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AFE4490 with Phototransistor – Preliminary measurement results

Health, Fitness, Imaging

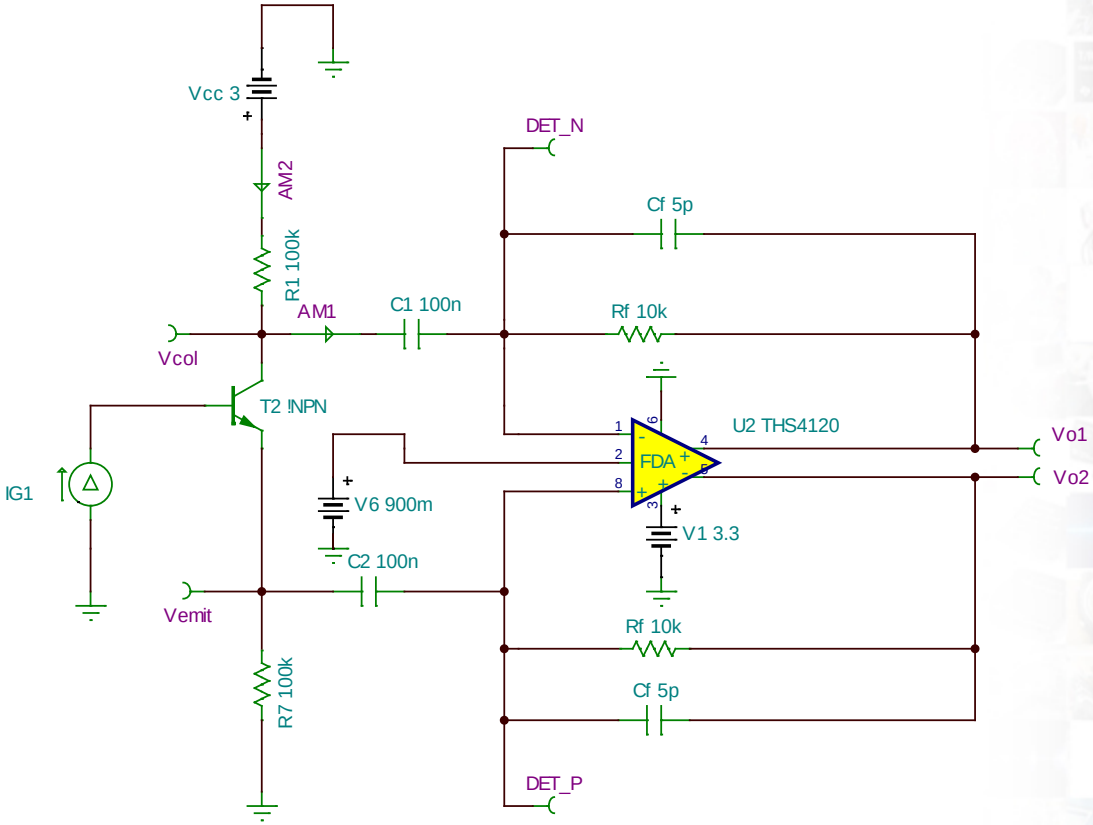
Summary

- The slide set presents the circuit configuration using NJL5501R (Dual LEDs + Phototransistor module) with AFE4490 and preliminary test and measurement results using the AFE4490SPO2EVM.
- Results:
  - NJL5501R is very sensitive to ambient noise. Any externally picked-up noise can dramatically degrade the quality of the PPG signal.
  - To capture any reasonable PPG signal, an optimal distance is required between the finger and the chip.
  - The test subject is definitely a concern. Depending upon the test subject, it might be necessary to set all the parameters (LED currents, Feedback (R_f) Gain accordingly.

