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Dear Friends of Slot Tech Magazine,

Tilt! There is a plethora of errors that might occur in a slot machine. You could have a printer error. The touch screen might not be communicating with the game’s CPU. You might have some sort of voltage “issue” or even a memory problem (the machine, not your own sell). In general, conditions such as these are referred to as “tilts.” Some are “soft tilts” that allow the game to continue operating. Others are “hard tilts” that stop the machine dead in its tracks.

Fortunately for us, the machine can and often will diagnose these conditions and give us a heads-up on the nature of the problem. This month, veteran slot tech Vic Fortenbach gives us the rundown on some IGT tilts and what they mean. Vic’s contribution begins on page four.

By the way, the term “tilt” (for those of you who may be unaware) comes from the invention by Harry Williams (the founder of Williams pinball. You know it as WMS now) of the “plumb bob” mechanism in 1932. The idea was to stop people from moving the machine in order to influence the movement of the steel ball on the playfield. The TILT mechanism solved this problem. The plumb bob tilt has a metal rod with a cone-shaped, lead weight on it. Surrounding the weight is a metal bracket with a hole in it. The unit acts as a simple switch contact. If the tilt bob makes contact with the collar, the machine shuts down.

As the story goes, it was a pinball player who coined the phrase, exclaiming that the machine had gone dark because he had “tilted” it and the name stuck, now to mean “error condition” when applied to a modern slot machine that could, arguably, operate on its side.
You’re on the casino floor having just finished a repair when you spot a candle light flashing on top of a machine nearby. Immediately, you start to think “does that flashing light indicate a simple problem, like the printer paper being out or could it be something more serious?”

As you get closer to the machine, you can see in the center of the video screen is a box graphic with text. Reading the text you know this problem is not just a simple paper out message; it’s more in-depth. It’s the dreaded “board monitor tilt error” message. As slot machines get more and more advanced, so do the error messages. The board monitor tilt is just one of these advanced error messages or “tilts” as they are sometimes called. This type of tilt is called a hard tilt, since the game is it’s not playable. Hard tilts indicate something is wrong and needs to be corrected or things could get worse.

Temporarily relief from a board monitor tilt is available; the remedy is listed in the error message text box on the screen. Just open and close the main door. However, opening and closing the main door will simply clear the screen and allow game play. It’s only a temporary fix (since the error is still there) it’s just not on the screen.

The board monitor tilt is all about the internal system monitoring of the slot machine and has nothing to do with the LCD monitor itself. This board monitor tilt message will display on all IGT AVP slot machines with a brain box. The tilt is better explained with additional text on the screen once you open the main door or key the machine over. On an IGT G23 cabinet there are six voltages, three temperatures, one fan that has the RPM monitored and three batteries that also have monitored preset settings. If any one of these preset settings goes too high or too low, it will trigger a board monitor tilt.

The six voltages that are monitored have names: NBVCC is the voltage for the Northbridge chip on the motherboard. This chip’s...
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function includes the communication between the RAM, video and the CPU chip on the machine motherboard inside the brain box. This NBVCC out of range voltage is not a common tilt. Repairs to correct this tilt include replacement of the RAM on the motherboard or the motherboard itself. The VCORE1 voltage is another of the monitored voltages. This voltage is used for the CPU chip. If this voltage is out of range (mainly too high over a long period of time) the CPU chip will self-destruct.

The standard +5, +12 and +3.3 voltages are also monitored and used on the motherboard. These voltages are created on the switching power supply board located on top or side of the brain box. The size of this board is about five inches square and is easy to spot with you open the main door. There are three surface mounted capacitors located on this board that tend to dry out over time requiring replacement. Since these capacitors dry out, the voltage output from this board cannot be regulated properly thus causing reboots and/or board monitor tilts. Another remedy to correcting voltage board monitor tilts is simply reseating the 24 pin white connector originating from the power supply board and connecting on the outside of the brain box. You should also reseat the opposite end of this connector and harness that is located inside the brain box on the motherboard.

