

Mini-Project – Wireless communication using High-Power White Light LEDs**Laboratory Location:**

Control Systems Laboratory P1404

Introduction:

Using high-power LEDs to replace the conventional incandescent and fluorescent lights are getting more and more popular due to their long life, energy efficiency, eco-friendly, low voltage operation and more recently lowering unit cost per Watt spent. LEDs can also offer fast switching speed making it suitable as a modulation device for wireless visible light communication (VLC).

The purpose of this mini-project is to investigate how to apply feedback control on an optical transmitter-receiver circuit for enhancing its stability and performance. The light source employed in the transmitter is a high-power white light LEDs which can be used in both lighting and sound broadcasting applications. Due to the scope of this mini-project, students should form themselves into groups of 2.

Learning outcomes:

1. Able to measure, analyze and apply feedback to a simple LED transmitter for sound broadcasting using transistors.
2. Able to measure, analyze and apply feedback to a simple receiver using photo-diode and transistors for picking up the signal generated by the LED transmitter.
3. Able to compare the theory with measured parameters of the optical link.
4. Able to identify the problems of open loop amplifiers and to apply feedback to the transmitter and receiver, respectively, for enhancing its stability and overall performance.

Deliverables:

1. Demonstration (Week 7, 9, 11)
2. Group Report (week 12)
3. Individual log book (week 12)

Major Components list:

- | | |
|-------------------------|-----------------------------------|
| 1. 2N3904 Transistor(s) | 2. J112 N-channel JFET Transistor |
| 3. White light LED(s) | 4. SFH 203P Photo-diode(s) |

Equipment list:

- | | |
|-------------------------|---------------------------|
| 1. Dual DC power supply | 2. Digital multi-meter |
| 3. Dual Channel CRO | 4. Audio Signal Generator |

Milestones for the mini-project

This mini-project runs in **week 7, 9 and 11**. An evaluation on the project progress will be carried at the end of each lab session on week 7, 9, 11. However, the evaluation can be done earlier if your progress is ahead of schedule.

Schedule	Task Lists
Week 7	i. To set-up an optical link using a transmitter and a receiver module ii. To study the given transmitter circuit and analyze descriptively its working principle. iii. To measure the properties of the transmitter with and without feedback resistor R1 iv. To evaluate the measured results with the theory
Week 9	i. To study the given receiver circuit and analyze descriptively its working principle. ii. To measure the properties of the amplifier of the receiver with and without feedback circuit iii. To evaluate the measured results with the theory
Week 11	i. To investigate methods how to maximize the transmission distance between the transmitter and the receiver. (optional)
Week 12	i. To submit a group report and individual log-books.

Laboratory progress during the sessions on week 7, 8 and 10 may affect your grades*. Late submission of log-book or group report will result in a reduction of a sub-grade. You still need to submit your group report (only one report per group) and individual log-book (each student) on week 12.

Remarks:

*The students are **expected to work hard on Week 7, 9 and 11** while you may catch up your work in other lab session (to be arranged with the technical staffs of P1404)

Principle of Assessment

It will base the individual (knowledge of the works, contributions, and participations), group (report, final achievement), progress (bonus or penalty according to lab schedule), and submission of log-book and group report (penalty on late submission).

Mini-project Tasks

Record all your **own work** in your log-book and demonstrate each of the finished group tasks shown below to your laboratory supervisor.

Brief description of the transmitter and receiver circuits

Figure 1 (a) and (b) shows the schematic of the transmitter and receiver circuit for a wireless VLC link. The corresponding transmitter and receiver circuit boards are shown in figure 2(a) and (b) respectively.

As shown in figure 1(a), the transmitter is a single-stage BJT transistor amplifier which will modulate the LED current by the input voltage. VR1 is for adjusting the Q-point of Q1. The terminal T1 of figure 2(a) provide external terminals for connecting the feedback resistor R1. Connect a wire between the two terminals of T1 to remove the feedback of R1. The default value for R1 is 20 Ω .

