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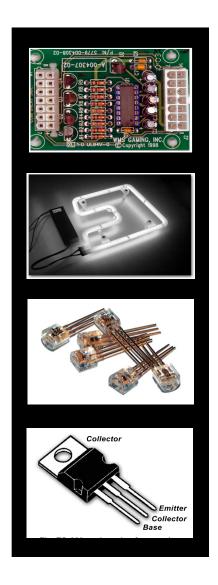
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TechFest 10 is Coming! Las Vegas, Nevada November 18-18 2009 Slot Tech Magazine is an Official Publication of







### **Slot Tech Editorial**

ummertime, and the living is easy. I actually had the entire month of August off (well, no travel or tech schools, at least). There's a lot going on in the industry but most of it is behind-thescenes as the industry prepares for the Global Gaming Expo in October. I can hint at some interesting new ticket printers but the details will have to wait until next month. You'll also have to wait until October for the next installment of John Wilson's "The Big, The Bad And The Bonus"

Randy Fromm's

Slot Tech Magazine

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as John is taking a break this month after contending with some serious flooding in his hometown of Peterborough, Ontario. That's in Canada. for those who are a little short in the geography department. Canada is the really big, mostly cold and/or wet place between the USA and the North Pole. John's okay (thanks for asking) but he reports that he has spent a great deal of time assisting his neighbors and others in the community and, as such, was unable to meet the deadline for this issue. Kevin Noble is on summer hiatus as well, which brings us to (trumpets blast) . . .

Herschel Peeler and his latest test fixture, a really simple unit for testing Williams' Bill Acceptor Interface Board. Herschel is an electronics purist who just hates to throw anything away if it can be tested and repaired quickly and inexpensively. His little test fixtures allow him (and now you) to do just that. The illustrated guide begins on page four. Also from Herschel is another Slot Tech Magazine look at optoelectronics, beginning on page 12.

I wouldn't normally use this editorial page to call attention to an advertisement but you should take a look at the 3M Touch Systems advertisement on page three. It's less of an ad and more of an invitation to attend the G2E show for free as their guest. All slot techs are invited to stop by the 3M Touch Systems (MicroTouch) booth and join the 3M Engineers who will be



providing technical demonstrations on:

- Replacing MicroTouchTM Touch Screens
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There is a limited number of free show passes available. At TechFest, 3M Touch is famous for their giveaway items. At G2E, they continue the tradition with the promise of a technical giveaway for all participants. Hmmmm. I wonder what they have for us this time. Now where did I put that pair of electronic dice I got at from them at TechFest 7 in Atlantic City? Anyway, you can meet them at the 3M Booth, #4569.

There's more inside as well. Enjoy the rest of your summer.

See you at the casino

Randy Fromm - Publisher



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### **Slot Tech Feature Article**

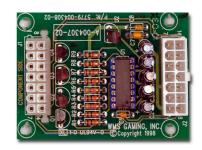


ow can such a little board cause such problems? This board is an interface between the game (in older Williams 360, 550, 40S era games) and the WBA bill acceptor. It isn't that there is anything tricky about the board. There just isn't room to troubleshoot the board while it is in the game. It is much easier to swap the

### Williams Bill Acceptor Interface Board A-004307-02, 5779-004308-02 By Herschel Peeler

board out and test, troubleshoot and repair the board at the bench. The board is not very expensive, but repairs are even cheaper. The board only has two ICs, four transistors and a few capacitors and resistors. All of the parts are easy to obtain and are not proprietary. The board converts the Open Collector signals coming from the Bill Acceptor to the RS-232 level signals going to the game.

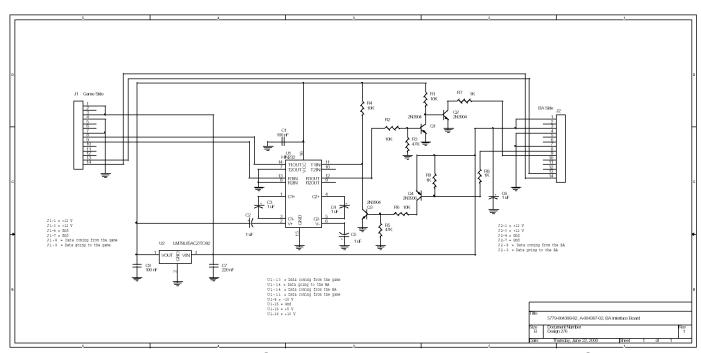
The board is powered from the +12 Volt line coming from the game. This same +12 Volts is passed on through the board to power the Bill Acceptor. This +12 Volts is dropped down to +5 Volts by U2, an LM78L05ACZ and this



+5 Volts powers U1, an HIN232CP / MAX232CP / ICL232CP (all plug-in replacements).

The HIN232CP has a built in oscillator that generates +V and -V for the RS-232 Interface. It also takes TTL signals (+5V and ground) and converts them to +V and -V for the RS-232 signals. This is a two-channel device. Only one channel is used.

Q1 and Q2 take the TTL sig-



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nal "R1 Out" from the HIN232CP and convert it to an Open Collector driver going to the Bill Acceptor. Q3 and Q4 take the Open Collector info coming from the Bill Acceptor and convert it to TTL going into the HIN232CP. The HIN232CP takes the TTL signals and converts them to RS-232 the Williams game expects.

The two connectors on the board are pin-to-pin on pins 1, 3, 4, 7, 13 and 14. Pins 1 and 3 are +12 Volts. Pins 4 and 7 are ground.

### **Troubleshooting in the Game**

Pins 1 and 3 on both connectors should be +12 Volts, with pins 4 and 7 being the ground. Pin 13 on each connector should be the same voltage. Pin 14 on each connector should be the same voltage. Pins 8 and 9 are the signals and the voltage here will depend on what the BA is doing.

U2 should have +12 Volts on pin 3 and +5 Volts on pin 1.

Pin 2 should be ground.

U1 should have +5 Volts on pin 16 (this comes from U2). Pin 15 should be ground. Pin 2 should be about +9 Volts and pin 6 should be about -9 Volts. These are voltages generated by the HIN232CP so if they are bad, the HIN232CP is likely to be bad. The other voltages around U1 are not predictable in the game. We need a test fixture to apply predictable signals to these other lines of U1 so we can check them.

### **Test Fixture**

Many games have a board with a similar function to the A-004307-02. With this in mind we made the design of the test fixture general in nature and envisioned sets of cables to go with different boards.

