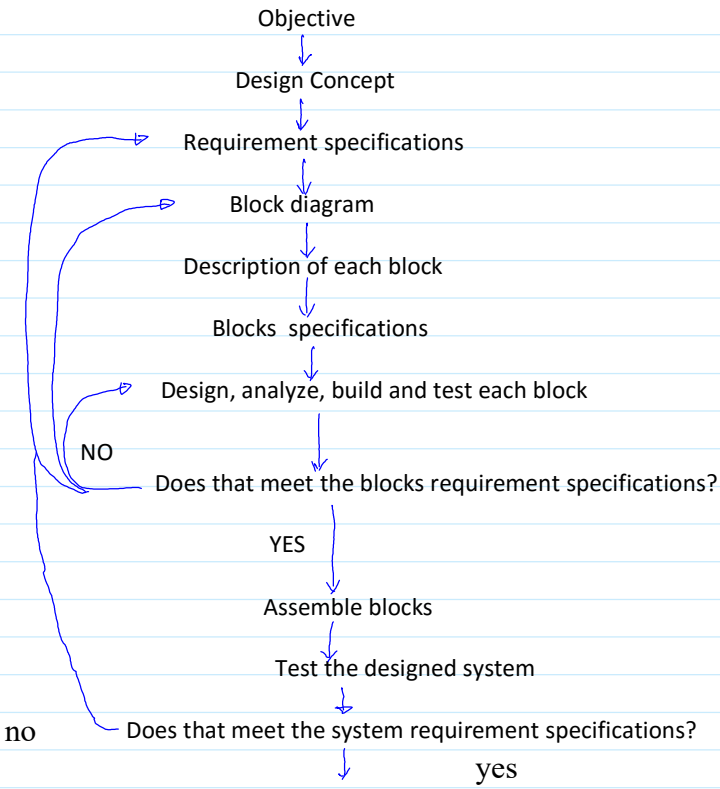
Lab2: Design, implement and test a 120Vac to +5Vdc supply with indicators and a USB connector for a cell phone/MP3 player charging.

To be used a power supply for the emergency light system.

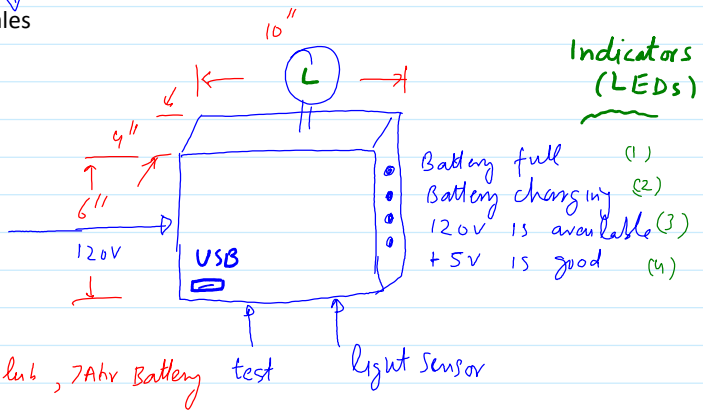
Emergency light system design:

Design Steps:



Objective: An emergency light for home use

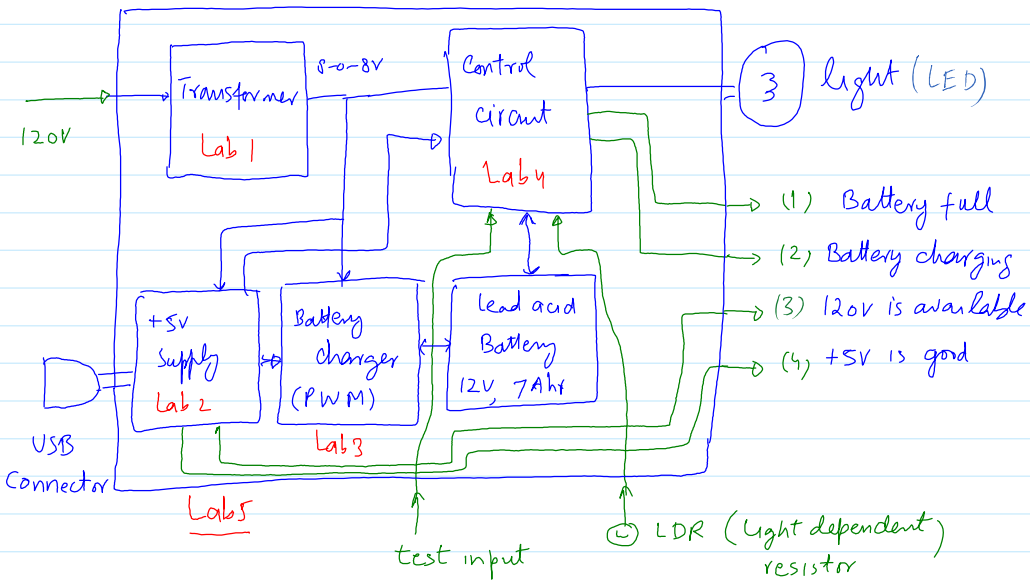
Initial Design Concept:



Requirement Specifications:

- size 6"x4"x10"
- 120V, 5V (USB), 10W bulb, 7Ahr Battery
- 4 indicators
- test input, light sensor

System Block Diagram:



Some description of each block: .

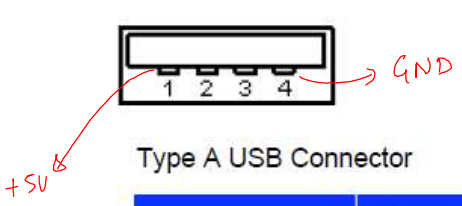
List specs of each block, design each block, test each block, assemble the system. Improve / fix issues as needed.

Lab2: Design, implement and test a 120Vac to +5Vdc supply with indicators and a USB connector for a cell phone/MP3 player charging.

Introduction to USB (Universal Serial Bus)

USB 1.1, USB 2.0, USB 3.0, USB 3.1

Black Connector — Blue Connector



Type A USB Connector

Type B USB Connector

Pin Number	Cable Colour	Function
1	Red	V_{BUS} (5 volts)
2	White	D-
3	Green	D+
4	Black	Ground

USB Yellow Connector
→ always on (supplies power even when computer is in sleep mode.)
→ used for charging.

The receiver defines a differential '1' as D+ 200mV greater than D- and a differential '0' as D+ 200mV less than D-.

There are three classes of USB functions,
- Low-power bus powered functions (100mA, 4.40V to 5.25V) **Thumb drives**
- High-power bus powered functions (100mA initially (configuration), but 500mA later, 4.75 - 5.25V range) **MP3 Players**
- Self-powered functions (100mA from the bus, remaining from its own power source) **External HD, FD, DVD etc.**

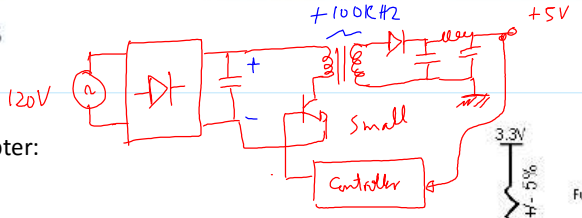
USB 3.0 → 900mA, 5Gb/s (USB 2.0 480 Mb/s)
USB 3.1 → upto 5A (for charging) 10Gb/s speed

Apple USB Power Adapter

·Input: 100-240V~ 0.2A 50-60Hz·Output: 5V up to 1.0A

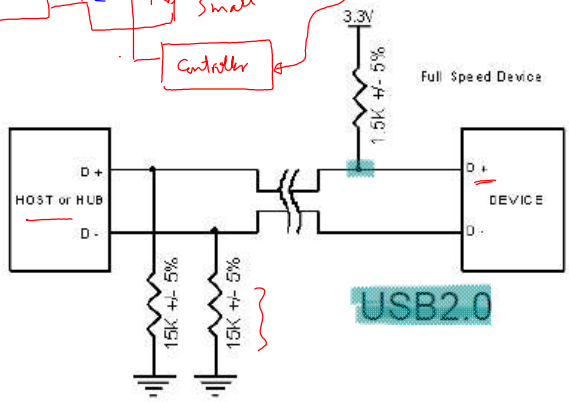
(Based on a switched mode power supply)