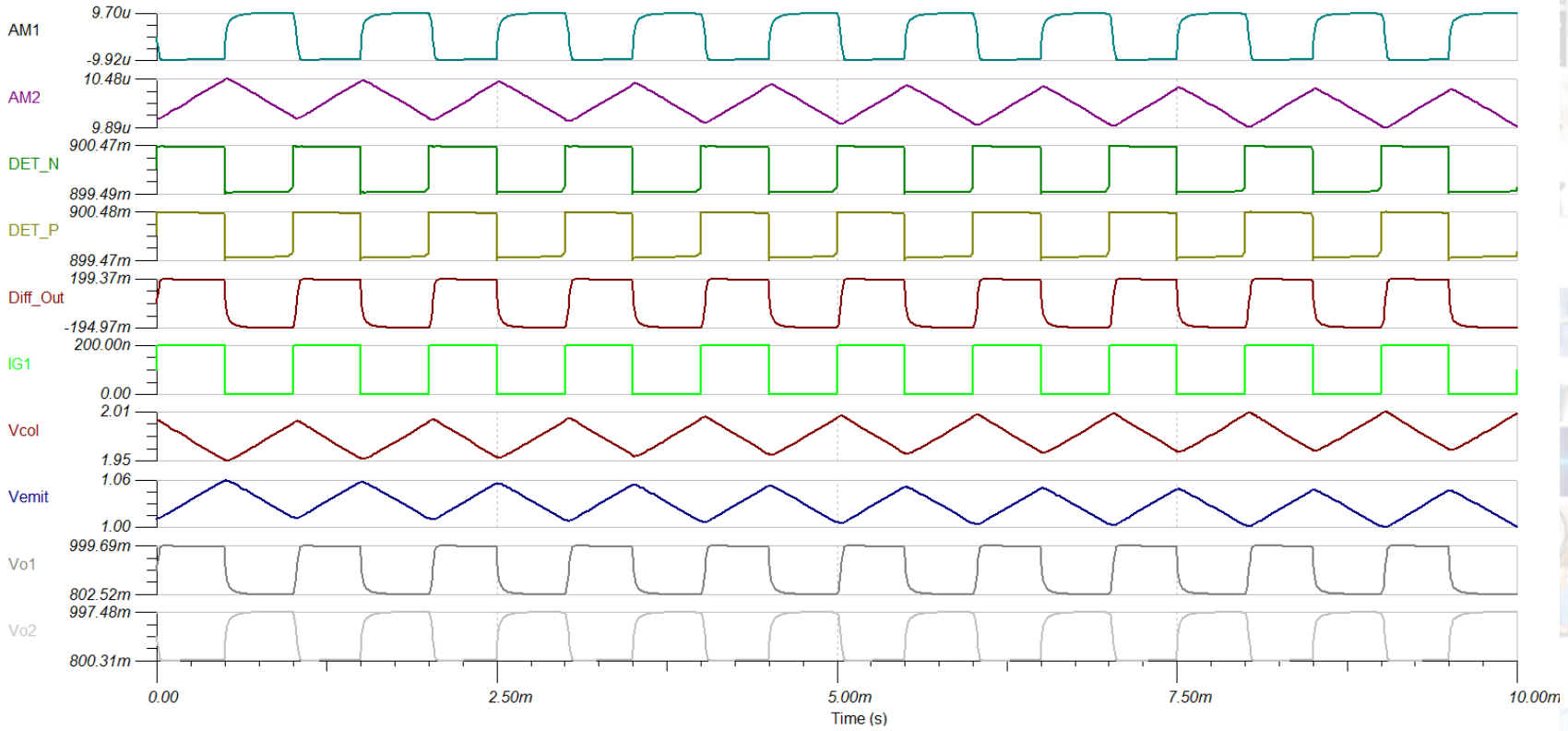
TINA-TI Simulations

Simulation Conditions:

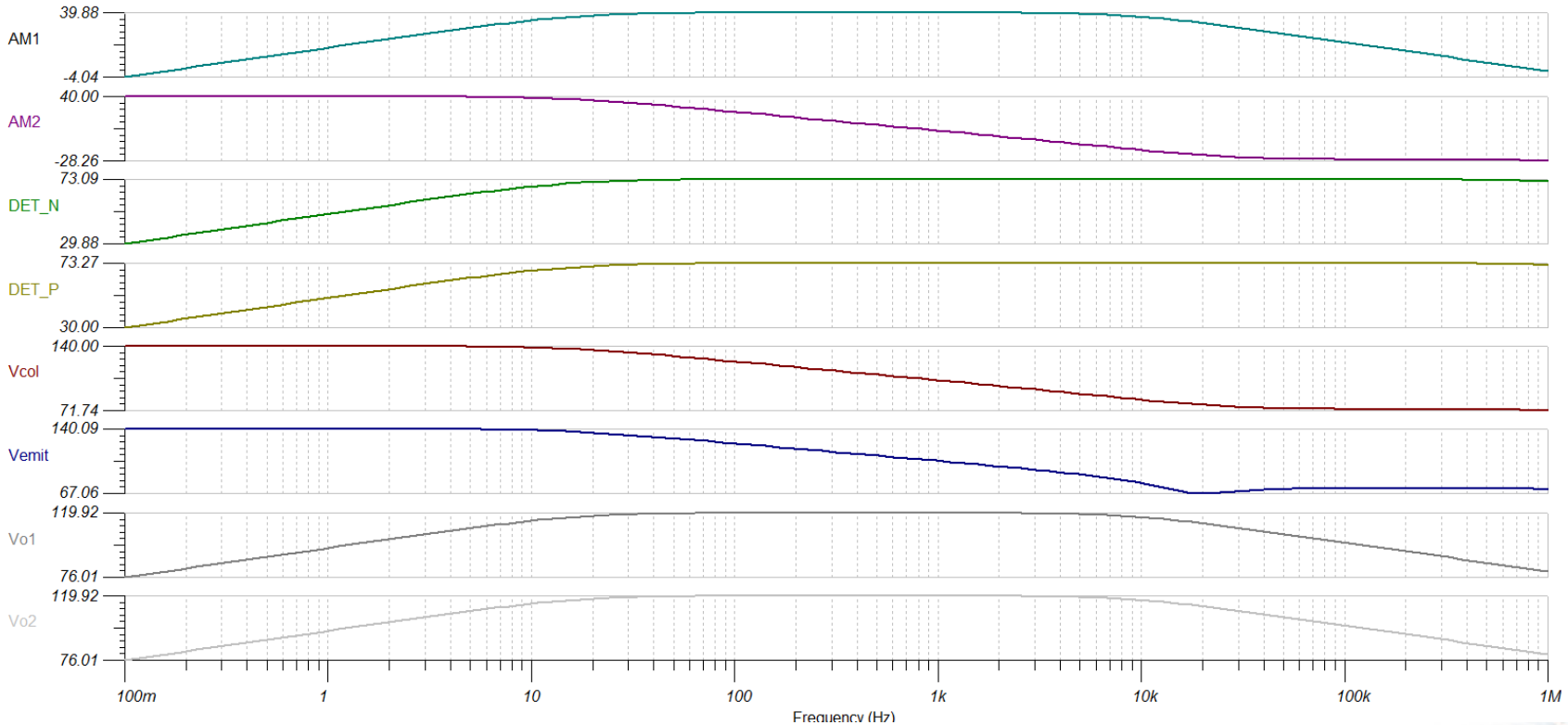
PRF = 1kHz
Rf = 10k
Cf = 5pF
C1 = C2 = 100n (AC coupling capacitors)
R1 = R7 = 100k
Vcc = 3V (phototransistor bias voltage)



Transient Analysis



Frequency domain Analysis



Simulation Results

- For 200nA input current, collector current is around 20uA for which 400mV differential swing is observed (swing=I*2Rf=20u*20k).
- Rf, Cf, R1, R7, C1, C2 values determines the corner frequencies of the band-pass filter. The chosen value make sure that the PRF frequency passes through the device. They have also to be determined accordingly to Bandwidth, Power Consumption, Speed trade-off:-

✓ C1, Rf, Cf fixed, ↑R1 → high bandwidth as the high pass filter corner frequency goes down, less speed due to a higher time constant, less dc collector current, because of a constant V_{CE}, hence less power consumption.

✓ Decreasing R1 we have less bandwidth as the high pass filter corner frequency goes up, more speed due to a lower time constant, more DC collector current hence more power consumption.

✓ C1, R1, Cf fixed, ↑Rf → less bandwidth as the low pass filter corner frequency goes down and higher gain. Decreasing Rf we have more bandwidth as the low pass filter corner frequency goes up but lower gain.

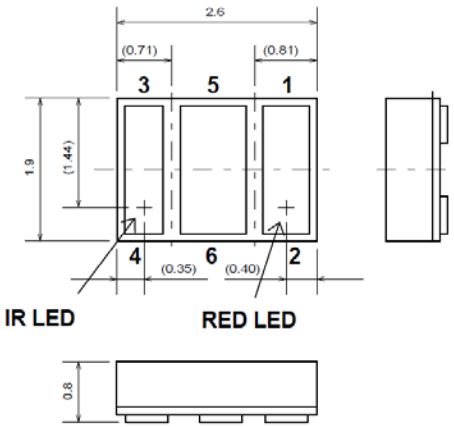
- For C1 = 100nF and R1 = 100k the corner frequency is around 16Hz at PRF = 1kHz. So, the 1kHz frequency passes through the TIA.

