What Is It

Simply put, trouble-shooting is the art and science of getting something to work. If you work in electronics then, at some level, you will be involved in trouble-shooting. If you are a repair-tech, trouble-shooting is the name of the game. If you are a designer, then you will have to "debug" your designs which means trouble-shooting of another sort. Trouble-shooting can be divided into two kinds of situations: repair and development.

In repair, you know that the equipment you are trouble-shooting did, at one time, work. Then something happened that made it stop working. Maybe a component failed. Your job is to find out what went wrong and then to fix it.

In development you are working on prototypes. Either new designs or modifications of existing designs. In such a case, when it doesn't work properly there are three possibilities. First, as in repair, there may be a faulty component. Second, the breadboard or prototype wasn't built according to design. Third, there may be a fault in the design. Usually, there is a combination of all three in an early prototype.

We'll discuss some basic ideas of trouble-shooting that will apply to all situations. One principle should be stated right here: SAFETY FIRST. Don't do anything that may harm you, others, or the equipment you are working on. Remember that high voltage can cause burns, and a shock across your chest can stop your heart.

What You Will Need

Before starting to trouble-shoot, there are a few things you should have:

- A good set of tools (see our catalog).
- Appropriate test equipment (see our catalog).
- Schematics, source-code, and other documentation.
- A knowledge of what the equipment is supposed to do.
- If possible, a working unit for comparison.
- A knowledge of basic electronics theory and devices.
- A clean, well-lit place to work.

Check The Obvious

Some things that can go wrong are so obvious that sometimes people forget to look for them. Here is a partial list of things to check before you start ripping the equipment apart:

- Is it plugged in?
- Is it turned on?
- If the "ON" light is not lit, is the light burned out?
- Is the fuse blown? NOTE: If the fuse is blown, replace it once and try again. If it blows again, then there is a major problem somewhere; do not keep replacing the fuse.
- Are all the cables connected? To the right places?

Think Logically

In their frustration, novice trouble-shooters have been heard to say: "There's nothing wrong with this thing, it just refuses to work!". Equipment is inanimate. If it doesn't work, then there is something wrong with it. It's not being stubborn. So just keep cool and use some basic logic on it. It has to follow the laws of science.

One basic thing you should know about logic is the idea of Logical Induction. It says that if "A" causes "X" and "A" is true, then "X" must be true. But be careful! If "A" causes "X" and "X" is true it does not necessarily follow that "A" is true. Look at the circuit in *Figure 1*. If switch "A" is closed (true) then light bulb "X" must be on (true). But if light bulb "X" is on, it is not necessary that switch "A" is closed since switch "B" might be closed instead. In other words, use common sense but don't leap to conclusions. Click Here For ASCII Version of *Figure 1.*
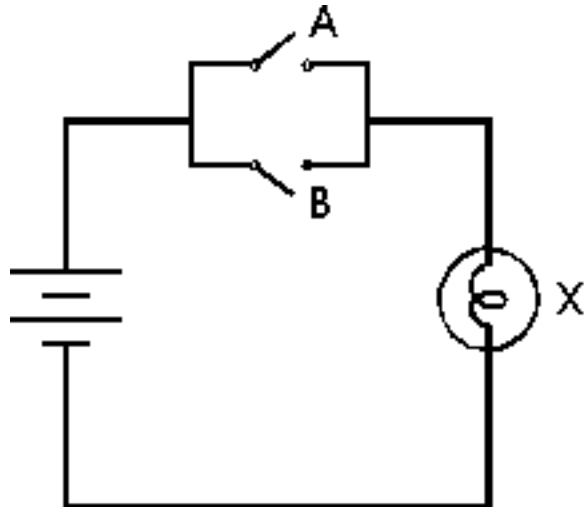
Figure 1