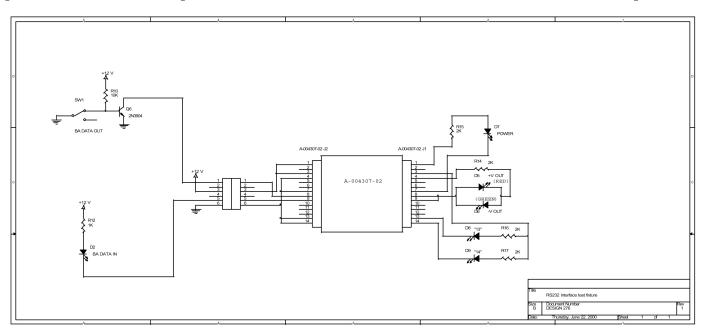
We need to take switch inputs (open collector) and feed them to the TTL side of the board. We will monitor the RS-232 side with LEDs. Use

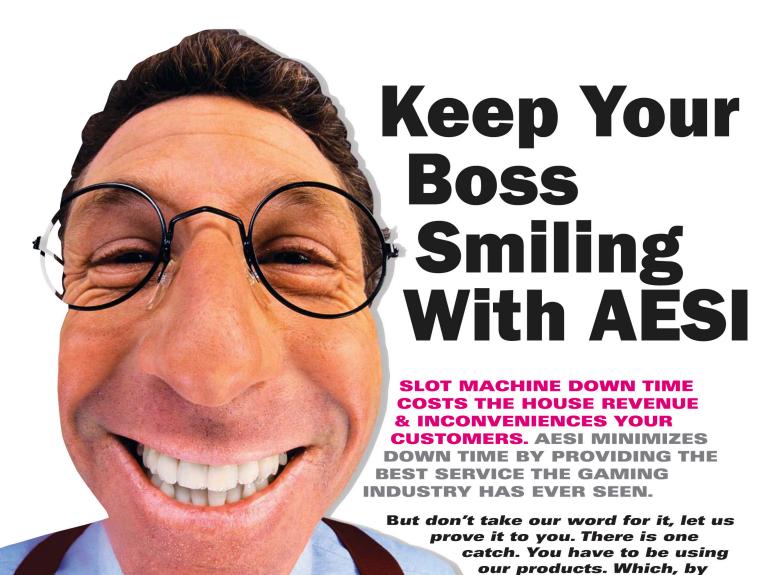
these same RS-232 signals to feed back into the board being tested as the returning RS-232 signals. Coming back out of the board, we should get our signals converted back to TTL signals and finally back to the Open Collector signals.

We could drive our signals directly with switches but we want to emulate the same drive capability as we would have from the game. A switch that can pull amps of current to ground might hide a problem on the board.

If we power our test fixture from a power supply with a current monitor on it, we can check for excessive current drain on the power line from a shorted capacitor or IC, so we will use a bench power supply.

Total cost if we had to go out and buy all the parts would probably around five dollars, not counting the case. In keeping with our general desires, we have designed the test fixture around parts we





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already have in stock for board repair. If you forego the box, the only added expense is a couple of dollars for the board to build it on (Radio Shack 276-168 with lots of room to spare).

### **Using the Test Fixture**

- 1.Set the power supply to 12 Volts. set Current Limit to 100 mA. Turn the power supply off.
- 2. Connect the test fixture to the board to be tested.
- 3. Turn the test fixture switch off (High out to the board).
- 4. Connect the test fixture to the power supply.
- 5. Turn the power supply on. All the red LEDs should light. 6. Turn the test fixture switch on (Low out to the board). The green LED should be on. The red LED on the BA side should be off.

If all this works, the board is good.

### **How the Test Fixture Works**

We have one switch that represents the data coming from the Bill Acceptor Transmit Data Line. When this switch is on, we apply a high (open) to the Interface board. When the switch is off, we apply a low to the Interface board. The Interface board converts this high and low to an RS-232 signal of +7 Volts and -7 Volts that would go to the game's RS-232 port.

In the test fixture, we have turned this RS-232 output back around and sent it into the RS-232 input side (like a loopback connector). We have two LEDs monitoring this RS-232 line. The red LED should light when the RS-232 output is high (+7 V). The green LED should light if the RS-232 output is Low (-7 V).

The board takes this "turned around RS-232 signal" and converts it to a TTL level. Circuitry on the board converts it to the Open Collector signal for which the BA is designed. An LED on the BA side indicates that the signal from the switch went both ways through the BA Interface board and it came out good.

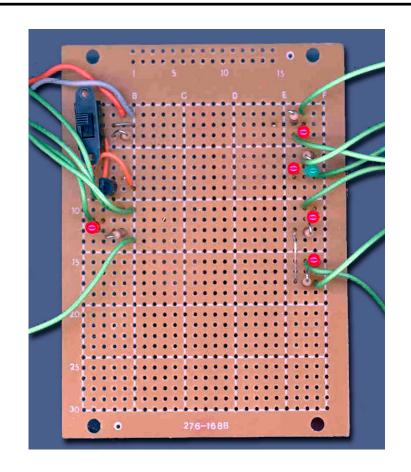
### Troubleshooting the board on the bench

The first six checks, and the very last, should always be the same. The others, starting from the signal coming from the switch and working through the board you should find these voltages.

### Herschel Peeler hpeeler@slot-techs.com

Visit the Herschel Peeler Collection at the Slot Tech Magazine FTP server.

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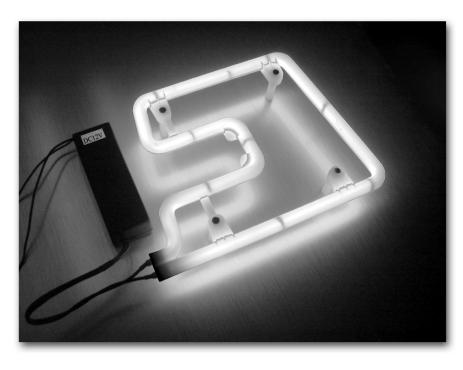
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### **Slot Tech Feature Article**



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 di-

# pt Devices

By Herschel Peeler

ode 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 "gal-

lium-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-

### **LED Range of Colors**

aluminium gallium arsenide (AlGaAs) - red and infrared gallium arsenide/phosphide (GaAsP) - red, orange and yellow

gallium nitride (GaN) - green gallium phosphide (GaP) - green zinc selenide (ZnSe) - blue indium gallium nitride (InGaN) - blue silicon carbide (SiC) - blue diamond (C) - ultraviolet

LEDs emit a wide range of colors. The secret is in the "dopants" that change the wavelength of the emitted light.



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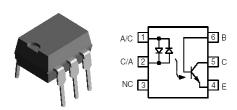
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ducting, which, in turn, energizes the transistor.

### Optocouplers, Optoisolators, Photocouplers (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.

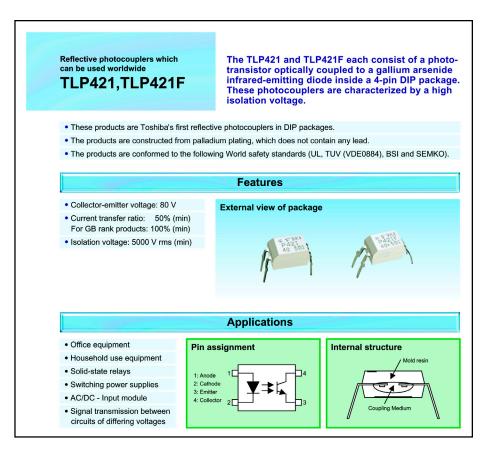
The input side may be a simple LED for a "DC Input" as shown in the illustration (right) or two LEDs connected in opposite directions for operating as an "AC Input" (below).



The output device may be a simple phototransistor for a "DC Output" or a photosensistive 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

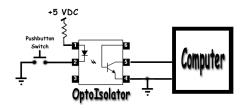
phototransistor. These are in popular use in various assemblies also.

### 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 optoisolator but will not carry through to the phototransistor so we protect our inputs.

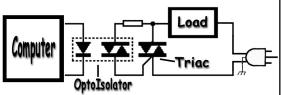


As an output device, the game sees only the very predictable load of the LED. The phototransistor side can connect to noisy, unregulated, higher voltage lines. Noise in

Slot Tech Magazine

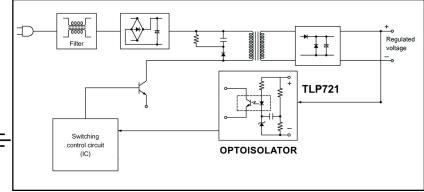
September 2004

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



We find optoisolators 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.