As shown in figure 1(b), the receiver is a three stage amplifier which amplifies the optical signal received by the photodiode (connected at terminal T2). The first two stages of the amplifiers use FET transistors Q1, Q2 while the last stage uses a BJT transistor Q3. VR2 is for adjusting the Q-point of Q3. There is a feedback network connected between the source of Q1 and the drain of Q2. The feedback strength can be varied by VR1. The feedback can be disabled by disconnecting jumper J1. Resistor R101, R102 and R103 are the feedback resistors for Q1, Q2 and Q3 respectively. They are connected externally through the terminals T2, T3 and T4 respectively as shown in figure 2(b). Connect a wire between the terminals of T2, T3 and/or T4 will disable the corresponding feedback effects of Q1, Q2 and/or Q3. The default values of R101, R102 and R103 are all 20 Ω . R11 is used for measuring the input current to Q1 and hence to calculate the input resistance of Q1. You have to remove jumper JP1 and short JP3 first before taking measurement on the voltage across R11 through TP3 and TP4. Short circuit Jumper JP2 will add a load resistor R10 to the amplifier output. R10 is used for measuring the output resistance of the receiver.

As part of the task, you need to analyze the working principle of the transmitter and receiver circuit yourself.

Group Tasks

Week 7

1. Based on the given transmitter and receiver modules (with feedback resistors) as shown in figure 2, set-up an optical link to transmit a 1KHz sinusoidal signal generated from a signal generator to the receiver. Display the output of the receiver on a CRO. Keep the distance D_T between the transmitter and receiver to be at least 30cm. You have to make sure no distortion at the output signal. If you find there are any clipping or distortion of the signal, please reduce the input signal voltage. As a start, please use 100mV. Measure the overall gain between the input of the

transmitter $v_{ti}(t)$ and the output of the receiver $v_{to}(t)$. Then reduce the distance D_T by half and measure the voltage again. Does these two measured values follow inverse square law? Please explain why?

Note: Demonstrate the function of optical link in task 1 to laboratory supervisor.

2. Measure the input resistance (=input voltage/ input current), voltage gain (voltage at the collector of Q1 / input voltage), trans-conductance gain (collector current / input voltage) at mid-frequency. Measure also the frequency response of the transmitter in terms of trans-conductance gain over 1Hz–1MHz range. Is there any 3dB cut-off being observed? Explain your results.
3. Replace R1 by a wire and measure the input resistance and voltage again. Compare the results with task 2. Discuss if the results agrees with theoretical prediction or not.

Note: Tabulate all the measured results in task 1, 2 and 3 and show them to the laboratory supervisor before you leave.

Week 9

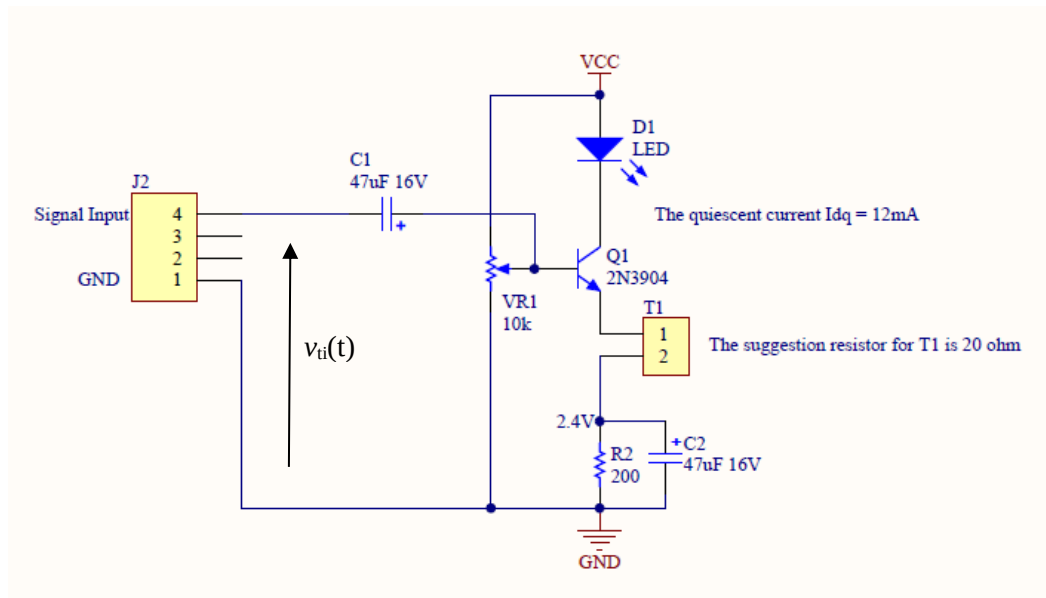
1. Disconnect JP1 and connect JP3 of the receiver as shown in figure 1(b) and 2(b). Disconnect the feedback enable pin J1. Measure the input resistance (through R11), voltage gain ($=v_{or}(t)/v_{oi}(t)$), output resistance (through R10) at mid-frequency. Measure also the frequency response of the transmitter in terms of trans-conductance gain over 1Hz–1MHz range. Is there any 3dB cut-off being observed? Explain your results.
2. Repeat task 1 by shorting the feedback enable pin J1. Evaluate and compare the results in both cases. Do the results agree with theoretical prediction?
3. Analyze the feedback topology of the feedback network VR1 and C4. Estimate the open-loop gain and the feedback network gain.