Here is an example of the above. In trouble-shooting, you often trace a signal from stage to stage to find out where it goes wrong. **Figure 2** shows a block diagram of a two-stage amplifier. Suppose the signal going into stage_1 is good but the signal coming out of stage_1 is bad. Does that mean that stage_1 must be defective? Not necessarily. Stage_2 could be defective in such a way that any signal on its input is shorted to ground. That will make the output of stage_1 look bad. If you disconnect the stages then the output of stage_1 might look good. But before separating stages, be careful! Does stage_1 need a certain load on its output to work? Find out first. Click Here For ASCII Version of *Figure 2.*
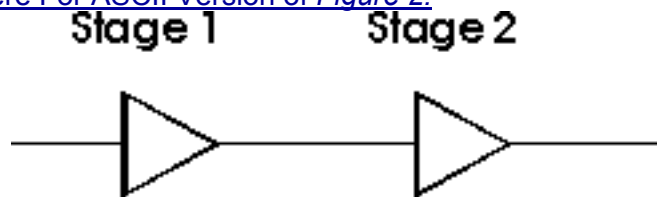

Figure 2

<u>Where to Start</u>

You check the obvious and decide that the equipment is actually broken. Where do you start? The answer is: where there is the most stress on the components. Stress kills. In electronic equipment stress takes the form of heat, vibration, moisture, corrosion, high voltages across components, and high current through components.

Places where you are likely to find high stress are:
- Power supplies.
- Power amplifiers.
- Output stages.
- Cable connectors, especially if subject to vibration or frequent coupling/uncoupling.
- Sockets.

If you are a field-service technician, then remember that to the customer in front of you with the broken equipment you are your company. You may have to "fix the customer" before you fix the equipment. People skills are important, especially if you're not going to be able to fix it that day.

Preventative Care

It is important to make sure all equipment is used properly,so that the team does not have to

deal with these problems. For example, check to make sure your connecting or plugging things into their appropriate places

What To Do Next

If you've looked at the usual suspects and they're not to blame, then the fun begins. Two useful things to do are "differential diagnosis" together with "what if". Differential diagnosis means you look at the problem and try to figure out all the things that could cause the observed symptoms. Then you try to figure out ways of telling one cause from another. For example, you see 5 Volts at a point where you should see 8 Volts. Possible causes may be:

1. problem in power supply
2. heavy load on 8 Volt bus
3. bad solder joint in 8 Volt bus

Then you go to those areas one by one looking for problems.

The what if technique is similar. You say to yourself something like: "OK, the 8 Volt bus is low. What if I disconnect the circuit from the bus and use an external 8 Volt supply? Can I damage something doing that? If that cures the symptom, then what have I learned? If it doesn't, then what have I learned?"

Time Is Money, Maybe Yours

Depending on how complicated the equipment is that you are trouble-shooting, you can divide it up into various levels as shown in *Figure 3*:
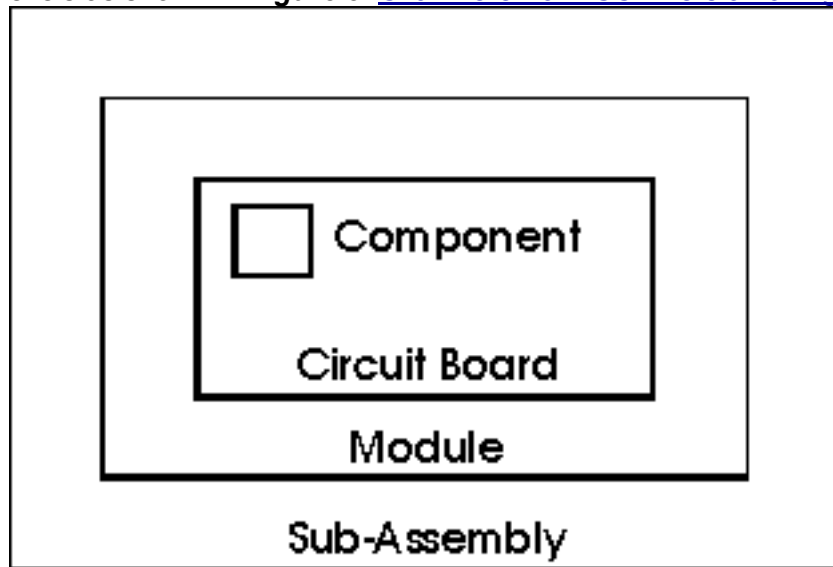

Figure 3

- sub-assembly
- module
- circuit-board
- component

How far down you go in finding the fault depends on the economics of the situation. If you are being paid $50 per hour and a module costs $20, then once you identify the faulty module it is cheaper to replace it than to repair it. On the other hand, if the module costs $500 but the circuit boards are $25, then it is cost-effective to continue trouble-shooting until you identify the bad board. But at that point it would be cheaper to replace the board than to trouble-shoot down to the bad component.

