current loop applications. See Opto 22 form #1271, *Using Power Supplies with Opto 22 Systems*, for more information.

Q: Are Opto 22's current loop outputs active or passive?

A: Opto 22's current loop outputs (DA3, DA3T, and G4DA3) are passive; they require an external loop supply. The G4DA3 module does not, however; it can supply 24 VDC for the loop and may be connected so that it behaves as an active current-sourcing device or as a passive device, at your option.

Q: What type of A/D interface does a G1 or G4 analog input module provide?

A: Opto 22 G1 and G4 analog I/O modules are not true analog-to-digital converters. Instead, each module contains a precision voltage-controlled oscillator (VCO) and outputs a frequency proportional to the input. Signal conditioning circuitry in front of the VCO guarantees that the correct gain and linearization is applied to whatever incoming signal the module is designed for.

The frequency output of the module is optically coupled to the brain board interface. A processing ASIC on the brain board then measures the incoming frequency and determines an appropriate count value from it. Over the module's normal operating range, an increase of 1 Hz on the module output is equivalent to a 1 count change in the input. This particular A-to-D methodology allows Opto 22 to provide effective conversion and isolation without having to use linear optocouplers or true serial A-to-D converters. This simplicity allows extremely high reliability. There is no conventional A-to-D converter used at any point in Opto 22's single-point analog I/O systems.

Q: What sort of interface does Opto 22 use for single-point analog output modules?

A: Opto 22's single-point analog outputs function very like inputs, except in reverse. The processor on the brain board sends a serial pulse train to the module, where it is converted to whatever output signal type the module was designed to supply. As with the input system, the use of a serial (pulse train) signal allows effective isolation through a standard optocoupler.

Q: Can I get information about how to use Opto 22 analog modules without Opto 22 brain boards for OEM applications?

A: Yes. Using the Opto 22 analog modules is not the same as using a conventional D-to-A or A-to-D converter. We think that it is easier and more economical. For an OEM, it moves the conversion process from a piece of hardware into processor software. While this potentially makes for a slightly longer code development cycle, it adds a great deal of flexibility to the end product. Software is easy to modify; hardwired circuits are not. Please contact Opto 22 Product Support (see page 1) for further information.

Q: What is the difference between your "T" modules and your normal analog modules?

A: The T suffix is used on G1 analog modules to denote transformer isolation. Normal G1 analog modules typically have a direct connection from the common field terminal through the internal circuitry of the module to the common terminal of the ±15 V power supply. Thus there is full optical isolation between the field and 5 V logic elements of the brain board, but there is no effective isolation between the field and the ±15 V analog module common. This is why Opto 22 recommends that the 5 V logic power supply for the brain board be isolated from the ±15 V supply for the same analog module.

In some installations, the lack of effective isolation between the field and power supply can cause the possibility of ground loops or common mode noise issues. T-suffix modules, on the other hand, are transformer isolated; they contain a small inverter that couples power from the ±15 V supply to the analog module circuitry through a transformer. Thus with a T module, there is no direct connection between the field device and the logic or analog module power supply circuitry, eliminating the possibility of common mode issues in the system.

All G4 analog modules feature transformer isolation.

Q: When should I use a "T" module?

A: Opto 22 recommends that transformer-isolated modules be used in all applications, because they prevent the possibility of the most common application issues we see with analog modules. Installations where T modules would be absolutely required include systems using grounded thermocouples, non-isolated signal generators, or systems where there are long wire runs between the signal source and the signal receiver.

At a minimum, a transformer-isolated analog module should be used anytime the possibility of a ground loop exists in the environment or in the installation. Examples of such environments would be metal plating or galvanizing plants, aluminum refining plants, or any environment where large currents are returned through earth ground.

Q: What is the signal overrange capability of Opto 22's G1 and G4 analog input modules?

A: The over- and under-range capabilities of Opto 22's analog modules are dependent upon the type of module, although most modules will exhibit over-range capability from 10 percent to 100 percent of scale. This large capacity is a result of the unique analog-to-digital conversion methodology used by Opto 22.

Keep in mind, however, that the same A-to-D process places a finite limit on resolution; when a module jumps into over-range operation, it loses roughly half of its precision (drops to 11-bit resolution).

G1 and G4 Analog Troubleshooting

Q: How do Opto 22 G1 and G4 analog modules typically fail?

A: As a rule, Opto 22's analog modules don't fail when they are properly applied. Our failure rate for these modules is less than one one-hundredth of one percent, and approximately 99 out of every hundred of those failures is directly attributable to incorrect installation or some "act of God," such as lightning strikes.

Q: What sort of drift over time might I expect to see in one of these analog modules?

A: A small amount of drift (a few counts) is quite normal for analog electronics of the type found in Opto 22 analog modules. This can be especially evident if the module is operated near its rated temperature limits or undergoes extreme and rapid changes in temperature on a regular basis. Typically, drift of this type will be at most a percent or two over several years. Larger amounts of drift may indicate an issue with the application or installation of the module. Calibration maintenance should be performed in all measurement applications.

Q: My analog input module is returning a large negative number of counts even though I've measured my incoming signal, and it appears to be in range. What might be happening?

A: The normal cause of an issue like this is low voltage powering the mounting rack where the analog module is installed, or insufficient isolation. Check to make sure that the 5 V and 15 V commons are isolated from one another. Also check to be sure that the 5 VDC supply is between 5.0 and 5.2 VDC, and that the ±15 volt supplies are accurate to within 0.25 VDC.

