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Optomistic Products' Universal LightProbes S2 Penta and S2 Spectra Sensors & Trident Fiber-optic Probes For Teradyne In-Circuit Test Systems

Overview:

Today, most circuit board designs include one or more Light Emitting Diodes or LEDs. These LEDs are often used to show some visual status to a user. They can show the "health" status of a system or be used to show some error. They can also be used to indicate a connection type or speed of a circuit such as a network card. It is common to use different color LEDs to quickly determine a system's overall ability to function correctly. Standard methods used for testing diodes in-circuit cannot detect color. Standard tests are used to prove parts presence and orientation only. This is where the Optomistic Products' Universal LightProbe Sensors are used to augment the overall test coverage.

For a cost effective solution, we suggest using either Optomistic Products' Universal LightProbe S2 Penta or the S2 Spectra Sensors with Trident Fiber-optic Probes. In this paper we will address the S2 Penta Sensor, with an addendum on using the S2 Spectra Senor.

The Universal LightProbe S2 Penta Sensor is powered from +5 volts to +28 volts with 3 Fiber-optic Probe inputs and 2 outputs. The Sensor tests for the five main LED colors plus white, and provides an output for color and an output for intensity. The 3 Fiber-optic Probes-to-1 Sensor allow for a more cost effective approach for testing the color of multiple LEDs at ICT.

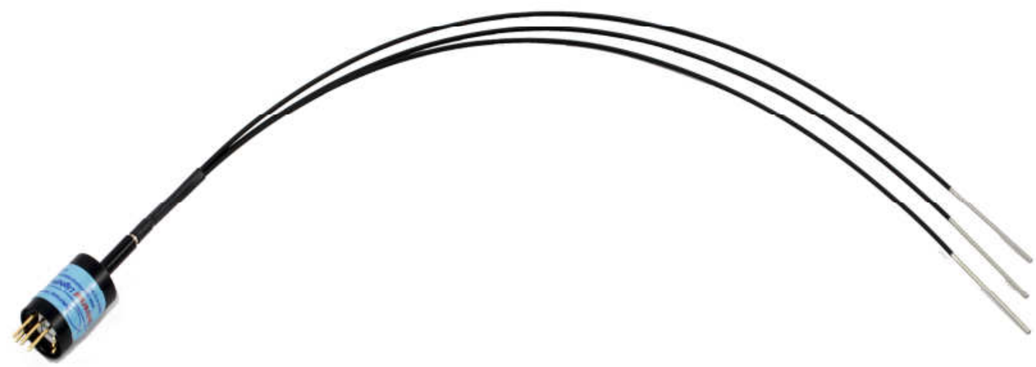

Figure 1

Optomistic Products' Universal LightProbe S2 Penta Sensor with Trident Fiber-optic Probes
<u>General Specifications:</u>

The Universal LightProbe S2 Penta Sensor is Optomistic Products' most popular Sensor and is very versatile in accommodating most LED color and intensity test applications. The Penta Sensor features built-in color binning, which saves valuable processing time.

Penta S2 Sensor's Color Response:

Blue:	1.0 volts
Green:	1.5 volts
Yellow/Amber:	2.0 volts
Orange:	2.5 volts
Red:	3.0 volts
White:	3.5 volts

S2 Penta Sensor Color Chart

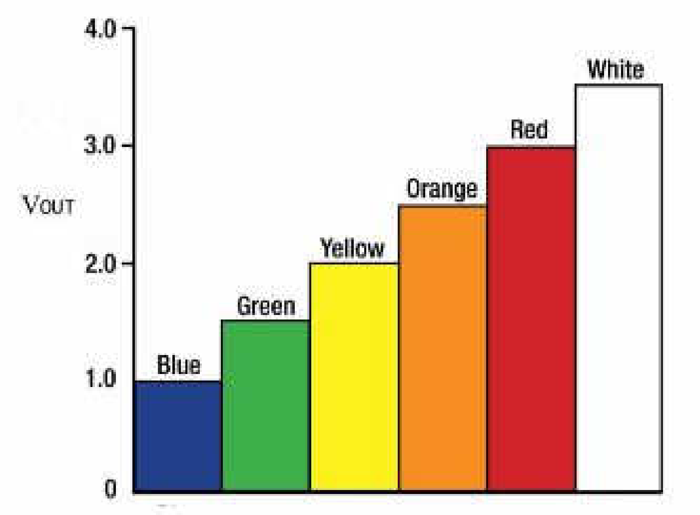

Figure 2

The Penta Sensor's color binning allows the programmer to set the test limits for each color with no overlapping values. The test is a common voltage measurement which simplifies implementation at ICT.

