TUNED LED DRIVER AND OPTICAL RECEIVER SCHEME FOR DETECTING THE PRESENCE OF VIALS WITHIN THE TOM CAT SYSTEM`

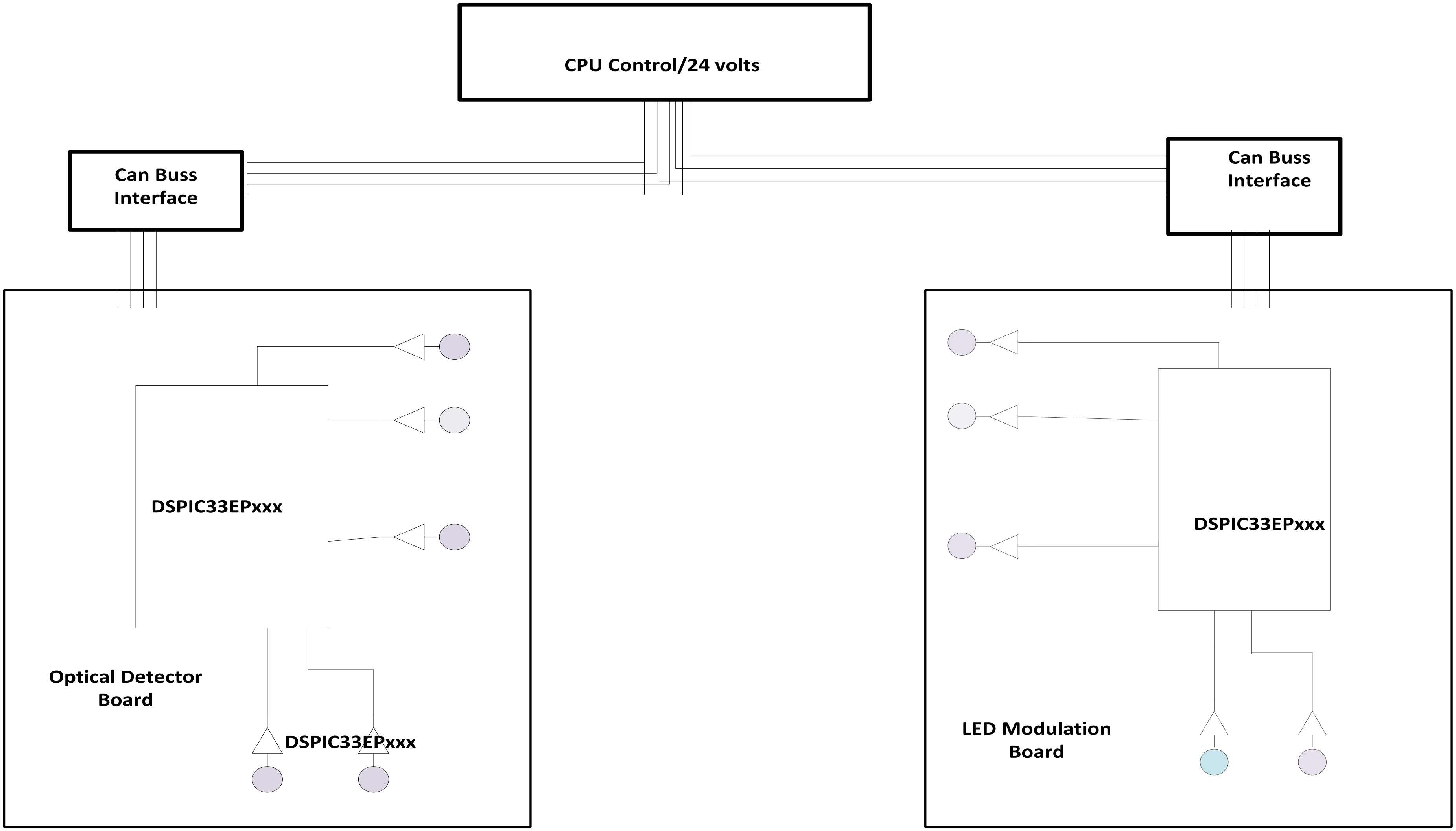
Optical detection scheme has the following features:

1. Five tunable (software controlled) LED drivers.
2. Five fixed frequency (hardware tuned) optical receivers.
3. CAN Bus communications with CPU control.
4. Precision mechanical mounts.

Summary of development efforts :

1. Five led/optical detector PCBs have been developed. Circuit enhancements discovered during testing will be added. (I.e. LED current control.)
2. A new revision of Lab View vial to accommodate five detection channel is under development.
3. A calibration/tuning algorithm and firmware operating with desk top application has been developed.
4. A variety of RED and IR LEDS have been evaluated

Simplified Vial Detection Concept implemented with the DsPic33EPxxx



Theory of Operation for the Vial Sensor Optical Detection Hardware

- Five LED light sources are modulated at frequencies ranging between 18khz and 40khz. (Optical detector response rolls off after 40khz).
- LEDs are selected to operate at 940nm for all channels.
- Five optical detectors are used that have a peak optical response at 900nm.
- An additional index channel will be will be used to detect proper placement of a vial carrier on a track. (This can be the lowest response channel).
- Modulation channels are separated by a minimum of 3 to 5khz overall. Modulation frequencies are best when not set at an even or odd harmonic of an adjacent channel. (This improve cross modulation).
- The Detection channels have a bandwidth of less than 14%. Overall channel bandwidth is related to component selection and modulation light intensity. (More light increases the bandwidth).
- Modulation frequency is selected to give the best channel separation with detection channels that are adjacent to each other.
- **Note: Detector channel response improves slightly with increased frequency of operation. See 567 PLL data sheet.**
- **An example is the Encoder channels:** The light path is very close in proximity. In the prototype, we use two 940nm LEDs each modulated at 30khz and 40khz respectively. The frequencies selected improve response at each channel. The lower vial sensor is set to 33khz, a frequency that helps with response and has good channel separation from the upper vial sensor which is set to 27khz.

- The DsPic33EP13x has a quadrature encoder module. This will be used to detect vial carrier placement and forward /backward motion of the carrier.

Vial Sensor Tuning Procedure for the Vial Detection Hardware

Tuning the Vial Detection hardware follows the procedure below:

Best case 0.1%(< 100ppm) resistors are selected around 1% NPO ceramic capacitors for each frequency of interest.

The detection channel center frequencies are calculated using a spread sheet.

The center modulation frequency, for each LED, is determined by sweeping the frequency of each LED until the until the bandwidth of the detection channel is captured. (Center frequency is = Bandwidth /2 – highest detected frequency)

When tuning each detection channel , LEDs that are not in the modulation path are turned off. (i.e. when tuning the upper vial channel, the lower vial, index, and encoder channel LEDS are turned off).

The procedure is repeated for each detection channel.

Upon completion of the above tuning, the modulation source for the detection channel "under test" is turned off.

Adjacent channels are unmasked. If the detection channel "under test" does not activate**, go active low,** the channel is properly tuned. (i.e. when testing the upper vial detection channel tuning , the upper vial LED is masked and the lower vial and encoder LEDS are allowed to modulate.)

The procedure is repeated for each detection channel.

The above procedure is repeated until all channels are properly tuned and there is no cross modulation.

IR Optical Sensor with integrated TIA

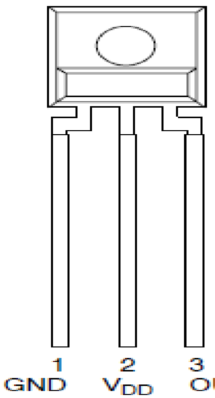
TAOS TEXAS ADVANCED OPTOELECTRONIC SOLUTIONS®

TSL260R, TSL261R, TSL262R
INFRARED LIGHT-TO-VOLTAGE OPTICAL SENSORS

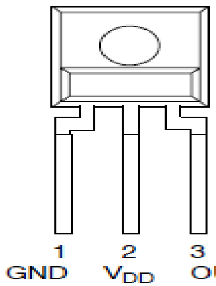
TAOS049E –SEPTEMBER 2007

- Integral Visible Light Cutoff Filter
- Monolithic Silicon IC Containing Photodiode, Operational Amplifier, and Feedback Components
- Converts Light Intensity to a Voltage
- High Irradiance Responsivity, Typically 111 mV/(μW/cm^2) at λ_p = 940 nm (TSL260R)
- Compact 3-Lead Plastic Package
- Single Voltage Supply Operation
- Low Dark (Offset) Voltage....10mV Max
- Low Supply Current......1.1 mA Typical
- Wide Supply-Voltage Range.... 2.7 V to 5.5 V
- Replacements for TSL260, TSL261, and TSL262
- RoHS Compliant (–LF Package Only)

PACKAGE S
SIDELOOKER
(FRONT VIEW)



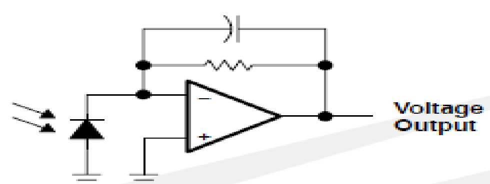
PACKAGE SM
SURFACE MOUNT
SIDELOOKER
(FRONT VIEW)



Description

The TSL260R, TSL261R, and TSL262R are infrared light-to-voltage optical sensors, each combining a photodiode and a transimpedance amplifier (feedback resistor = 16 MΩ, 8 MΩ, and 2.8 MΩ respectively) on a single monolithic IC. Output voltage is directly proportional to the light intensity (irradiance) on the photodiode. These devices have improved amplifier offset-voltage stability and low power consumption and are supplied in a 3-lead plastic sidelooker package with an integral visible light cutoff filter and lens. When supplied in the lead (Pb) free package, the device is RoHS compliant.

