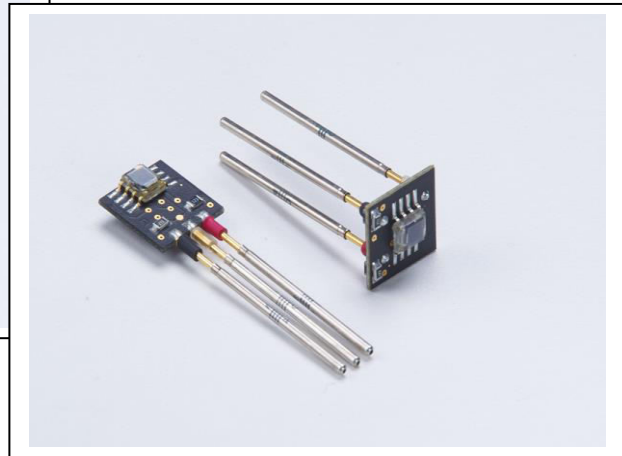


Smart FINN® and Smart FINN® Bright Specification Manual



Smart FINN®



Smart FINN® Bright

Information in this document is provided in connection with the Smart FINN® products. FINN Test Electronics (FTE) shall not be liable for errors or damages sustained in connection with the delivery, use or performance of this document and the information contained herein. Provision of this document does not in any way constitute recommendation of product fitness for a specific purpose.

In future publications, FTE may make changes to specifications and product descriptions at any time, without notice.

Contact FTE or your distributor to obtain the latest specifications prior to placing your product order.

U. S. Patent Nos: 6,490,037; 7,023,554; 7,227,639 and 7,265,822. Additional patents pending.

Table of Contents

1.	Part Numbers and Descriptions	3
2.	Principal of Operation.....	3
3.	Method of Operation	3
4.	Features	3
5.	Applications.....	3
6.	Properties.....	4
6.1.	Dimensions.....	4
6.2.	Power Source.....	4
6.3.	Sensor	4
6.4.	Controller.....	4
6.5.	Smart FINN Table of Typical Measurements.....	4
6.6.	Smart FINN Bright Table of Typical Measurements	5
7.	Understanding Measurements.....	5
7.1.	Voltage and Brightness	5
7.2.	Frequency and Color.....	6
7.3.	Recommended Timing and Test Flows	6
8.	Sources of Error.....	7
8.1.	Wiring	7
8.2.	Outside light and adjacent LED's	7
8.3.	Distance	7
8.4.	Vdd other than 5V	7
8.5.	Saturation	7
8.6.	Temperature.....	7
8.7.	Socket Set Height	8
9.	Fixture Considerations	8
9.1.	Wiring and Sockets	8
9.2.	Distances.....	8
9.3.	Light pipe and light conduit	8
9.4.	Socket Set Height	9
10.	Absolute Maximum Ratings	9
11.	Recommended Operating Conditions	9
12.	5-V DC Electrical Characteristics	9
13.	3-V DC Electrical Characteristics	10
14.	Other Application Notes	10
14.1.	Low Pass Filter for DC Measurements	10
14.2.	Passive Measurements for Wiring Verification	10
15.	Drawing – TC11SF-R, Smart FINN® Right Angle	11
16.	Set Height for Right Angle Smart FINN®	12
17.	Drawing – TC11SF-V, Smart FINN® Vertical	13
18.	Technical Support.....	14
19.	Revision History and Control.....	14
19.1.	Rev D 3.0 – January 2016	14
19.2.	Rev D 3.0 – December 2010.....	14
19.3.	Rev C 2.5 – June 2009	15
19.4.	Rev C 2.5 – January 2008	15
19.5.	Rev C 2.42 – August 2006.....	15
19.6.	Rev B 2.42 – March 2005	15
20.	APPENDIX A	16

1. Part Numbers and Descriptions

Smart FINN Part numbers – LEDs intensity up to 100mcd

<u>Part Number</u>	<u>Description</u>
TC11SF-R	Right Angle Smart FINN®
TC11SF-V	Vertical Smart FINN®
TC11SF-C	3-Pin Header Connector Smart FINN® (no probes)

Smart FINN Bright Part numbers – LEDs intensity greater than 100mcd

<u>Part Number</u>	<u>Description</u>
TC16SFBright-R	Right Angle Smart FINN® Bright
TC16SFBright-V	Vertical Smart FINN® Bright

2. Principal of Operation

The Smart FINN® boasts an all-in-one sensor – four sensors combined into one. Each sensor is designed to detect a certain range of color – blue, red, green or clear. By comparing readings we can get a very accurate measurement of the wavelength of the light hitting the sensor. The key to the design is simplicity. Other than a power and ground connection, the only connection to the sensor is the output. This output indicates both the color and the strength of the LED under test.

3. Method of Operation

The output frequency is directly related to the wavelength (color) of the light. The signal is pulse-width modulated to indicate the intensity of the light. Taking a DC measurement of the signal gives you a measurement of the light intensity.