If you are reading a large negative value and you don't know what the signal input is, check it. Large negative numbers are the analog module's way of indicating an out-of-range condition. Also verify that the polarity of the field signal is correct with respect to the polarity of the Opto 22 input module.

Q: The input from my module is noisy, changing value by several percent constantly. What can I do to prevent this?

A: Noisy analog readings are normally symptomatic of three things: a noisy input signal, a grounding issue, or a power supply issue.

Noisy inputs and grounding issues can be checked by looking at the input signal using an oscilloscope across the inputs of the module. If you see noise on the oscilloscope, then there is noise on the input line or the common line. Locate the noise source and eliminate it, or at least filter it. You may need to use a transformer-isolated module, if you aren't already.

If there is no noise on the input line, check the voltage on the ±15 VDC supply to the module. If the voltage on either rail is not 15 V ±0.25 V, the electronics within the module may not be functioning in a linear or stable fashion, leading to noise on the input.

If you can't identify a source of interference, please call Opto 22 Product Support (see). The G4AD3 is known to self-oscillate when driven by some types of current transmitters.

Q: Why won't my G4AD3 4-20 mA input module reach full scale?

A: The G4AD3 has a 3.3 V Zener diode in series with the precision resistor used to generate a voltage signal from the current loop signal. This non-linear element will cause the effective loop source voltage to be 3.3 V less than the actual applied voltage. In a high-impedance loop, this difference may prevent the loop from ever reaching a full-scale current of 20 mA. Furthermore, the measured resistance across the module terminals will be nearly infinite, as most ohmmeters do not generate sufficient excitation voltage to bias the Zener diode into conduction.

Note that the G1 AD3 and AD3T modules do not share this feature; they will measure an actual resistance of 249 Ohms.

Q: Is there a way to calibrate an analog input module?

A: Both the Optomux and *mistic* I/O systems have the ability to apply gain and offsets to both input and output modules in order to provide increased accuracy. The gain and offset operations are actually performed at the brain board level, rather than at the modules themselves. The modules are not programmable.

The Pamux family of equipment does not support brain board level offset and gain. Be aware that because the offset and gain are applied to the module signal after it has been digitized, any changes in gain and offset will also have a negative impact on module resolution. The gain and offset commands should not be used for engineering unit conversion purposes.

PAMUX SYSTEMS

Pamux was Opto 22's first computer-based I/O product family. Pamux is really an acronym that stands for PArallel MUltipleXed, which is essentially a description of what Pamux is: a parallel bus I/O communications system that allows many digital and analog I/O points to be addressed by a relatively small number of I/O lines from a computer bus.

The Pamux family consists of the following products:
- three classic brain boards: B4, B5, and B6 (obsolete)
- two SNAP brains: digital-only SNAP-B4 and mixed analog/digital SNAP-B6
- three adapter cards: PCIe bus PCIe-AC51, PCI bus PCI-AC51, and ISA bus AC28 (not recommended for new development)

SNAP and classic I/O can be mixed on the same data link.

A PC with an adapter card installed communicates with up to 32 brain boards, up to 500 feet away. Adapter cards come with a free software development kit (SDK). This bus operates at an extremely high speed, making Pamux suitable for applications from simple warehouse bin lighting control to low-level interfacing with multi-axis, high-speed motion controllers.

If you have an Opto 22 product that you believe to be part of the Pamux family but is not identified here, give Product Support a call (see).

Pamux Applications

Q: What are the advantages of using Pamux over a serial interface I/O system?

A: The primary advantage of Pamux over other I/O systems is its speed reading and writing digital I/O. The bus is theoretically capable of 200,000 send-receive transactions per second. This is about 80 times faster than a serial data link operating at 38.4 Kbaud. This means that with good driver programming, this bus is suitable for performing operations such as bringing a high-speed A/B-phased quadrature signal into a host computer— something not possible on a serial link without preprocessing.

Q: What are the limitations of the Pamux system?

A: The primary performance limitations of the Pamux system are two-fold. First, the bus length limit is 500 feet total, using 50-conductor ribbon cable. The ribbon cable itself is the second limitation. Because of the bus operating speed, cable impedance becomes a major concern. Shielded, bundled, rolled, or ground-plane ribbon cable does not work well with Pamux, leaving the unshielded, flat ribbon cable of the bus somewhat susceptible to noise pickup.

The signal duration on the bus is such that it is possible to have noise interpreted as signal; there is no error-checking provision in the Pamux bus protocol. Opto 22 has modified the Pamux brain boards to include some time-base digital filtering of the bus signals. These additions have made Pamux more noise-immune to moderate noise-level industrial environments.

The other potential issue introduced by the ribbon cable is that of physically running the bus cable; it is difficult to pull a 2.5-inch flat ribbon cable through conduit less than three inches in diameter. If the Pamux bus is to be run in conduit, plastic conduit should be used.

Q: Do other manufacturers support Pamux?

A: Pamux is an Opto 22 product, though there are many third-party manufacturers using Pamux within larger systems. Additionally, some manufacturers use the Pamux bus standard to add additional I/O capacity to their control systems. Hence, it is not uncommon to be performing maintenance on a machine and find a Pamux B4 brain board buried somewhere inside.

Q: Does Opto 22 have an HMI or control package that uses Pamux?

A: No. Opto 22 has not developed HMI or control software for the Pamux system. The software development kit may be used to create such a package using commercially available development languages. Some third-party HMIs have Pamux support.

Pamux Troubleshooting

Q: What are the most common causes of issues with Pamux systems?