IGT issued a customer notification number regarding this connector harness. Its number is CN4790B. You can look up this CN on the IGT website, www.igt.com. You may need to set up an account for access to this and other IGT information. This CN dealt with a voltage fluctuation issue that occurred on this multi-pin harness on IGT machines with a brain box. This CN was issued in 2011 so it may not be applicable to newer machines.

The VBAT is the battery of the CMOS chip that stores the setup information used by the machine to boot up the game. This CMOS chip configuration is used on all personal computers as well as IGT slot machine motherboards. The CMOS chip holds the setup information used to boot up the motherboard. Some of these settings include the hard drive and memory size of the machine. This CMOS chip requires a battery to keep its memory when the machine is turned off. A low or dead CMOS battery will cause the chip to lose its memory and the slot machine to not boot up. The CMOS battery is a small, flat, coin-sized battery in a battery holder on the motherboard, part number CR2032. This is a common battery, with a nominal voltage of about 3.10 volts. If this battery voltage goes too low (about 2.99 volts) the machine would trigger a board monitor tilt. This tilt is rare and only seen when the machine has been powered down for an extended time. Normally, slot machines are powered up 24 hours a day so this battery is never really used (but it still needs to be installed) and should last
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more than five years. Once you replace this battery, you do not need to reset any of the motherboard options or complete a RAM clear since are all of the needed information is preset or defaulted and self-loading.

Three temperatures are also monitored on the motherboard: CPU, GPU and the Northbridge chips. When the CPU temperature exceeds its average preset level it usually means dirt has accumulated on the small fan as well as the heat sink. Cleaning the heat sink of dirt and replacing the fan will allow cool air to circulate to bring the CPU chip back to the normal temperature range. It’s a good idea to replace the heat sink paste that is between the CPU chip and the heat sink. This paste tends to dry out limiting the heat transfer to properly cool the CPU chip. The GPU and Northbridge chips do not have fans to cool them, but they do have heat sinks attached to them. Cleaning and replacing the heat sink paste should bring down a board monitor tilt cause by heat on these two chips.

There are three additional batteries that are monitored and located within the slot machine cabinet: The Telltale, NVRAM1 and NVRAM2 batteries do not have monitored voltages but rather a normal or too low of an output range. The telltale battery is actually three rechargeable batteries in a shrink wrap packaging. These batteries are easily replaced by just cutting the tie wrap that holds them to the backplane. A small connector connects the battery pack to the backplane board.

The NVRAM1 and NVRAM2 batteries are located on the interface board that is plugged into the motherboard. The interface board connects to the ribbon cable that comes from the backplane board. The NVRAM1 battery is farthest from the ribbon cable and the NVRAM2 battery is the closest. When you replace one or both of these batteries, you will have to do a machine RAM clear.

The last remaining monitored tilt that is on the IGT AVP machines is the CPU fan speed. This fan is located on the heat sink attached to the CPU chip inside the brain box. This fan is a 5 volt fan with a third wire which is connected to a tachometer contained within the fan assembly. This tachometer reports back to the motherboard how fast the fan is turning. If this fan starts to turn too slow (usually caused by dirt in the fan bearings) the CPU will get too hot, which is not a good thing. Once the fan fails to turn fast enough, a board monitor tilt is generated. Cleaning the fan bearings might buy you some time, but since you have the brain box open, you might as well as replace it.

Another type of tilt or error message that tends to pop up on the IGT AVP machines is an error or tilt which I referred to as the red screen of death or non-recoverable tilt.
This tilt is caused by quick fluctuations by any of the power voltages, batteries or fans previously mentioned. These quick fluctuations will fill up the slot machines safe storage memory area. The safe storage memory size is only 8K, once the safe storage is full, the system will generate the red screen. Keying over the machine will clear the safe storage, but you will have to re-option the machine since the “no game enabled” message will be displayed. If the voltage or fan continues to fluctuate, the red screen will appear again, causing more headaches. To actually look at what the system is reporting for the voltage, temperatures, batteries and fan speed settings, enter the self-test screen of the machine, touch support and then diagnostic and finally the system monitor icon. These four screens list all of the voltages, fan speed, temps and batteries listed in this article. The averages and the triggers for the board monitor tilt do vary between IGT AVP cabinets so a preset voltage on a G23 cabinet may not be the same for a Trimline cabinet with a 2.5 brain box.