Measurement Setup Hardware Description

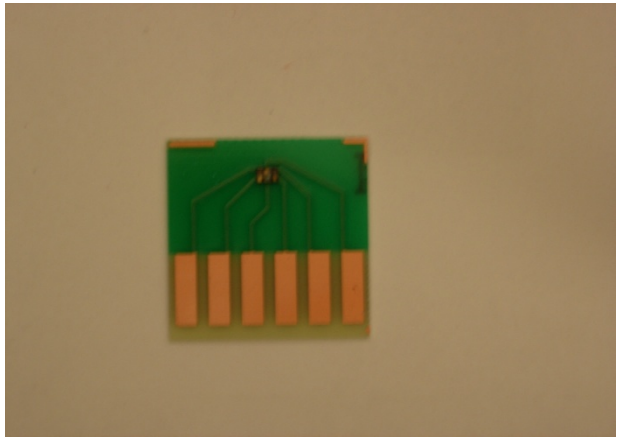
NJL5501R – Dual LEDs (RED + IR) Phototransistor module

NJL5501R

PACKAGE DIMENSION (mm)



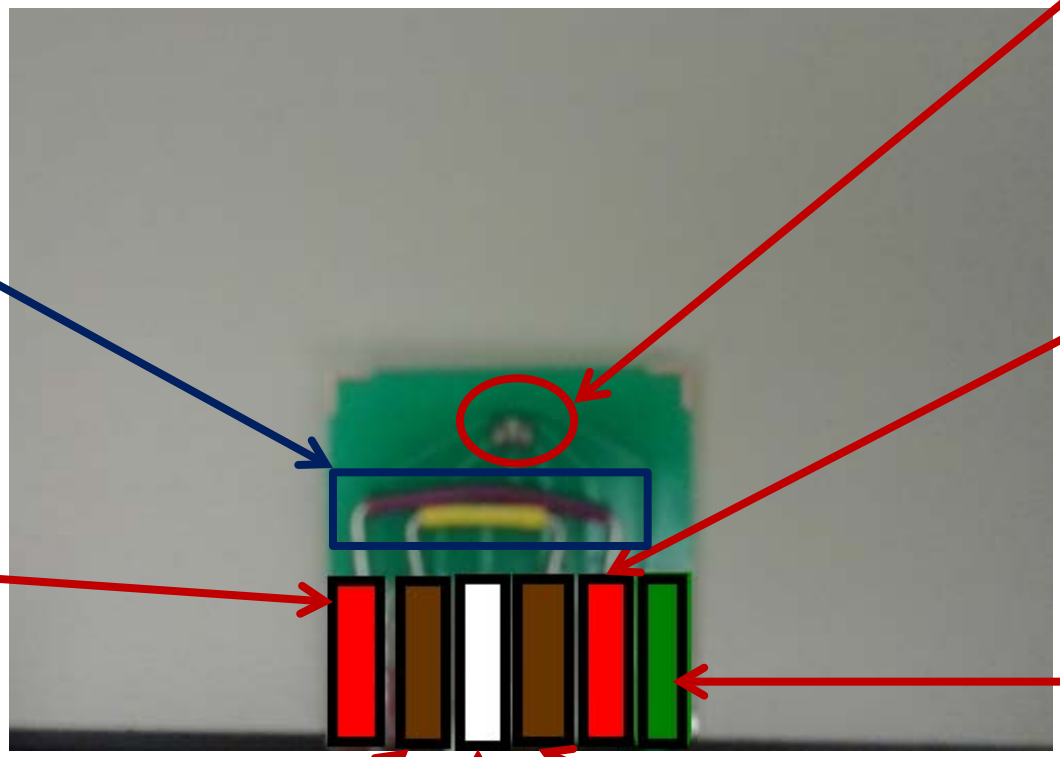
NJL5501R Breakout Board



1. Cathode for RED LED
2. Anode for RED LED
3. Anode for Infrared LED
4. Cathode for Infrared LED
5. Collector
6. Emitter

NJL5501R Board Overview

The 2 LEDs are shorted in a back-to-back configuration in order to use the AFE4490 EVM default settings