4. Features

- Full color detection from ultraviolet through infrared
- Wide operating voltage (2.7 Vdc – 5.5 Vdc)
- Standard bed of nails probes used for connections
- Can be powered directly from a digital output
- Color identification determined with one signal
- Intensity reading supplied with one signal
- Right angle mounting is similar to the Agilent TestJet™
- Totally automated, no operator action required
- Significantly faster than operator inspection

5. Applications

- Any test environment when LED color verification is required
- Used across a broad range of industries – automotive, telecommunication, network solutions, medical
- Quality control for most in-line manufacturing environments



6. Properties

6.1. Dimensions

0.486 inch x 0.485 inch x 0.176 inch (not including spring probes)

6.2. Power Source

Unlike the original FINN®, the Smart FINN® requires a minimal power voltage source, which may vary from 2.7 volts to 5.5 volts, current is typically 8mA@5V. Power is marked with a + (plus) sign on the PCB and red heat-shrink on the probe. Ground is marked with a – (minus) sign on the PCB and black heat-shrink on the probe.

6.3. Sensor

Four sensors combined into one specially designed to detect color: Blue, Red, Green and Clear.

6.4. Controller

Because this system is microcontroller based, enhancements can be made in software. Look forward to additional application features.

6.5. Smart FINN Table of Typical Measurements

TYPICAL MEASUREMENTS @Vdd=5.0				
Color	nm	mcd	kHz	Vdc
Red	635	150	12.2	4.5
Amber	608	10	10.6	2.0
Yellow	585	150	9.3	4.0
Green	565	150	8.5	3.0
Blue	430	x	6.8	x
OTHER MEASUREMENTS @Vdd=5.0				
Infrared	Up to 660	x	12.5	x
Ultraviolet	Down to 380	x	6.25-6.5	x
Fluorescent	multiple	x	4.0	x
White(red dominant)	multiple	x	4.4-6.0	x
White(blue dominant)	multiple	x	3.2-4.0	x
Saturation	n/a	Above 200*	2.02	4.8
Dark	n/a	Below 1*	0.998	0.2

*These values are for typical environments (25 degrees Celsius). For additional detail, please refer to the technical discussions later in this document. Please note the voltage output is dependent on the color. The highest voltage is output for red and declines as the wavelength declines.

6.6. Smart FINN Bright Table of Typical Measurements

TYPICAL MEASUREMENTS @Vdd=5.0				
Color	nm	mcd	kHz	Vdc
Red	635	15,000	12.2	4.6
Amber	608	1,000	10.6	3.8
Yellow	585	15,000	9.3	4.5
Green	565	15,000	8.5	4.5
Blue	430	x	6.8	x
OTHER MEASUREMENTS @Vdd=5.0				
Infrared	Up to 660	x	12.5	x
Ultraviolet	Down to 380	x	6.25-6.5	x
Fluorescent	multiple	x	4.0	x
White(red dominant)	multiple	x	4.4-6.0	x
White(blue dominant)	multiple	x	3.2-4.0	x
Saturation	n/a	Above 20,000*	2.02	4.8
Dark	n/a	Below 100*	0.998	0.2

*These values are for typical environments (25 degrees Celsius). For additional detail, please refer to the technical discussions later in this document. Please note the voltage output is dependent on the color. The highest voltage is output for red and declines as the wavelength declines.

7. Understanding Measurements

7.1. Voltage and Brightness

Smart FINN

This sensor is designed to accommodate a wide range of LED's. The sensor has 2 ranges for output brightness. Please note that many factors affect the amount of light from the LED hitting the sensor and the milli-candela (mcd) figures in the examples may be different from the mcd figures of the LED's.

The lower range is for LED's with lower output intensity, typically less than 20mcd. The lower range output is from 0 to Vdd/2, if using Vdd@5Vdc then a 20mcd LED gives an output of 2.5V. The output is not linear so a 10mcd LED would give 2.0Volts DC out.

The upper range is for LED's with roughly 20-200mcd outputs. The output of the range starts at Vdd/2. The increase in voltage per mcd is 1/8 the increase on the lower scale. So, for a 30mcd LED the first 20mcd accounts for 2.5volts in the output and the next 10mcd accounts for only 0.75Volts DC.

Smart FINN Bright

This sensor is designed to accommodate a wide range of LED's. The sensor has 2 ranges for output brightness. Please note that many factors affect the amount of light from the LED hitting the sensor and the milli-candela (mcd) figures in the examples may be different from the mcd figures of the LED's.



The lower range is for LED's with lower output intensity, typically less than 2,000mcd. The lower range output is from 0 to Vdd/2, if using Vdd@5Vdc then a 2,000mcd LED gives an output of 2.5V. The output is not linear so a 1,000mcd LED would give 2.0Volts DC out.

The upper range is for LED's with roughly 2,000-20,000mcd outputs. The output of the range starts at Vdd/2. The increase in voltage per mcd is 1/8 the increase on the lower scale. So, for a 3,000mcd LED the first 2,000mcd accounts for 2.5volts in the output and the next 1,000mcd accounts for only 0.75Volts DC.