A: The three most common causes of issues with Pamux systems are low voltage at the brain, electrical noise, and cabling issues. Together, these account for 80 percent or more of all issues the Opto 22 Product Support Group sees with Pamux system installations.

Revisions to the Pamux brain boards (B4, B5, and B6) included the addition of a voltage "watchdog" chip, which forces the board into reset mode if the power supply voltage moves out of a specified operating range. Pamux brain boards should be operated at 5.0 to 5.2 VDC, as measured across a capacitor on the brain board. Current requirements are 0.5 A for all but the last board on the link, which requires 1.0 A, plus the requirements of the installed modules, at about 10 mA each.

If the supply voltage is out of range and the voltage watchdog has forced the board into reset mode, both the WD and ADDR LEDs will be on. Normally, the operations causing these LEDs to light are mutually exclusive. Symptoms of power supply issues with Pamux equipment generally range from garbled data on multiple channels and improper operation of outputs, to periodic inability to communicate at all.

Bus noise issues typically cause periodic garbled data on multiple channels and/or improper output operation of multiple channels. Often, bus noise issues are due to the lack of proper termination at the end of the Pamux bus. Make sure a TERM1 terminator is correctly installed on the last board on the bus. If noise issues persist, use of a flat shielded or ground-plane ribbon cable and a TERM2 terminator may be an option, though Opto 22 does not recommend this. If shielded cable is used, the bus length will be limited to approximately 250 feet. Pamux will not function properly with braided, twisted, or rolled ribbon cable.

One last common cause of issues with Pamux equipment is inconsistency of jumper settings for the board reset level. All of the brain boards on the Pamux bus must be set to the same reset level, high or low. Typically, this issue is seen on new installations or when one or more brain boards have been replaced in an existing system. Power supply and noise issues may appear at any time and at any point in a system's life.

Q: How can I test my Pamux system?

A: Opto 22 has created a software utility called PAMSCAN that runs on a PC for testing Pamux systems. The utility may be set to poll information from a given board address on the Pamux bus and can also find s attached to a Pamux network. While this is often very useful, it does not work reliably on all types of computers, or on extremely old Pamux equipment. If the find command finds phantom s or skips addresses, don't be too concerned. Instead, attempt to test each board manually.

Alternatively for DOS users, the DOS DEBUG utility may be used to directly write to the AC28 I/O port. While this can be very educational, it is not easy to do unless you are very familiar with DEBUG and the Pamux bus protocol. The relevant information may be found in chapter 4 in form 726, the *Pamux User's Guide*.

Q: I just replaced an older Pamux brain board with a new board, and now my system does not work. What might be happening?

A: Opto 22 added some time-based digital filtering to newer Pamux brain boards. While this should not be an issue with most systems, some third-party software drivers do not conform to the Pamux bus timing specification, or try to perform unsupported operations.

Before the addition of the filtering, Pamux brain boards were not very selective in terms of what they considered valid data. It was possible in some cases to cause the bus to operate at a speed other than that specified, or to perform operations such as 16-bit reads and writes, effectively folding together read and write cycles. This is no longer possible. Any driver compliant with the Pamux bus timing specification will work with the new s. If you suspect that the software driver may be at fault, contact the driver vendor for upgrade information.

A second possibility in this case is that the power supply voltage on the board is too low or, less likely, too high. Newer Pamux brain boards will not operate on voltages less than 4.85 V. If the voltage is low, both the WD and ADDR LEDs on the new brain board will be on. Ensure that the voltage is 5.00 to 5.20 VDC as measured across one of the capacitors or across one of the unused jumper pairs on the brain. If you're using an adjustable power supply, we recommend adjusting it so that the voltage as measured on the brain is ~5.15 VDC.

Finally, some manufacturers who use Pamux brain boards in larger pieces of equipment modify the s to suit their application better. Modified B4s are especially common. If you suspect a modified board, it is best to contact the company that the original equipment was acquired from to get information about replacements.

Q: I have a Pamux system attached to my PC. When the Pamux system is powered on, my computer boots just fine, but when the Pamux system is off, my computer refuses to boot properly. What is happening?

A: This is an extremely rare issue; usually it is caused by the use of a non-isolated power supply on the bus terminator. It is possible, right at powerup, for the remote supply to draw current off the PCI bus of the PC through the PCI-AC51, causing a momentary voltage sag. This sag may cause devices like network cards or hard disk controllers to initialize improperly. The only real solution is to unplug the Pamux system from the PC when it is not being used or to get an isolated power supply without much post-regulator filter capacitance.

Q: My Pamux system seems to occasionally get bad data or command outputs that the host computer did not command. What might be happening?

A: Pamux, having a relatively unprotected ribbon cable bus, is susceptible to external noise pickup. In extreme situations, this noise pickup can lead to inputs and outputs latching on or off or behaving randomly. Behavior like this is much more common with older Pamux equipment, as new board revisions have introduced basic filtering to the data lines. If you suspect you have a noise issue, please contact Opto 22 Product Support (see page 1), and we will try to offer some solutions that will eliminate the issue.

Q: All the power lights on my Pamux equipment are on, but I can't communicate with it. The watchdog lights also come on a few seconds after powerup. Why won't this work?

A: The most likely cause of issues here is a mismatch between the reset level chosen by jumper on the brain boards and the value at the reset port address on the PC. Check to make sure that all reset levels are the same at all brain boards and that the correct value is present on the PC reset port. Occasionally there is a conflict between the reset port address on the computer and another system device; a few different reset addresses might need to be tried.