Thanks to Shawn E from the IGT forums for detailing some of the board monitor tilt text used in this article.

- Vic Fortenbach
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December 2015
Chicago is one of my most favorite cities in the world. As many Slot Tech Magazine readers are aware, before I joined the casino industry, I was a "pinball mechanic" and the global hub of pinball manufacturers was Chicago, Illinois. Bally made pinball machines. WMS (then known as “Williams,” the company formed by Harry Williams, inventor of the plumb-bob “tilt” mechanism found in pinball machines) made pinball machines. There were others as well, all located in Chicago where we held our yearly trade show at the venerable Conrad Hilton Hotel.

Flash forward to 2015 when I was pleased to return to Chicago for training at the Rivers Casino (located near O’Hare airport) for a week of technical training for their slot techs. This was my “standard” tech class where we cover component-level repair of power supplies and LCD monitors. A couple of weeks later, I made my way out to Oklahoma for another week of training at the Indigo Sky casino in Wyandotte, Oklahoma, located right on the border with Missouri. Both casinos were super nice with around 1200 machines in each.

We have a lot of “hands-on” training during the four-day class. One of our hands-on labs is a semiconductor testing lab.

One of our labs is a construction lab. Here is “Oat” building his “Decision Maker” project. In the foreground you see the “Two-Tone Siren” which he had already completed.
opto- pref.
From the Greek "optos" meaning eye; vision: optometry, opto-electronics

LED
A light emitting diode is just what the name implies, a diode that emits light. To some degree, all semiconductor diodes emit light when they are forward biased. A silicon diode emits a small amount of infrared light any time it is conducting. When electrons and holes combine in the area of the junction, energy is released in the spectrum we perceive as heat; it is infrared radiation. How much is released and the frequency (color) of the radiation is dependent on the chemistry of the semiconductor.

Silicon is not the only element used in an LED. Various "dopants" are used as well. These dopants are small amounts of additional elements that are added to the silicon during the manufacturing process. Gallium and arsenic are used to make "gallium-arsenide" LEDs. Other materials include indium, aluminum phosphides and nitrides. With each one, we get a different color and intensity of light. With recent developments in LED technology, we can cover the whole range from infrared to ultraviolet. A white LED is actually a blue LED with a phosphor coating. When the blue radiation hits the phosphor, it makes the phosphor glow white.

Phototransistor
All diodes and transistors react to light to some degree. When electromagnetic radiation hits the junction region, it causes minority current carriers in the diode, making the diode conduct slightly. To make a phototransistor more sensitive to light, all we had to do was redesign the physical makeup so light can get to a photo diode between the base and collector of a transistor. The light hits the diode and starts the diode con-
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ducting, which, in turn, energizes the transistor.

Optocouplers, Optoisolators, Photocouples (Call Them What You Will)

If we put an LED and a phototransistor in the same package, we have a device that can transfer a signal from one circuit to another with no electrical connection between the two circuits. The input current makes the LED shine. The light turns on the transistor and we have an output signal. The light makes the connection between the two circuits.

The input side may be a simple LED for a “DC Input” as shown in the illustration (right) or two LEDs connected in opposite directions for operating as an “AC Input” (below).

The output device may be a simple phototransistor for a “DC Output” or a photosensitive Darlington, SCR, triac, FET, or even an elaborate circuit like a Schmitt Trigger or a logic compatible output.

Most of them have fairly low output current levels, but some are made to drive a light load directly (up to about 100 mA).

Usually the LED and the phototransistor sit on one surface and a reflective dome over the two bounces the light from the LED over to the phototransistor.

Optointerruptors

If we rearrange the LED and phototransistor opposite one another with a gap between them, we can detect the presence of an object passing between the LED and the phototransistor. These are in popular use in various assemblies also.