Functional Block Diagram



IR Sensor Response Curves.

TYPICAL CHARACTERISTICS

OUTPUT VOLTAGE
vs
IRRADIANCE

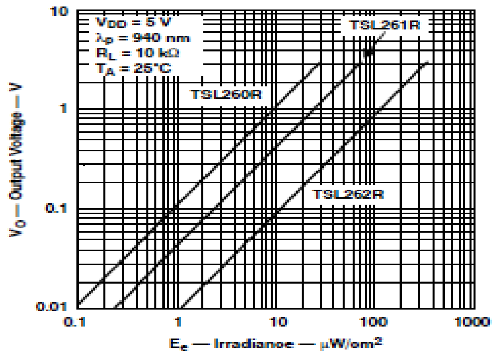


Figure 3

PHOTODIODE SPECTRAL RESPONSIVITY

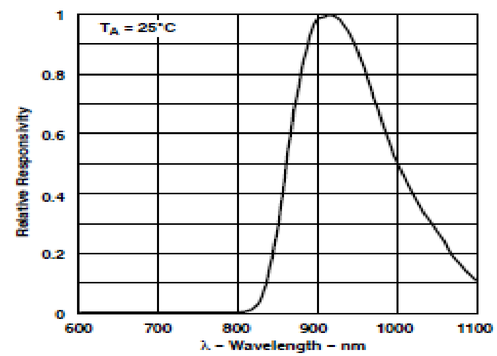


Figure 4

MAXIMUM OUTPUT VOLTAGE
vs
SUPPLY VOLTAGE

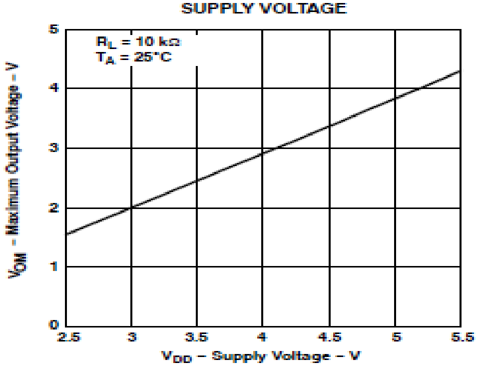


Figure 5

SUPPLY CURRENT
vs
OUTPUT VOLTAGE

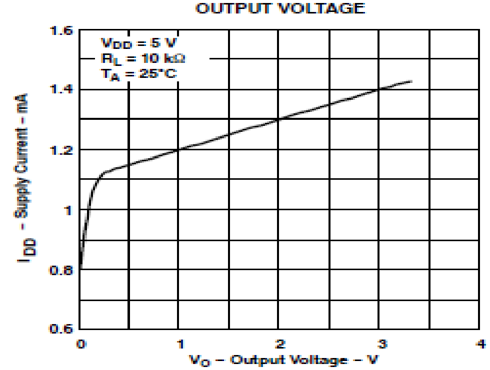


Figure 6

LM567 FEATURES AND CALCULATIONS

TEXAS INSTRUMENTS

LM567, LM567C

www.ti.com

SNOSBQ4D – MAY 1999 – REVISED MARCH 2013

LM567/LM567C Tone Decoder

Check for Samples: LM567, LM567C

FEATURES

- 20 to 1 Frequency Range with an External Resistor
- Logic Compatible Output with 100 mA Current Sinking Capability
- Bandwidth Adjustable from 0 to 14%
- High Rejection of Out of Band Signals and Noise
- Immunity to False Signals
- Highly Stable Center Frequency
- Center Frequency Adjustable from 0.01 Hz to 500 kHz

APPLICATIONS

- Touch Tone Decoding
- Precision Oscillator
- Frequency Monitoring and Control
- Wide Band FSK Demodulation
- Ultrasonic Controls
- Carrier Current Remote Controls
- Communications Paging Decoders

DESCRIPTION

The LM567 and LM567C are general purpose tone decoders designed to provide a saturated transistor switch to ground when an input signal is present within the passband. The circuit consists of an I and Q detector driven by a voltage controlled oscillator which determines the center frequency of the decoder. External components are used to independently set center frequency, bandwidth and output delay.

CONNECTION DIAGRAM

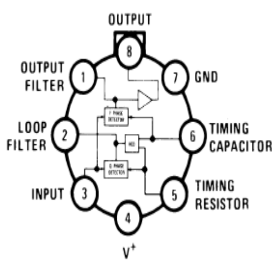


Figure 1. Metal Can Package
Top View
See Package Number LMC0008C
OBSOLETE

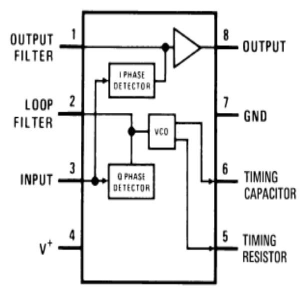
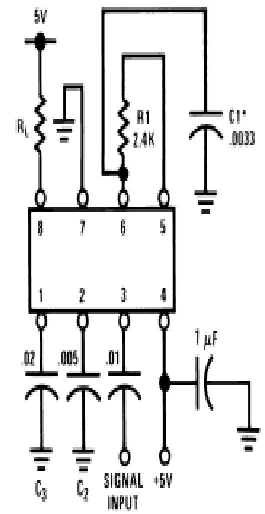


Figure 2. PDIP and SOIC Packages
Top View
See Package Number D0008A
See Package Number P0008E

AC TEST CIRCUIT



f_i = 100 kHz + 5V

***Note:** Adjust for f_o = 100 kHz.

APPLICATIONS INFORMATION

The center frequency of the tone decoder is equal to the free running frequency of the VCO. This is given by

$$f_o \cong \frac{1}{1.1\, R_1 C_1}$$

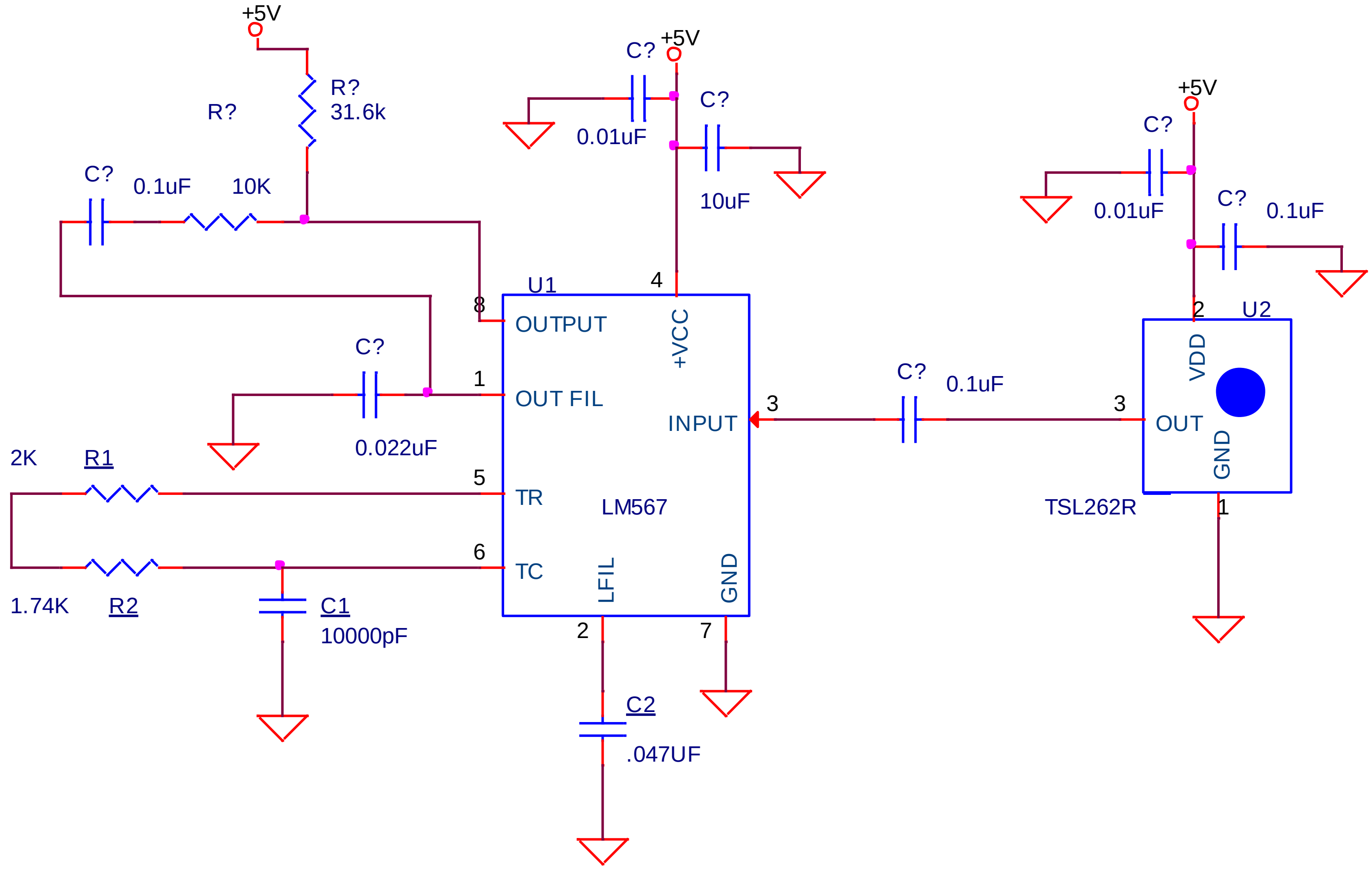
The bandwidth of the filter may be found from the approximation