The Penta Sensor's **Intensity** response for the LED under test is (0-4.0 volts). This can be used to determine if the light pipes are aligned properly or if the LED is bright enough to accurately measure. Another use for the intensity is to detect the difference between a low and high intensity LED where both types are used on a single design.

Connections:

The S2 Penta Sensor has only four connections per sensor. These consist of GROUND, COLOR, INTENSITY and POWER. The S2 Penta and S2 Spectra Sensors have the same pinouts.

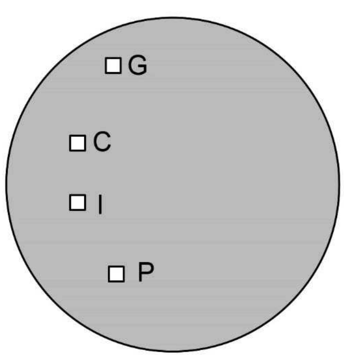

Figure 3 Universal LightProbe S2 Penta and S2 Spectra Sensors - Rear View

The POWER pin can be connected to a tester power supply or it can be driven using the digital drivers in the tester. It is recommended to use the power supply option to simplify the wiring and to allow for faster test results when capturing the color of each LED.

When using a tester power supply, you can power up all of the Sensors at the same time that power is applied to the UUT. Since all of the Sensors are powered together, there is only one wait time needed for all of the Sensors to be ready to take measurements. Most of the time this does not affect the test time at all since the power up time is usually satisfied by executing the normal board voltage measurements.

If you choose to use the driver sensor method, you must ensure that your timing and looping structure allows enough time for the Sensor to power up prior to taking measurements. Failure to allow the Sensor enough time for power up will result in unreliable readings. Each measurement will need to have this wait time accounted for since the driver sensors will be driven and then released between measurements. This method is only recommended if a tester power supply is not available.

The GROUND pin can be connected to the single point reference for the power supplies and digital drivers.

The COLOR pin is connected to a driver/sensor from the tester. Each Penta Sensor must be assigned a unique driver/sensor. You can accomplish this in two ways. First, you can add a “dummy” device (in the .CKT, or product database depending on method of generation) to allow Teradyne ATG to automatically assign the required resource. The second method is to choose an unused resource after normal nail assignment has been executed.

The INTENSITY pin can be treated in the same manner as the COLOR pin. It also needs to have a tester resource assigned to it.

<u>Considerations:</u>

The first thing to consider is the method used to light up each LED. There are several methods that can be used depending on the surrounding circuitry.

In one case the LEDs can be turned on using the Teradyne Teststation’s analog or digital drivers without power being applied to the board. This method can be used when the LED is isolated from a power bus or from direct connections to a digital device (see Figure 4). When using this method, care must be taken to ensure that the diodes can be driven safely without backdriving any other circuits. It is highly recommended not to drive directly on the LED under test. Control the LED through a resistor in series with the LED to limit the available current.

Since power must still be applied to the Penta Sensor and the LED must be turned on using powered instrumentation, the digital subsystem must be grounded using the “SET PIO(0) HRLY(CLOSE 3);” command. At this point the test programmer can use either the powered analog test or digital test to turn on the LED and then use the tester’s built-in DC measurement instrumentation to measure the COLOR and INTENSITY pins.