over-heating

Electrical devices are designed to run on specific voltages. If you put too much voltage through the device, the circuitry and wiring will be damaged. This is due to the fact that the electricity really is energy, and one form of energy is heat. Check to see if there are any melted wires, or if the circuits appear blackened or fused together. Make sure the voltage for the device is being properly applied.Load

Electric motors are built to to transfer a certain amount of energy to the load (e.g., a wheel). If your motor works slowly or grinds, make sure that you are not putting excessive requirements on the motor by making it transfer more energy than it is capable of transferring (put in list of motor specs). If action is not taken, the motor may become inoperable or operate in an undesired way.

Shorts

The wires and contact points in electric motors sometimes break or become weak. This causes the motor to try to operate on less than optimal voltage, which strains the parts of the motor. The result is overheating and burnout. Check to see if the wires have any bare points, or if there is corrosion on the contacts. If needed, replace the wires and clean the corrosion off with a wire brush or basic (non-acidic) solution that will reduce oxidization.

Poor Insulation

Electrical wiring in an electric motor must have proper insulation to work correctly, because poor insulation causes shorts and heat transfer. Look for any insulated parts that seem to have cracked, incomplete or otherwise compromised insulation, and replace the parts or the insulation.

Dirt

Dirt, dust and other contaminants can build up on the circuits, wiring and parts of the electrical motor. This can cause the connections between the motor and the electrical source to function inefficiently. They also can block heat vents and fans that are meant to cool the motor. Check to see that the motor isn't dirty, and if it is, disconnect the power source from the motor and clean it out

Buttoning Up

In summary, to be an effective electronics trouble-shooter you need to know how the circuits works, you need documentation, you need the right tools, and you need to be able to think logically. It also helps to have self-confidence, which will only increase with experience. So roll up your sleeves, turn on your test-equipment, get the schematic and a cup of coffee, and make that thing work!

And that's today's technical tip.

General Tips

-Remember, the electronics are inanimate, if it does not work the way you intended, there is something wrong

-Try not to get frustrated, You **can** solve your problems. If you are having problems, take a

break and come back to it later.
-

Make sure that the wires somewhat resemble the schematic or diagram you have. Usually this will be the least complicated layout for your wires and connectors and will make it easier for you to check wires.

General Checklist:
1. Charged battery
2. Looseness of wires
3. Clear of unnecessary dust, debris, etc.

Jaguars

General Jaguar Precautions:
- Mount the Jaguar module so that the vents in the top and sides of the unit are not restricted in any way. Maintain a clearance of at least ½ inch between modules.
- Reverse wiring is unprotected; doing so voids the Jaguar module's warranty.
- Do not exceed the absolute maximum supply voltage (30 V_{DC} for MDL-BDC24, 13 V for MDL-BDC). Doing so causes permanent damage to the module.
- Protect Jaguar from all situations where debris could enter through ventilation slots or connector openings.

The LED status is as follows (not all conditions recreated here..)
Fast flashing yellow means you're NOT getting a valid signal on the wire. If you've got this, check your code or your wiring.

Solid yellow means you're getting a valid signal on the wire and that it is in the neutral range, and should produce 0 V on the output.

Fast flashing green means that you are going forward, and should produce between 0 V and 12 V.
Solid green means that you're at full forward, and should produce 12 V on the output.

Fast flashing red means that you are going reverse, and should produce between 0 V and -12 V.
Solid red means that you're at full reverse, and should produce -12 V on the output.

Output voltage measured across M+ and M- (white terminal to green).

Also, check your limit switch jumpers are both installed (up and down orientation.. see web site for documents).

Your report says that it goes to green light.. this could be characteristic of an untrimmed USB controller (joystick). Are you using the KoP joysticks? They self trim at start up so be careful not to be touching them during the power on sequence.

If you unplug your PWM cable, you should see a flashing yellow light.