7.2. Frequency and Color

The Smart Finn® uses a microprocessor with a built-in oscillator circuit. All output frequencies and pulse widths are dependent on the frequency of the oscillator circuit. This oscillator is trimmed to 3.2 MHz with a Vdd of 5Volts DC and 25 degrees Celsius. The accuracy under these conditions is within 0.5%. The microprocessor creates the frequency output by increasing the period of the repeating signal. The period is increased in increments of 312.5nsec. For a typical green the period is $376 \times 312.5\text{nsec} = 117.5\mu\text{sec}$ (8.511khz). For typical yellow the period is $350 \times 312.5\text{nsec} = 109.4\mu\text{sec}$ (9.142khz). There are 26 other possible frequencies between green and yellow to detect minute differences in color. There are 74 possible frequencies between yellow and red.

The frequency will vary slightly due to temperature and supply voltage. See sections 8.4 and 8.6 in the manual for options to increase accuracy. The frequency variation has no affect on the voltage readings used for brightness tests.

The Smart Finn® will identify if the light source contains significant amounts of all three primary colors (red, green, and blue) and treat it as white light. The response to white light is a variable frequency between 3.1khz and 6.2khz and will be closer to 3.1khz for white light with a majority blue component and closer to 6.2khz if the major component is red. Also, the brightness of the light is proportional to the dc average of the output signal.

Saturation (2.02khz) will occur if the light is too bright. The Dark reading (998.4hz) is given if the light is too dim to be measured. If the SmartFINN saturates (2.02kHz) then a SmartFINN Bright should be used instead to test the bright LED.

7.3. Recommended Timing and Test Flows

A) Turn on LED:

- Power up sensor:
- Delay Wait Time for reading
- Measure Voltage for Intensity
- Measure Frequency for Color

B) Power up sensor:

- Turn on LED:
- Delay Wait Time for reading
- Measure Voltage for Intensity
- Measure Frequency for Color

Good voltage reading Worst case wait time*

Less than 0.5	400msec
0.5-1.5	200msec
1.5-2.5	100msec
2.5-3.5	50msec
above 3.5	25msec



*If the sensor is powered up before the LED the first reading cycle may have samples from the unlit time period and thus a second sampling period is needed. If using Test Flow A, then the wait can be reduced to half the worst case. Also wait times can be reduced if the voltage is measured before the frequency.

8. Sources of Error

8.1. Wiring

Special care should be paid to the wiring instructions in section 9.1. Improper wiring will result in over-heating and damage to the part. If miss-wiring has occurred, immediate replacement of the damaged part is recommended.

8.2. Outside light and adjacent LED's

Light from sources other than the device being tested should be prevented from reaching the sensor surface while making measurements. The ambient light from factory lighting could make a green led that normally reads 8.68kHz read 8.9kHz.

8.3. Distance

The further away the sensor is from the LED, the lower the voltage response of the sensor. If the LED is dim (20mcd or less), the sensor face should be around 0.10" to 0.15" from the LED. LED's that are medium brightness (20-100mcd) can have a greater distance 0.15" to 0.25". And very bright LED's (100-200mcd) should be 0.25" or greater for best results. If using light pipes or light conduit this distance should be measured from the LED lens to the front face of the light pipe with a small gap between sensor and other end of conduit.

When using SmartFINN Bright for super bright LEDs, the sensor face should be at least 0.25" from the LED.

8.4. Vdd other than 5V

As Vdd is decreased to 3.5Vdc the frequency of the microprocessor will increase to about 2% above the 5V Vdd frequency. From 3.5V to 2.7V the frequency will start to return to the 5V value. Use 5V for Vdd when possible. When using 3.0v or 3.5v as the power source, the frequency limits can be adjusted based on the dark reading. For example the reading for dark is nominally 998.4Hz at 5V but you are using 3.3V as the power source and the dark reading is 1016Hz. This is a difference of 1.8% so all the expected frequency readings will be 1.8% higher. So instead of testing green for a frequency of 8.68 kHz +/-3% at 5V, the test would look for 8.84 kHz +/-3%.

8.5. Saturation

If the output frequency is 2.02 kHz the sensor is in saturation. Reduce the intensity of the LED if possible. Another way to get out of saturation is to move the sensor further from the LED or switch to a smaller diameter light conduit.

8.6. Temperature

As the temperature is increased, the frequency of the microprocessor decreases slightly. So if testing at 50 degrees Celsius the frequency readings may drop 1%. Likewise, if testing at 0 degrees Celsius the frequency would rise about 1%. Most test environments are kept between 20-35 degrees Celsius and the frequency variation due to temperature in this range is less than 0.3 percent.

8.7. Socket Set Height

When multiple Smart FINNs are used in the same fixture or duplicate fixtures, then socket set height of each Smart FINN must be the identical. If the socket set heights are varying from location to location, then the voltage(intensity) reading of the Smart FINNs will also vary since some of the Smart FINN will be closer to the LED making the voltage reading stronger, and vice versa.

9. Fixture Considerations

Drawings in section 15, 16, and 17 show the TC11SF-R (Right Angle Smart FINN) and the TC11SF-V (Vertical Smart FINN). There are 2 other part numbers available (TC11SF-C and TC11SF-L) which are the same as the TC11SF-V except the slotted probes are installed to the PCB. TC11SF-C leaves holes which will accept 25mil square posts for flexible fixture needs.