$$BW = 1070 \sqrt{\frac{V_i}{f_o C_2}} \text{ in \% of } f_o$$

where

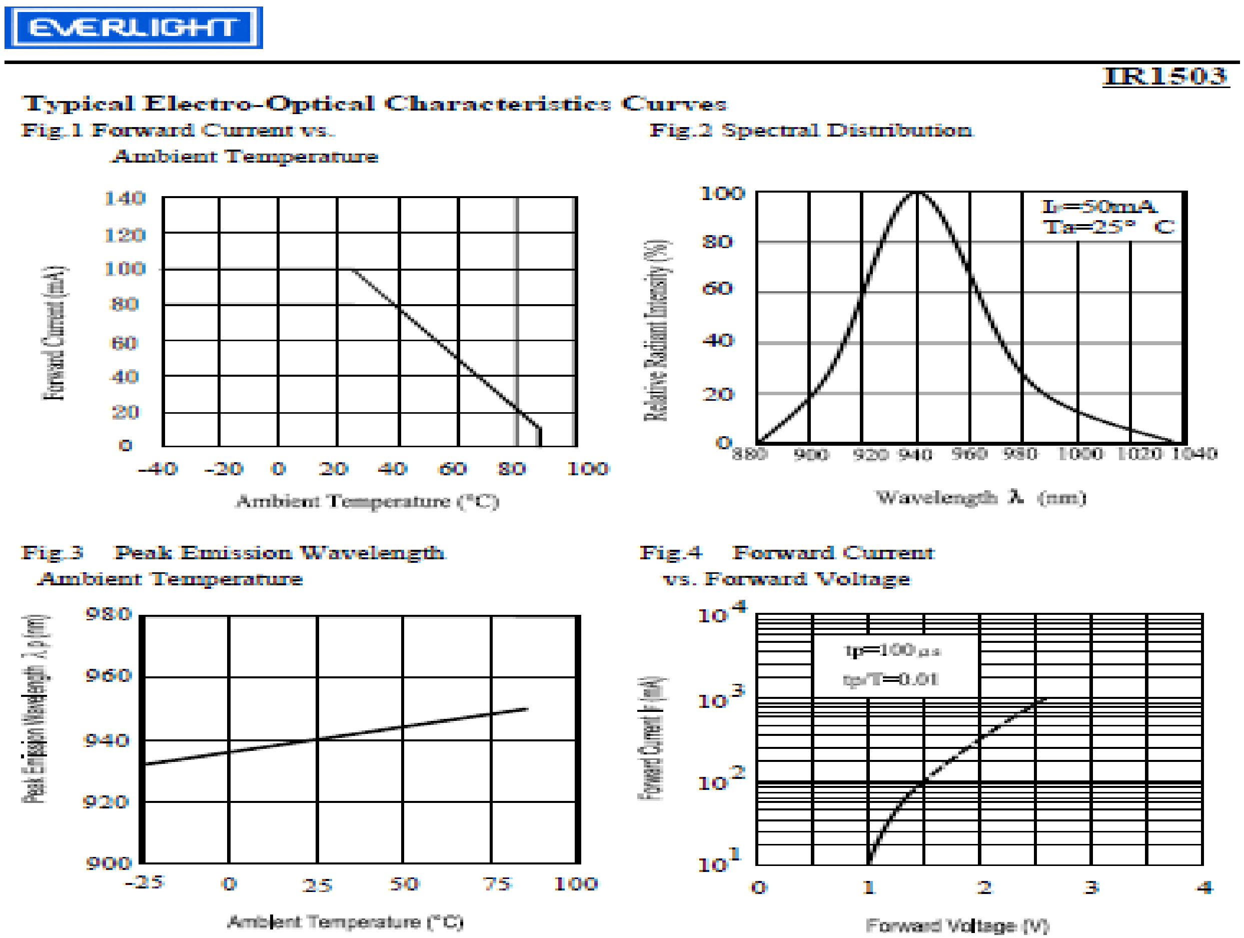
- V_i = Input voltage (volts rms), $V_i \le 200$mV
- C_2 = Capacitance at Pin 2(µF)

Example Tone Decoder Circuit



- Example of Upper Vial Decoder (Fo approximately = 27hz)
- R1=2k, R2=1.74K, C1=10000pF, C2=.047uF

