ECE 342 Optical Link Project

LAB 4: LED DRIVER

Function in the Optical Link Project

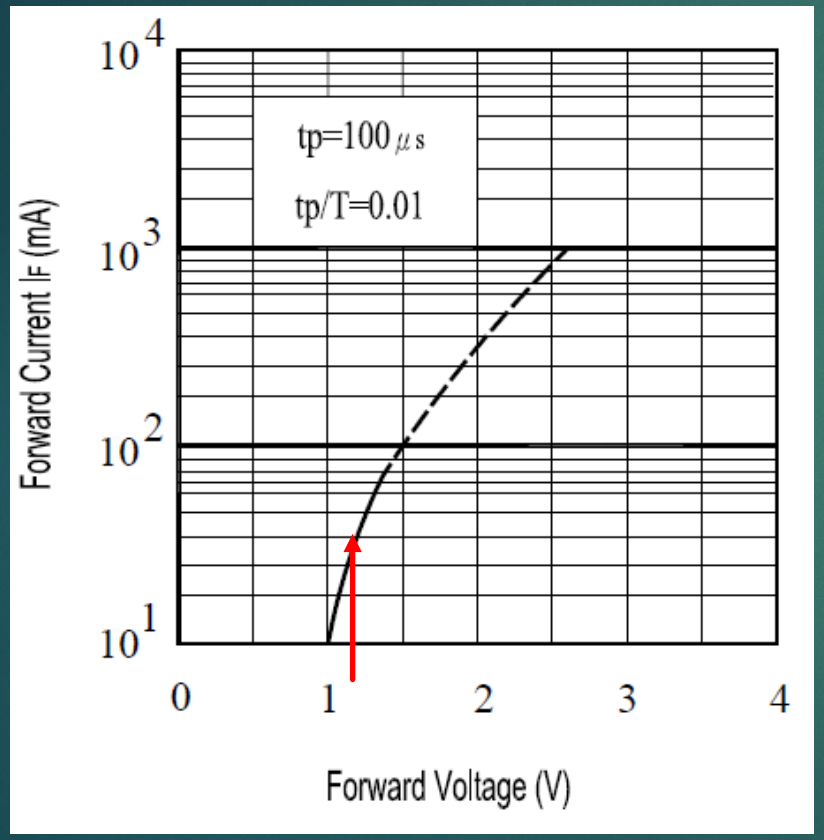
- The second stage in the transmitter transmits an optical signal that is modulated at the clock frequency provided by the signal generator stage
- An LED driver sources a specified amount of current to an LED
  - LED light output is a function of the drive current (approximately linear)
  - The LED driver can modulate the current as a function of the input
  - In this case, the LED driver will turn the LED on and off at a rate of 20 kHz
- A signal conditioning circuit may be necessary to modify the signal generator output to a 50% duty cycle rail-to-rail square wave

Task Objectives

- Design, construct and test an LED driver that sources a 50% duty-cycle 40 mA peak current square wave to the IR LED
- Design, construct and test a signal conditioning circuit that will convert the output of the 3-stage ring oscillator circuit to an approximately 50% duty cycle square wave