OPTOMUX SYSTEMS

Optomux refers to a data protocol as well as a family of Opto 22 data acquisition and control products. Opto 22 developed the Optomux system in the early 1980s as a serial I/O system. More recently, newer hardware and a newer driver toolkit offered customers the ability to use either serial or Ethernet networks with the Optomux protocol. The Optomux protocol has been so successful that it has become a standard protocol for serial data acquisition systems worldwide.

The original Optomux family included two brain boards, the digital B1 and the analog B2. These have been replaced by the digital E1 and the analog E2, which offer both serial and Ethernet capability. Serial SNAP brains B3000-B and B3000 (obsolete) also can be used with the Optomux protocol.

Optomux Applications

Q: What are the advantages of using an Optomux I/O system?

A: Optomux is a cost-effective, powerful, modular system for monitoring and controlling moderate amounts of I/O. The serial data link, while not extremely fast, is very reliable over distances up to 4,000 feet. Because the communications line can be shielded, it is suitable for use in just about any environment. Given its power, the Optomux ASCII protocol is extremely simple to use. Many third-party HMI and control packages have a driver to support the Optomux protocol.

Q: What are the limitations of the Optomux system?

A: The primary performance limitation of the Optomux system is the serial data link. While this link is very secure and completely error-checked, it is not as fast as a parallel link like Opto 22's Pamux system uses.

Over a serial network, the maximum baud rate supported by the Optomux brain boards is 38.4 Kbaud; the maximum usable baud rate for a given system is also typically dependent on the length of the communication lines. In theory, at maximum speed, the Optomux system should be capable of polling roughly 3,400 digital positions per second, or roughly 600 analog positions per second. However, that's assuming that all the positions are on the same brain board, which is not possible with Optomux. A more realistic speed figure would be about half of the previous numbers.

For faster serial data communication, Opto 22's *mistic* protocol and hardware may be used at speeds to 115.2 Kbps. Or a B3000-B brain using the Optomux protocol can communicate at speeds up to 230.4 Kbaud.

Q: What comprises an Optomux system?

A: An Optomux system is typically made up of three main elements:
- A host device to poll the Optomux brain boards
- Optomux brain boards
- I/O mounting racks carrying the individual I/O modules, to which the brain boards are attached

Q: Does Opto 22 have software support for Optomux equipment?

A: Opto 22 provides a free software development kit (SDK) called Optomux Protocol drivers and utilities, used to develop custom applications. This SDK supports Optomux communications over both Ethernet and serial networks.

Opto 22 does not have a software package specifically developed for the Optomux family. However, because the Optomux ASCII serial protocol has become an industry standard, many HMI and control interface software packages are available with Optomux drivers.

In addition, E1 and E2 brain boards running on an Ethernet network can use the following software:
- custom applications using Modbus/TCP

- custom applications using the OptoMMP protocol (Opto 22 provides the OptoMMP Software Development Kit for this protocol.)
- integration with systems using Opto 22's PAC Project, a complete software suite including control and HMI development tools plus an optional OPC server, database communication tool, and software-based controller for PC-based control.

Q: Can I use Optomux on a 2-wire RS-485 serial link?

A: In theory it should be possible, but Opto 22 does not recommend or support Optomux used in 2-wire mode. This means that if you use 2-wire, we won't be able to help if you have an issue. If you want to use 2-wire RS-485 communications, Opto 22's *mistic* protocol and equipment is designed for 2-wire.

Q: Is it possible to put other serial devices on the Optomux network?

A: Yes, this is possible as long as the devices use ASCII protocol and are tolerant of the Optomux protocol, and as long as the serial device's communications protocol can be ignored by the Optomux brain boards. All valid Optomux host messages begin with ASCII character 62 (>); all other messages on the link will be ignored. As long as character 62 is not used by the additional serial device, everything works.

Opto 22 also makes an addressable interface converter called the AC31. This device lets messages be sent to RS-232 devices connected to the RS-422/485 network. More than one AC31 can be installed on the network, since they are addressable like Optomux brain boards. Essentially, the host sends an ASCII message to the AC31, framed by an Optomux style packet. The AC31 strips off the header and checksum elements of the packet, and passes the rest of the message to the RS-232 device.

Q: Does Opto 22 make a power supply for Optomux equipment?

A: Opto 22 manufactures a series of power supplies usable with digital Optomux B1 and E1 brain boards. They are the PBSA (120 VAC), PBSB (240 VAC), and PBSC (12/24 VDC). The power supplies attach to contact points on Opto 22 "H" suffix digital I/O module racks and will sit under a brain board if one is installed. Opto 22 does not have a power supply for analog Optomux brains.

In any case, choose an isolated power supply and make sure the supply can meet the needs of the brain boards and the modules. See Opto 22 form #1271, *Using Power Supplies with Opto 22 Systems*, for more information.

Q: Will old Optomux equipment work with new Optomux equipment?

A: Yes; current Optomux hardware will work in conjunction with old Optomux equipment with no issue at all. One word of caution, however; over the years, new commands have been added to the Optomux protocol. New brain boards still support the old commands, but old brain boards may not support the new commands. Thus, new Optomux driver software may not necessarily function with old Optomux brain boards.

Q: Are E1 and E2 brain boards really drop-in replacements for B1s and B2s?

A: Yes, E1 and E2 brain boards were specifically designed with features identical to B1s and B2s, while adding Ethernet capability. E1s and E2s should work with your current Optomux software applications without modification.

If you are considering migrating your system from Optomux to SNAP PAC, be sure to see the *E1 and E2 Architecture and Migration Guide*.