Everlight IR1503 LED



IR1503 Operating Parameters

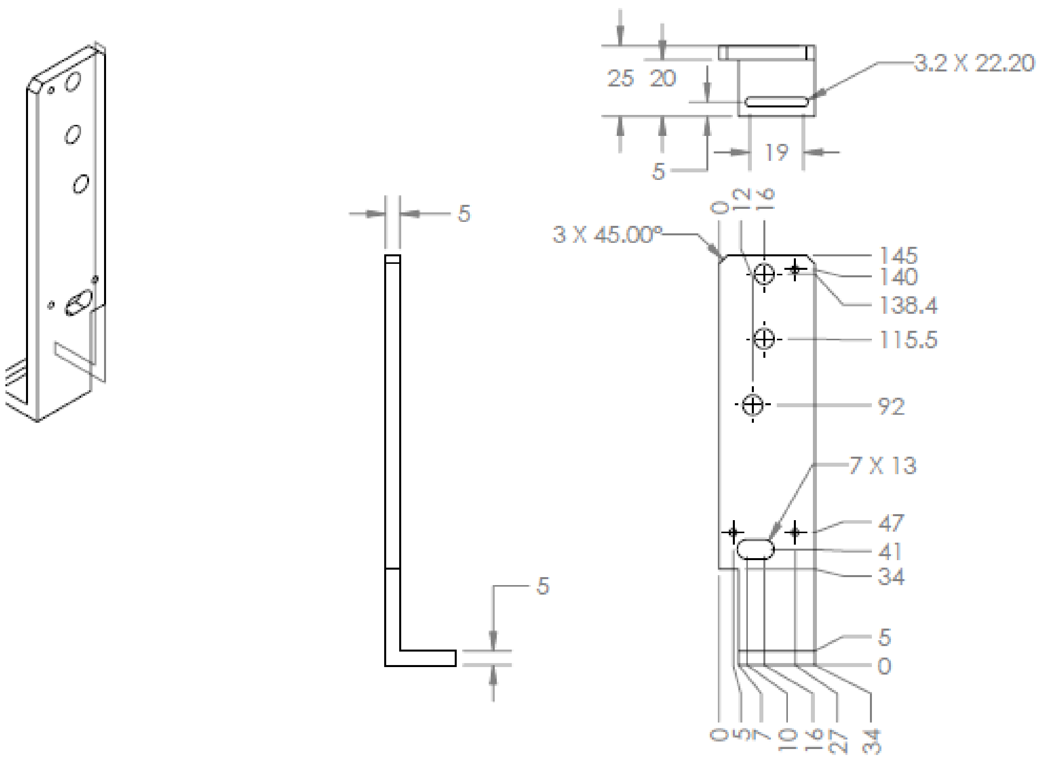
EVERLIGHT

IR1503

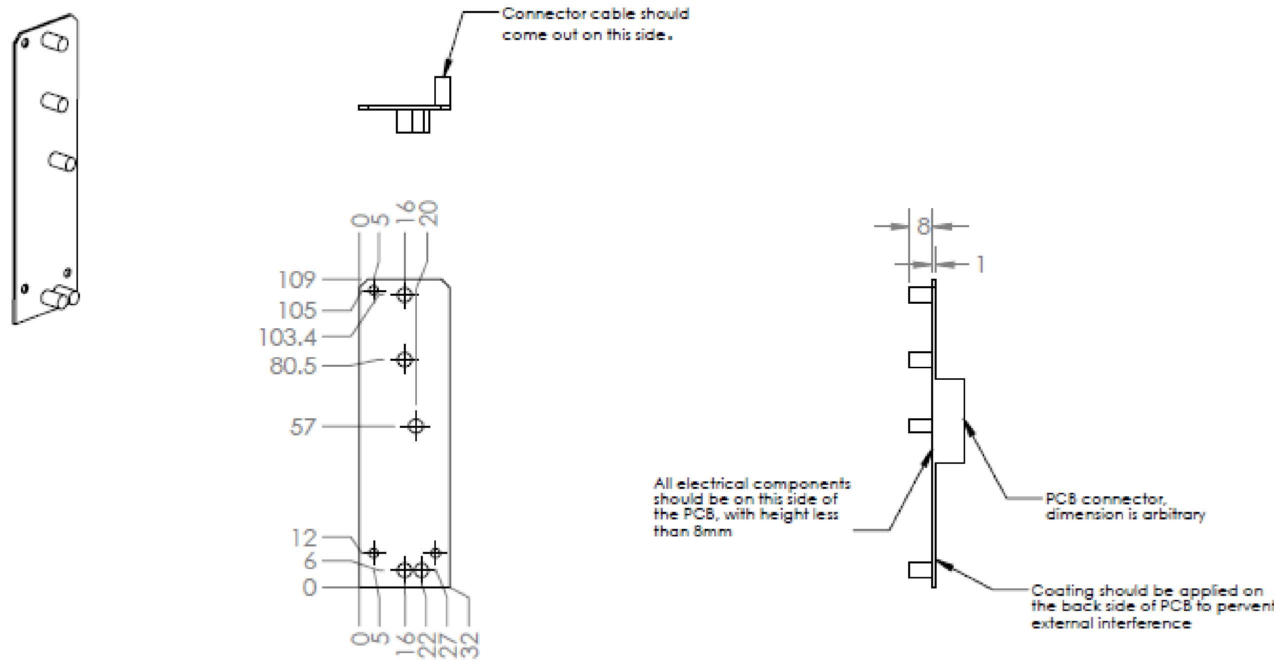
Electro-Optical Characteristics (Ta=25℃)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Units
Radiant Intensity	Ee	I_F=20mA	21	28	--	mW/sr
		I_F=100mA Pulse Width≦100μs ,Duty≦1%	--	120	--	
		I_F=1A Pulse Width≦100μs ,Duty≦1%.	--	1000	--	
Peak Wavelength	λp	I_F=20mA	--	940	--	nm
Spectral Bandwidth	Δλ	I_F=20mA	--	80	--	nm
Forward Voltage	V_F	I_F=20mA		1.2	1.5	V
		I_F=100mA Pulse Width≦100μs ,Duty≦1%	--	1.4	1.85	
		I_F=1A Pulse Width≦100μs ,Duty≦1%.	--	2.6	4.0	
Reverse Current	I_R	V_R=5V	--	--	10	μA
View Angle	2θ1/2	I_F=20mA	--	20	--	deg

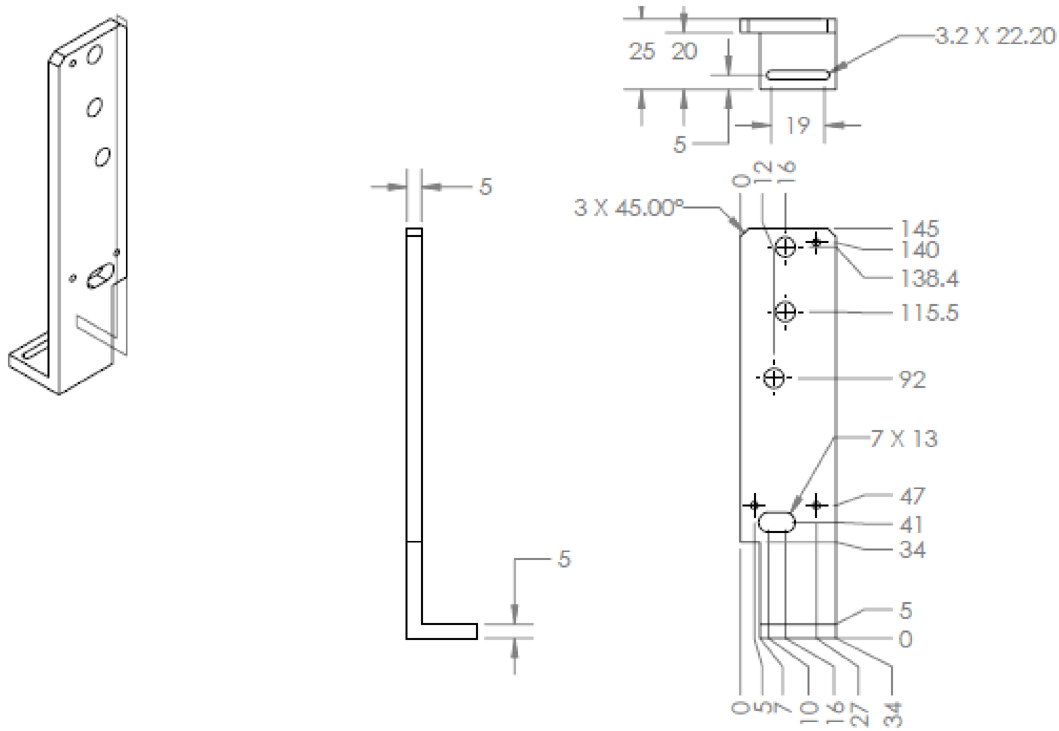
Detector board “mount “ for the Vial Detector PCB within Tom Cat System.



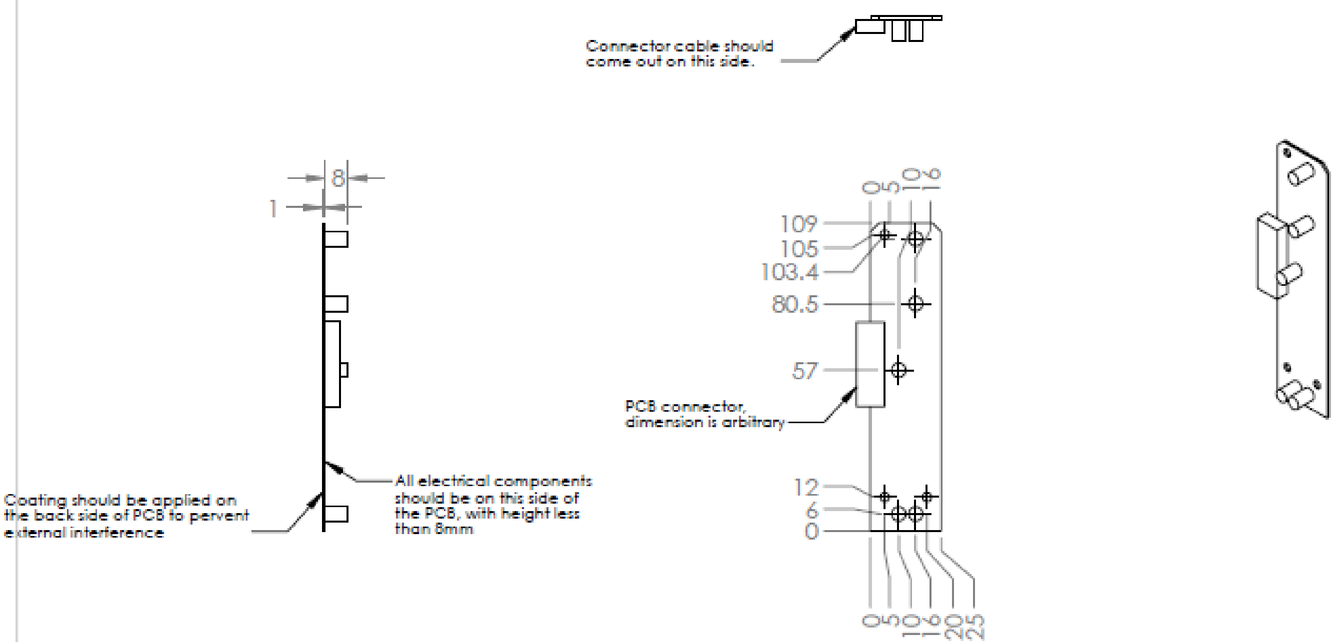
Detector PCB Dimensions for the Vial Detector PCB within Tom Cat.