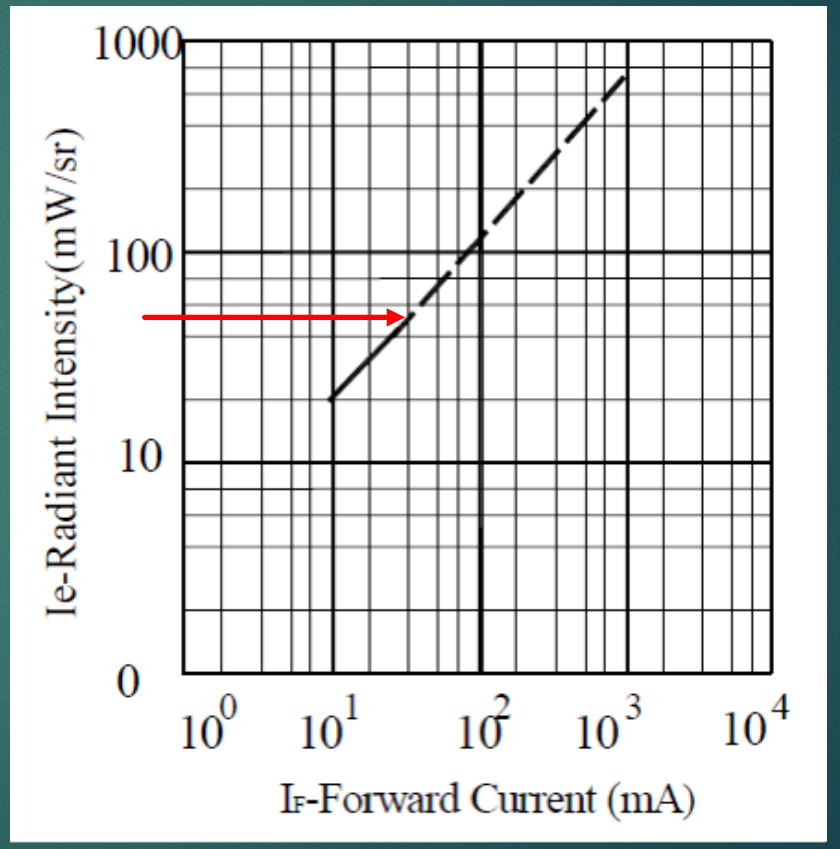
IR1503 LED Characteristics

I-V Characteristics



$V_F \cong 1.2$ V for $I_F = 40$ mA

Radiant Intensity vs. Forward Current



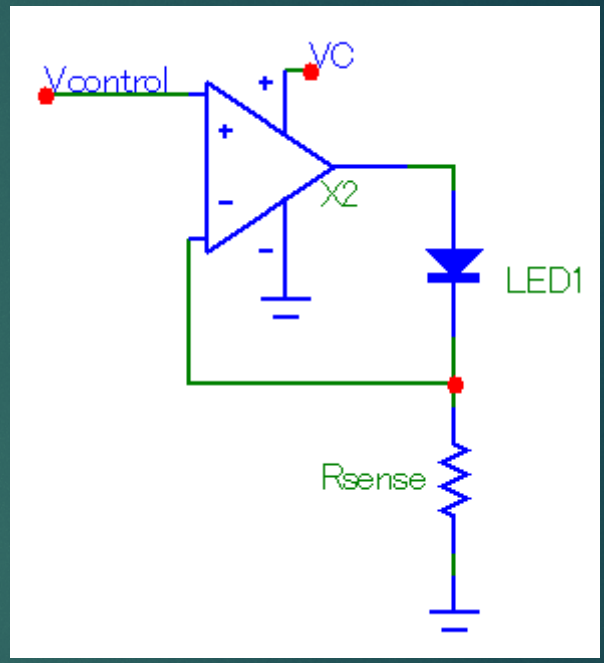
Radiant intensity ≅ 50 mW/sr for $I_F = 40$ mA

LED Driver – Basic Principle

- The LED driver uses an op-amp transconductance circuit
  - Input is voltage
  - Output is current
- The current through the LED is:

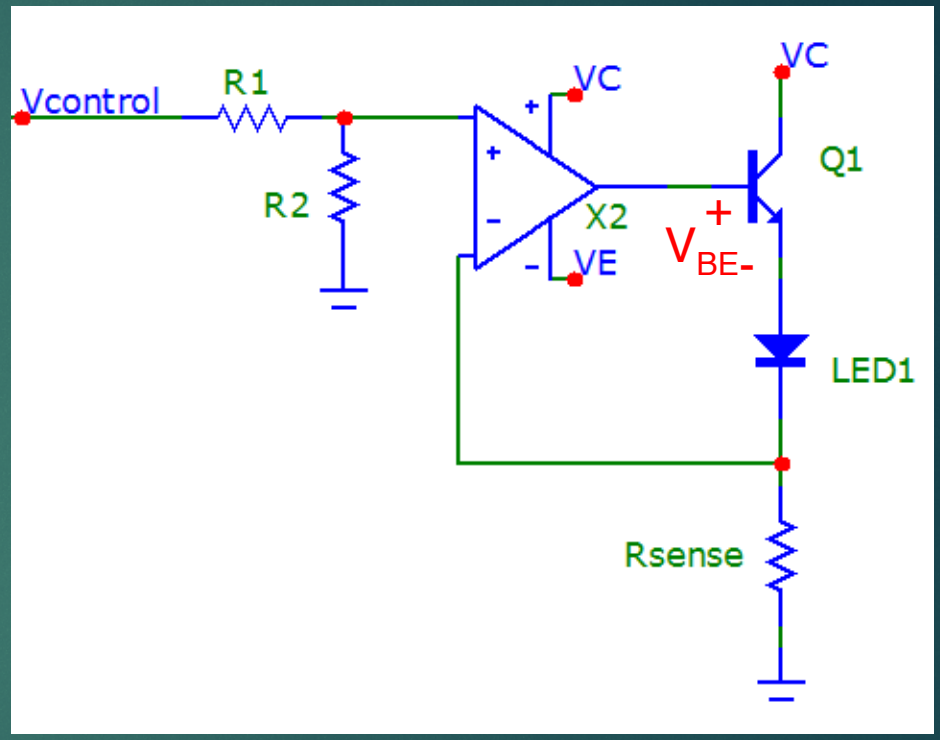
$$I_{LED} = \frac{V_{control}}{R_{sense}}$$