NJL5501R chip

Cathode IR Led

Anode RED Led

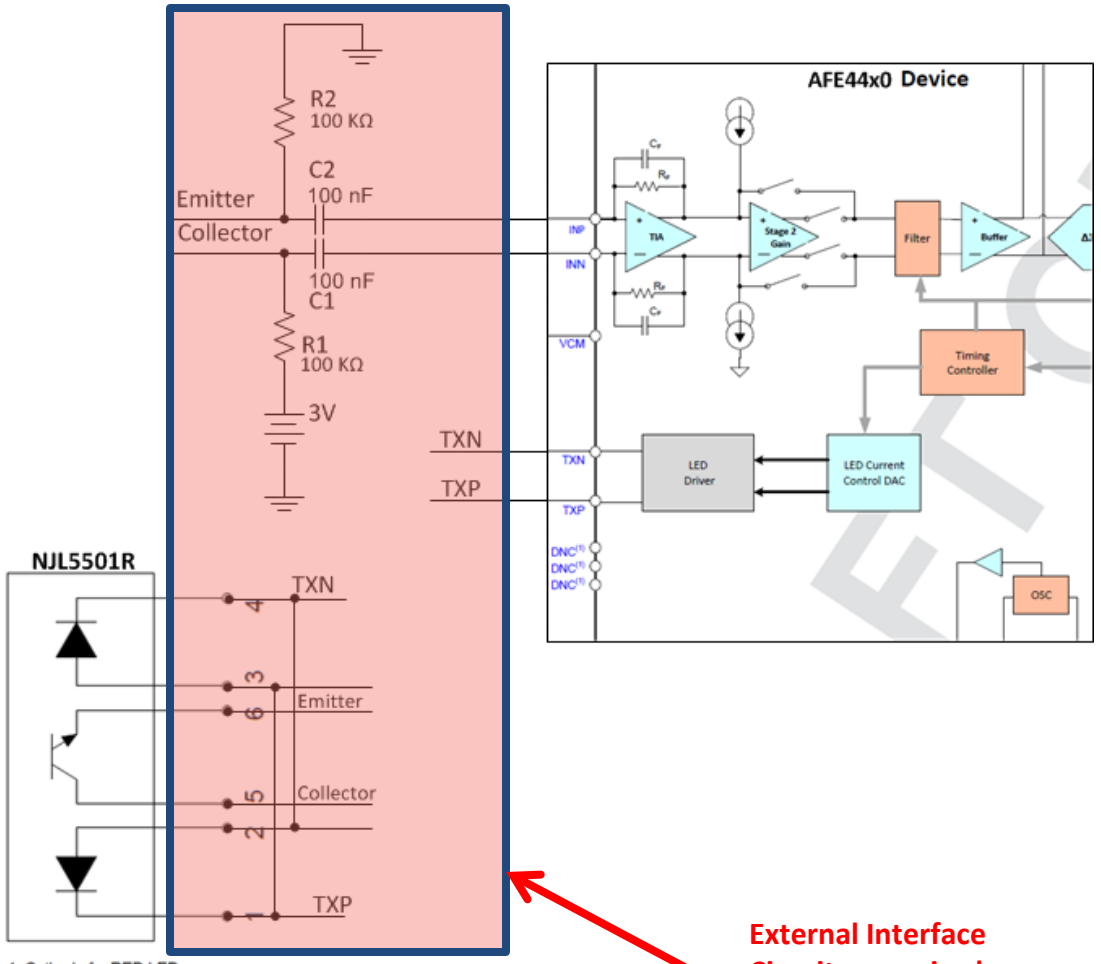
Phototransistor Emitter

Cathode RED Led