LED PCB MOUNT



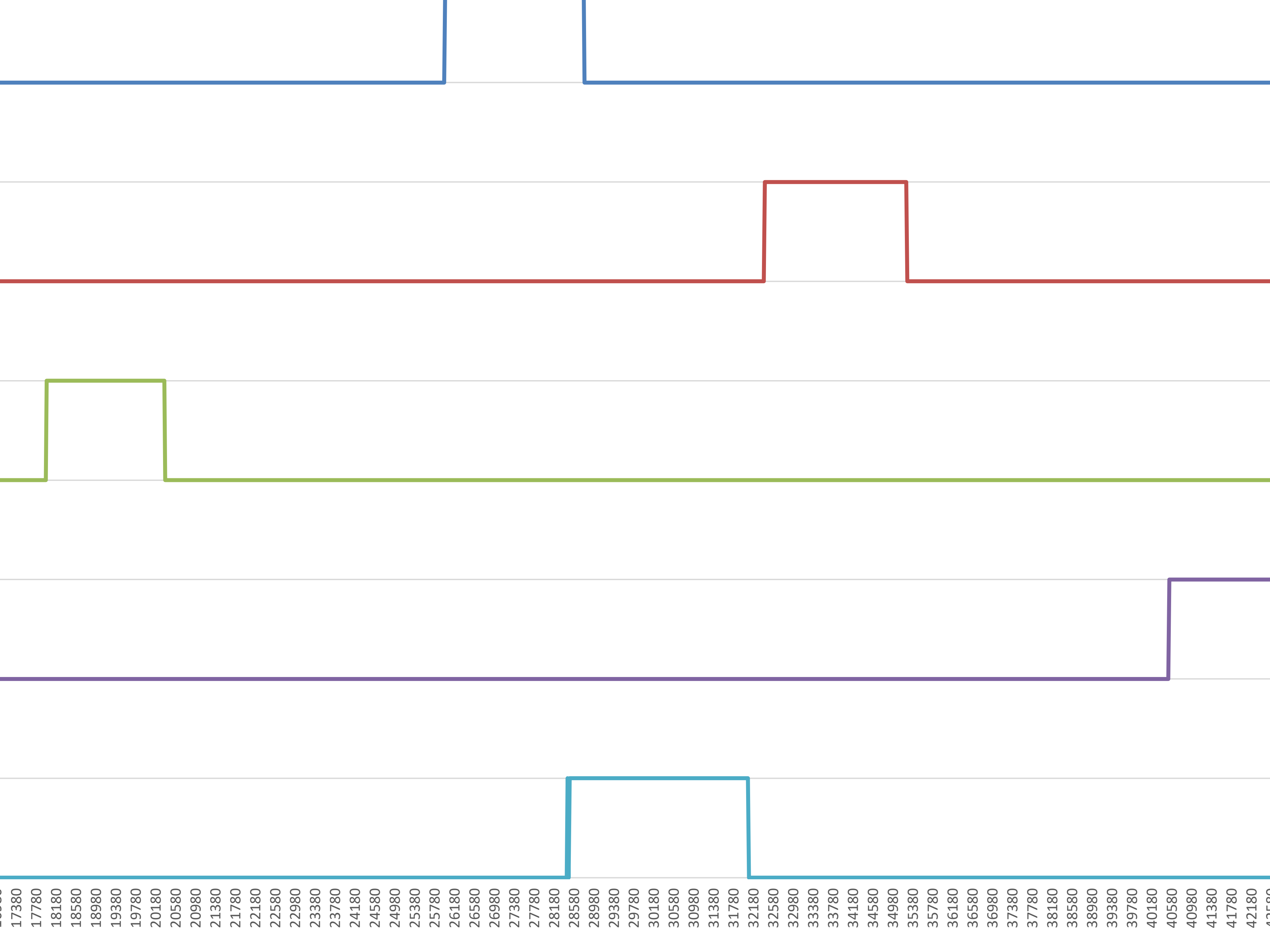
LED BOARD PCB DIMENSIONS



Summary of Testing to Date.

- A five channel “fixed frequency” optical detection scheme was developed and tested.(Four board sets were tested).
- Initial testing found that “cross modulation” at frequencies too close in detection will corrupt the detection event.
- Improvements were made by separating modulation/ detection channels by a minimum of 5 kHz.
- Due to the fast rise time of the LM567 tone decoders additional filtering and additional hysteresis was added to the detection circuitry with a dramatic reduction of glitching (easily a 99%) reduction.
- Tests have been successful at a variety of forward vial carrier velocities with the vial platform fully populated with vial carriers. Average rise time for a detection channel is less than 1millisecond (500ns for 40khz).
- The detection technique will sustain a forward velocity of less than 1 meter per second.
- This has been tested with an algorithm developed in Lab View.

This slide for performance summary of Optical Detectors


17380
17780
18180
18580
18980
19380
19780
20180
20580
20980
21380
21780
22180
22580
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23380
23780
24180
24580
24980
25380
25780
26180
26580
26980
27380
27780
28180
28580
28980
29380
29780
30180
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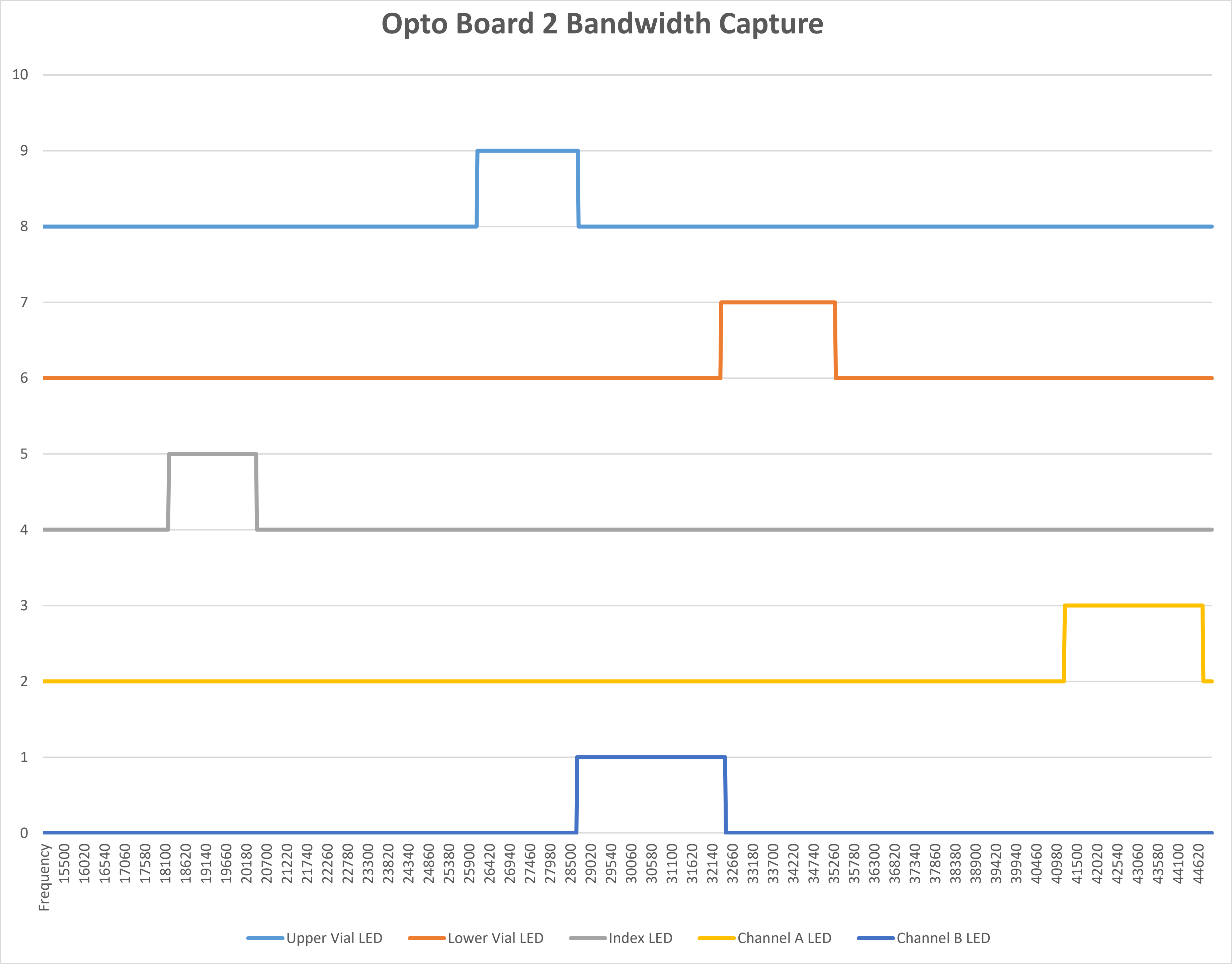
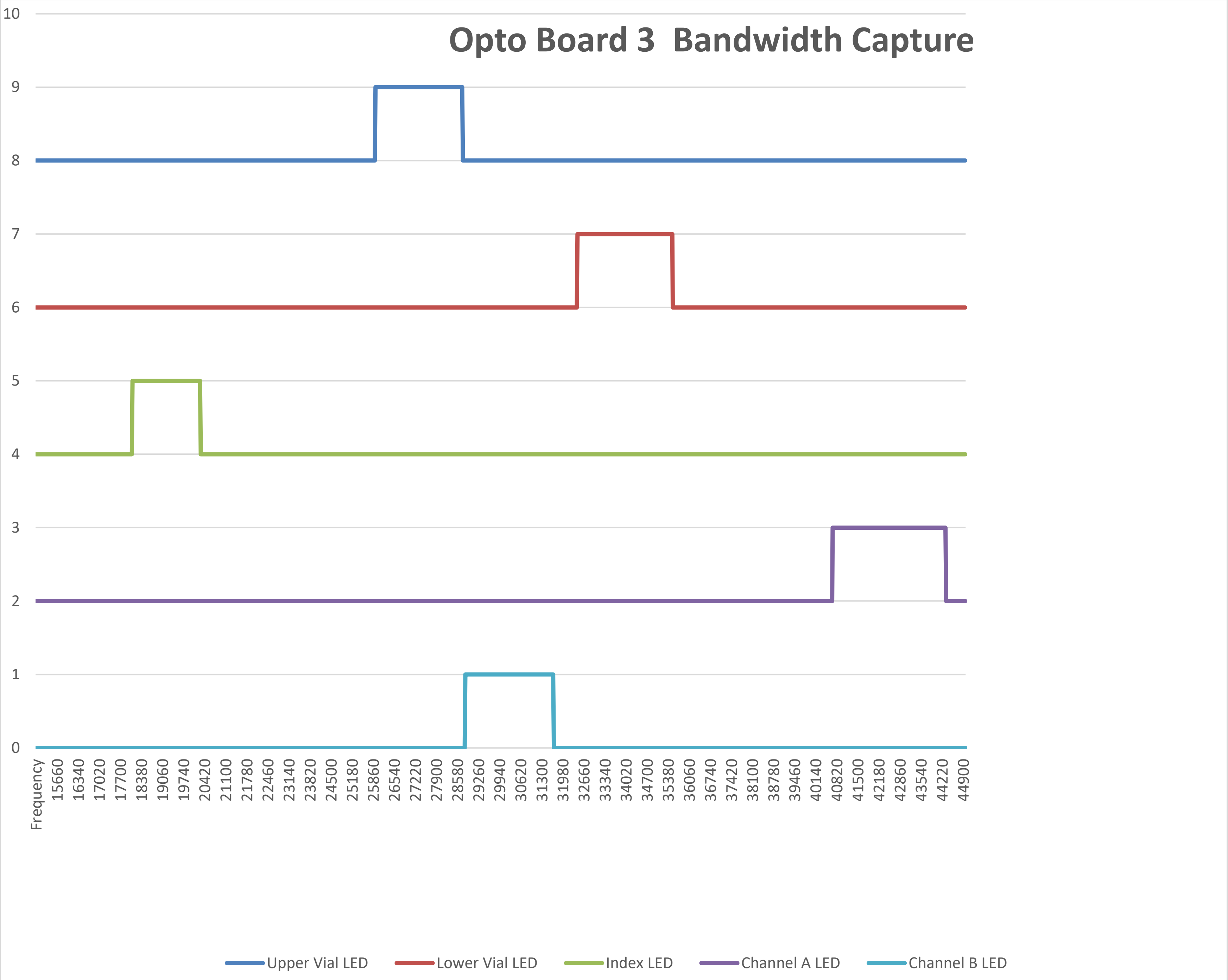
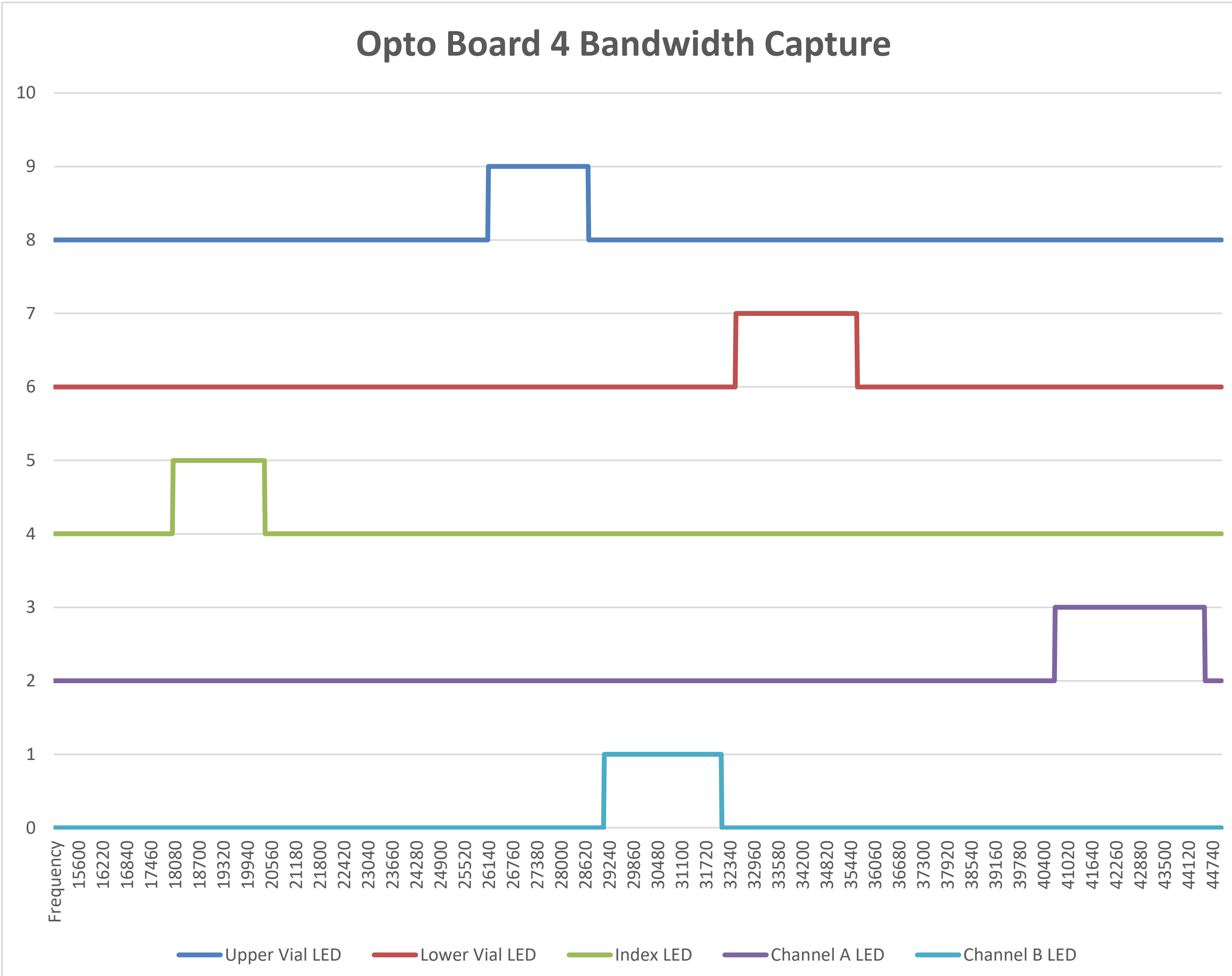
40980
41380
41780
42180