9.1. Wiring and Sockets

The sensor is mounted using three 100mil sockets. Industry standard 100mil sockets:

QA part number 100-SDN250W *For longer set heights QA 100-SDN251W may be useful.*
 ECT part number SPR-25W-2
 IDI part number R25W

Red Heatshrink (+) to Vdd (switched 5V typical)
 Black Heatshrink (-) to Ground(0V ref)
 Clear Heatshrink (o) Output to measurement device or switch matrix

When using the TC11SF, without probes and heat-shrink, please note that Power is marked with a + (plus) sign on the PCB and Ground is marked with a – (minus) sign on the PCB.
Improper wiring will result in over-heating and damage to the part.

9.2. Distances

One major advantage of the Smart Finn® is that it does not need to be touching the LED. As a matter of fact it should be at least 0.1 inches from the LED. Distances are not critical unless the LED is very dim or very bright.
 When using SmartFINN Bright for super bright LEDs, the sensor face should be at least 0.25” from the LED.

9.3. Light pipe and light conduit

If devices are too close together and light conduit is needed there are several options available. First, you can use jacketed or unjacketed. We recommend unjacketed because it has a greater core diameter. Some people prefer jacketed because it has a visible barrier to outside light but the outer shell of the unjacketed reflects outside light as well. In typical applications, the distance is short (less than 12”) and conduit is somewhat protected by fixture hardware so jacketed is not needed.

Core diameter must also be selected. For the Smart Finn® the sensor surface is a square with 1.00mm sides. 2mm diameter unjacketed conduit will cover the complete surface of the sensor. Now consider the other end. The LED which may vary slightly in placement, must remain in front of the transmitting portion of the conduit. For small surface mount LED's 2mm is sufficient to make consistent measurements. For other physical situations 2.5 or 3mm may be needed.

Cutting and polishing is not difficult. Remember we are not making a critical fiber optic coupling, we merely want to get the light in the conduit. After cutting the conduit, smooth the surface using fine sandpaper. You must remove any melted or opaque material created during the cutting.

Once the face appears smooth use cardboard (unpainted) for a final polishing. If you would like to check your finish, view an LED through the conduit and verify the brightness is not diminished. If the end is not polished enough, then some light will reflect off the jagged surface rather than enter the conduit and brightness will be reduced.

9.4. Socket Set Height

All of the sockets set height must be identical in a fixture. If the socket set height varies from location to location then the voltage (intensity) reading will also vary for each location.

10. Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted)†

Supply voltage, VDD (see Note 1)	6V
Operating free-air temperature range, TA	0C to 70C
Storage temperature range	-25C to 85C
Maximum current or output	±25 mA

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTE 1: All voltage values are with respect to GND lead.

11. Recommended Operating Conditions

	Min	Nom	Max	Unit
Supply voltage, VDD	2.7	5	5.5	V
Operating free-air temperature range, TA	0	25	70	Celsius
Supply current	-	7.5	12(Note1)	mA

Note 1: Additional loads on output pin not included

12. 5-V DC Electrical Characteristics

Characteristics(1)	Symbol	Min	Max	Unit
Output high voltage	VOH			V
I _{Load} = -2.0 mA, all I/O pins		VDD-0.4	VDD	
I _{Load} = -15.0 mA, all I/O pins		VDD-0.8	-	
Output low voltage	VOL			V
I _{Load} = 1.6 mA, all I/O pins		V _{ss}	0.4	
I _{Load} = 6.0 mA, all I/O pins		-	0.8	

1. VDD = 4.5 to 5.5 Vdc, V_{ss} = 0 Vdc

13. 3-V DC Electrical Characteristics

Characteristics(1)	Symbol	Min	Max	Unit
Output high voltage	VOH			V
I _{Load} = -0.6 mA, all I/O pins		VDD-0.3		
I _{Load} = -4.0 mA, all I/O pins		VDD-1.0		
Output low voltage	VOL			V
I _{Load} = 0.5 mA, all I/O pins		V _{ss}	0.3	
I _{Load} = 6.0 mA, all I/O pins			1.0	

