Organic Light Emitting Diode Lifetime Measurement System Implemented with Arduino and Raspberry Pi

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ABSTRACT

This paper adopts Arduino DUE and Raspberry Pi for organic light emitting diode (OLED) lifetime measurement. Using digital-analog converter (DAC) port of Arduino DUE output voltage to control the constant current source and generate the constant current to drive OLED, and using analog-digital converter (ADC) port to read the photodetector voltage (then converting to luminance) and OLED voltage. The Qt Creator was installed in Raspberry Pi to control the measuring processes and display the data. Longtime measurement results of OLED luminance were shown in the coordinate graph that was drawn through Qt program Especially studied were to filter the noise in the hardware circuit and to set a constant current for OLED. With suitable filters to delete the noise, the stable and correct signal from photodetector can be acquired then.

I. HARDWARE ARCHITECTURE

Through DAC port of Arduino DUE to output voltage to control OLED driving circuit, and generate the constant current source. When OLED emits light and irradiates the photodetector, the photodetector circuit amplified and converted photo-current to voltage which was input into Arduino DUE ADC port. While the OLED voltage was read through the instrumentation amplifier, Arduino DUE reads these two values (photodetector and OLED voltages), respectively. Then the data shall be sent to Raspberry Pi through USB for processing.

OLED driving circuit:

1. Subtracter
   The output voltage range of Arduino DUE DAC port is 0.55-2.7V, while the constant current source shall output 0mA current only when receiving the minimum voltage of 0V, thus there adds one set of subtracter to meet the demand.
2. Voltage follower:
   In order to avoid the impedance mismatch, the voltage follower was added.
3. Instrumentation amplifier:
   In order to measure the voltage in the two ends of OLED, the instrumentation amplifier is applied to the circuit, to measure the voltage difference in the two ends of OLED, and then output to ADC port of Arduino DUE. However, the maximum input volta[illegible] of DUE is 3.3V, so when selecting the amplificat[illegible] factor, the voltage shall be controlled below 3.3V.
4. Constant current source:
   Using NPN type of transistor (3055), $I_b=(V_{in}-V_{be})/R_b$ and $I_c=\beta I_b$, while I_c current is irrelevant with the load in collector. So the transistor can realize the function of constant current.

Photodetector circuit:

When OLED gives out light and irradiates the photodetector, the photodetector [1-4] would generate the antidromic light current, while the primary OPA output is the negative voltage, so it needs another inverting amplifier, to convert the primary negative voltage into the positive voltage, and then Arduino DUE reads. However, DUE maximum input voltage is 3.3V, thus it shall control the amplification factor of inverting amplifier in the secondary OPA, to control the output voltage below 3.3V.

II. SOFRWARE DESIGN PROCEDURE

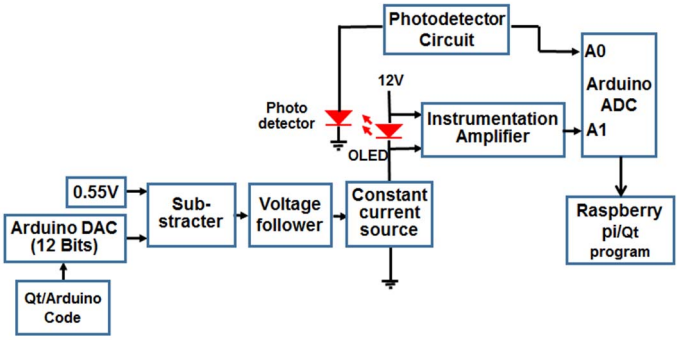

Fig.1 Circuit blocks

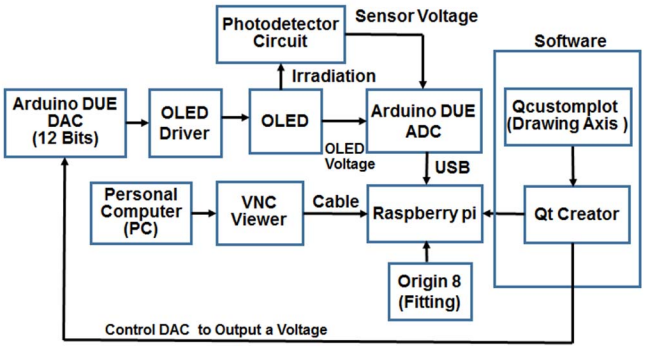

Fig.2 Software flow chart

The software used includes Origin8, Arduino procedure code and Qt Creator installed on Raspberry Pi. Firstly,

connecting Raspberry Pi and Arduino DUE, then Raspberry Pi shall control DAC port output of Arduino DUE to simulate the voltage for OLED driving circuit to generate the constant current to lighten OLED. When OLED emits light, the photodetector circuit shall measure the voltages across OLED, and be converted to a related luminance value according to the voltage value.