Opto Board 2 Bandwidth Capture
10
9
8
7
6
5
4
3
2
1
0
Frequency
15500
16020
16540
17060
17580
18100
18620
19140
19660
20180
20700
21220
21740
22260
22780
23300
23820
24340
24860
25380
25900
26420
26940
27460
27980
28500
29020
29540
30060
30580
31100
31620
32140
32660
33180
33700
34220
34740
35260
35780
36300
36820
37340
37860
38380
38900
39420
39940
40460
40980
41500
42020
42540
43060
43580
44100
44620
Upper Vial LED
Lower Vial LED
Index LED
Channel A LED
Channel B LED



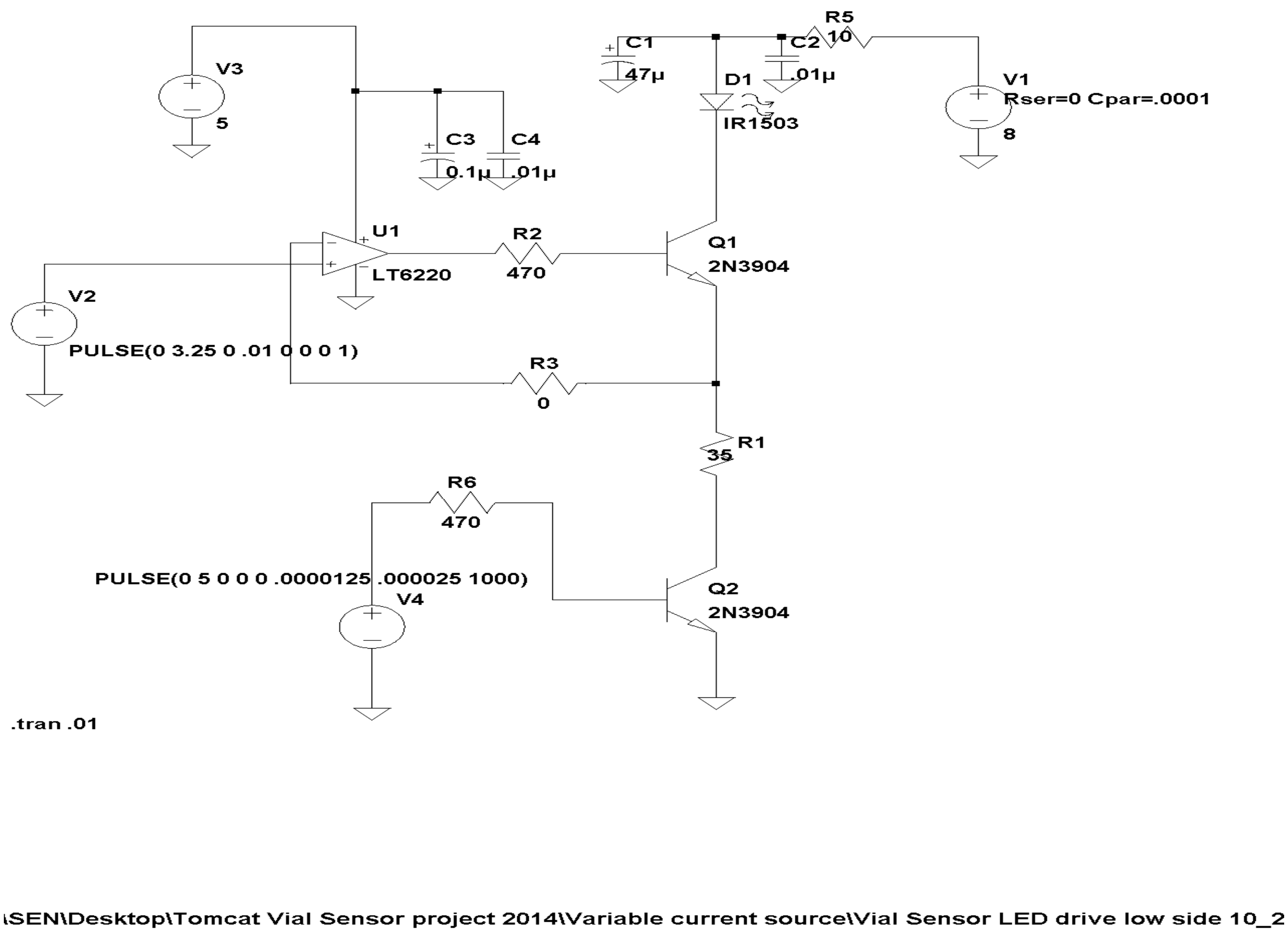
Opto Board 3 Bandwidth Capture
10
9
8
7
6
5
4
3
2
1
0
Frequency
15660
16340
17020
17700
18380
19060
19740
20420
21100
21780
22460
23140
23820
24500
25180
25860
26540
27220
27900
28580
29260
29940
30620
31300
31980
32660
33340
34020
34700
35380
36060
36740
37420
38100
38780
39460
40140
40820
41500
42180
42860
43540
44220
44900
Upper Vial LED
Lower Vial LED
Index LED
Channel A LED
Channel B LED