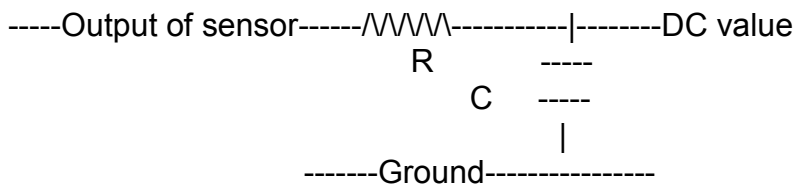
1. VDD = 2.7 to 3.3 Vdc, V_{ss} = 0 Vdc

14. Other Application Notes

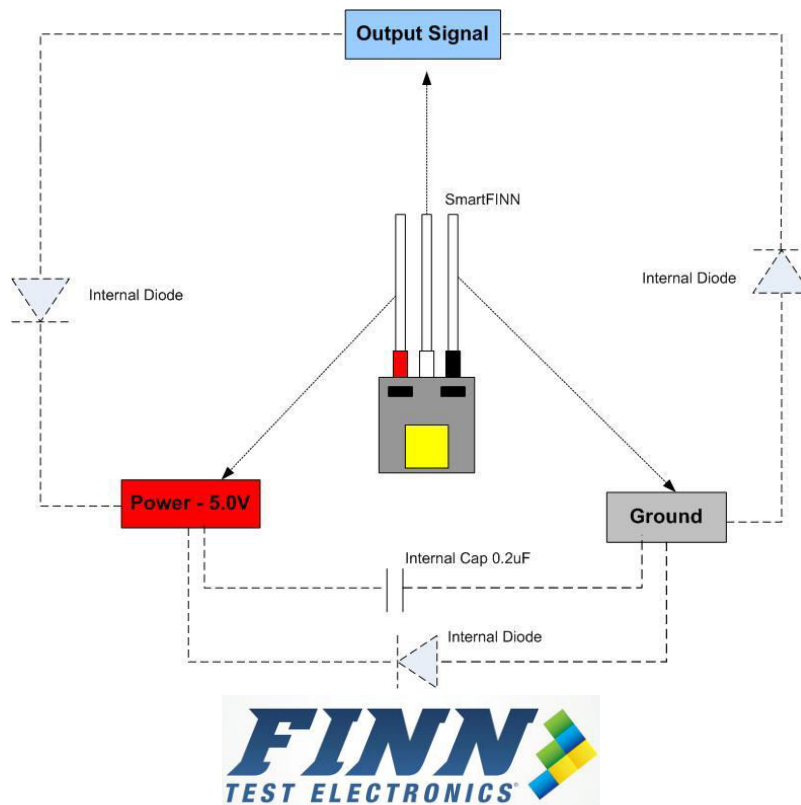
14.1. Low Pass Filter for DC Measurements

Some meters will not average for DC voltage measurement. If your meter does not average you can add a simple low pass filter (R=10k, C=0.1uf) to the output for DC measurements. You must wait at least 5msec after the sensor has acquired a reading to get a stable voltage on the capacitor of the low pass filter.

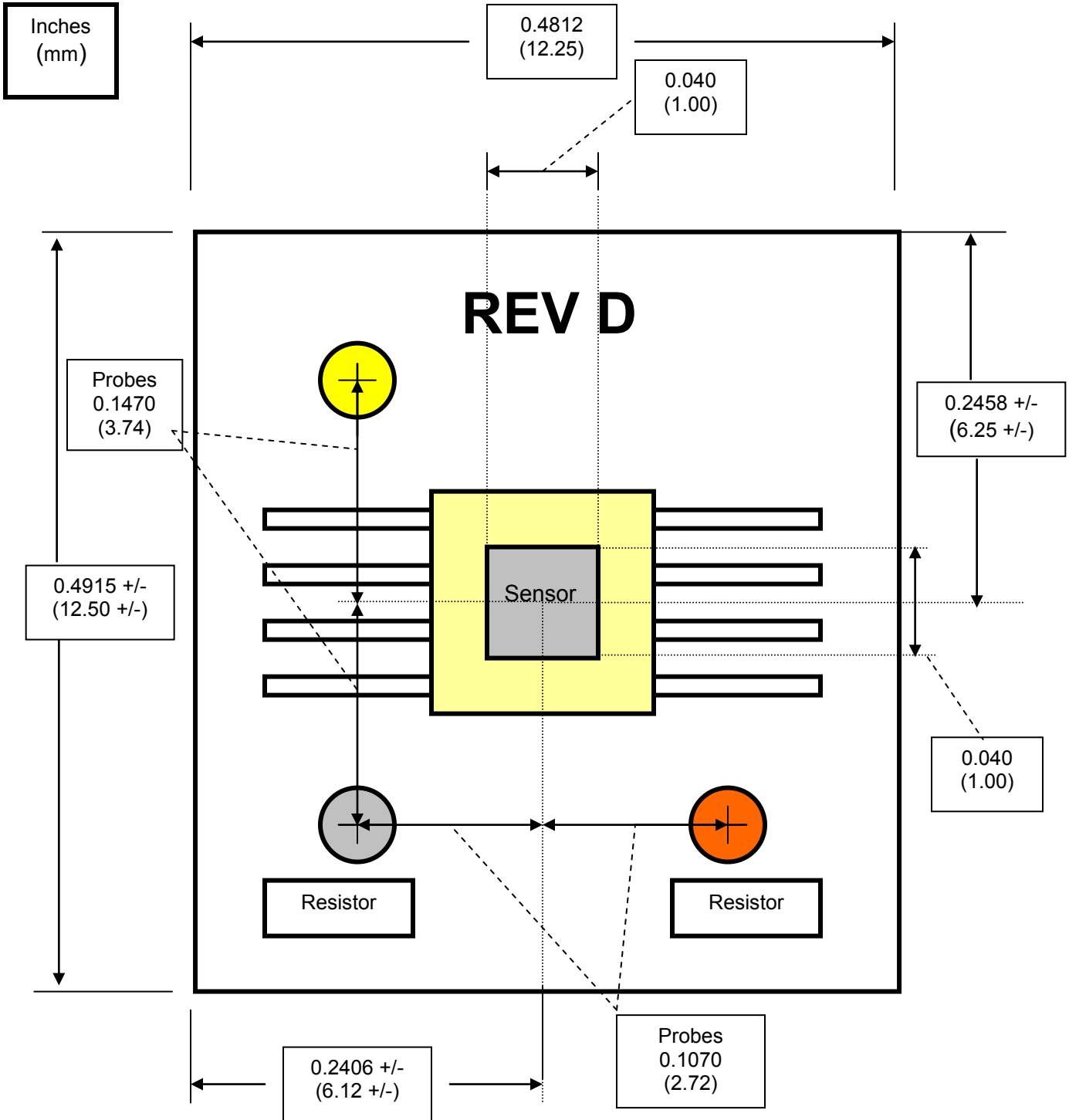
Also, frequency measurements should still be made at the output of the sensor.