Do you have anything mounted in parallel with the Jaguar? I.e. are you splitting the PWM wire and then putting one branch to a Jaguar and another to a Victor or something like that?
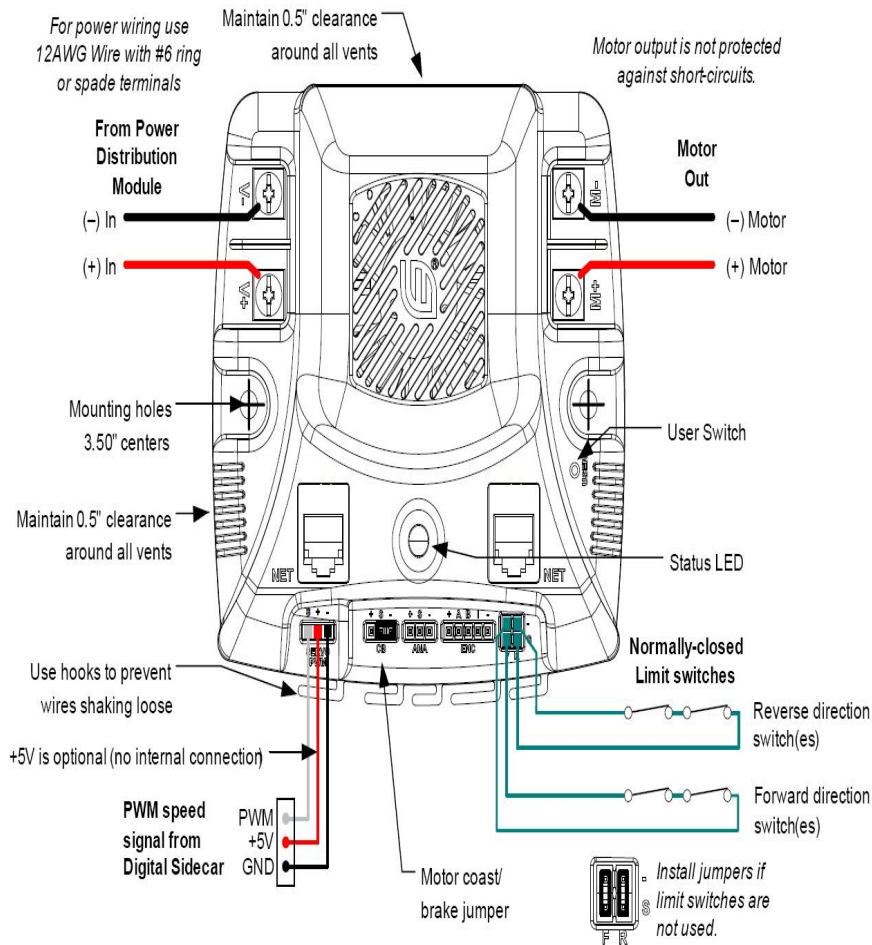
Assembly:
http://www.usfirst.org/uploadedFiles/Community/FRC/Game_and_Season__Info/2010_Assets/2010%20Electronics%20Board%20Assembly-2.pdf

control set-up:
http://www.usfirst.org/uploadedFiles/Community/FRC/Game_and_Season__Info/2010_Assets/Control%20System%20Setup.pdf
for more help: http://wtcs.ca/wiki/index.php/FRC_Controller_Research_Database
http://www.ehow.com/how-does_5008347_troubleshooting-overheated-electrical-motor.html

http://wtcs.ca/wiki/index.php/FRC_Controller_Research_Database
http://www.usfirst.org/uploadedFiles/Community/FRC/Game_and_Season__Info/2010_Assets/
2010%20Electronics%20Board%20Assembly-2.pdf

Sensors:

gyroscope- howstuffworks.com/gyroscope.htm
accelerometer
all at the website-http://en.wikipedia.org/wiki/Accelerometer
touch
potentiometer
encoder- rotary encoder converts motion of a shaft or axle to a digital code. the sensors
determine the angle of position, either mechanical or optical.
camera
ultrasonic- emits frequencies above human sensitivity. the unit then senses for the
reflected waves. the waves will shift slightly if there's movement. covers wide areas, no
blind spots with high sensitivity to movement and range up to 40 ft.
photogate: Basically it was an IR light and a sensor, so when the line of sight was
broken, it would send a signal. I know cRIOs weren't around back then, but it just used a
digital input, same as on the cRIOs.