Opto Board 4 Bandwidth Capture
10
9
8
7
6
5
4
3
2
1
0
Frequency
15600
16220
16840
17460
18080
18700
19320
19940
20560
21180
21800
22420
23040
23660
24280
24900
25520
26140
26760
27380
28000
28620
29240
29860
30480
31100
31720
32340
32960
33580
34200
34820
35440
36060
36680
37300
37920
38540
39160
39780
40400
41020
41640
42260
42880
43500
44120
44740
Upper Vial LED
Lower Vial LED
Index LED
Channel A LED
Channel B LED

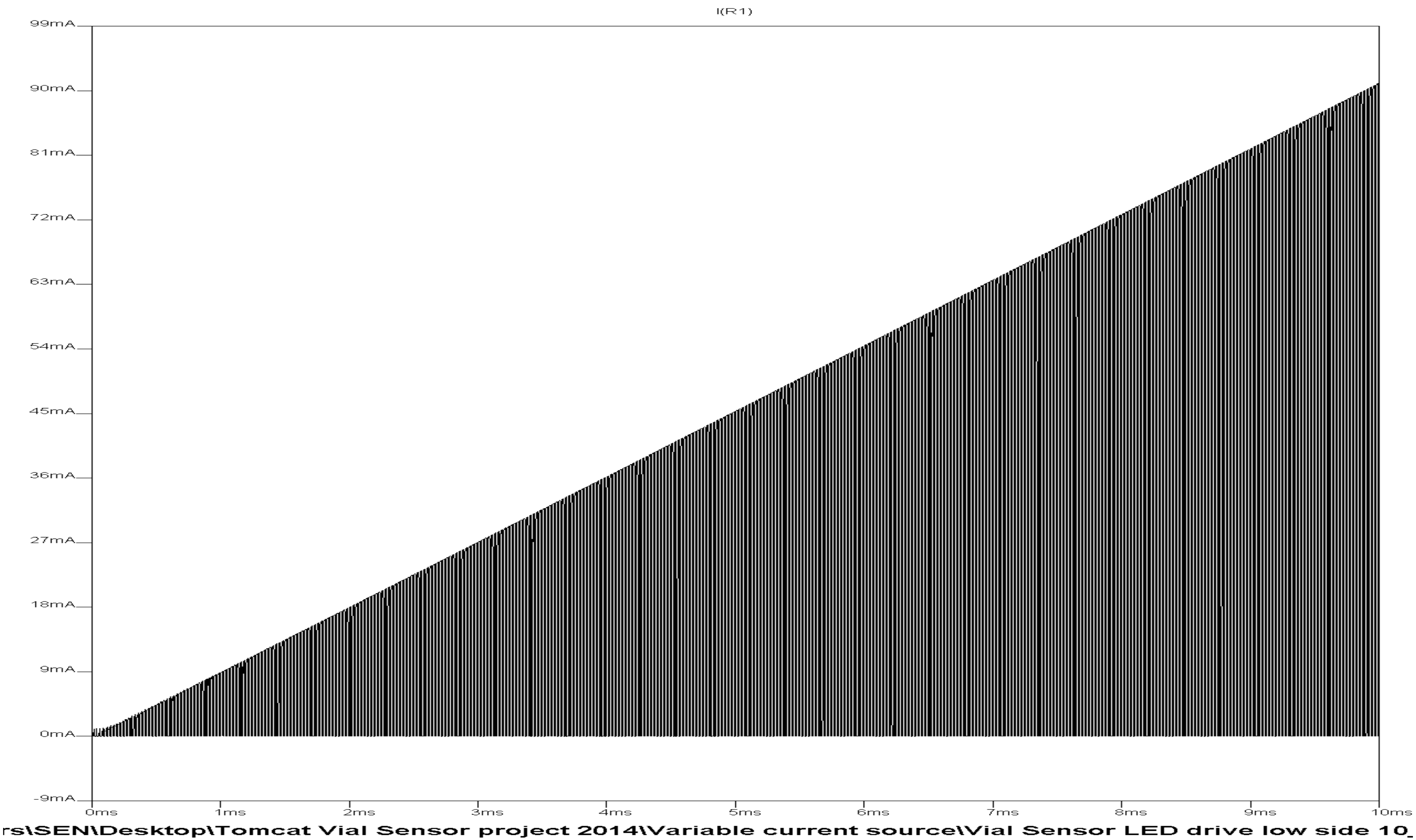
Design Improvements/Tom Cat System Integration

- Adding variable current control for the LEDs will eliminate the need for sorting LEDs.(Model results are included in this report)
- This can be used to equalize out LED intensity differences and potential shading effects with non optimal mechanical mounting.
- Enhancing the vial detection algorithm (adding the Index) channel will improve detection of “false” vial carrier insertion.
- Porting the Lab View algorithm to the DsPic. (Do we have enough code space with the existing DsPic ?)
- Integrate the Vial detection hardware into the Tom Cat system.

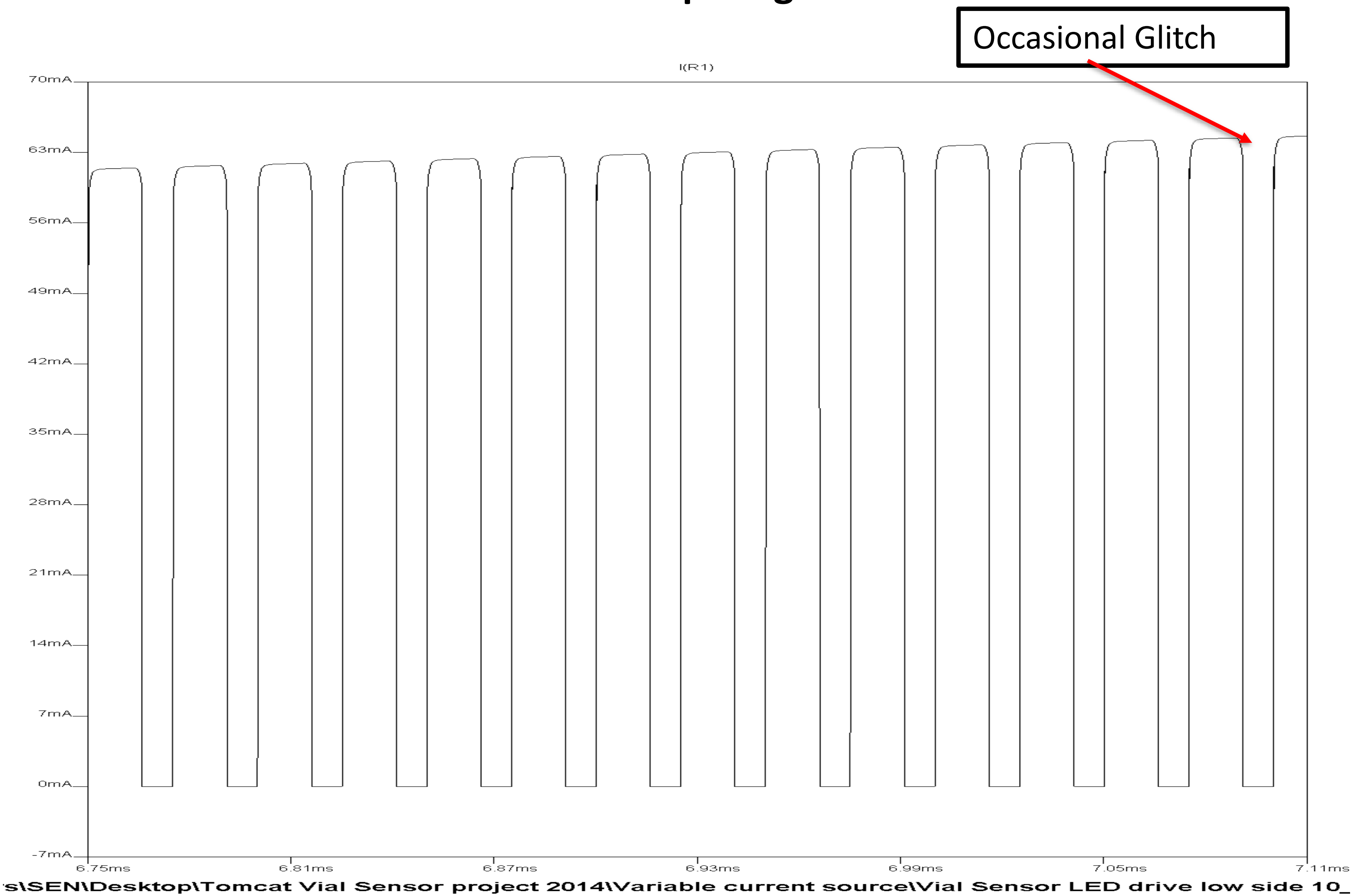
Spice Model of Variable Current Source and LED Drive