Looking at some real world devices

DC to DC

Starting with the simpler devices, these are the most popular. These are used to couple a DC level circuit to another DC level circuit. In the gaming industry we find these in I/O circuits. As an input circuit, the optoisolator prevents electrostatic zaps from the player panels from surging over to the MPU’s sensitive circuits. An electrostatic zap from the player panel may cause a surge in the LED side of the optoisolator but will not carry through to the phototransistor so we protect our inputs.

As an output device, the game sees only the very predictable load of the LED. The phototransistor side can connect to noisy, unregulated, higher voltage lines. Noise in
the output circuit cannot feed back through the optoisolator, so the MPU is protected.

We also find them in switching regulators. We monitor the output voltage level with the LED side (on the secondary side of the transformer) and feed it back to the regulating side on the primary. The transformer has isolated the two circuits and we have to keep these two circuits separate or things will catch fire. The optocoupler couples the signals, keeping the ground references unique.

On the input, we have the same characteristics we would find on an LED. We can expect to find a 1.2 to 1.6 Volt level when forward biased. A digital multimeter should find what looks like a diode.

On the output side, we should find what looks like the emitter-collector circuit of a transistor. If we hook a digital multimeter across it, there should be a very high resistance when the LED is not on. As we turn the LED on, we should see a lowering of the resistance between the emitter and collector. Current should flow into the emitter Lead and out the collector lead.

What makes one device different from another?

One important characteristic is a thing called "current transfer ratio" or CTR. As the name suggests, this is the ratio of input current (through the LED) to output current (through the phototransistor). Typically this is a value around 10% to 100% on simpler devices.

Maximum output voltage is another consideration. What is the maximum voltage the

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output transistor can withstand when the transistor is off?

Maximum output current is another consideration. What is the maximum current we can pass through the output transistor?

Maximum output voltage at saturation is something to consider. When the transistor is fully turned on (known as "saturation") what is the maximum voltage we will have between emitter and collector? What current are we talking about? These considerations are essentially the same we would ask in specifying a transistor.

DC to Darlington

If we add a second transistor (in Darlington configuration) to the output transistor, we make the device more sensitive to light. Our CTR can easily exceed 100%.

DC to AC
(The Solid State Relay)

Yes, we can make a photosensitive triac and have the ability to control an AC load (on an isolated line) from a DC driving source. These may be low output current devices, designed to drive a high current triac or we can incorporate the high current triac in the same case and call it a Solid State Relay (SSR).

AC to DC

If we use two LEDs on the input side of our optoisolator, we can monitor an AC signal. As the positive half of the AC cycle comes through, one of the LEDs is turned on. As the negative side of the signal comes through, the other LED turns on. From a 60 Hz AC line, we get 120 Hz pulses out the output.

DC to Logic

Other devices are simply designed for data communication. We see these on RS-232 and other serial ports. We may use them for both the input and output side of our circuits. If we are driving a long line (hundreds of feet) there is a possibility of picking up noise in our line. More than just screwing up our communications, this noise on the line may be of a high enough voltage and current that it can cause damage to the I/O circuits themselves. Opto devices to the rescue! The DC to DC devices work okay at low speeds, but LEDs tend to turn off slowly and speed is limited to a few thousand (or even hundred) Baud. High-speed devices have been designed with diodes that turn off quicker and outputs that are Schmitt Trigger to give a clean square wave, or even logic level compatible outputs.

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Tuesday, May 24, 2016
9:00 am - 12:00pm
Electronic Components and Component Testing
Presented by Randy Fromm

Electronics repair is actually pretty easy, once you know how to test the components. It often doesn’t matter if you know anything at all about how something actually works in order to fix it. You just look for bad parts and replace them. This seminar covers all of the discrete components commonly found in electronic gaming machines. We'll look at how they work, how they fail, and how to test them as accurately, inexpensively and safely as possible. Each attendee receives a digital multimeter and sample components, theirs to keep following TechFest.

1:15pm - 3:15pm
JCM Bill Validators

JCM is a huge player in the gaming industry. This session covers UBA troubleshooting and configuration as well as IIVIZION. This presentation will be given by JCM’s Dan Petersen.