Other products

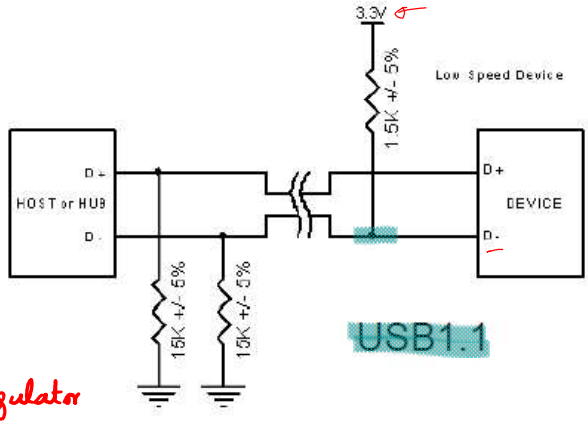


Typical circuit in a switching power adapter:

A USB device must indicate its speed by pulling either the D+ or D- line high to 3.3 volts. A full speed device, pictured below will use a pull up resistor attached to D+ to specify itself as a full speed device.



These pull up resistors at the device end will also be used by the host or hub to detect the presence of a device connected to its port. Without a pull up resistor, USB assumes there is nothing connected to the bus. Some devices have this resistor built into its silicon, which can be turned on and off under firmware control, others require an external resistor.



Connect 15k resistors on charger Side. (D+ and D- to GND)

How to get a stable +5V supply?
→ use a fixed voltage regulator
LM78XX ; LM79XX
LM7812 → 12V

Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Input Voltage (for V_O = 5V to 18V) (for V_O = 24V)	V_I V_I	35 40	V V
Thermal Resistance Junction-Cases (TO-220)	RθJC	5	°C/W
Thermal Resistance Junction-Air (TO-220)	RθJA	65	°C/W
Operating Temperature Range	TOPR	0 ~ +125	°C

LM7805
Up to 1A output current

Absolute Maximum Ratings

LM 101?

Parameter	Symbol	Value	Unit
Input Voltage (for V_O = 5V to 18V) (for V_O = 24V)	V_I V_I	35 40	V V
Thermal Resistance Junction-Cases (TO-220)	$R_{\theta JC}$	5	°C/W
Thermal Resistance Junction-Air (TO-220)	$R_{\theta JA}$	65	°C/W
Operating Temperature Range	T_{OPR}	0 ~ +125	°C
Storage Temperature Range	T_{STG}	-65 ~ +150	°C

LM7905 → -5V LM7824 → 24V LM7809 → 9V

LM7805
Up to 1A output current

Electrical Characteristics (MC7805/LM7805)

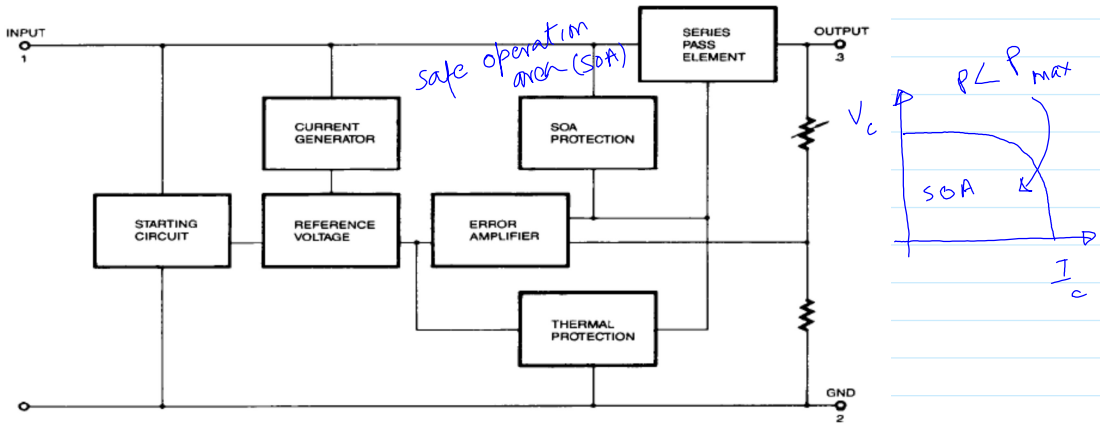
(Refer to test circuit ,0°C < T_J < 125°C, I_O = 500mA, V_I = 10V, C_I= 0.33µF, C_O= 0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		MC7805/LM7805 Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25 °C		4.8	5.0	5.2	V
		5.0mA ≤ I_O ≤ 1.0A, P_O ≤ 15W V_I = 7V to 20V		4.75	5.0	5.25	V
Line Regulation (Note1)	Regline	T_J=+25 °C	V_O = 7V to 25V	-	4.0	100	mV
			V_I = 8V to 12V	-	1.6	50	mV
Load Regulation (Note1)	Regload	T_J=+25 °C	I_O = 5.0mA to1.5A	-	9	100	mV
			I_O =250mA to 750mA	-	4	50	mV
Quiescent Current	I_Q	T_J =+25 °C		-	5.0	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1.0A		-	0.03	0.5	mA
		V_I= 7V to 25V		-	0.3	1.3	mA
Output Voltage Drift	$\Delta V_O/\Delta T$	I_O= 5mA		-	-0.8	-	mV/°C