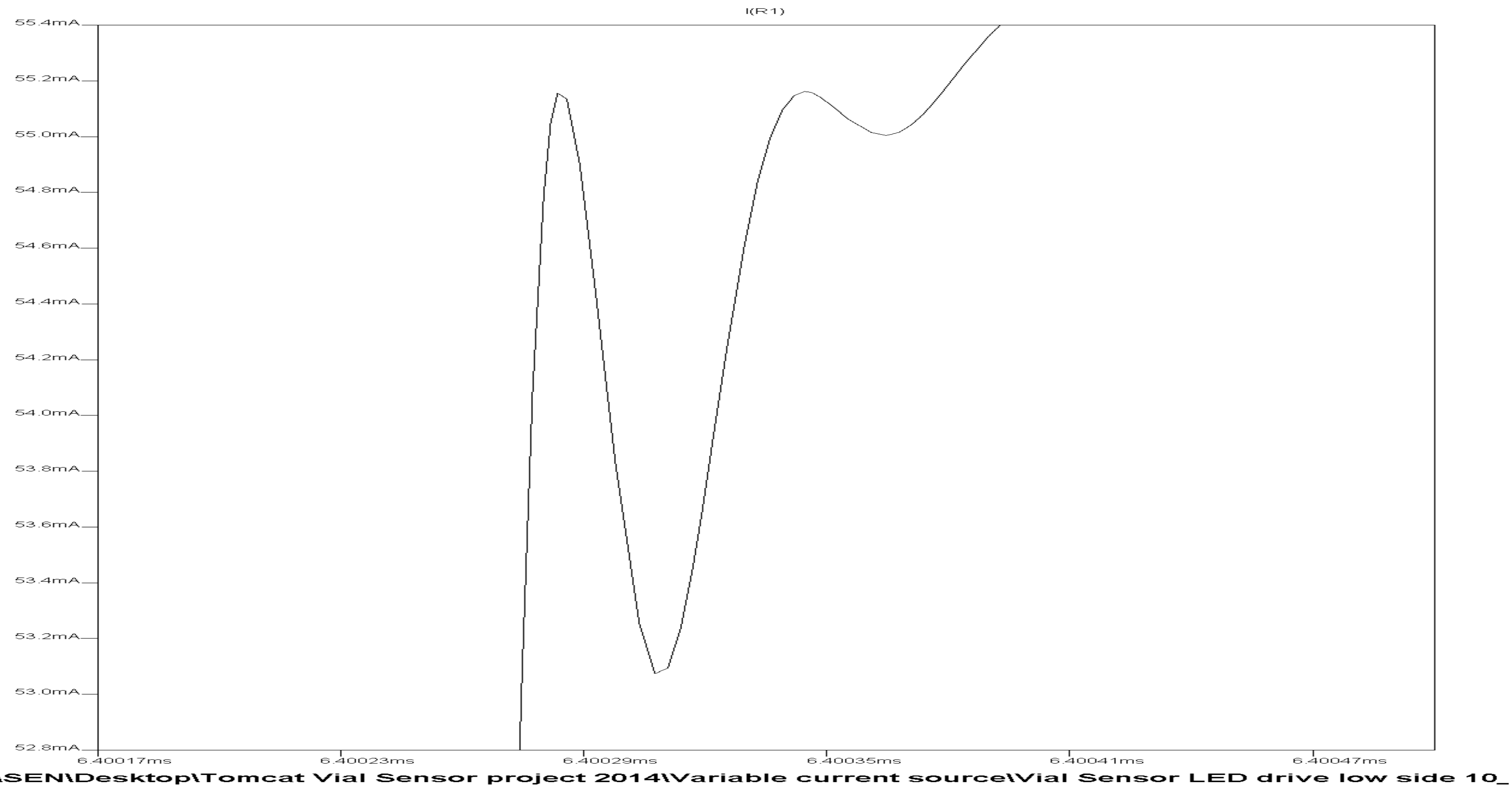
Linear Current Ramp Output Ramp (Modeled)



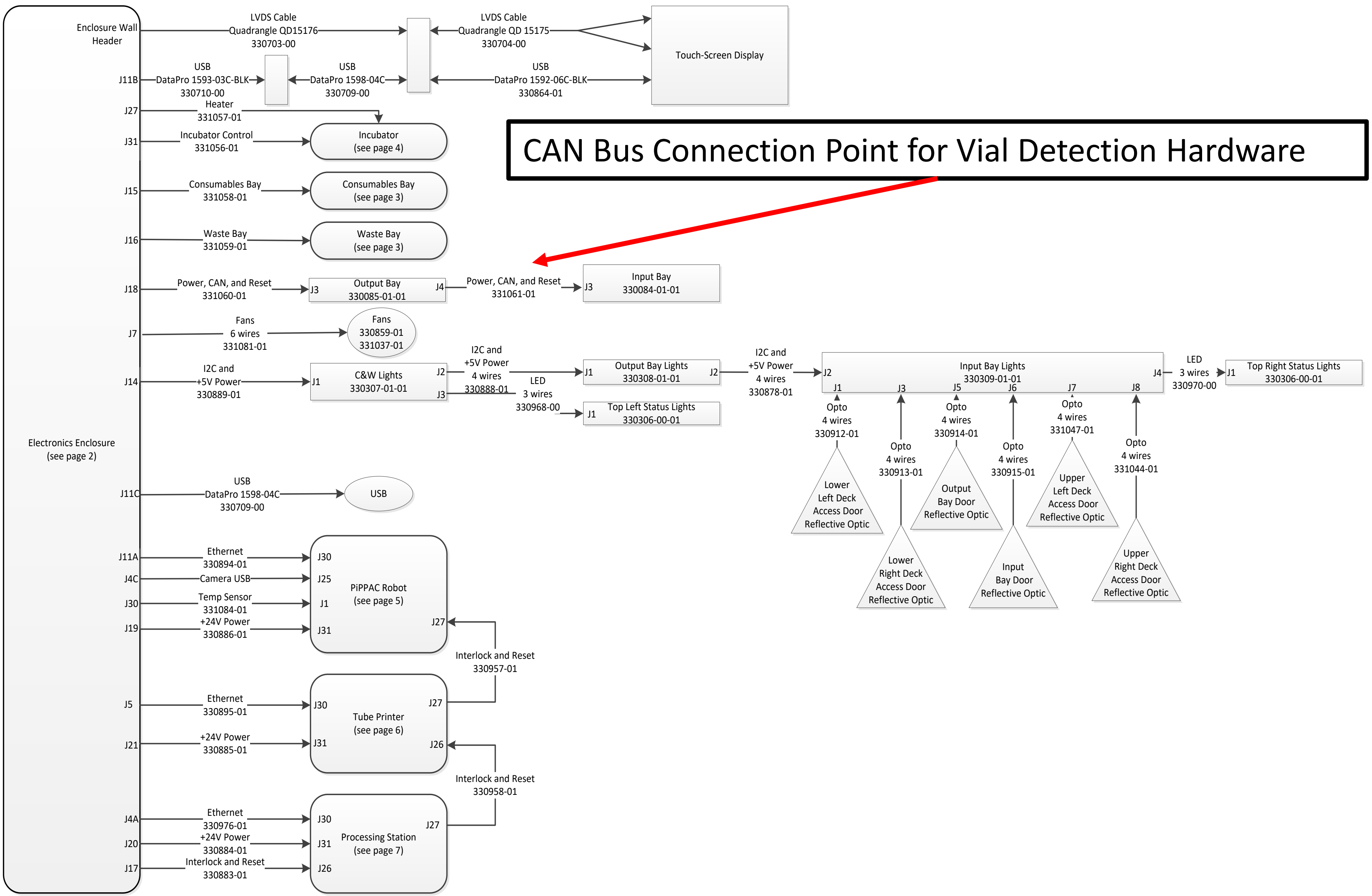
Current Ramp Magnified



.49 Microsecond Glitch



Tomcat Top-Level Wiring Diagram



Wiring Integration between the Tom Cat CPU and the Optical Detector Board.

- The previous slide shows the top level block diagram of the Tom Cat system.

- **Power for the optical detection and LED boards will be supplied from the CAN Bus interface.**

- The central processor used in Tom Cat system can issue commands to the DsPic regarding house keeping, tuning, and querying for vial positions when a carrier is placed with a carrier track.