The second method is used with power applied to the circuit board. This method is used with three different scenarios. The first scenario is when the anode of an LED is tied directly to a power rail (see Figure 2). If the unpowered method is used, the analog or digital driver does not have enough current to turn on the LED. This is due to all of the alternate current paths to other devices that share the power rail. In this case, we let the board's power supply provide the rail voltage to the anode. The LED is then controlled by changing the voltage on the cathode. To turn the diode on, you would provide a ground path to the cathode. Care must be exercised to limit the current flowing through the diode in the "on" state. Normally, this type of circuit would have a current limiting resistor RI between the cathode and the ground source. When turning the LED on, the stimulus should always be applied through this resistor. To turn the LED off, you would drive the cathode to the same potential as the rail voltage on the anode. This can be applied directly to the cathode since there should not be any current flowing through the LED.

The second scenario occurs when the diode is connected to a digital device that cannot be tri-stated (see Figure 6). To prevent damage to the digital device, you must use the digital logic to provide the stimulus to the LED. This is using the circuit in a more functional sense to control the LED.

In the last scenario, the LED is connected to device that can be controlled or tri-stated. A burst-active test can be used to tristate the digital device and then the powered analog or digital test can be applied to the tri-stated output. Or you can simply let the normal digital circuitry turn on the LED by controlling the digital device's input pin (see Figure 7).

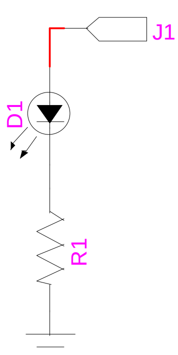

Figure 4: LED not connected to power net or digital device.

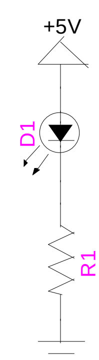

Figure 5: LED tied to power net, no digital connections.

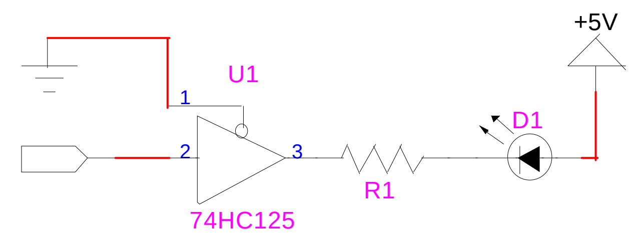

Figure 6: LED tied to power rail and to a digital non-tristate device.

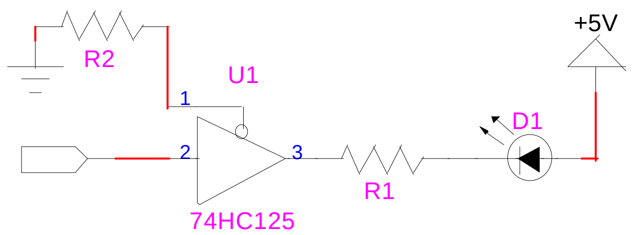

Figure 7: LED tied to power rail and to a digital tristate device.

Sample Code for S2 Penta Sensor:

(ex 1)

The version below uses the analog section to stimulate the LED and measure the output of the S2 Penta Sensor. This type of test allows for control of the input current to the LED and is considered safer than the BURST mode type of testing. This example can be used with the circuit both powered or unpowered.

```
LED_D1: /* Green */

    SET SCAN AT (CHA=LightProbe Color:CHB=Reference:CHC=LED anode:CHD=LED cathode);
     SET MUX AT(CHA=DCMVHI:CHB=DCMVLO:CHC=DCSVHI:CHD=DCSVLO:REF=DCSVLOSNS);
     SET DCV DCS V=3 I=10M DLY=10M; /* Adjust as necessary */
      MEAS DCV INTO VVAL1 MAX=1.5 HI=1.6 LO=1.4 DLY=2M RDLY=2M FAIL(1)
      [
        WRITE ID=MESFILE 'LED1 failed Optomistic testing Measured: %7.3F% V%NL%'VVAL1;
        WRITE ID=MESFILE 'Expect a GREEN LED %NL%%NL%';
      ];
```

(ex 2)