Arduino:

For the need of digital to analog converter (DAC) in Arduino DUE, it can adjust the current of OLED through Arduino DAC port. Arduino DUE is also responsible for reading the photodetector voltage (output from photodetector circuit) and OLED voltage (output from instrumentation amplifier) back to Arduino DUE, and then transfer the readout to Qt software installed on Raspberry Pi.

Qt creator

To install Qt Creator on Raspberry Pi, and transfer the data of Arduino DUE to Raspberry Pi through USB, and process and display the measured data in Qt. Converting the photodetector voltage read into corresponding luminance through the formula, and using Qcustomplot function library to draw the coordinate graph, for the convenience of long-time observation for OLED luminance change, it shall draw the tendency chart of luminance vs. time. And then using QFile function library for data saving, the user can save the measurement data through this function library.

While Qt shall also send the instruction to Arduino DUE, Qt Creator designed port shall control DAC foot position of Arduino DUE to output the certain voltage, and then the constant current source circuit shall output the needed current to drive OLED.

Origin 8

The above-mentioned photodetector voltage should be converted into corresponding luminance, which Origin 8 could realize it. Firstly, PR650 standard spectrum measurement system was used to measure OLED voltage, current and luminance characteristics. Then it has been known that how much current could generate related luminance (cd/m2). And then the user controls Arduino DUE and OLED driving circuit in Qt software to output the needed current for OLED. And then the photodetector circuit will measure the output voltage values of photodetector for the related OLED luminance. So the relationship between the photodetector voltage and correct OLED luminance (measured from PR650 system) can be established.

After the above relationship was established, it shall acquire the correction formula, and use this formula into Qt program code, thus when Qt received different voltage values, it could directly apply this luminance formula, to convert into corresponding luminance.

III. RESULTS and DISCUSSION

The OLED lifetime measurement results are shown in Fig.3. The driving circuit for OLED is important which should supply a constant and stable current (i.e. constant current source), otherwise the emitting light detected by the photodetector will vibrate as shown in Fig.4. There is a fluctuation noise generated in the photo current. The DC voltage source from power system is also unstable or sometime has spike noise. Except for the capacitance filter, a stable DC voltage supplier circuit (regulator circuit) is also necessary. The photodetector signals for OLED lifetime measurement with constant current source (driving OLED) and stable regulator circuit are shown in Fig.5. The final signals are more stable with less fluctuation.

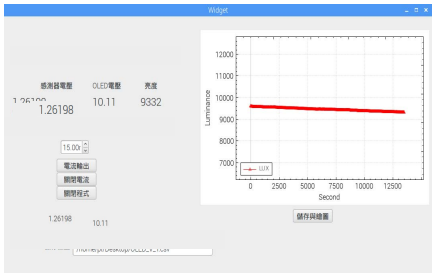

Fig.3 OLED lifetime measurement results in Raspberry Pi system.

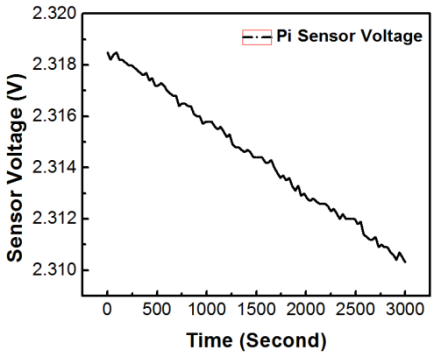

Fig.4 Measured photodetector signal without constant current source and voltage regulator circuit.

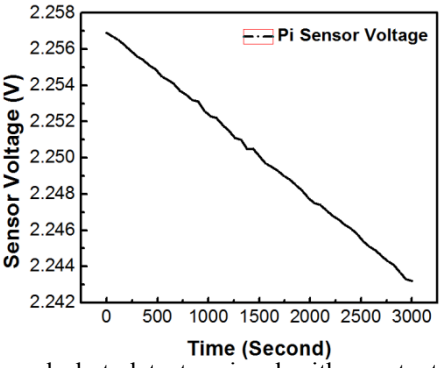

Fig.5 Measured photodetector signal with constant current source and voltage regulator circuit.

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