Temperature sensor (thermocouple), I bet there's a team out there at some point who put this
on a robot.
used them to tell us when to give the robot a break to prevent overheating. Really useful, and I
think all our future robots are going to be sporting one per motor.

The 2010 *FIRST* Robotics Competition (FRC) sensors are outlined in this document. It is being
provided as a courtesy, and therefore does not supersede any information or rules provided in
the 2010 *FIRST* Robotics Competition Manual.

Additional information on programming for these sensors may be found in the WPILib User's
Guide which is available through the 2010 FRC Control System Webpage http://www.usfirst.org/
roboticsprograms/frc/content.aspx?id=10934

Analog Devices ADXL345 and ADW22307 Sensor Board

The sensor board in the 2010 FRC Kit of Parts hosts both an Analog Devices ADXL345 3-axis
Digital Accelerometer and an Analog Devices ADW22307 1-axis Analog Gyroscope.

Teams may choose to use the board as is or to separate it along the scored line. Keeping the sensors connected may be helpful in cases where you want to use one to back up the other. For example, the gyroscope is very good at finding rate of angular change, but poor at finding absolute angle. The accelerometer can determine absolute angle when the robot is stable, but is easily confused when the robot moves.

To separate the two sensors, gently and slowly flex the board. Do not attempt to "snap" it, as you may damage the surface mounted components. Gradually increase the applied force until you hear the faint ripping noise of the fibers splitting. It will suddenly "give", at which point you may bend it fully in half. Rub the newly separated edges together over a garbage can to remove any left over debris. Remember to follow proper ESD safety procedure any time you are handling the devices.

The dimensions of the printed circuit board are shown below. Units are mils (thousandths of an inch).

Digital Accelerometer

(Analog Devices PN ADXL345)

The 3-Axis Accelerometer measures both dynamic acceleration (vibration) and static acceleration (gravity). Accelerometers are sensitive to rough handling. Please remember to handle with care.

The module is designed to permit standoff mounting using 4-40 hardware. Note that plastic fasteners should always be used to isolate the PCB from chassis contact.

This sensor can communicate with the FRC system digitally with either of two protocols: I2C or SPI. The SPI port is found on J4 and was setup to be easily wired to the Digital I/O on the Digital Sidecar. Although the pins can be connected to any GPIOs in any order, it is easiest to use Digital I/O 1-4. Connect 0V and 5V to the (-) and PWR pins that are just beyond Digital I/O 1, and [CK, DI, DO, CS] in order.

The I2C port is found on J2 and was designed to be easily wired to the pins on the Digital Sidecar found directly behind the NXT connector. Connect 5V to 5V, SCL to SCL, SDA to SDA, and (-) to 0V. By default, the I2C address is 0x3A. The address can be set to 0xA6 by shorting J1 with a blob of solder.

Two optional interrupt pins, I1 and I2, are found at the end of the SPI connector but can be used with either I2C or SPI. These pins can be set to alert if the ADXL345 detects a tap (bump) or a

fall, or they may be used for some of the advanced flow control functions. Connect one or both of them to any of the Digital I/O on the Digital Sidecar to use these functions.

Please see the code examples included with your software to get started with the ADXL345 once it is wired in. detailed operation of the Analog Devices ADXL345 accelerometer, refer to the Analog Devices website which can be found at http://www.analog.com/.

Note: The ADXL345 starts in a power saving mode. You must turn it on by writing 0x08 to POWER_CTL (0x2D) before it will do anything interesting.

Yaw Rate Gyro

(Analog Devices PN ADW22307)

The angular rate sensor (gyroscope) senses angular changes about the top surface axis of the device and provides an output voltage proportional to the angular rate change. The output is useful for guidance, stability, and control of the robot platform. The lowest apparent drift on the gyro will occur when the module is mounted flat in or near the center axis of the robots rotation.

The module is designed to permit standoff mounting using 4-40 hardware. Note that plastic fasteners should always be used to isolate the PCB from chassis contact.

The ADW22307 can measure up to 250°/s of rotation. Nominal output is 2.5V at standstill, plus 7mV/°/s. The carrier board adds a double pole low-pass filter set to 400Hz: Teams are encouraged to experiment with digital filters in order to select a bandwidth appropriate for their specific usage.

The ADW22307 has an integrated temperature sensor to assist in temperature compensation. Nominal output is 2.5V at 25°C plus 9mV/°C.