The BURST ACTIVE is used to control digital logic which in turn stimulates the LED and the SET SCAN section is used to read the output of the S2 Penta Sensor. This example can only be used when the circuit is powered.

```
LED_D1: BURST ACTIVE MAXTIME=3 NOFAULT;
          IC(1) IH(1);     /*1=digital input */
        END BURST;

        DELAY 5M;  /* ADJUST TIME TO IMPROVE STABILITY  */

        SET SCAN AT (CHA=3:CHB=4);
        SET MUX AT(CHA=DCMVHI:CHB=DCMVLO);
        MEAS DCV INTO VVAL1 MAX=1.5   HI=1.6 LO=1.4 DLY=2M RDLY=2M FAIL(1)
        [
          WRITE ID=MESFILE 'LED1 failed Optomistic testing Measured: %7.3F% V%NL%'VVAL1;
          WRITE ID=MESFILE 'Expect a GREEN LED %NL%%NL%';
        ];
```

(ex 3)

The BURST ACTIVE is used to stimulate the LED and the SET SCAN section is used to read the output of the Penta Sensor. It is advised to only drive only through a series resistor to limit the drive current to the LED. This example can be used with the circuit both powered or unpowered and should only be used if absolutely necessary.

```
LED_D1: BURST ACTIVE MAXTIME=3 NOFAULT;
          IC(1,2) IH(1) IL(2);     /*1=Anode, 2=Cathode */
        END BURST;

        DELAY 5M;  /* ADJUST TIME TO IMPROVE STABILITY  */

        SET SCAN AT (CHA=3:CHB=4);
        SET MUX AT(CHA=DCMVHI:CHB=DCMVLO);
        MEAS DCV INTO VVAL1 MAX=1.5   HI=1.6 LO=1.4 DLY=2M RDLY=2M FAIL(1)
        [
          WRITE ID=MESFILE 'LED1 failed Optomistic testing Measured: %7.3F% V%NL%'VVAL1;
          WRITE ID=MESFILE 'Expect a GREEN LED %NL%%NL%';
        ];
```

For all three of the above examples the Penta Sensor is powered using one of the tester’s power supplies.

The object of this test was to compare the new version of the S2 Penta LightProbe Sensor to the previous version. The test setup consisted of a red LED, one Penta Sensor, and one S2 Penta Sensor a storage Oscilloscope. The results were as you will see quite an improvement to say the least.

Previous version Penta Sensor times:

Turning on the LED to the sensor capture time was 310ms.

New version S2 Penta Sensor times:

Turning on the LED to the sensor capture time was 7.5ms.

The improvement of the capture time on the new version is substantial and will drastically reduce test times versus the previous version Penta Sensor.

All times were captured side by side and delays were minimized to the point that proved stabile. This was not performed on a loaded circuit card. All times were captured side by side.

```
OLD_VERSION:
        BURST ACTIVE MAXTIME=3 NOFAULT;
           IC(1,2) IH(1) IL(2);     /*1=Anode, 2=Cathode */
         END BURST;

         DELAY 500M;  /* ADJUST TIME TO IMPROVE STABILITY  */

         SET SCAN AT (CHA=3:CHB=4);
         SET MUX AT(CHA=DCMVHI:CHB=DCMVLO);
         MEAS DCV INTO VVAL1 MAX=3   HI=3.2 LO=2.8 DLY=200M RDLY=200M FAIL(1)
         [
           WRITE ID=MESFILE 'LED1 failed Optomistic testing Measured: %7.3F% V%NL%'VVAL1;
           WRITE ID=MESFILE 'Expect a GREEN LED %NL%%NL%';
        ];

NEW_VERSION:
        BURST ACTIVE MAXTIME=3 NOFAULT;
           IC(1,2) IH(1) IL(2);     /*1=Anode, 2=Cathode */
         END BURST;

         DELAY 0;  /* ADJUST TIME TO IMPROVE STABILITY  */

         SET SCAN AT (CHA=3:CHB=4);
         SET MUX AT(CHA=DCMVHI:CHB=DCMVLO);
         MEAS DCV INTO VVAL1 MAX=3   HI=3.2 LO=2.8 DLY=2M RDLY=2M FAIL(1)
         [
           WRITE ID=MESFILE 'LED1 failed Optomistic testing Measured: %7.3F% V%NL%'VVAL1;
           WRITE ID=MESFILE 'Expect a GREEN LED %NL%%NL%';
         ];
```

Highlighted in red are the delays used with the new sensor. The new version is quite a bit faster than the previous version.