14.2. Passive Measurements for Wiring Verification

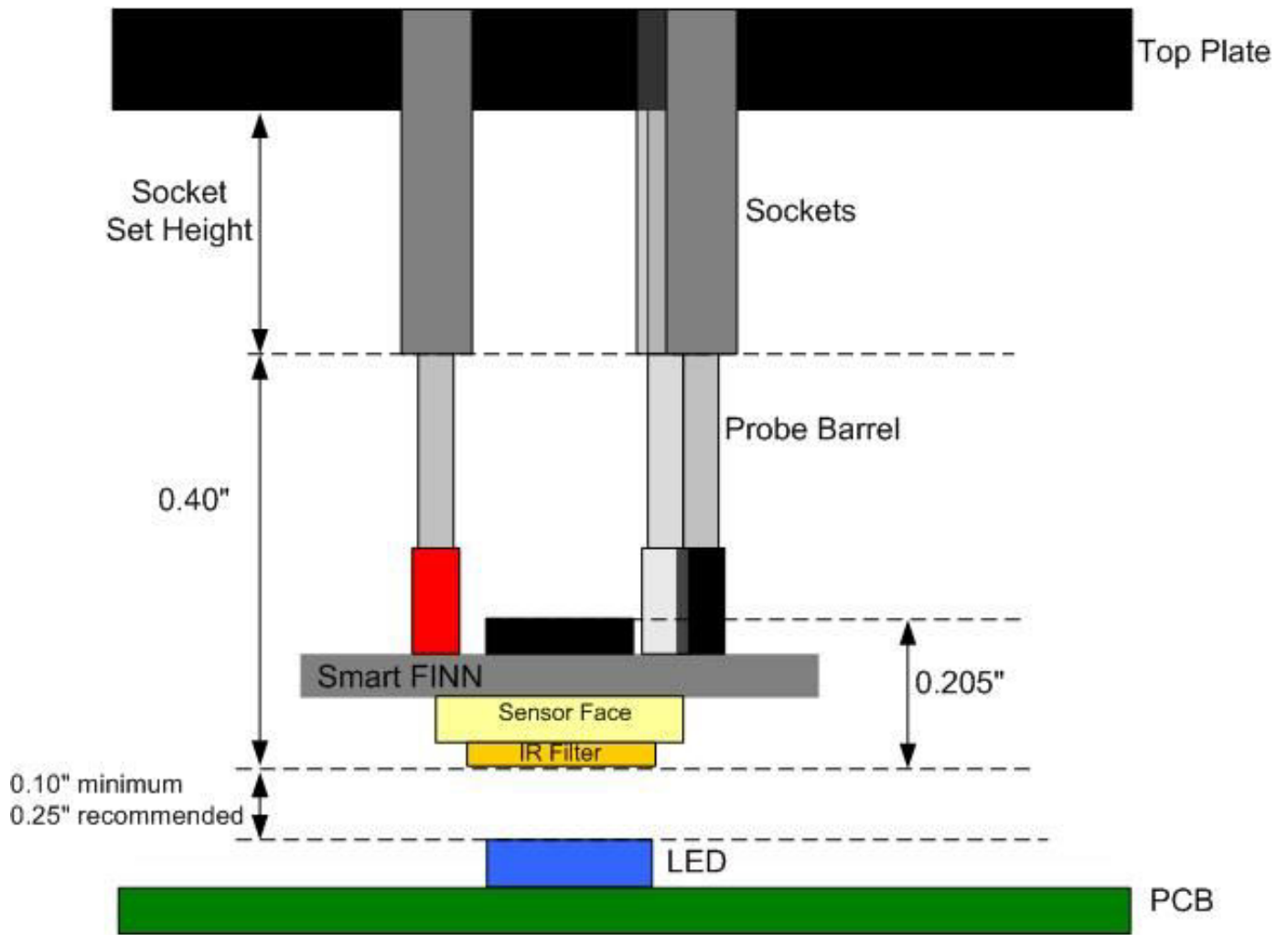


15.Drawing – TC11SF-R, Smart FINN® Right Angle



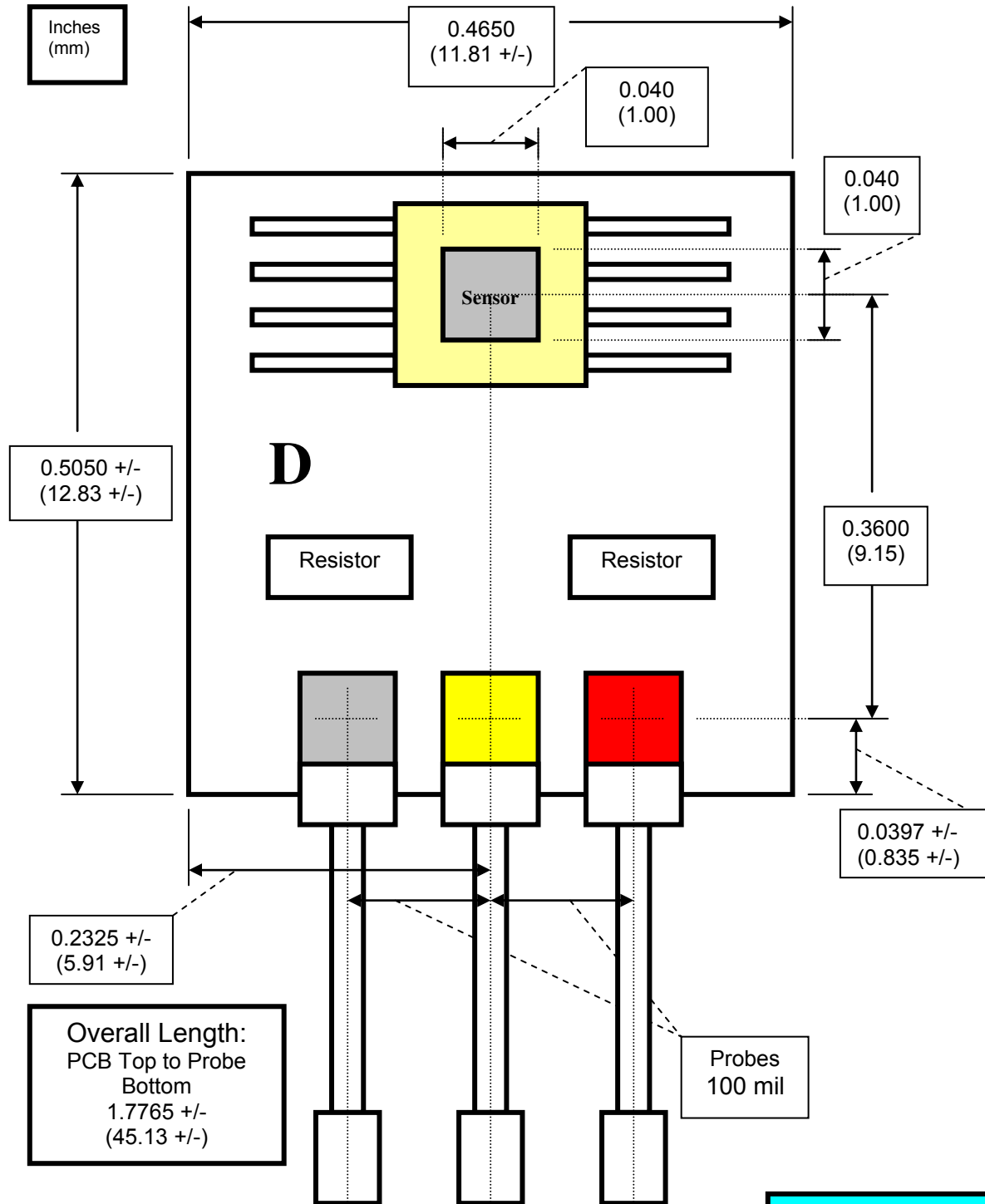
TC11SF-R
Top/Sensor View

16. Set Height for Right Angle Smart FINN[®]



Note: Drawing not to scale.

17.Drawing – TC11SF-V, Smart FINN® Vertical



**TC11SF-V
Sensor View**

18. Technical Support

Our product engineers are available to assist you with choosing the correct FINN™ product to fit your specific needs as well as to answer any technical questions you may have regarding installation and/or implementation.

Please contact us at:

Email: FINNsales@FINNTest.com

Phone: 224-662-0383

19. Revision History and Control

19.1. Rev D 3.0 – January 2016

No Rev Change to part - Logo and layout changes to manual only. Added information on new part: Smart FINN Bright.

19.2. Rev D 3.0 – December 2010

The Smart FINN TC11SF-x incorporates new part changes which have some minor effects on its functionality. Please review the following details outlining these changes.

- A new RGB color sensor replaces the previous, now obsolete sensor.
- The new sensor incorporates an Infra Red filter which reduces the IR effects on the Smart FINN readings.