3:30pm - 5:30pm
FutureLogic Troubleshooting

FutureLogic printers have been a mainstay of the industry since TITO was born. They are easy to configure and to troubleshoot. This seminar will be presented by Dan Petersen.

Wednesday, May 25, 2016
9:00 am - 12:00pm
LCD Monitor Repair
Presented by Randy Fromm

LCD monitor repair is easy. This is the first of two presentations on LCD monitor repair at TechFest. During this seminar, we will cover the theory of operation of LCD monitors and you’ll see just how simple they really are. We will also cover circuit analysis of the electronics with an emphasis on what fails and how it can be repaired in any casino’s tech shop.

1:15pm - 3:15pm
Touchscreens
Presented by 3M Touch Systems

Touchscreens rule the casino world. This presentation will introduce you to touch technologies and how they work. Troubleshooting and repair techniques will be presented. Everyone will receive diagnostic programs as well.

3:30pm - 8:00pm
Component Removal and Replacement
Presented by HAKKO

Soldering skills are the most important skills a technician can possess. It doesn't do any good to be able to diagnose a failed component if you can't remove it and replace it properly and it's no good trying to work on modern, surface-mount components without the proper equipment. This exciting new seminar will present the latest in soldering techniques and rework equipment. A special “Hands-On After Hours” session will allow extended time for everyone to try out the gear themselves.

Thursday, May 26, 2016
9:00 am - 12:00pm
Ceronix LCD Monitor Repair
Presented by Ceronix

Although it can be argued that all LCD monitors are more-or-less the same, it's nice to get the inside track on specific monitors from the manufacturers themselves.

This is a “hands-on” session where everyone will have the opportunity to tear-down and rebuild an LCD panel as well as troubleshooting actual failures on LCD monitors in a "power-on" lab where you will actually make repairs. This is the most fun thing we do at TechFest.

1:15pm - 3:15pm
Transact Technologies Ticket Printers

Transact Technologies presents servicing and troubleshooting Transact brand, thermal ticket printers. These units are simple to understand and troubleshoot, once you know how they’re put together. We have covered these printers extensively in Slot Tech Magazine. This is your chance to ask questions of the expert.

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December 2015
Slot Tech Magazine
Slot Tech Magazine is strictly technical. As such, the magazine's contents are not time critical. The repair information and technical data contained in past issues is just as valid today as it was the day it was published.

Additionally, current and future articles more-or-less assume that readers are already familiar with what has been covered in past issues. This editorial policy assures that Slot Tech Magazine's contributing writers are not limited to "writing down" to the level of a novice technician but are free to continue to produce the most comprehensive technical articles in the gaming industry.

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“I can help you bring down the cost of casino electronics repairs”
Randy Fromm

Buying Replacement Units!

Is your casino totally self-sufficient in repairing monitors, power supplies, bill validators and ticket printers or are you throwing away hundreds or thousands of dollars purchasing replacement units? While it is not exactly a “hidden” cost to your department, some slot managers simply accept the price of replacements as the “cost of doing business” while it progressively nibbles away at the casino’s bottom line. IT DOESN’T HAVE TO BE THIS WAY.

“OK. You asked and I listened. My new tech class eliminates obsolete CRT monitor repair and the associated monitor repair lab. In just four or five days, your slot techs can learn to repair Power Supplies, LCD Monitors, Ticket Printers, Bill Validators and more. It’s easy and it’s fun.”- Randy Fromm

In truth, most electronic repairs are pretty easy. Often, it’s just a matter of testing and replacing a small handful of inexpensive, off-the-shelf electronic components. Sometimes, it’s just one. For example, it costs less than 25 cents in parts to repair the most common failure in Bally power supplies. The entire process takes about five minutes.

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About Randy Fromm: I am the publisher of Slot Tech Magazine. First published in 2001, Slot Tech Magazine is a monthly trade journal focusing on casino slot machine repair. I have been repairing electronics for the gaming industry since 1972. I really enjoy what I do and I love showing others how easy it can be. No previous knowledge of electronics is required.

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