Q: Is analog Optomux available with more than 12-bit resolution?

A: At one time, there existed a 14-bit version of analog Optomux. Opto 22 does not offer this version anymore, due to some technical issues with the design. Currently, all Optomux is 12-bit resolution, plus half-resolution over-range.

Q: Is there a controller available to work with the Optomux system?

A: At one time the LC4 controller supported Optomux for a serial system, but that controller is obsolete.

Controllers running PAC Project software, such as SNAP PAC controllers, can work with Ethernet-based Optomux systems using E1 and E2 brain boards; however, these controllers use the OptoMMP protocol. Also note that the digital and analog features available on these brain boards differ depending on the protocol used (OptoMMP, Optomux, or Modbus/TCP). See Opto 22 form #1546, the *E1 and E2 Brain Board Data Sheet*, for specifics.

Optomux Troubleshooting (Serial Network)

The following standard procedures should be able to identify 80–90% of field issues when troubleshooting Optomux over a serial network.

- For E1 and E2 brain boards on an Ethernet network, see troubleshooting information in Opto 22 form #1563, the *E1 and E2 User's Guide*.
- For serial networks, if you are receiving communication errors, see the section below.
- If you have no communication, see "No Communication (Serial)" on page 20.
- General questions and answers for Optomux begin on page 20.

Communications Errors (Serial)

1. Measure the voltage across an unused jumper pair or across one of the capacitors on each Optomux brain. The voltage should be 5.00 to 5.20 VDC. Any noise or AC ripple must stay within this range. If you're using an adjustable power supply, we recommend adjusting it so that the voltage is ~5.15 VDC at the brain board.
2. Make certain the 5 VDC supply common is not connected to earth ground. Also make sure that the COM terminal on the RS-422/485 is not connected to earth ground and that any shields attached to this terminal are also non-grounded. If a communications wire shield is grounded, it must not be terminated on any of the brain boards.
3. If more than one 5 VDC power supply is used, make certain that all the commons are connected together. Normally, this is done through the logic ground or COM terminals on the communication lines.
4. Make sure the communications cable is daisy-chained from brain board to brain board; no Ts or branches are allowed under the RS-422/485 specification.
5. Make certain both ends of the communications cable are properly terminated. The last brain board on the physical link must have jumpers A0 and A6 installed. The AC24AT and AC422AT must have jumpers B2, B4, B5, and B6 installed; LC4s should have jumpers 1 and 2 in the communications group installed.
6. Make sure that shielded twisted pair cable is used for communications links. Two pairs are required by Optomux. If the shield is to be earth-grounded, make sure it is not also connected to logic ground and that another conductor is used for logic common. If the shield is used for logic common, it is no longer a shield. Make sure that it is tied into all the logic ground/logic common terminals, but not earth ground.
7. Make sure the communications pairs are not crossed. In some types of cable, one wire from each pair is the same color. This makes it very easy to get those wires mixed up. If the jacket and shield are stripped back far enough, it will become obvious which wire belongs to which pair.
8. Make sure that the 5 VDC supply common is not connected to the ±15 VDC common terminal on analog brain boards; this can cause analog readings to be unstable.
9. Try running the system at a slower baud rate.
10. Try to test out the system using one of the OptoScan utilities. These utilities, covered below in the questions section, have error trapping ability. Often, the errors received can help determine where the issue might lie. If OptoScan works properly, the issue is likely to be caused by the host software being used in the Optomux system.
11. Call Opto 22 Product Support (see page 1).

No Communication (Serial)

1. Make certain that the baud rates and addresses are set correctly. No two brain boards on the same network should have the same address, and all brain boards (plus the host device) must be operating at the same baud rate. If you see receive LEDs but not transmit LEDs flickering on the brain boards, the issue can be an incorrect baud rate or address setting on one or more brain boards, a bad cable, low voltage at the brain (s), or electrical noise.

2. Check the polarity of the + and – communication lines. If you have one or more receive lights stuck on, this is likely the cause.

3. Re-check the communications wiring. You can check the communications wiring in a multidrop system simply by measuring the impedance across the + and – lines of each wire pair. If the last brain board is terminated properly, you should see about 220 ohms. Make certain that in a multidrop system, only the last physical brain board has jumpers A0 and A6 installed.

4. Make sure that CTS handshaking is disabled on the host, or if that is not possible, jumper RTS to CTS at the host. If RTS/CTS handshaking is enabled, the host may not even transmit on the serial data link.

5. If you're using an ISA bus RS-485/422 adapter card in the computer, make sure that there are no port or IRQ conflicts on the host. If the host device is a PC, it is possible to verify the operation of the RS-422/485 port by jumping TX+ to RX+, and TX- to RX- (these are TO and FO on Opto 22 cards). A communications program such as Windows Terminal or HyperTerminal may be used to communicate with the port; in Terminal, make sure the terminal is set up with no flow control and that the local echo is turned off. Once started, anything typed on the key should be displayed on the screen. If this does not happen, there may be a hardware or configuration issue with the communication port. Also remember that Opto 22 serial cards do not use standard communication port base addresses or IRQ lines for COM3 and COM4. Make sure that the host software is using the correct base address and IRQ.

6. Call Opto 22 Product Support (see page 1).

Optomux General Troubleshooting

Q: Does Opto 22 have any troubleshooting software for the Optomux system?

A: Yes. Opto 22 has two applications for troubleshooting an Optomux system attached to a PC, OptoScan (OSWIN32.EXE) and Omuxuser (Omuxuser.exe). Both are included in the *Optomux Drivers and Utilities* software development kit.