- The op-amp output voltage swing must be able to support the voltages across the LED and sense resistor
  - The supply voltage $V_{CC} > V_{control} + V_{LED}$
- The op-amp must be able to supply the LED current
  - Most op-amps can source 20-30 mA



LED Driver for Higher Current

- Use a bipolar junction transistor (BJT) to source higher amounts of current
  - The op-amp only needs to source 1/10th to 1/100th of the LED current
  - Output voltage swing must include the base-emitter voltage drop V_{BE}
  - V_{BE} is usually ~ 0.7 V
- The resistive voltage divider R1-R2 lowers $V_{control}$
  - $V_{control}$ is 0 V to 5 V
  - Op-amp supply is 5 V
  - Voltage at V- needs to be at least 2 V below supply, to accommodate $V_{BE} + V_{LED1}$



The Bipolar Junction Transistor (BJT)

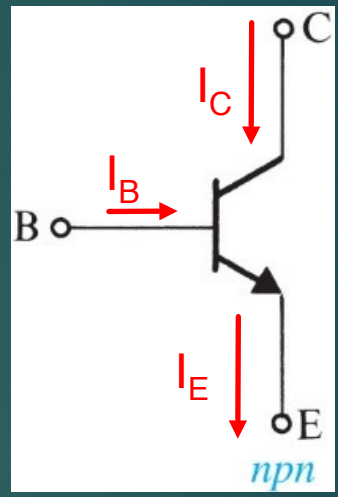
- A three terminal device which can be used as a current amplifier
  - Base (B)
  - Collector (C)
  - Emitter (E)
- The collector current is an amplified version of the base current

$$I_C = \beta I_B$$

  - True only for the forward active mode
- The emitter current is the sum of the two