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



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?

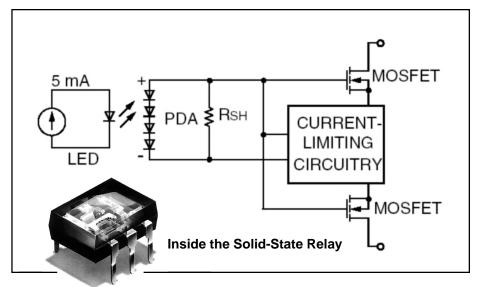
Maximum output voltage at saturation is something to consider. When the transistor is fully turned on (known as "saturation") what is the maximum voltage we will have between emitter and collector? What current are we talking about? These considerations are essentially the same we would ask in specifying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

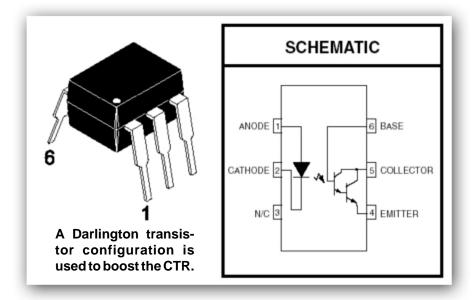
### AC to DC

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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What's the best way for a gaming professional like you to keep moving ahead despite mounting competition, a challenging economy, and constant change in the industry? Come back to Las Vegas for this year's **Global Gaming Expo (G2E)**. G2E is a sure thing for anyone looking for a competitive advantage. And in gaming, who isn't? Join us for a dynamic show floor and conference. Also new this year are F&B at G2E a culinary marketplace, and the Design & Décor Pavilion. Plus exciting keynotes and special events and networking opportunities galore.

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## High Speed Diodes

By Randy Fromm

Dear Randy,

I am a graduate of your school (about eight years ago). I have been coming across more and more of the "fast-switching" diodes in monitors as well as general repair. I have been trying to order the same part number when possible but this creates a lot of downtime waiting for the part to come in. I would like to stock several different types of these diodes that I would be able to substitute for a large portion of the ones I come across, similar to regular diodes where I find that 1N4007 and 1N5404 cover most applications. Can vou recommend a few that I can stock to substitute for the "fast-switching" applications? Any help would be appreciated.

Mark

That's a good question. Although not a super common failure, it's nice to know about these speedy little guys. Here's the deal:

Most of us are familiar with the common, general-purpose replacement diodes Mark mentioned. The 1N4000 series is probably the most commonly used diode in the world. These 1-amp diodes range in voltage rating from 50 to 1000 PRV. Since you can always replace a diode with one of a higher voltage rating, it makes sense to stock the 1N4007 since it is the highest rated one available. The cost of the 1N4007 (1000 PRV) is not significantly higher than the 1N4001, which is just 50 PRV.

Likewise, the 1N5404 Mark mentioned is a 3 amp, 400-

volt diode, and also a good choice as a general replacement diode. It's suitable as a replacement diode for just about any input bridge rectifier for just about any monitor. Many monitors use 2 amp diodes in this application but a diode of a higher current rating can always be used as a replacement. The 1N5404's 400 volt rating is plenty high enough for the 120 VAC power used in the USA or the 240 VAC used in most of the rest of the world. Four discrete 1N5404 diodes also can be connected together to form a bridge rectifier if that configuration is required.

With just these two diodes, you can replace just about anything you come across, just by following the twin rules of using a replacement diode of the same or higher voltage,

NTE # Crosses for:

NTE552 - 1N4937 FF1004

NTE558 - BA159

NTE572 - FR607 TF604 TF606 TF607

NTE575 - HER108 UF4005

NTE576 - HER204 HER205 UF5404

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the same or higher current, or both.

However, there is another important consideration when selecting a replacement diode: Speed. The generalpurpose rectifiers mentioned above are really designed to work at 60hz. They may be used for a myriad of other functions such as clamping, damping and steering but their raison d'etre is rectification; turning alternating current into direct current. As such, they are low frequency (read S-L-O-W) devices. They cannot rapidly switch from forward conduction to reverse blocking. Attempts to use these devices in high-speed circuits often results in inefficient circuit operation, component overheating and, ultimately, destruction of the component itself as well as other circuit components.

### Where Do We Need High-Speed Diodes?

There are a couple of places where we have to use special, high-speed (also known as "fast-recovery" or "fastswitching") diodes. One is in power supplies. Old-fashioned linear power supplies are now few and far between. Switching power supplies are the name of the game in modern electronics. Switching regulator power supplies operate at anywhere from 25 kHz to 100 kHz (or higher) and as such, require highspeed output diodes in their secondary circuits (the primary side of a switching regu-Slot Tech Magazine

### Features:

- Low Cost
- Low Leakage
- Low Forward Voltage Drop
- High Current Capability
- Supplied in DO41 Package

### NTE552 Silicon Rectifier General Purpose, Fast Recovery

# Maximum Ratings and Electrical Characteristics:(Ratings at 26°C ambient temperature unless otherwise noted. Single phase, half wave, 60Hz, resistive or inductive load. For capacitive load, derate current by 20%)Maximum Recurrent Peak Reverse Voltage600VMaximum RMS Voltage420VMaximum DC Blocking Voltage600VMaximum Average Forward Rectified Current (.375" (9.5mm) Lead Length at $T_A = +75^{\circ}C$ )1APeak Forward Surge Current (8.3ms Single Half Sine—Wave Superimposed on Rated Load).50AMaximum Instantaneous Forward Voltage at 1A DC1.2VMaximum DC Reverse Current at Rated DC Blocking Voltage ( $T_A = +25^{\circ}C$ )5.0μAMaximum Full Load Reverse Current

### NTE558 General Purpose Silicon Rectifier

### Description:

The NTE558 is a general purpose silicon rectifier in a DO41 type case designed for low high voltage fast recovery applications.

### Maximum Ratings:

Peak Repetitive Reverse Voltage, V <sub>RRM</sub>	
DC Blocking Voltage, V <sub>R</sub>	
RMS Reverse Voltage, V <sub>R(RMS)</sub>	
Average Rectified Forward Current. I <sub>O</sub>	
(Single Phase, Resistive Load, 60Hz, T <sub>A</sub> = +75°C)	
Peak Forward Surge Current, I <sub>ESM</sub>	
(8.3ms Single Half Sine–Wave Superimposed on Rated Load) 50A	

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lator power supply operates off the 50/60 Hz power line and uses conventional diodes). Of course, modern monitors also use switching power supplies and a monitor's SMPS also requires the use of high-speed diodes in the secondary outputs.

The other place that highspeed diodes are used in the monitor is in the horizontal output circuit. In a standard resolution television, this circuit operates at approximately 15, 750 Hz. As the monitor's resolution increases, so does the horizontal deflection circuit's operating frequency. VGA resolution (640X480) is 31.5 kHz. Moving up to 800 X 600 resolution (where most video slots are) we see a horizontal frequency of 35 kHz or higher! We need high-speed diodes here. Not only in the primary side of the horizontal circuit but as output rectifiers for any flyback derived power supplies as well.

In order to satisfy Mark's request, I did some research. I looked at the schematics for some commonly-used monitors and cross-referenced the high-speed diodes to their commonly available NTE replacements. It didn't surprise me that the resulting list was rather short, regardless of the fact that there were dozens of different parts with part numbers like FR607, HER205, RG4C, RGP15J, EGP20C and the like.