Note: Tabulate all the measured results in task 1, 2 and 3 and show them to the laboratory supervisor before you leave.

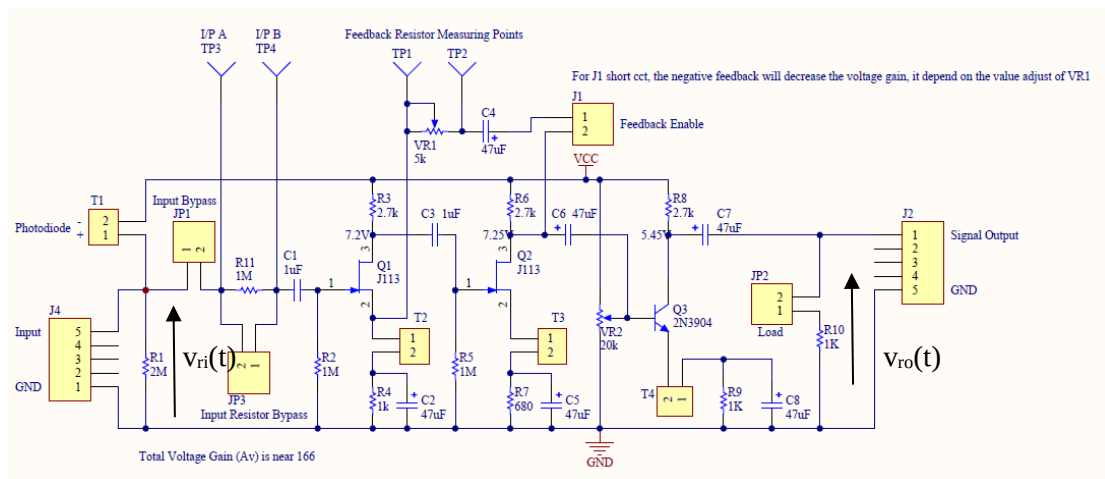
Week 11 (optional)

1. Investigate methods how to maximize the transmission distance between the transmitter and the receiver.

Note: if you cannot finish the work in week 7, 9, you can also use week 11 as a backup.



(a) – VLC Transmitter

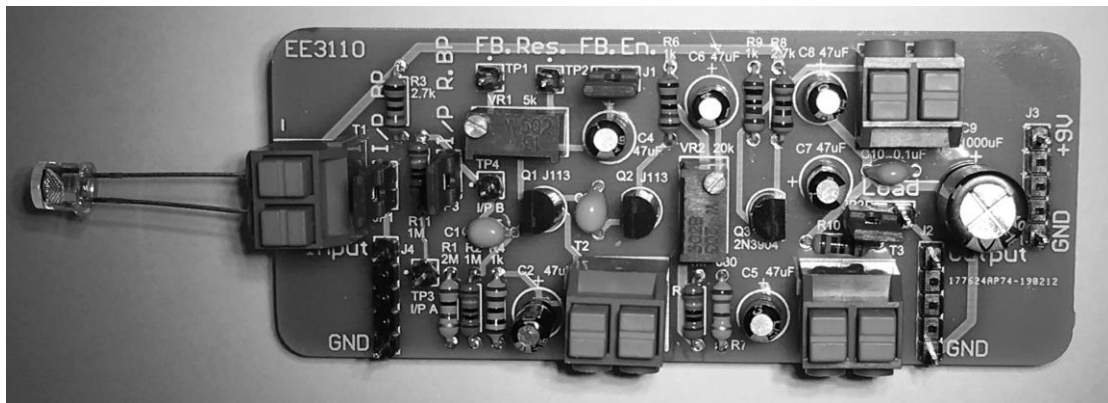


(b) – VLC Receiver

Figure 1



(a) Transmitter Board



(b) – Receiver Board

Figure 2