Each of these applications includes the ability to manually configure and poll a digital or analog brain board, as well as the ability to scan for attached brain boards at various baud rates and addresses. They also have an error-trapping utility and a utility that lets you compare brain board jumpers.

For reading or setting jumpers on E1, E2, B1, or B2 brain boards, use the online configurator demos as follow:

* Read E1/B Jumper Settings
* E1/B1 Brain Jumper Configurator
* Read E2/B2 Jumper Settings
* E2/B2 Brain Jumper Configurator

Enter your protocol, brain board address, baud rate, and communication mode, and the online tool will show you exactly how to set your jumpers. Or you can input current jumper settings and find out what they mean.

Additionally, PAC Manager can be used to troubleshoot E1 and E2 brain boards that have an Ethernet connection. For information, see the Troubleshooting chapter in Opto 22 form #1563, the *E1 and E2 User's Guide*.

Q: Can I test the Optomux brain boards using the TEST jumpers?

A: No. The test jumpers are used by a specialized test fixture at Opto 22's manufacturing facility. There is no meaningful way to use the TEST jumpers without the test fixture.

Q: Why does the power light on my Optomux brain board not come on, even though I have 5 VDC attached to my rack?

A: Make sure that your rack is one with an "H" suffix on the part number. I/O racks without the "H" suffix may not have the correct on connections to supply power to the brain board. For example, the G4PB16 has a header connector that will accept a B1 brain board, but it has no power connections to this header. Thus, the brain board will not get power. A G4PB16H rack is physically similar but does have the power connections and thus will work properly with a B1.

SNAP I/O MODULES

While not a legacy product, SNAP I/O modules are included in this guide because many of them are used with the serial B3000 and B3000-B brains as well as with the most recent Ethernet-based SNAP PAC brains and on-the-rack controllers.

The SNAP I/O family was introduced by Opto 22 in 1996, in response to the growing need for high-density digital and analog I/O with high performance. SNAP provides Opto 22 I/O quality in a lightweight, extremely modular, high-density package with up to 32 points per module.

A typical SNAP I/O installation consists of a SNAP mounting rack, SNAP modules, and a SNAP brain or on-the-rack controller. SNAP racks can be mounted directly to panel backplanes or to standard 35-millimeter symmetrical DIN rail, using the optional SNAP-RACKDIN adapter clips. SNAP mounting racks are available in 4-, 8-, 12-, and 16-module capacities. A unique locking system allows the secure attachment of the modules to the rack without requiring hold-down screws; however, screws can be used for applications requiring them.

SNAP Digital Troubleshooting

Q: I have a SNAP digital module that has stopped working. What may have caused this?

A: Failure of SNAP digital I/O modules is very rare and normally caused by misapplication, miswiring, or using the module at the wrong logic voltage. As with Opto 22's other digital I/O module families, there is no one way in which SNAP I/O modules fail. Output modules normally fail in a different way than inputs.

Output modules usually fail open, or half-wave for AC, and the failure is typically caused by the application of too much current or by degradation of the semiconductor switch by overvoltage. Because the module is separated into two parts by the optical isolator, it is possible to have an output module that behaves properly on the logic side but is broken on the field side. The LED will in most cases continue to turn on and off as commanded by the driving logic device, even though the module has failed.

The first step to troubleshooting a failed output module is to check the fuse. If it is blown, simply replacing it should get the module working again. If the module continues to blow fuses, analyze the load to see if the module is really suitable for the application.

When input modules fail, they usually do so on the field side, typically from overvoltage or overcurrent resulting from overvoltage. Unlike output modules, an input module's LED normally will not function as expected when the module has failed.

Q: I have an input module that seems to flicker when a voltage is applied to it. What is happening here?

A: Some Opto 22 SNAP digital input modules contain full-wave rectifiers. In an AC application it is possible to destroy one-half of the rectifier and still have the module appear to function. The full-wave rectifier turns into a half-wave rectifier, causing the module to turn on and off at the line frequency when an input is applied. You may see this as flicker on the channel status LED, or it may be too fast to see.

Digital logic devices, being much faster than the human eye, can cause serious issues with this failure mode. For example, a digital counter attached to a failed module will count at the input frequency.

This failure occurs most commonly in applications where the input module is placed in parallel with an inductive load. When the load turns off, the voltage spike (the back-EMF) goes right through the module, destroying one-half of the bridge.

To significantly reduce the frequency of this type of failure, place a transorb or large R-C snubber in parallel with both the load and the input module.

Q: I have an output module driving a load. The load turns on but never seems to turn off, unless I remove power from the module entirely. What might be happening?

A: This issue may occur when using an output module with a high-impedance load, such as a neon lamp or a small solenoid. Loads like these often have relatively large initial currents but relatively small "hold-in" currents. The result is that the off-state leakage current through the module is sufficient to keep the load on, once it has been turned on.

The solution to this issue is to place a power resistor, sized for 8–10 times the rated maximum leakage current for the module, in parallel with the load. Make sure that this resistor has a high enough power rating for the application.

See the equations on , which also apply to digital output modules.

Q: I have a new AC output driving a solenoid. It turns on once, but will not turn on again. What is going on?

A: Some loads, like certain solenoids, some types of halogen lights, and some types of strobe lights incorporate a diode in series with the coil or filament. This causes the load to behave as a half-wave rectifier.

Opto 22 output modules have a built-in R-C snubber circuit in parallel with the output. The capacitor in this circuit charges up but cannot discharge through the series diode, causing a voltage to appear across the output terminals. Because the module must see a zero voltage across the terminals to come on, it can't turn on again in this situation.