Figure 1 shows a list of these commonly available replace-

### <u>Features:</u>

- Fast Switching
- Low Leakage
- Low Forward Voltage Drop
- High Current Capability
- High Current Surge
- High Reliability

### **NTE572** Silicon Rectifier

### General Purpose, Fast Recovery

Peak Forward Surge Current (8.3ms single half sine—wave superimposed on rated load) 300A Maximum Instantaneous Forward Voltage ( $I_F$ = 6A DC) 1.3V Maximum DC Reverse Current (At Rated DC Blocking Voltage, $T_A$ = +25°C) 10 $\mu$ A Maximum Full Load Reverse Current (Full Cycle Average .375" (9.5mm) lead length, $T_L$ = +55°C) 150 $\mu$ A	
Maximum Reverse Recovery Time (Note 1)	
Typical Junction Capacitance (Note 2)	

### Features:

- Low Switching Noise
- Low Forward Voltage Drop
- Low Thermal Resistance
- High Current Capability
- High Switching Capability
- High Surge Capability
- High Reliability

### **NTE575 General Purpose Silicon Rectifier Fast Recovery**

### Maximum Ratings and Electrical Characteristics:

(T<sub>A</sub> = +25°C unless otherwise specified. Single Phase, half wave, 60Hz, resistive or inductive load. For capacitive load, derate current by 20%) 

Maximum RMS Voltage, V<sub>RMS</sub> ..... Maximum DC Blocking Voltage, V<sub>DC</sub> ..... 

Maximum DC Reverse Current (V<sub>DC</sub> = 1000V), I<sub>R</sub> ...... 

ment diodes and their specifications.

Of course, there are times when the original diode cannot be cross-referenced directly to an NTE component. In that case, you may be able to Google the part number and look at a datasheet for the OEM component. You're looking for the voltage rating (Vceo) and the current rating (Ic) as well as the speed of the component. As long as you're "equal to or better than" these specifications, your substitution is likely to function properly.

You can also sort of cheat and look at the function of the component instead of the part number. Compare the schematic of monitor you're working on with another one from a different manufacturer. Try to use similar monitors in terms of resolution and CRT size. If, for example, you have a shorted diode in the diode modulator circuit, look for the same diode in the same circuit in a different monitor and cross-reference it's part number. Functionfor-function, they're likely to be equivalent, regardless of part number differences.

Please note that regardless of careful cross-referencing, some replacements may not function properly. This is not uncommon in manufacturing where two components, one from each of two manufacturers, will have identical specifications but one will function properly and the other will not. It sounds preposterous but it's a fact of life in electronics. Something to do with the precise amount of magic smoke in each component, I suspect.

If you're looking to stock-up on high-speed diodes, laying in a stock of a half-dozen each of these diodes will go a long way toward providing suitable replacement diodes for most of your high-speed requirements. Of course, if you can get the OEM components, you should always do so if for no other reason than that they are very likely to be much less expensive. Generally speaking, NTE components will be significantly more expensive as they are intended to be replacement parts and as such, are not purchased in bulk. You're paying for the convenience of the quick cross-reference and the ability to purchase in single units or small quantities.

For more information about NTE replacement components, visit the website at www.nteinc.com.

### - Slot Tech Magazine

### Features:

- Low Forward Voltage Drop
- High Current Capability
- High Reliability
- High Surge Current Capability

### **NTE576**

### 5.0 Ampere Super Fast Rectifier

Maximum Ratings and Electrical Characteristics: (T<sub>A</sub> = +25°C unless otherwise specified. Resistive or inductive load 60Hz. For capacitive load, derate current by 20%.)

Resistive of inductive load 60Hz. For capacitive load, defate current by 20%.)	
Recurrent Peak Reverse Voltage, V <sub>RRM</sub>	)V
RMS Voltage, V <sub>RMS</sub>	V
DC Blocking Voltage, V <sub>DC</sub>	V
Average Forward Output Rectified Current,	
[.375 (9.5mm) lead length at T <sub>A</sub> = 55°C]	۱V)
Peak Forward Surge Current,	
(8.3ms single half sine–wave superimposed on rated load )	γK)
Instantaneous Forward Voltage Drop at 5.0A	γK)
Full Load Reverse Current at Rated DC Blocking Voltage	
$T_A = +25^{\circ}C$	ιA
$T_A = +100$ °C	
Maximum Reverse Recovery Time (Note 1)	ns
Typical Junction Capacitance (Note 2)	ρF

### NTE577 Silicon Diode General Purpose, Fast Recovery Switch

Electrical Characteristics:	
Maximum Peak Reverse Voltage, P <sub>RV</sub>	1000V
Maximum Average Rectified Current ( $T_A = +50^{\circ}$ , half–wave, resistive load 60Hz), $I_O \dots$	5A
Maximum Forward Peak Surge Current (8.3ms superimposed), I <sub>FSM</sub>	. 200A
Maximum Reverse Current (T <sub>A</sub> = +25°C, P <sub>RV</sub> = 1000V), I <sub>R</sub>	. 10μΑ
Maximum Forward Voltage (T <sub>A</sub> = +25°C, I <sub>F</sub> = 5A), V <sub>FM</sub>	. 1.7V
Maximum Reverse Recovery Time, t <sub>rr</sub>	. 70ns

### NTE580 General Purpose Silicon Rectifier Fast Recovery

### Features:

- High Temperature Metallurgically Bonded–No Compression Contacts
- Fast Switching for High Effeciency
- 3A Operation at T<sub>A</sub> = +25°C with No Thermal Runaway

Maximum Ratings and Electrical Characteristics:

 $(T_A=+25^{\circ}\text{C}$  unless otherwise specified. Single phase, half wave, 60Hz, resistive or inductive load. For capacitive load, derate current by 20%)

Maximum Recurrent Peak Reverse Voltage	600V
Maximum RMS Voltage	420V
Maximum DC Blocking Voltage	600V
Maximum Average Forward Rectified Current (.375" (9.5mm) Lead Length, T <sub>A</sub> = +7	′5°C) 3A
Peak Forward Surge Current (8.3ms Single Half Sine-Wave Superimposed on Rte	d Load) . 100A
Maximum Instantaneous Forward Voltage (I <sub>F</sub> = 3A)	1.3V
Maximum DC Reverse Current (V <sub>DC</sub> = 600V, T <sub>A</sub> = +25°C)	5μΑ
Maximum Average Reverse Current (P <sub>RV</sub> = 600V)	
$T_A = +25^{\circ}C$	
$T_A = +100$ °C	100μΑ
Maximum Reverse Recovery Time (Note 1)	150ns
Typical Junction Capacitance (Note 2)	65pF

### NTE588 Silicon Diode 200V, 3A, Ultra Fast Switch

### Features:

- High Reliability
- Low Leakage
- Low Forward Voltage
- High Current Capbility

- Super Fast Switching Speed < 35nS</li>
- High Surge Capability
- High Surge Capability
- Good for 200kHz Power Supplier