- The surface area of the new sensor is slightly smaller. To compensate for this, the Smart FINN now includes a diffuser which aids in reading non-diffused LEDs. Another benefit of the diffuser is that the Smart FINN can now measure brighter LEDs without going into saturation. However, the Smart FINN saturation output frequency (2.02k HZ) did not change.
- The new sensor, with the Infra Red filter, is 0.025" taller than the old sensor. Please note this height change when setting the recommended clearance between the LED and the sensor.
- Although the frequency response has changed slightly, the ability to discriminate between colors is improved over the old revision Smart FINNs. All part changes have been adjusted for in the new firmware for the Smart FINN TC11SF-x. **** Please see Appendix A to compare TC08SF-x and TC11SF-x readings.**
- The Smart FINN printed circuit board for the TC11SF-R is now marked with "REV D" located above the sensor. The printed circuit board for the TC11SF-V, TC11SF-C, and TC11SF-L is now marked with a letter "D" at the bottom left of the sensor. Prior version boards are marked with 'C' instead of 'D'.
- New part numbers are:
 - TC11SF-R Smart FINN® Right Angle
 - TC11SF-V Smart FINN® Vertical
 - TC11SF-C 3-Pin Header Connector Smart® FINN (no probes)
 - TC11SF-L L-shaped Smart® FINN



19.3. Rev C 2.5 – June 2009

- Corrected an error in section 6.1 regarding the output voltage.
- Changed example in section 6.2 regarding the frequency output to match typical values provided in “Typical Measurements” table in Section 5.5.