The solution is to find a lamp or solenoid that does not have an internal diode; a potential work-around would be to put a high-value resistor (several tens of kilohms) across the output terminals of the module, to allow the capacitor to drain.

Q: I have an AC output module in a circuit, wired in series (ANDed) with another contact. When that other contact closes, my load turns on momentarily, even though my output module is off. Is my module broken?

A: This situation arises when the output module does not see a voltage across its terminals. This occurs when another contact is wired in series with the module, between the module and the "hot" side of the supply. Because the module is totally isolated from field to logic, the field (or contact) side of the module must power itself from the attached line. Because of the pilot circuit in the module, the switching semiconductor is in an indeterminate state when there is no voltage across the module. It may turn on for up to a half cycle if it suddenly receives power. The pilot circuit realizes that the module is on but cannot turn it off until the voltage crosses zero again.

There is no easy solution to this issue. Typically a solution involves either maintaining a minimal voltage across the module, pre-wetting it with a low voltage, or absorbing the energy from the half-cycle turn-on with an R-C network in parallel with the load.

Q: Why are all four loads connected to my SNAP output module coming on when I'm activating only one of the channels?

A: The SNAP digital output is likely connected on the wrong side of the loads. Remember that all four channels share one fuse; thus one side of each output is common with one side of all the others. If the module is on the wrong side of the load, any one channel is effectively connected to all four. If the output is a SNK type, try switching to a SRC type, or vice versa. In AC applications, reverse the module wiring.

Q: I keep having failures on one channel of my SNAP output module. Why might this be happening?

A: Failures of only one of the four output channels would indicate an issue with the load being driven by that channel. Make sure that the load characteristics, including transients, do not exceed the specifications of the module. Also be sure that the module is properly transient protected, using either an R-C snubber (AC) or a commutating diode (DC) across the load. Modules may also be protected through the use of transient voltage suppressors across the module itself.

SNAP Analog Troubleshooting

SNAP analog modules require a fairly substantial amount of current due to their onboard isolation power inverters. Because of this, it is important to make certain that the entire SNAP installation is supplied with 5.0 to 5.2 V, even while under full load.

See Opto 22 form #1120, *SNAP Power Supplies Data Sheet*, for help in determining the full load required for an I/O unit, which includes the brain or on-the-rack controller and all modules.

An insufficient power supply really means a power supply that cannot provide the full load current required by the brain and modules, or a power supply that is not adjusted to provide 5.00 to 5.20 VDC as measured at the rack. The SNAP equipment is designed with a fail-safe voltage watchdog feature that inhibits operation when power supply voltage levels get too low, thus eliminating the possibility of unintentional output or input. Opto 22 offers DIN-rail-mountable power supplies for use with SNAP I/O systems.

Keep in mind that unless you purchase an isolated module, the channels on a SNAP input or output module are not isolated from one another. Make certain that any transducers or equipment that these modules are used with are floating, isolated from local earth ground. If the equipment is not floating, make certain that the two pieces of equipment being connected are at the same ground potential in order to eliminate the possibility of a ground loop through the module. A ground loop through the module could result in almost anything, from inaccurate readings to failure of the module.

SNAP SERIAL B3000 AND B3000-B BRAINS

Serial B3000 and B3000-B Brain Applications

NOTE: This section covers the obsolete B3000 brain and its replacement, the B3000-B, which communicate serially. For information on SNAP brains that communicate over an Ethernet network, see Opto 22 form #1689, the SNAP PAC Brains Data Sheet, available on our website.

Q: What are the B3000 and B3000-B brains?

A: The B3000 and B3000-B brains are independent I/O processors for use with SNAP I/O systems on a serial network. The B3000 or B3000-B brain mounts to a B-series SNAP rack and can address up to 32 digital and 32 analog I/O points. It offers the same event reaction and PID control capability as Opto 22's *mistic* Remote Multifunction Bricks.

NOTE: For new applications that require serial communication, we do not recommend the B3000-B. Instead, use SNAP PAC SB serial brains with the SNAP PAC System.

Q: What protocol do the B3000 and B3000-B support?

A: The obsolete B3000 supports both the Optomux and *mistic* protocols, with protocol choice determined by jumpers on the brain. The B3000-B supports the *mistic* I/O protocol. If you need to use the Optomux protocol with a B3000-B, contact Opto 22 Product Support (see page 1) for available options.

NOTE: If you need an Optomux brain for new development, see the E1 or E2 brain board.

Q: How is the B3000 or B3000-B organized?

A: The B3000 or B3000-B brain is functionally equivalent to four separate, independent, 16-channel brain boards. It occupies four consecutive addresses (Base, Base+1, Base+2, and Base+3). The first two addresses (Base and Base+1) are digital and the last two addresses (Base+2 and Base+3) are analog. Each of these logical brain boards can address up to 16 channels of I/O for a total of 32 digital and 32 analog channels. However, the rack and modules selected will determine the maximum number of I/O channels possible for each B3000 or B3000-B and rack combination.

Used with the *mistic* protocol, the brain functions as two mistic Digital Multifunction brain boards (for example, the G4D16R), and two mistic Analog Multifunction brain boards (for example, the G4A8R).

NOTE: When the obsolete B3000 is jumpered for the Optomux protocol, it functions as two B1 digital brain boards and two B2 analog brain boards.

Q: How do I use the B3000 or B3000-B?