Maximum Ratings and Electrical Characteristics: $(T_A = +25^{\circ}\text{C} \text{ unless otherwise specified.}$ Single phase, half wave, 60Hz, resistive or inductive load. For capacitive load, derate current by 20%.)Maximum Recurrent Peak Reverse Voltage150VMaximum RMS Voltage105VMaximum DC Blocking Voltage150VMaximum Average Forward Current (.375" (9.5mm) lead length at  $T_A = +55^{\circ}\text{C}$ )3APeak Forward Surge Current,  $I_{FMS}$ urge<br/>8.3ms single half sine—wave superimposed on rated load125AMaximum Forward Voltage at 3.0A DC0.95VMaximum DC Reverse Current at Rated DC Blocking Voltage5μAMaximum DC Reverse Current at Rated DC Blocking Voltage,  $T_A = 150^{\circ}\text{C}$ 50μAMaximum Reverse Recovery Time (Note 1)35nsTypical Junction Capacitance (Note 2)155pF

# Atronic Systems' 'Progressive' Products at Global Gaming Expo

t this year's G2E Show, Atronic Systems' main focus will be on innovative new "progressive" and mystery jackpot schemes as well as player bonus functionality. Based on the success of its wide-area progressive jackpot module, Atronic Systems will introduce a Wide Area Mystery Jackpot system at this year's G2E. Atronic Magic WAP links run very successfully in the states of Arizona, California, Michigan, New Mexico and Wisconsin and have recently even connected within several states to create the top-award winning America Magic Jackpot.

Contrary to a progressive jackpot that is triggered by the top winning combination of the machine, the mystery jackpot is triggered by coinin only which means that players can win the jackpot regardless of whether or not they have got a winning combination on their slot machine. Taking the mystery jackpot philosophy one step further, mystery jackpots are now also available on wide area links, thus ensuring bigger or more frequent prizes and pay-outs.

In addition, Atronic Systems will introduce several new features to its successful range of jackpot modules at this year's G2E show, such as:

- \* Jackpot Scheduler This feature allows defining time periods during which a jackpot is active. This means that casino operators can define a jackpot running for example, only two hours a day, during low gaming periods or during happy hours.
- \* Hit Delimiter Casino operators can pre-define a maximum number of hits after which the jackpot is automatically suspended. This is a handy feature to give away a pre-defined quantity of prizes (e.g. show tickets, holidays, cars, etc.).
- \* Minimum Bet Mystery Jackpot Atronic Systems is now introducing a mystery jackpot that will only be triggered if players play a minimum defined bet thus enticing players to play more in order to participate in the mystery jackpot.

In addition to its jackpot module, Atronic Systems will



introduce several new features to its state-of-the-art CHIP CASH (smart card cashless) system, such as multisite and multi-currency operation.

Dynamic solutions from Atronic Systems combine sophisticated proven software modules with the industry's most acclaimed hardware platforms, Crystal Web(R) for slot operations and Golden Eye(R) for table games. Together with the GALAXIS(TM) range of software modules, Atronic Systems offers an allcompassing management package for casino operators, including slot machine and table games management, player tracking and loyalty programmes, integrated jackpot management, cashless, cage and credit management as well as a real-time analysis and reporting tool — all these modules for either single-site or multi-site operations!

Through its holding company, Atronic International, Atronic Systems is a member of the family-owned and operated Gauselmann Group, which

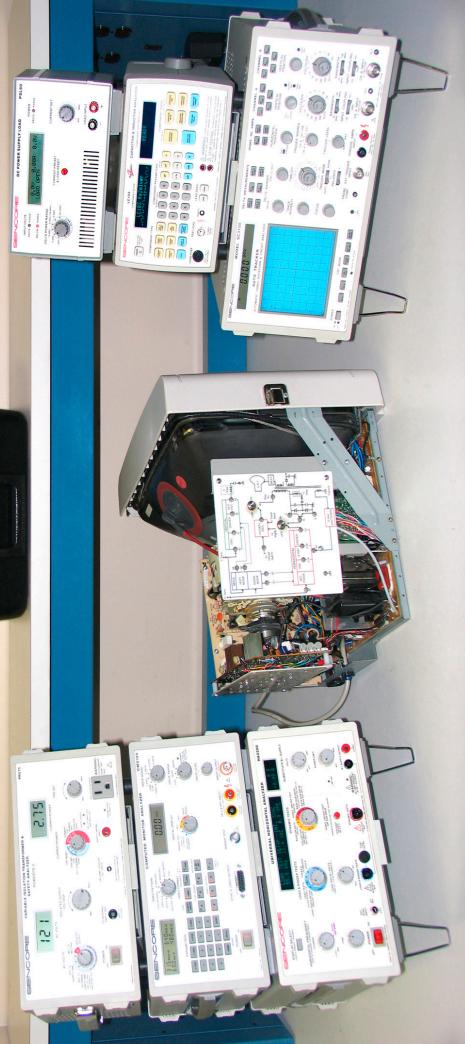
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has sold more than 1.9 million machines since inception, and is the second largest manufacturer of gaming devices worldwide.

Atronic Systems has offices in Graz, Austria, Monaco and Scottsdale, USA and sales offices in Lima, Peru and Buenos Aires, Argentina.

Atronic Systems (formerly MIS Group) was created out of a merger between MIS (Monaco Informatiques Systemes), a Monegasque gaming software company, founded in 1991, and GRIPS, an Austrian company founded in 1985 and famous for their Crystal Web(R) hardware and network solutions. Atronic Systems develops, sells, installs and maintains integrated casino management systems for both slot and table game operations on a worldwide basis. Atronic Systems has a dedicated and professional team of 200 employees worldwide, a portfolio of hundreds of customers in more than 50 countries across five continents and is a recognized leader of cashless gaming solutions.

For more information, visit the company's website at www.atronicsystems.com.

CONTACT:

Daniela Schmied 43 316 7255-151 dschmied@atronicsystems.com Katie Stage +1-480-609-5867 kstage@atronic.com

### **Slot Tech Upcoming Event**

### **Monitor Repair and More!**

Slot Tech Magazine Announces Two-Week Technician School

As many of you are aware, Slot Tech Magazine offers a two-week technician training course called (for lack of a better term) the Casino School. It's kind of a "Super TechFest" where we have time to cover everything from basic electronics and troubleshooting to component-level monitor repair. Throw in a good mix of detailed training on coin acceptors, bill validators, ticket printers and touchscreens and you sort of get the idea. Add the "handson" training that is impossible at a three-day TechFest and you have a program can really boost the skills of a beginning to intermediate level slot tech.

Normally, a casino that wants this type of training will reserve a class exclusively for their own technicians. We bring the training right to the casino. The class size is small for the two-week class. In fact, it's limited to just 16 people. But even that number of folks can be tough for a single casino to spare for two full weeks.

In order to make this training available to more slot techs, Chip In's Island Resort in Harris, Michigan has offered to sponsor the program and allow technicians from other casinos to join them for the two-week class.

So, the program is set and we're on for Slot Tech Magazine's Casino School. To reserve your place in the class at Chip In's Island Resort and Casino in Harris, Michigan (September 13-24) please go to the website at slot-tech.com, download and return the enrollment form along with your tuition of \$1295.00.

As the class size is exceedingly small, reservations for the class are strictly on a "first-come, first-served" basis. When we receive your tuition, you're in. Purchase orders are welcome and will be invoiced but placement is not guaranteed until tuition is in hand.

For more information and an enrollment form, please visit the website at slot-tech.com or give us a call at Slot Tech Magazine, 619.593.6131.

See you at the Casino School!

Randy Fromm

# Ukraine will see Unicum Adventures in September



he Ukrainian premier of the latest of Unicum's developments, Unicum Adventures video slot will take place at the Kiev Entertainment Industry trade show on September 15-17.