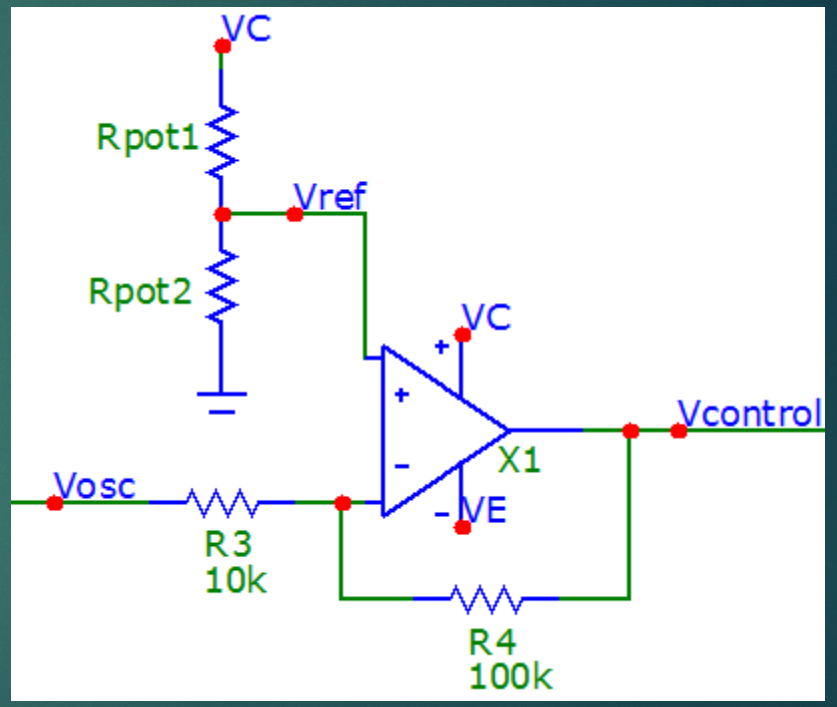
$$I_E = I_B + I_C$$

- Will study BJTs in Chapter 6
- See Chapter 6 pre-lecture videos 1 and 2 for more information on device structure, operation principle and I-V characteristics



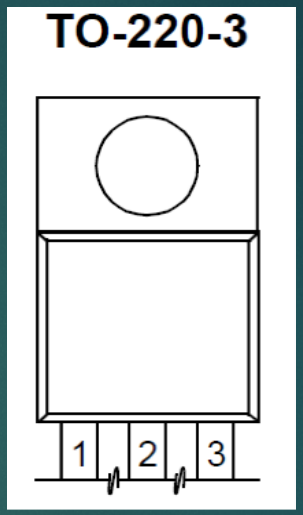
Signal Conditioning Circuit

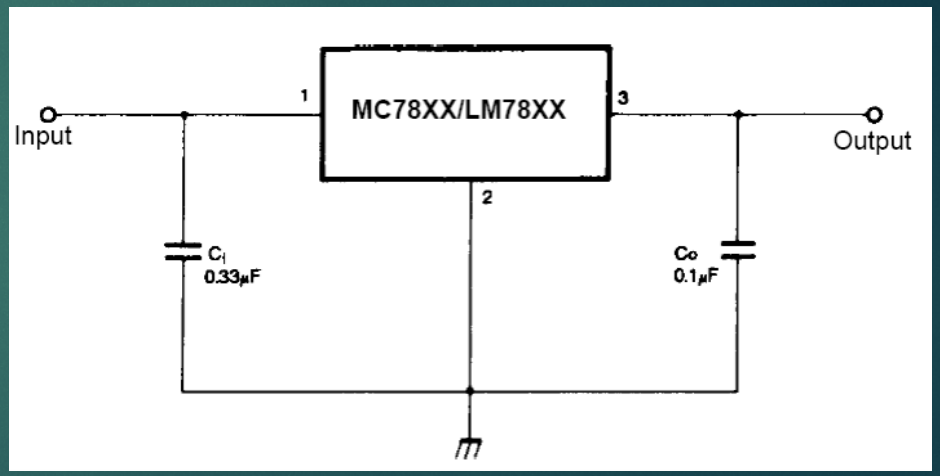
- The output of the digital oscillator may not be a 50% duty cycle square wave
  - Ring oscillator output probably not 0 V to 5 V
- Need a signal conditioning circuit
  - Analog voltage comparator (e.g. LM319)
  - Op-amp based voltage amplifier
- The MCP6004 has four op-amps
  - One will be used for the LED driver
  - Three more op-amps available
- Potentiometer used to adjust V_{ref} to obtain a 50% duty cycle square wave
- The PSRR of the shown circuit is only 6 dB
  - Can this be improved?



Linear Voltage Regulator

- Transmitter circuit will be powered by a 9 V battery
  - Use a power supply for this Task
- LM7805 +5 V linear voltage regulator
  - Regulates the supply voltage down to +5 V
  - Will drop 9 V – 5 V = 4 V
- TO-220-3 package with
  - Pin 1: Input
  - Pin 2: GND
  - Pin 3: Output
  - Backside metal: GND
- Smoothing capacitors at input and output





Tasks

- Design LED driver to deliver 40 mA peak current to LED
  - Calculate the values for R1, R2, and Rsense, assuming 0 V to 5 V input
- Design the signal conditioning circuit
- Simulate the full transmitter circuit
- Construct and test the full transmitter
  - Ensure LED drive current is 40 mA peak 50% duty cycle square wave

Tips and Tricks

- This lab should be straightforward and quick to do
- Measure voltage across Rsense to determine the LED drive current
- An alternative LED driver places the LED between the BJT's collector and the battery
- If a signal conditioning circuit is required, make sure the PSRR at 20 kHz is at least 60 dB