A: The B3000 or B3000-B can be used directly with a PC, with an Opto 22 *mistic* controller running an OptoControl™ strategy, or with an Opto 22 SNAP PAC S-series controller running a PAC Control Professional strategy.

When used with a PC, the PC requires an Opto 22 PCI-AC48 serial adapter card (PCI bus), an AC37 serial adapter card (ISA bus), or an AC38 external RS-232 to RS-485 converter. Communications are handled using the *mistic* protocol drivers from the AC28 and PCI-AC48 Adapter Card Toolkit. Extremely adventurous people may consider writing their own low-level drivers for the B3000 or B3000-B; in this case, it supports the full range of *mistic* commands found in the Opto 22 *mistic* Analog and Digital Commands Manual.

Q: What are the PID capabilities of the B3000 or B3000-B?

A: The B3000 or B3000-B can perform PID (proportional integral derivative) control on analog points only, and only between analog inputs and outputs on the same logical analog address. It cannot perform cross-address PID, for example, TPO control of a digital output based on an analog input, or PID using an input on one analog I/O unit address to an output on a different I/O address. A maximum of 8 PID loops per analog address can be configured on the brain.

Q: What are the event-reaction capabilities of the B3000 or B3000-B?

A: The B3000 or B3000-B brain can perform the standard *mistic* multifunction event-reactions, but these event-reactions are restricted to operation between I/O points on the same logical address.

Q: Can the B3000 or B3000-B be used as an independent processor?

A: Yes. The brain's built-in event-reaction capability essentially makes the B3000 or B3000-B into a simple-state machine, with some expanded "time-based-state" capability provided by counters and frequency inputs, as well as analog input levels.

Serial B3000 and B3000-B Brain Troubleshooting

NOTE: For a SNAP Ethernet-based brain, see the Troubleshooting chapter in the brain's user guide, available on our website.

If you are receiving communication errors, see the following section. If you have no communication, see .

Communication Errors

1. Measure the voltage across an unused jumper pair or across one of the capacitors on each SNAP brain. The voltage should be 5.00 to 5.20 VDC. Any noise or AC ripple must stay within this range. If you're using an adjustable power supply, we recommend adjusting it so that the voltage is ~5.15 VDC at the brain.

2. Make certain the 5 VDC supply common is not connected to earth ground. Also make sure that the COM terminal on the RS-422/485 is not connected to earth ground, and that any shields attached to this terminal are also non-grounded. If a communications wire shield is grounded, it must not be terminated on any of the brains.

3. If more than one 5 VDC power supply is used, make certain that all the commons are connected together. Normally this is done through the logic ground or COM terminals on the communication lines.

4. Make sure the communications cable is daisy-chained from brain to brain; no Ts or branches are allowed under the RS-422/485 specification.

5. Make certain both ends of the communications cable are properly terminated. The last brain on the physical link must have communication jumpers 1, 4, and 7 installed. Termination switches on *mistic* controllers should be set to TERM YES.

6. Make sure that shielded twisted-pair cable is used for communications links. If the shield is to be earth-grounded, make sure it is not also connected to logic ground and that another conductor is used for logic common. If the shield is used for logic common, make sure that it is tied into all the logic ground/logic common terminals, but not earth ground.

7. Make sure the communications pairs are not crossed when using 4-wire communication. In some types of cable, one wire from each pair is the same color. This makes it very easy to get those wires mixed up. If the jacket and shield are stripped back far enough, it will become obvious which wire belongs to which pair.

8. Try running the system at a slower baud rate.

9. Try to test out the system using the OptoControl or PAC Control debugger. These utilities have error trapping ability. Often, the errors received can help determine where the issue might lie. If the debuggers work properly, the issue is likely to be caused by the control strategy, especially where serial communications to third-party devices are being used and are configured improperly.

10. Contact Opto 22 Product Support (see page 1).

No Communication

1. Make certain that the baud rates and addresses are set correctly. No two brains on the same network should have the same address, and all brains (plus the host device) must be operating at the same baud rate. If you see receive LEDs but not transmit LEDs flickering on the brains, the issue is likely an incorrect baud rate or address setting on one or more brains, a bad cable, low voltage at the brain(s), or electrical noise.

2. Check the polarity of the + and – communication lines. If you have one or more receive lights stuck on, this is likely the cause.

3. Recheck the communications wiring. You can check the communications wiring in a multidrop system simply by measuring the impedance across the + and – lines of each wire pair. If the last brain is terminated properly, you should see about 220 ohms. Make certain that in a multidrop system, only the last physical brain has termination jumpers installed.

4. Make sure that CTS handshaking is disabled on the host, or if that is not possible, jumper RTS to CTS at the host. If RTS/CTS handshaking is enabled, the host may not even transmit on the serial data link. CTS handshaking is by default disabled on *mistic* controllers.

5. If the host is not a *mistic* controller, make sure that there are no port or IRQ conflicts on the host when using the AC422AT or the AC24AT. If the host device is a PC, it is possible to verify the operation of the RS-422/485 port by jumping TX+ to RX+, and TX- to RX- (TO and FO on Opto 22 cards). A communications program such as HyperTerminal can be used to communicate with the port; in HyperTerminal, make sure that the local echo is turned off. Once started, anything typed on the key should be displayed on the screen. If it is not, there may be a hardware or configuration issue with the communication port. Also remember that Opto 22 ISA serial cards, such as the AC422AT and the AC24AT, do not use standard communication port base addresses or IRQ lines for COM3 and COM4. Make sure that the host software is using the correct base address and IRQ.

6. Contact Opto 22 Product Support (see page 1).