Unicum Adventures slot was introduced to the public during the EELEX 2003 show in Moscow in December 2003, when the project was passing the final beta-

testing stage. The machine development was based on the operators' and players' preferences thoroughly studied by the company specialists. That is why the slot is fully adapted to the CIS market necessities. Adventure's advanced functions make it compatible with machines of a higher class. This new platform supports rich-graphics and 3D effects: the flat touchscreen makes gaming process exciting and extremely comfortable for a player. The operation menu was designed to provide reports in various formats. The user-friendly interface allows the operator to trace both the slot machine and the individual game's performance.

"Adventures' launch has a great importance for the development of Unicum's activities in the Ukrainian market," said Gennady Soga, head of the Unicum's Kiev office. "Unicum has always been known to the Ukrainian operator as a provider of high-quality and reliable slot machines from the world leading suppli-

ers. Adventures is not inferior to its foreign competitors in quality, but produced in Russia, the production and shipping costs are lowered. It is definitely reflected in the price of Adventures and makes the slot a very promising platform in CIS and Ukrainian markets in particular."

Unicum Adventures machines will be available in Ukraine in two versions: One is a multi-game package with five games: Bonus Golden Devil. Poker. Golden Devil-25 line. Golden Magic, One-Eyed Joe. The other one, a singlegame slot, comes out in September and will premier at the Entertainment Industry show. The amusing unusual story and soundtrack are not the only advantages of the game. Unicum's development team worked hard on detailed graphics, doubling, multi-denomination and other features which will be available for inspection at the Unicum stand (# A48) at the Kiev expo.

### **Bally Taps Colwell as Director**

Bally Gaming and Systems has announced that it has named Christopher Colwell as Director of National Accounts and Participation Sales.

In his new position, Colwell will oversee the relationships and account activity of the major Bally national casino accounts at the corporate level. He will also be responsible for the development of partnerships and agreements on product deployments with these casino operators. Additionally, Colwell will provide focused sales leadership on participation-style slot products.

"This is truly an exciting time to be joining the Bally Gaming sales team," Colwell said. "The product pipeline is full and our products on the casino floor are performing well. My focus will be on ensuring the major casino companies in the country understand the value the Bally product has and that its placement will lead to a more profitable casino floor. The next several years will be extremely fast paced as Bally enters into a new growth phase with the integration of SDG and development of new platforms. Needless to say, I have joined a company whose outlook is very bright indeed."

Colwell comes to Bally Gaming and Systems after having worked in various executive management capacities with Harrah's Entertainment, Inc. Most recently, Colwell was Director of Gaming Operations for the Harrah's Casino in North Kansas City, Mo. Previously, Colwell had served as that property's Director and Assistant Director of Slots.

Prior to joining the Harrah's organization, Colwell was a Lieutenant Commander in the United States Navy, serving as the Executive Assistant to the Auditor General of the Navy. As a Certified Nuclear Engineer, Colwell also served as the Reactor Propulsion Officer aboard the aircraft carrier U.S.S. Dwight D. Eisenhower. In addition, Colwell also served as an Ordnance and Gunnery Officer



aboard the naval warship, U.S.S. Antietam.

Additional information on Bally Gaming and Systems can be found at www.BallyGaming.com.

### The first Russian regional operators conference will take place in Yekaterinburg on September 30

he success of the first con-L ference held in Moscow in April determined Unicum Group of Companies to organize a new event with emphasis on operating. The participants showed a great interest in further discussion of urgent issues. The dynamic growth of the Russian regional gaming market forces local operators pay bigger attention to the quality and number of offered services and effectiveness of business strategies. Unicum specialists plan to discuss modern

methods and operation techniques with operators from Ural, Siberia and Far East regions. Other discussion topics will include human resources, management and administration. The conference will be held in discussion format where participants will exchange their experience and ask questions. After the event, all guests are invited to a presentation of Unicum video slots and a party devoted to Unicum's new office in Yekaterinburg.

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"On behalf of Table Mountain Casino I just wanted to express our thanks to you and your team. I couldn't have asked for anything better."

**Brian Rankin - Slot Technical Manager** 

# **On-Site Slot Tech Training Customized Classes Available**

Randy Fromm's Casino School is a practical, no-nonsense look at how gaming machines work and how to repair them when they don't. No previous knowledge of electronics is required to get the most out of the school. The Casino School is geared for those who want to learn how to fix gaming devices without having to learn complex electronic theory or purchase expensive test equipment.

Be prepared for six hours of accelerated learning each day. Class begins at 9:00 am sharp each day and continues until 4:00 pm. The Casino School provides each student with reference materials and troubleshooting guides that will be valuable aids for repairing equipment on location and in the shop.

### Students learn how to work with:



### THE DIGITAL MULTIMETER

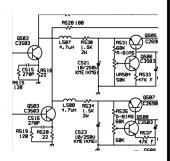
This relatively inexpensive piece of test equipment is easy to operate. Casino School students learn to use the digital multimeter to perform tests and measurements that will pinpoint the cause of a failure down to a single component.

### **ELECTRONIC COMPONENTS**

The individual components used in games are introduced. Parts such as resistors, capacitors, diodes, potentiometers and transistors are covered individually. Students learn how the components work and how to test them using the meter.

### **SCHEMATIC DIAGRAMS**

Schematic diagrams are the "blueprints" for electronics. Learning to read schematics is easy once you know how the parts work!



### **POWER SUPPLIES**

Power supply failure is a common complaint in many different types of systems. Power supply failures are discussed during the class, along with shortcuts for troubleshoot-

ing and repairing them.



### MONITOR REPAIR

The monitors used in video slots are designed for quick, easy, and safe repair. Students will

learn the theory of operation of all types of monitors and how to repair monitors down to the component level. Of course, monitor safety will also be discussed.

You do not have to send your slot techs to Las Vegas or Atlantic City for training. The Casino School brings the training to you. Contact Randy Fromm's Casino School today to reserve a date for your tech school

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### **Slot Tech Product Introduction**

### **Better Connected**

hich would you say are the most common repairs in your casino? I've never done any statistical analysis but in addition the common problems with buttons, bill validators, coin mechanisms and, if you still use 'em, hoppers (the things that move or allow for the insertion of foreign matter) I would put "bad connections" on my list of "Things That Fail."

Bad connections happen so frequently (in all types of electronic systems, not just slots) that I often remove and reseat connectors without bothering to determine what the connector actually "connects" and whether or not it could actually have anything to do with the problem I am working on. The same holds true for reseating some of the socketed integrated circuits such as the EPROMs. The way I figure it, even if it's not bad, I may be preventing a future failure by assuring that the contacts are good and clean.

As most experienced techs know, this technique is often successful in reviving an otherwise dead or malfunctioning PCB or system. Just the act of pulling it all apart and putting it back together will often make things work. We

may not know exactly what we did to fix it but it's working and that's really our only concern. This is sometimes referred to as an "FM" repair. Freakin' Magic.

This type of repair is simple and doesn't require much in the way of troubleshooting skills but wouldn't it be better to not have to make this type of repair at all? What if there was a way to prevent connector problems before they happen? I have found the cure for the connector plague. Oddly enough, the solution is right in my own back yard in San Diego, California.



ProGold provides protection for connectors

Preaching the gospel of "preventative maintenance" for connectors, CAIG Laboratories manufactures a product that is ideally suited to the rugged, 24/7 demands of the casino. It's called "ProGold" and it's a chemical treatment that is formulated to improve conductivity and provide long-lasting protection on gold, precious metals and their base metals. It conditions connectors, contacts



CAIG Laboratories' president Mark Lohkemper shows off his company's electronic maintenance kits.

and other metal surfaces to enhance their conductivity and their ability to efficiently transmit electrical signals.