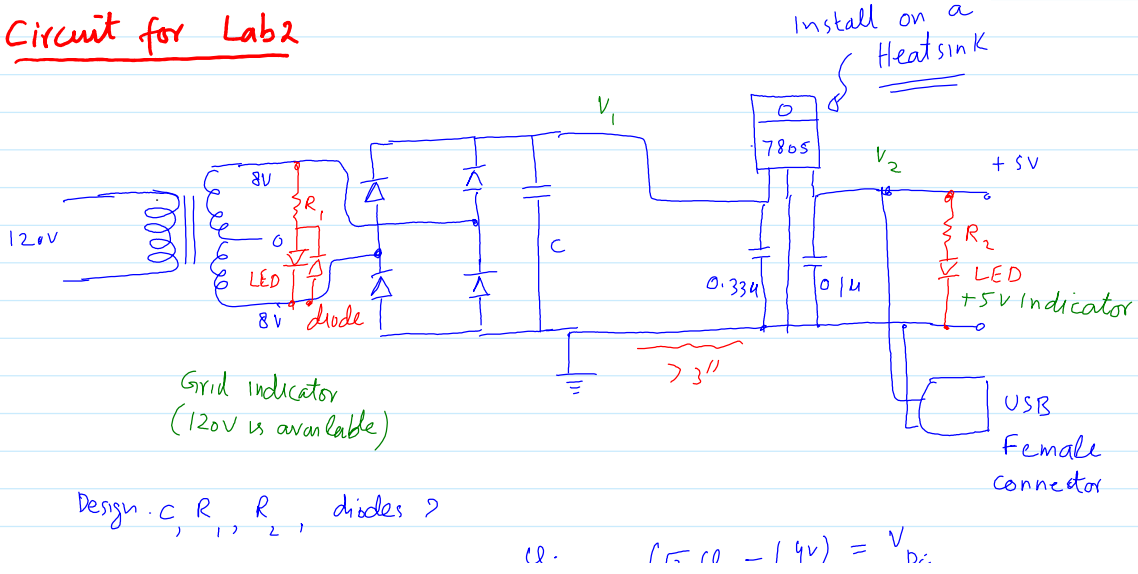
LM78L05

Up to 100mA output

Internal Block Digram (Fixed voltage regulator)