Phototransistor Collector

Anode IR Led

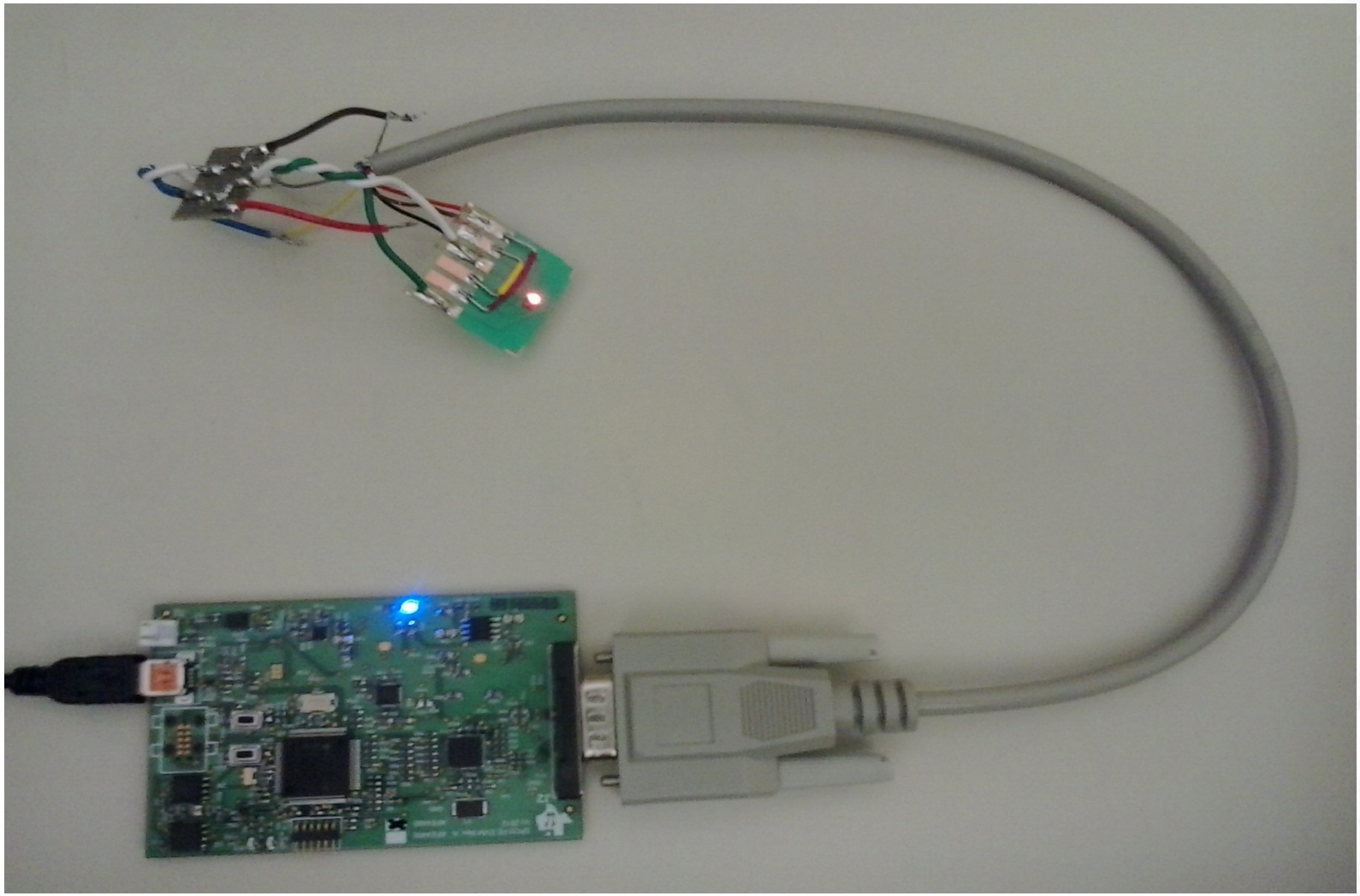
AFE4490/NJL5501R Interface Circuit Description