Pin-out is as follows, in same orientation as photo above:

Rate	Temperature
+5V	+5V
Ground	Ground

Please refer to the datasheet, which may be found on the 2010 *FIRST* Robotics Competition Manual and Related Documents Page at http://www.usfirst.org/roboticsprograms/frc/content.aspx?id=452, for tolerances and other specifications.

austriamicrosystems Magnetic Encoder

(austriamicrosystems PN AS5030)

The AS5030 is a contactless magnetic rotary encoder that can be used to measure absolute angle (8 bits over 360 degrees), angular rate (up to 30,000 RPM), and magnetic field strength (6 bits) by looking at the field created by a 2-pole magnet rotating over the center of the chip. Two boards and two magnets are included in the 2010 Kit of Parts. It can be used in applications that typically used potentiometers or quadrature encoders. It has less resolution than the provided encoders from US Digital, but is rated for a higher maximum speed and does not require mechanical coupling between the sensor and the shaft being measured.

The module is designed to permit standoff mounting using appropriate hardware. Note that plastic fasteners should always be used to isolate the PCB from chassis contact.

There are 4 supported communication methods for this device, listed below in order of increasing complexity. Each has benefits and drawbacks and must be selected based on the application.
1)   Filtered PWM: Connect the Ana pin (JP2.3) to an input pin on the Analog Breakout. The voltage is proportional to the angle. NOTE: There is a 4.8 Hz filter on this output, so it is only useable for very low bandwidth (slowly moving) angular position measurements and is not appropriate in angular rate applications. This output can be sampled at 10Hz.
2)   PWM: Connect the PWM pin (JP2.5) to a Digital I/O pin on the Digital Sidecar. The pulse length is proportional to the angle. This option is best suited for angular position measurement, but has a much higher bandwidth that Option 1 and therefore can be used for some moderate angular rate measurements. This option has lower resolution (~6-bit) due to the sampling rate of the digital input. This output can be sampled at 1.7 kHz.
3)   Analog Sine-Cosine: Clear P1 of solder. JP3 now presents the raw analog sine and cosine voltage. Connect the SIN and COS signals to the Analog Breakout. You must also power the sensor with 5V from the analog breakout. This option is the only one that can support high-speed angular rate applications (up to 30,000 RPM). It is also the best option for tracking position across multiple rotations.
4)   4 Wire SPI Mode: Enabled by default on JP1. Same as Option 5, but the DI pin (JP1.6) is used for commands and the DIO pin (JP1.5) is used for data output. This allows for operation with the Digital Sidecar because all lines are uni-directional. This mode is best suited for angular position measurement with multiple sensors sharing a bus. The data also indicates

magnet proximity. Because this is a digital data interface it can deliver the position with no encoding error, unlike Options 1 and 2. This output can be sampled at 3.5 kHz. NOTE: Commands sent using the DI pin are inverted.

5)   3 Wire SPI Mode: Enabled by default on JP1. See Datasheet for details on operation. This option is not available when using the Digital Sidecar because it does not support a bi-directional DIO line.

6)   2 Wire SPI Mode: Enabled on JP1 by clearing P2 of solder. See Datasheet for details of operation. This option is not available when using the Digital Sidecar because it does not support a bi-directional DIO line.

The MAG pin (JP2.6) can be used to determine if the magnet is too far from the sensor. If out of range, the MAG pin will be high. If the magnet is detected, MAG will be low.

Magnet placement requirements, along with other details on this unit, are included in the user manual, which may be found on the 2010 *FIRST* Robotics Competition Manual and Related Documents Page at http://www.usfirst.org/roboticsprograms/frc/content.aspx?id=452. Teams are encouraged to review this information.

US Digital Encoder

(US Digital PN E4P-360-250-S4149)

The US Digital E4Ps are incremental encoders outputting a 2-channel quadrature signal. They are capable of measuring shaft position, speed and direction, and fit on a 0.25" shaft. The encoders provided are 360 Codes per Revolution (CPR). With 4X quadrature decoding, you get 1,440 positions per revolution, which gives you a unique position every 0.25 degrees. The maximum RPM for these encoders is 10,000 RPM.

Much more detail on these encoders is available on US Digital's FIRST webpage, www.usdigital.com/first