Circuit for Lab2

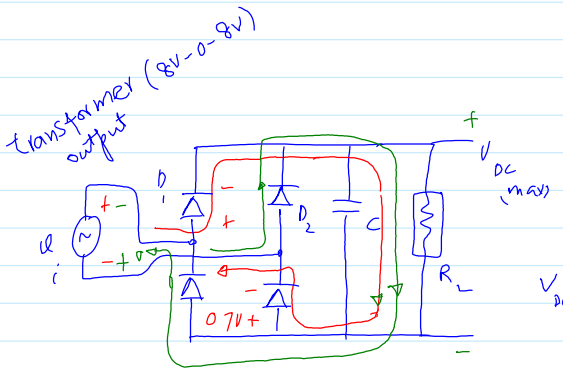


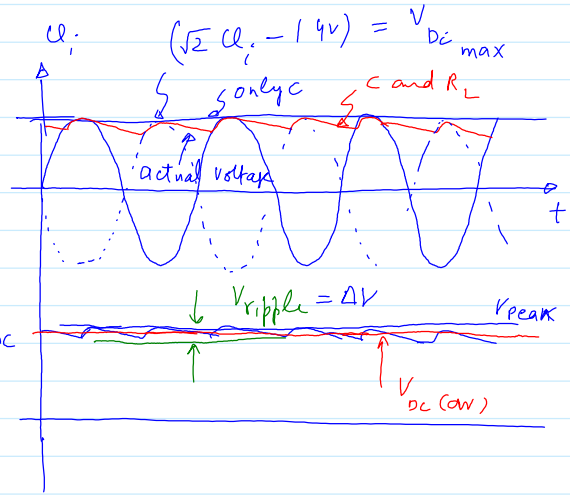
Design C, R_1, R_2, diodes ?

(e.g. $(V_{in} - 14V) = V_{D_1}$

connector

Design C, R_1, R_2, diodes ?

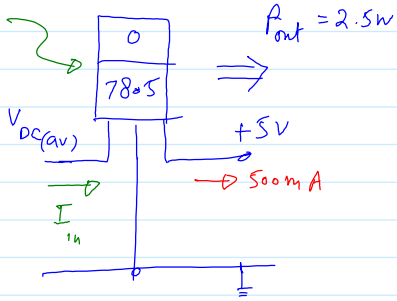




Engi 4854

$$C = \frac{V_{max}}{2 f_i \Delta V_q R_L}$$

$\eta = 80\%$



USB 2.0 ; 500mA, 5V

$P_{out} = 2.5W$

$V_{max} = \sqrt{2}(16) - 1.4V = 21.22V$

ΔV = ripple voltage = 0.5V (assume)

$V_{DC(av)} = 21.22 - \frac{0.5}{2} = 20.97V$

say $\eta = 80\%$

$$I_{in} = \frac{(2.5)}{(0.8)\,V_{DC(av)}} = \frac{2.5}{0.8 \times 20.97} = 0.15A$$

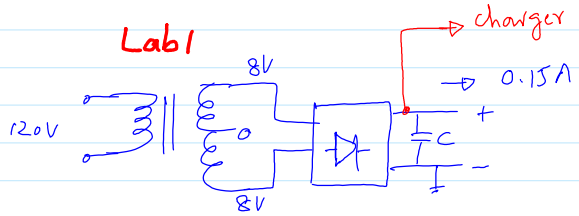
$$R_L = \frac{V_{DC(av)}}{I_{in}} = \frac{20.97}{0.15} = 139.8\,\Omega \quad \text{(equivalent)}$$

$$C = \frac{21.22}{2(60)(0.5)(139.8)} = 2529\,\mu F$$

use 2200μF 35V

standard

Lab1



Current drawn will be higher when a charger is connected

→ ripple will increase

→ Regulator will take care of that.

diode current = $\frac{0.15}{2} = 0.075\,A$

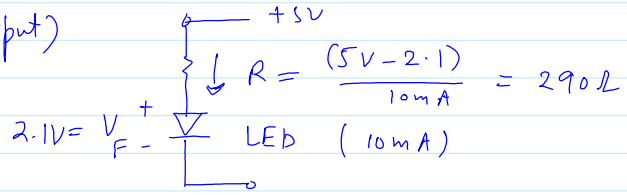
diode current $= \frac{0.15}{2} = 0.075$ A — care of that.

PIV $= \sqrt{2}\, V_{rms} - 0.7$ } for full bridge rectifier (Engi 4854)

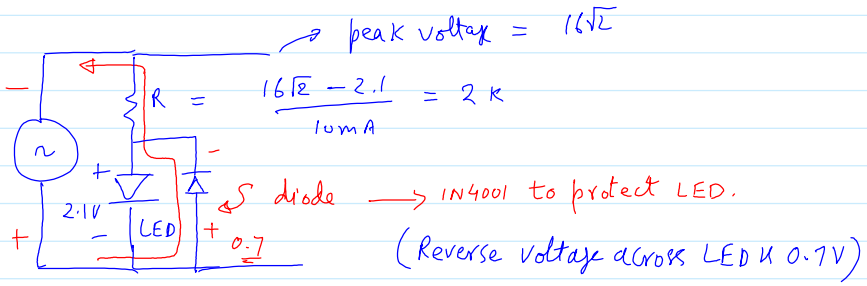
$= \sqrt{2}(16) - 0.7 = 21.2$ V

use ⟹ Diodes → 50V, 1A 1N4001 (good for charger and +5V supply)