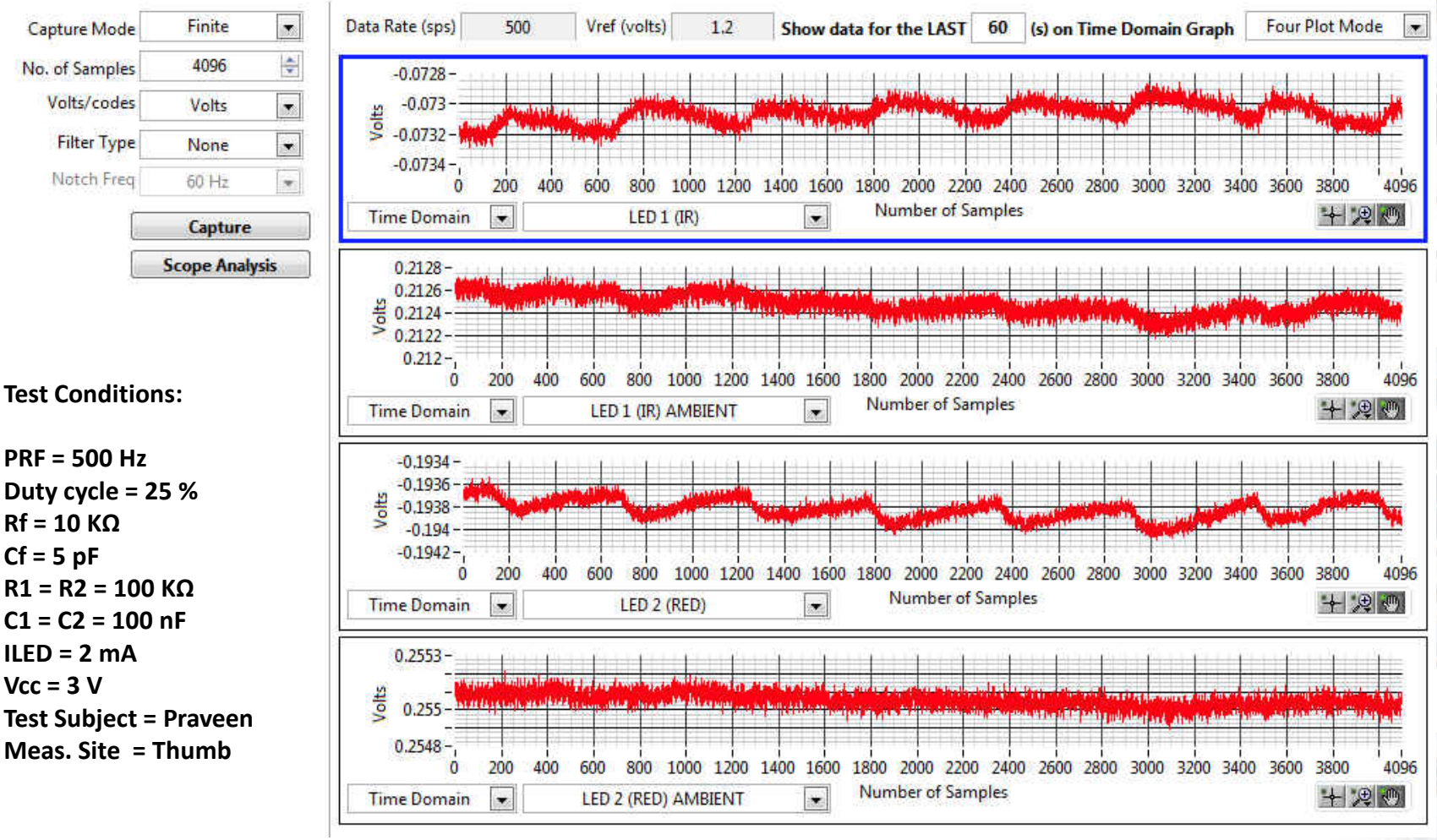
1. Cathode for RED LED
2. Anode for RED LED
5. Collector
6. Emitter
3. Anode for Infrared LED
4. Cathode for Infrared LED