19.4. Rev C 2.5 – January 2008

The manufacturer of the sensor used on the Smart FINN product has made a slight change to their sensor. The original part is now obsolete and has been replaced with a new part. As of January 1, 2008, the Smart FINN will have the new sensor. Although in most cases, this change will be functionally transparent, some users may notice a very slight change in readings.

Minor firmware changes were made to compensate for the manufacturer part change of the sensor. The difference is most notable on blue or blue-green LEDs.

The new replacement parts are mechanically equivalent to the now obsolete part.

The new part numbers are:

TC08SF-R Smart FINN[®] Right Angle
 TC08SF-V Smart FINN[®] Vertical
 TC08SF-C 3-Pin Header Connector Smart[®] FINN (no probes)
 TC08SF-L L-shaped Smart[®] FINN

- PCB Marking Change

The new Smart FINN can be easily identified visually by a resistor component marking change from 103 to 123.

19.5. Rev C 2.42 – August 2006

As of August 1, 2006, a lead-free version of Smart FINN[®] became available.

The lead-free PCB of the Right Angle Smart FINN[®] (TC03SF-R) is marked with “REV C” at the top of the sensor.

The firmware code remained at revision 2.42.

- PCB Marking Change

The lead-free PCB of the Vertical Smart FINN[®] (TC03SF-V) is marked with a letter “C” at the bottom left of the sensor

19.6. Rev B 2.42 – March 2005

As of March 17, 2005 the following enhancements were completed on the Smart FINN[®].

- Improved Accuracy - New Output Frequency Readings

The sampling algorithm was enhanced, improving the accuracy of the sensor readings and the output frequency. As a result, some minor changes to the output frequency may be noticed from the previous revision. The new output frequency readings for revision 2.42 are listed in The Table of Typical Readings.



- PCB Marking Change

The 2.42 revision code may be physically identified by a marking on the black PCB of the Smart FINN®.

The PCB of the Right Angle Smart FINN® (TC03SF-R) is marked with “REV B” at the top of the sensor.

The PCB of the Vertical Smart FINN® (TC03SF-V) is marked with a letter “B” at the bottom left of the sensor.

20.APPENDIX A

Reading differences from TC08SF-x (Rev 2.5) to TC11SF-x (Rev 3.0).

Typical Measurements			
Color	nm	Smart FINN Rev 2.5 (kHz)	Smart FINN Rev 3.0 (kHz)
Red	635	11.7	12.2
Amber	608	10.6	10.6
Yellow	585	9.1	9.3
Green	565	8.5	8.5
Blue	470	6.90	6.80
Other Measurements			
Infrared	Up to 660	12.1-12.5	12.5
Ultraviolet	Down to 380	6.25-6.8	6.25-6.50
Fluorescent	multiple	4.0	4.0
White(red dominant)	multiple	4.4-6.0	4.4-6.0
White(blue dominant)	multiple	3.2-4.0	3.2-4.0
Saturation	n/a	2.02	2.02
Dark	n/a	0.998	0.998

Typical Measurements for Revision 2.5

TYPICAL MEASUREMENTS @Vdd=5.0				
Color	nm	mcd	kHz	Vdc
Red	635	150	11.7	4.5
Amber	608	10	10.6	2.0
Yellow	585	150	9.1	4.0
Green	565	150	8.5	3.0
Blue	430	x	6.9	x
OTHER MEASUREMENTS @Vdd=5.0				
Infrared	Up to 660	x	12.1-12.5	x
Ultraviolet	Down to 380	x	6.25-6.8	x
Fluorescent	multiple	x	4.0	x
White(red dominant)	multiple	x	4.4-6.0	x
White(blue dominant)	multiple	x	3.2-4.0	x
Saturation	n/a	Above 200*	2.02	4.8
Dark	n/a	Below 1*	0.998	0.2

Typical Measurements for Revision 2.3

TYPICAL MEASUREMENTS @Vdd=5.0				
Color	nm	mcd	kHz	Vdc
Red	635	150	12.0	4.5
Amber	608	10	10.6	3.0
Yellow	585	150	9.38	4.3
Green	565	150	8.68	4.0
Blue	430	x	6.90	x
OTHER MEASUREMENTS@Vdd=5.0				
Infrared	Up to 660	x	12.1-12.5	x
Ultraviolet	Down to 380	x	6.25-6.8	x
Fluorescent	multiple	x	4.0	x
White(red dominant)	multiple	x	4.4-6.0	x
White(blue dominant)	multiple	x	3.2-4.0	x
Saturation	n/a	Above 200*	1.996	4.8
Dark	n/a	Below 1*	0.998	0.2