Indicators (output)



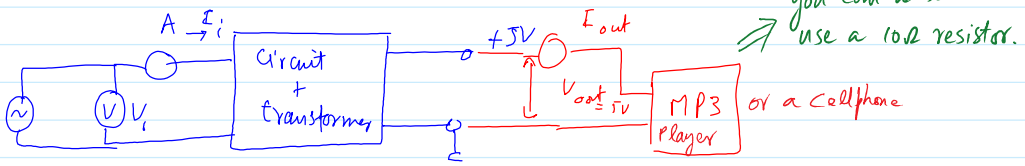
Input indicator



V_R for LED $\simeq$ 5V

Task #1 : Build above shown circuit on a prototyping board. (soldering)

Task #2 : Testing #1 Find no load losses of the circuit $= V_i I_i$



#2

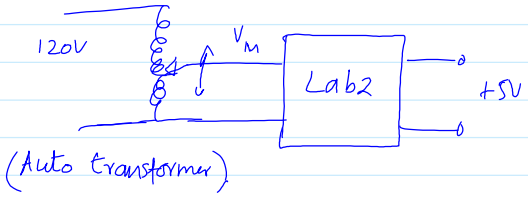
#2 Find η when a MP3 player or a cell phone or a 10Ω resistor is connected as a load.

$$\eta = \frac{V_o I_o}{V_{in} I_{in}}$$

#3 Draw V_c and +5V waveforms when a 10Ω load is connected.

across +5V output (V_1, ΔV_2) (500mA, USB 2.0)

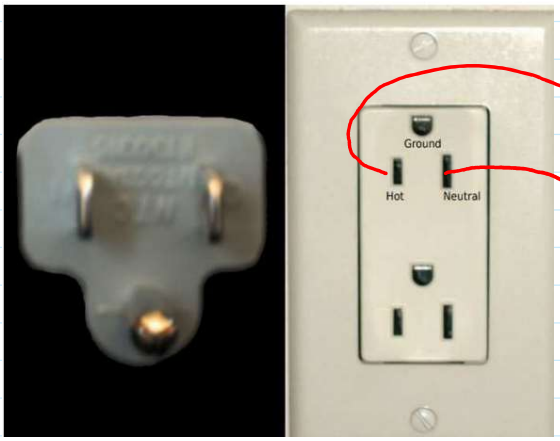
#4 Find $V_{in(min)}$ for proper operation (+5V output)



(Auto transformer)

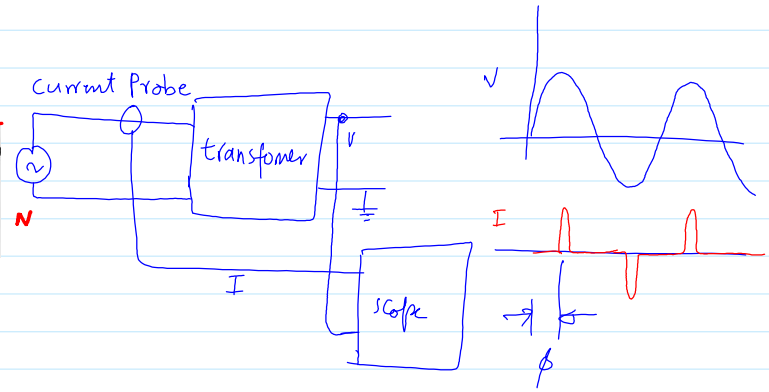
#5 Find No load and loaded power factor

Warning



DO NOT CONNECT PROBE DIRECTLY TO LINE. USE TRAMFORMER LOW VOLTAGE SIDE.

Current probe



$PF = \cos(\phi)$

#6 Find energy consumed in a year (No load operation)

$= V_{in} I_{in} \times 8760$

#7 Compare result #6 with the result of a commercial adapter

(your η may be low since charger part was ignored)

(Most of the transformer output current will go to PWM charger)