"Usually customers or service people come to us after there's a problem, instead of treating the potential problem before it starts," said CAIG president Mark Lohkemper.

Stressing the importance of taking a proactive approach to service, Lohkemper said that the best time to take action is when the game is new; ideally at the time the game is manufactured.

"The problem is that as soon as you remove and replace the connector a few times, you scratch the gold off," said Lohkemper. "It's actually worse! When you apply this [connector] a few times, you scratch the gold off. Now you have bare copper to bare copper and copper oxidizes very quickly. When you fix something by taking the connector off and putting it back on, you're breaking through that layer of oxidation."

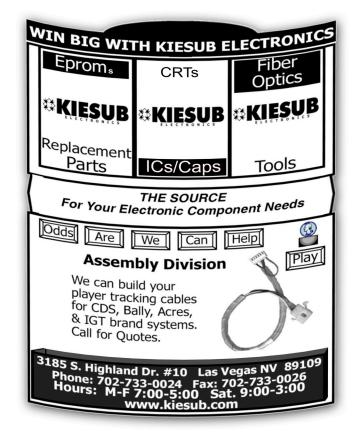


Progold can be applied with a premoistened wipe as well as by numerous other methods.



"What our product does for any surface, especially the gold, is that it lubricates to reduce insertion resistance which helps protect the gold surface." said Lohkemper, indicating the value of using ProGold at the OEM level,

before the connectors are applied. "If this is a brand new connector and hasn't been inserted yet, our product will penetrate the gold plating and molecularly bond to the base metal. It seals out oxygen."



Conduction through ProGold coated surface takes place in three ways. First, ProGold can be displaced by electrical arc, shock wave or simple mechanical pressure and will redistribute itself along the surface when the disturbance is removed. Second, a thin insulating film of ProGold can be dispersed by an electrical field. Finally, conduction takes place through very thin films of ProGold by means of a quantum-mechanical phenomenon called "tunneling" where electrons travel from one side of a thin film of ProGold to the other without passing through. This is the same effect that gives the tunnel diode its name. ProGold also fills the gaps in the contact surfaces, increasing the surface area and current flow.

However, any connector, no matter how old, can benefit from the treatment. If the gold

surface is already broken or if the connector is not gold plated (such as older PCBs or connector pairs with male and female pins that are "tinned" copper) ProGold will keep it from oxidizing and/or corroding.

The product can be applied in a variety of ways. CAIG packages ProGold as bottles of solution, aerosol cans, minispray cans, pinpoint drop applicators, porous tip pens, syringe dispensers or premoistened wipes. Depending on the environment, a single application can last from one to ten years.

This product may be especially interesting to those operating near the ocean or on cruise ships. The sea air can be murder on connectors. If you find yourself making a lot of FM repairs, ProGold may be just the thing you need to these intermittent failures.

### **Other Products**

CAIG manufactures a variety of other products. Some are suitable to our industry. Others are not. They have a good, general purpose electrical contact cleaner called DeoxIT. DeoxIT dissolves oxides and sulfides that

form on metal contact surfaces, removing these sources





Eliminate those pesky static problems on CRTs, glass and carpets with OpticALL and StaticALL.

of resistance. This restores the contact's integrity and leaves a thin, organic layer that coats and protects the metals. Special additives prevent the dissolved oxides from re-attaching, keeping them in suspension and allowing them to be dispersed easily by the mechanical action of the contact.

DeoxIT works with similar or dissimilar metals. Even when a treated connector mates with an untreated one, DeoxIT will migrate and coat the other surface. When the connectors are separated, DeoxIT will re-coat the exposed metal surfaces.

CAIG also manufactures a couple of other products that we can use on a regular basis in gaming. One is an aerosol glass cleaner called OpticALL. Call it Windex with an attitude. It's a general purpose, anti-static glass cleaner.



DeoxIT is a general-purpose contact cleaner.

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Winter days can cause annoying problems with static electricity. While slot machines are specifically hardened against ESD hits, it's better if the static electricity can be neutralized at the source rather than zapping your customers every time they walk up to a machine.

CAIG makes a product called StaticALL that kills static on floors (and anything else it touches, for that matter). When static becomes a problem, simply spray the carpeting in the area immediately in front of the game. Lightly spray a radius of five feet or so. I have no personal experience with this product so I cannot tell you if it works any better than a couple of capfuls of fabric softener in a pistol grip sprayer full of water when it comes to killing static electricity on carpeting.

### **Locating Thermally Intermittent Failures**

Another CAIG product is a component chiller called FreezALL. FreezALL cools circuits down to -54 degrees C and comes packaged with a precise one-piece trigger valve and extension tube for controlled application. Naturally, this product contains no CFCs/HCFCs.

Here is a repair trick that's worth its weight in gold. Many games fail when they get hot. The game will work fine when it is first turned on but after

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warming up, the CPU board (or some other sub-assembly) fails. This type of failure is "thermally intermittent" and you can locate the defective component with just two tools: a hair dryer and a can of FreezALL. With the game turned on, use the hair dryer on the hottest setting to heat the components on the board. If you're working on a CPU, start with the socketed ICs: the EPROMs and EEPROM. Practical experience has shown that heat related CPU failures are often caused by the memory devices. Don't be afraid to get them good and hot. You cannot damage an IC (or any component, for that matter) with the heat of a normal hair dryer. When you heat the bad part, the game will fail. This will lead you to the general area of the failure.

To precisely locate the bad part, use the FreezALL. The nozzle comes with a tube that allows you to aim the spray on a single component. Once you have induced the failure by heating the components on the board, carefully spray the parts one at a time with the FreezALL. The FreezALL spray will cool the component instantly. If the defective part works properly when it's cold, the game will suddenly begin to work when it is hit with the cold FreezALL spray. To make absolutely sure that you have isolated the bad IC, try heating and freezing it a few times. Each time you heat it with the hair



Isolate thermally intermittent problems with environmentally friendly FreezALL.

dryer it should fail. Freezing the IC should cause the computer to regain consciousness or otherwise restore the functionality of the circuit.

Of course, freezing the bad part is only a way to locate it. The FreezALL spray does not fix the bad component. The defective part must be replaced. This method works for any electronic failure that is thermally intermittent. The success rate is 100 percent.

For further information, contact: CAIG Laboratories, Inc. 12200 Thatcher Court Poway, CA 92064-6876 E-mail: caig123@caig.com www.caig.com tel.800/CAIG-123 (800/224-4123)Main Line: 858/486-8388

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# **Darlington Transistors**

e have discussed a couple of different types of transistors in past issues of Slot Tech Magazine. We have discussed conventional, bipolar transistors and we have taken look at field effect transistors or MOSFETs. Now, it's time to introduce you to yet another type of transistor. It's called the Darlington transistor.

There is really nothing mysterious about a Darlington transistor. It is simply two transistors, in a single transistor package. Darlington transistor, the emitter of the first transistor is connected to the base of the second transistor (see figure 1). The two collectors are tied together. This still leaves us with a single device with three leads coming out of the package: the emitter, the base, and the collector. They're in the same place as they are in a standard TO-220 package. That is to say, the leads are in alphabetical order from left to right: base, collector, and emitter (see figure 2).