External Interface Circuitry required with phototransistor

AFE4490 EVM Board mating with NJL5501R Sensor Board



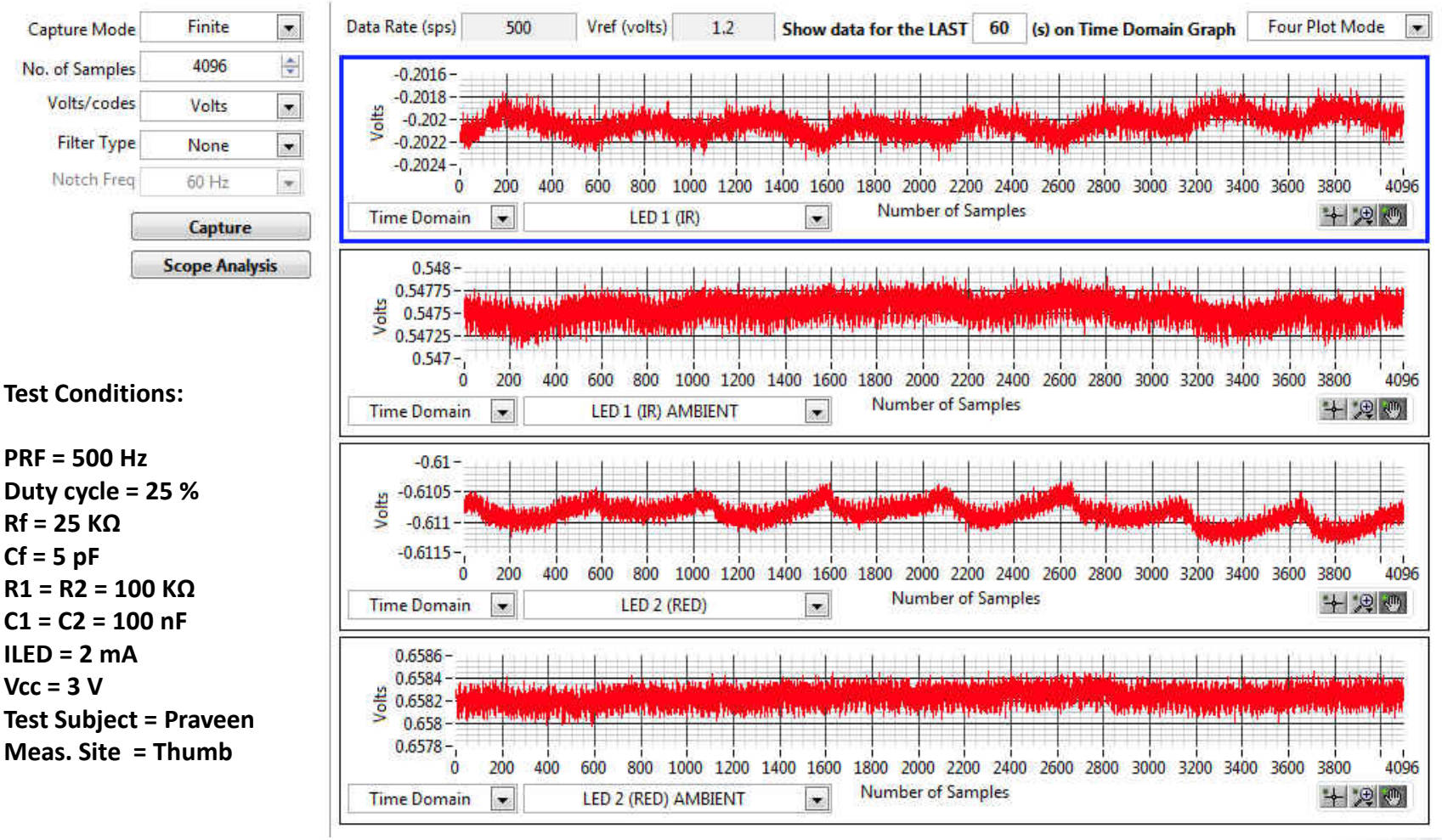
AFE4490 EVM GUI Results Screenshots



Test Conditions:

PRF = 500 Hz
Duty cycle = 25 %
Rf = 10 KΩ
Cf = 5 pF
R1 = R2 = 100 KΩ
C1 = C2 = 100 nF
ILED = 2 mA
Vcc = 3 V
Test Subject = Praveen
Meas. Site = Thumb

AFE4490 EVM GUI Results Screenshots



Test Conditions:

PRF = 500 Hz
Duty cycle = 25 %
Rf = 25 KΩ
Cf = 5 pF
R1 = R2 = 100 KΩ
C1 = C2 = 100 nF
ILED = 2 mA
Vcc = 3 V
Test Subject = Praveen
Meas. Site = Thumb

Measurement analysis

- The measurement setup is a concern while capturing – the environment noise (ambient light, interference...) has to be kept as low as possible since the NJL5501R is very sensitive. Any external picked-up noise can dramatically degrade the quality of the PPG signal. 因为NJL5501很敏感，所以环境噪声要很小
- To capture any reasonable PPG signal, an optimal distance is required between the finger and the chip. Pressing the finger too much or keeping it too far away from the sensor does not allow to capture any reasonable PPG signal but just noise. This is a big deal while testing and doesn't make it possible to guarantee reproducibility of the results – it's pretty tough finding the right distance, it might be necessary to capture several times, as well as keeping it fixed. Accordingly to the datasheet, JRC tested the chip at a distance of 0.7mm from an Aluminum Surface. Using the skin such distance might be different – more investigation needed. 捕获任何合理PPG信号,一个最佳的手指和芯片之间的距离是必需的。用力按下或手指和传感器过远会使得波形都是噪声
- The test subject is definitely a concern. The measurements were done with three test subjects.
  - With test subject 1, a clear PPG signal was captured as shown in the previous slides driving the LEDs with just 2mA.
  - With test subject 2, it was necessary to increase the current from 2mA up to 10mA-50mA to observe a clear PPG signal.
  - With test subject 3, even with increasing the current, it was pretty tough capturing a clear PPG signal.
  - So, depending upon the test subject, it might be necessary to set all the parameters accordingly.