This section will address the S2 Spectra Sensor and include the Spectra color response formula:

LED Wavelength = (100(Vout + 4)nm) and white is still 3.5 volts.

The S2 Spectra Sensor's color response allows the programmer to set the test limits for any color wavelength (see figure 8).

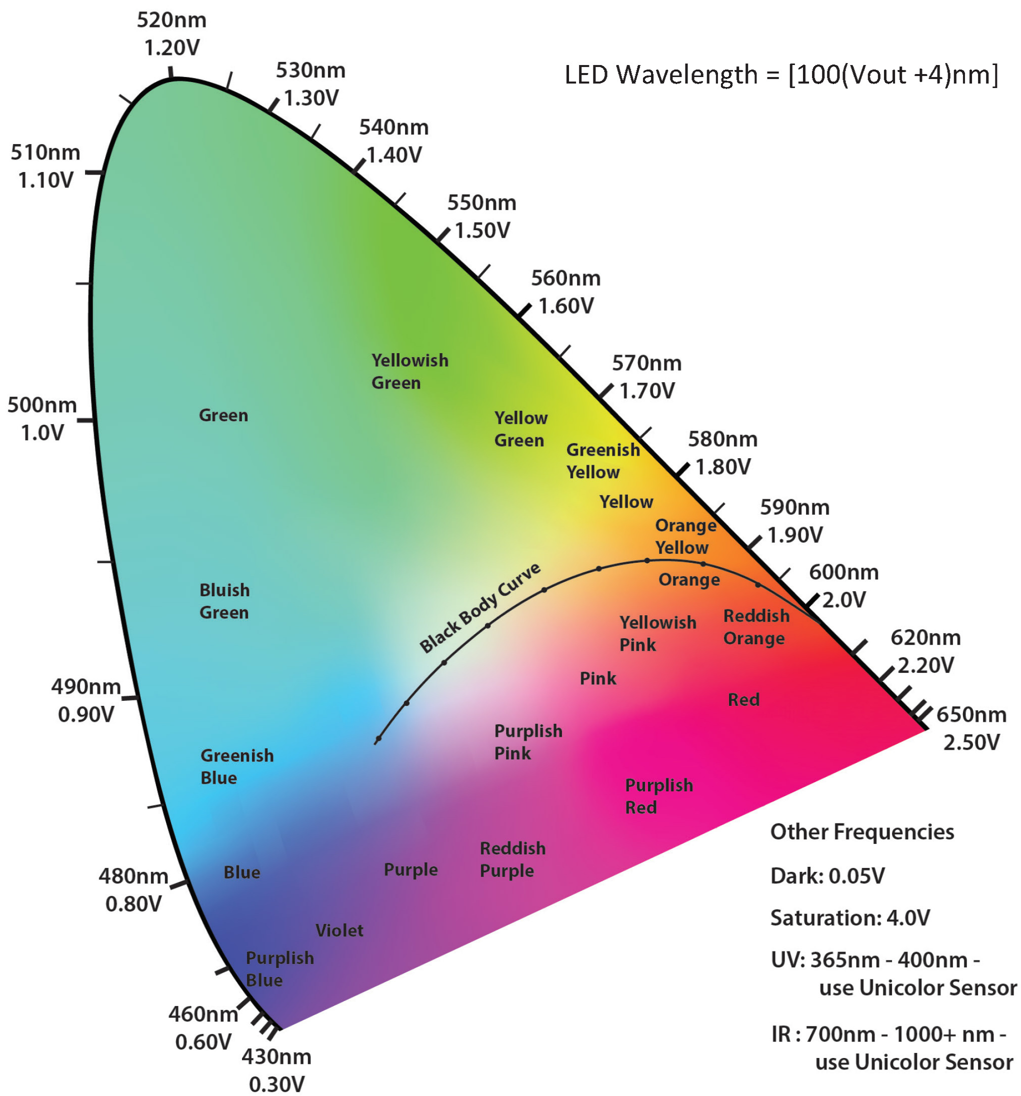

Figure 8

Sample Code for S2 Spectra Sensor:

(ex 1)

The version below uses the analog section to stimulate the LED and measure the output of the S2 Spectra Sensor. This type of test allows for control of the input current to the LED and is considered safer than the BURST mode type of testing. This example can be used with the circuit both powered or unpowered.

```
LED_D1: /* Green */
    SET SCAN AT (CHA=LightProbe Color :CHB=Reference:CHC=LED anode:CHD=LED cathode);
     SET MUX AT(CHA=DCMVHI:CHB=DCMVLO:CHC=DCSVHI:CHD=DCSVLO:REF=DCSVLOSNS);
     SET DCV DCS V=3  I=10M DLY=10M; /* Adjust as necessary */
      MEAS DCV INTO VVAL1 MAX=1.35 HI=1.40 LO=1.00 DLY=2M RDLY=2M FAIL(1)
      [
        WRITE ID=MESFILE 'LED1 failed Optomistic testing Measured: %7.3F% V%NL%'VVAL1;
        WRITE ID=MESFILE 'Expect a GREEN LED %NL%%NL%';
      ];
```

(ex 2)

The BURST ACTIVE is used to control digital logic which in turn stimulates the LED and the SET SCAN section is used to read the output of the S2 Spectra Sensor. This example can only be used when the circuit is powered.

```
LED_D1: BURST ACTIVE MAXTIME=3 NOFAULT;
             IC(1) IH(1);      /*1=digital input */
           END BURST;

           DELAY 5M;  /* ADJUST TIME TO IMPROVE STABILITY  */

           SET SCAN AT (CHA=3:CHB=4);
           SET MUX AT(CHA=DCMVHI:CHB=DCMVLO);
           MEAS DCV INTO VVAL1 MAX=1.40 HI=1.40 LO=1.00 DLY=2M RDLY=2M FAIL(1)
           [
             WRITE ID=MESFILE 'LED1 failed Optomistic testing Measured: %7.3F% V%NL%'VVAL1;
             WRITE ID=MESFILE 'Expect a GREEN LED %NL%%NL%';
           ];
```

(ex 3)

The BURST ACTIVE is used to stimulate the LED and the SET SCAN section is used to read the output of the S2 Spectra Sensor. It is advised to only drive only through a series resistor to limit the drive current to the LED. This example can be used with the circuit both powered or unpowered and should only be used if absolutely necessary.

```
LED_D1: BURST ACTIVE MAXTIME=3 NOFAULT;
           IC(1,2) IH(1) IL(2);     /*1=Anode, 2=Cathode */
         END BURST;

         DELAY 5M;  /* ADJUST TIME TO IMPROVE STABILITY  */

         SET SCAN AT (CHA=3:CHB=4);
         SET MUX AT(CHA=DCMVHI:CHB=DCMVLO);
         MEAS DCV INTO VVAL1 MAX=1.40 HI=1.40 LO=1.00 DLY=2M RDLY=2M FAIL(1)
         [
           WRITE ID=MESFILE 'LED1 failed Optomistic testing Measured: %7.3F% V%NL%'VVAL1;
           WRITE ID=MESFILE 'Expect a GREEN LED %NL%%NL%';
         ];
```

Troubleshooting Hints for all types of Universal LightProbe Sensors:

1) Verify that the LED is turning on and is the expected color.
2) Make sure ambient light is at a minimum to reduce bleed over.
3) For a Sensor with 3 Fiber-optic Probes connected to one Sensor, make sure only one LED is turned on at any given time. The digital test may need to drive the other two led circuits to their off state while testing the LED under test.
4) Examine the Fiber-optic Probe tip and verify that it is aligning with the LED under test. It should be centered to the LED and relatively close to the LED under test.
5) Note that Optomistic Products tests each and every product before it ships, however, if you are receiving product indirectly, there are some cases where you may need to verify that the Fiber-optic Probes are fully inserted into the Universal LightProbe Sensor. This can be fine-tuned by connecting an O-Scope to the output and moving the Fiber-optic Probe in and out looking for the highest result. This needs to be done with the test running.