So what is the advantage of a Darlington transistor over a conventional transistor? Think about the specifications for transistors for just a moment. Remember that

transistors are rated by voltage, current, and another parameter known as gain. This is where the Darlington transistor has its advantage.

The gain of a transistor is an indication of the transistor's ability to amplify an incoming signal. The higher the gain, the less current it takes to drive the transistor. For example, a transistor with a gain factor of 100 will require just 1/100 amp of base current for 1 amp of collector current.

There are three general categories for gain in transistors. There are low gain transistors, there are medium gain transistors, and there are high gain transistors. A low gain transistor is a transistor that has a gain of up to around 250. A medium gain transistor might have any gain from 250 to 750. A high gain transistor would be higher than 750. These gain assignments are somewhat arbitrary.

In a Darlington transistor, the gain of the first transistor is multiplied by the gain of the second transistor. To illustrate, let's look at an example. Let's say that this first transistor has a gain of only 100. That makes it a low gain

transistor. Let's say, for the sake of discussion, that the gain of the second transistor is just 20. That's also a very low gain transistor. Together, the Darlington transistor has a gain of 2000. That's a very high gain transistor.

What do you suppose is the advantage here? Why do we need a high gain transistor? Darlington transistors are often used as driver transistors. They often are used to drive coils or solenoids. We might also use them in slot machines as lamp drivers. In a slot machine, a lamp circuit (a lamp matrix, for example) draws a reasonably high amount of current. But remember that the transistor is driven by the CPU, the computer in the game. Well, the computer is very smart, but it's also very weak. The com-

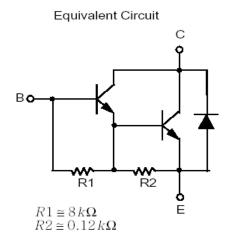
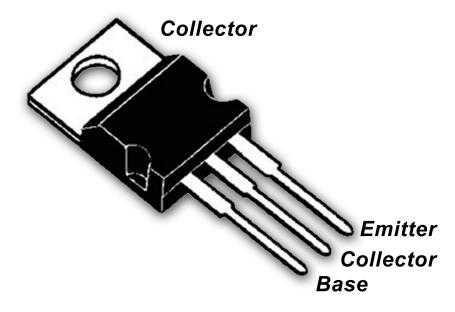


Figure 1.
The Darlington configuration

puter itself cannot put out enough current to drive a lamp. Instead, the weak signal from the CPU is used to drive the Darlington transistor. Since the Darlington transistor has a huge amount of gain, the tiny, weak signal from the CPU can be used to drive the high current lamp circuit.

### **Testing**

When you test a Darlington transistor, it tests differently from a conventional, bipolar transistor. When you test the Darlington transistor between base and collector, you to get a normal junction drop. That is to say, with your meter set on the diode test setting, you see a typical forward junction drop voltage of between around .5 volt or .6 volt. On the other hand, when you test between the base and the emitter, you still see a junction drop but it is somewhat higher than the junction drop that we saw between the base and collector. As you know, in a normal, bipolar transistor, the junction drop reading obtained between the base and collector is normally about the same as that between the base and emitter. In this case however, when you measure between base and emitter, the junction drop that you get is somewhat higher because you are actually measuring between two PN junctions and they are in series. When you test the Darlington transistor be-



# The TO-220 package is often used to house a Darlington transistor when it is used as a lamp driver or solenoid driver

PN junction of the first transistor is being tested in series with the PN junction of the second transistor. Therefore, the junction drop reading that you get on your meter is somewhat higher. For example, if you measured .5 volt between base and collector, you might obtain a reading of .6 between base and emitter.

Yet another interesting reading you will get is when you measure between the collector and emitter. In a conventional, bipolar transistor, you will normally get an open reading between collector and emitter. You will get the same open reading both ways. That is to say, with red meter lead on the collector and the black on the emitter, your meter will read open. When the leads are reversed and the black lead is on the collector

emitter, you will get the same open reading.

Not so with the Darlington transistor. When you test the Darlington transistor between collector and emitter, you will get open reading in one direction but you'll read a junction drop when the leads are reversed. Hmmmm . . . That's very interesting. What component do we know that tests that way? What component tests open in one direction and junction drop when the leads are reversed? It's a diode of course. Built into the Darlington transistor, between the collector and the emitter, there is a diode. This diode is a protection diode. In a nutshell, any time we use a transistor to drive a coil of some sort, you will see some protection diodes used. Since a common function of the Darlington transistor is that it is used as a coil driver, the diode is built right in to the Darlington transistor.

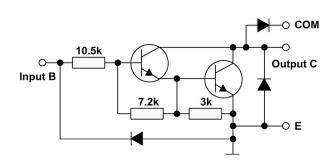
But that's not all. In addition to the diode, there are typically a couple of resistors that are also built in to the Darlington transistor (see figure 1). These resistors are connected between the base and emitter of each of the two transistors that are in the Darlington transistor. The presence of these two resistors profoundly affects the transistor test. Where you normally see a junction drop in one direction and open reading when your meter leads are reversed, the resistors allow current to pass even in the reversed direction. Instead of reading open on your meter, you will typically get some sort of voltage drop.

The reading you get depends on a couple of factors. One is the value of the resistors themselves; the other is your meter. Different meters pass different amounts of current and voltage through the device under test. While some meters might read something like 1.8 volts of voltage drop when the leads are reversed (actually reading the resistors themselves and not through the transistors at all) other meters might show something like 1.2 V. The best way to determine what's normal, is simply to try testing some known good Darlington transistors with your meter. Whenever it is that you're reading with your meter, that is what's normal.

Specifications for Darlington transistors are the same as those of regular transistors. That is to say, they are rated by voltage, current, and gain. Substitution is the same as well. You can always substitute the Darlington transistor for another Darlington transistor as long as the voltage rating is the same or higher, the current rating is the same or higher, and it has sufficient gain. Remember these are the rules when substituting any transistor. Voltage and current can be the same or higher but you need to try to match the gain. It doesn't have to be exact, it

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### schematic (each Darlington pair)



### ULN2804A DARLINGTON TRANSISTOR ARRAY

### N DUAL-IN-LINE PACKAGE (TOP VIEW)

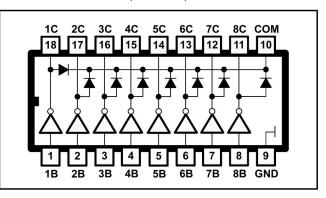


Figure 3 HIGH-VOLTAGE, HIGH-CURRENT DARLINGTON TRANSISTOR ARRAY

just has to be close.

Darlington transistors come in both polarities (NPN and PNP) and in all the same transistor packages as conventional transistors. The most common package that we see in gaming is the TO-220 package.

### **Darlington Array**

Another place we use Darlington transistors in gaming is as a Darlington transistor array that looks just like an integrated circuit. One popular type is the ULN2084A.

The ULN2804A is a monolithic high-voltage, high-current Darlington transistor array, comprising eight NPN Darlington pairs. All units feature high-voltage outputs with common-cathode clamp diodes for switching inductive loads. The collector-current rating of each Darlington pair is 500 mA. Outputs and inputs can each be paralleled for higher current capability.

Applications include relay drivers, hammer drivers, lamp drivers, display drivers (LED and gas discharge), line drivers, and logic buffers. The ULN2804A has an approximate 10.5 kilohm series input resistor to allow its operation directly from CMOS or PMOS, utilizing supply voltages of 6 to 15 volts.

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