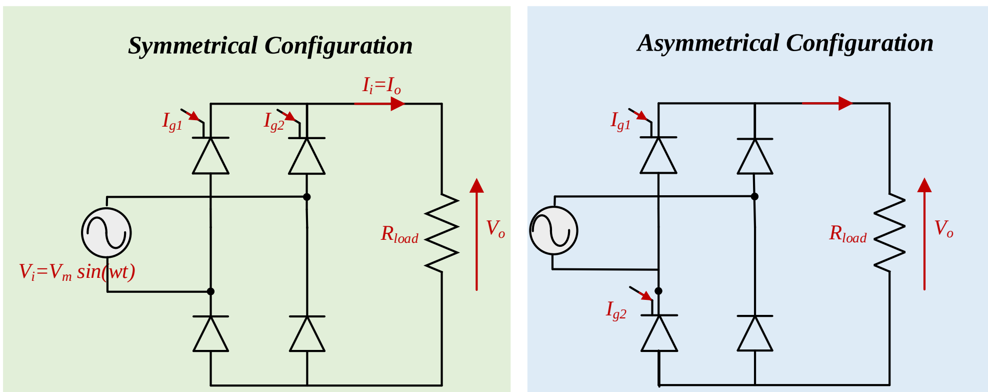
Power Electronics 1

Lab 3

Introduction

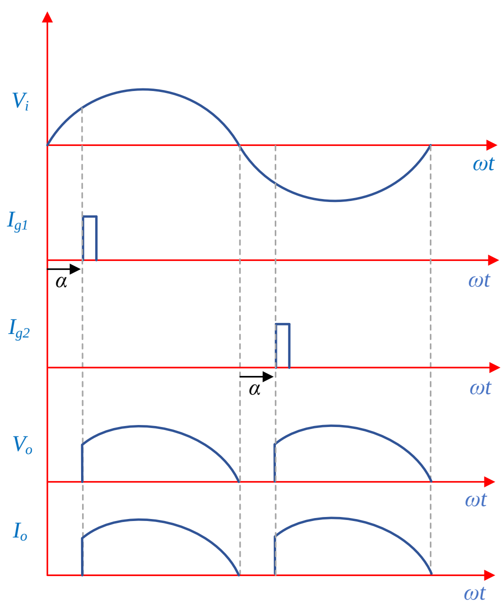
Single-phase full-wave semi-controlled rectifier is used to provide a controlled DC voltage with a higher maximum DC value and a lower AC component compared to the half-wave. it can be used to drive a DC motor. Also, it can be called single-phase half-controlled rectifier.

Single phase full-wave semi-controlled rectifier



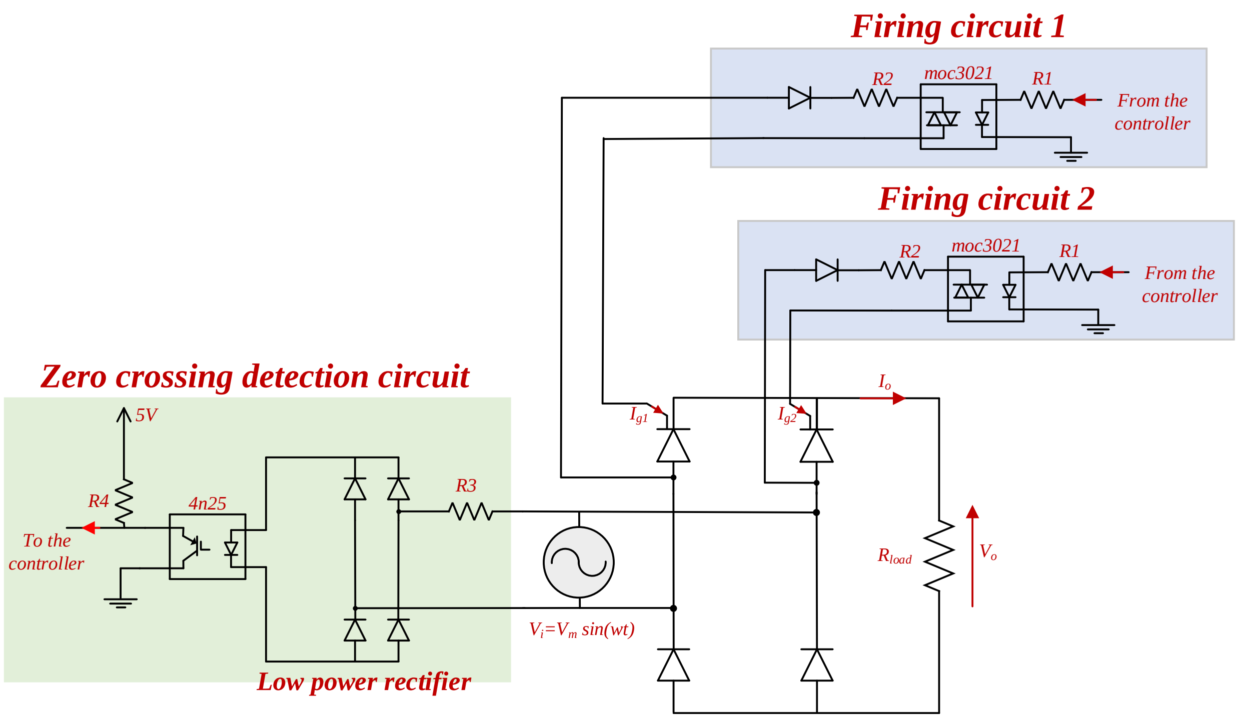
The DC component (average value) of the output voltage in case of a single phase half-wave controlled rectifier is given by;

$$V_{o_{av}} = \frac{V_m}{\pi}(1 + \cos(\alpha))$$



The hardware circuit using MOC 3021 in the firing circuit

In the hardware circuit in order to provide the gate pulse to the thyristor:
two firing circuits (using MOC 3021 for each thyristor) and a zero-crossing detection circuit are needed.

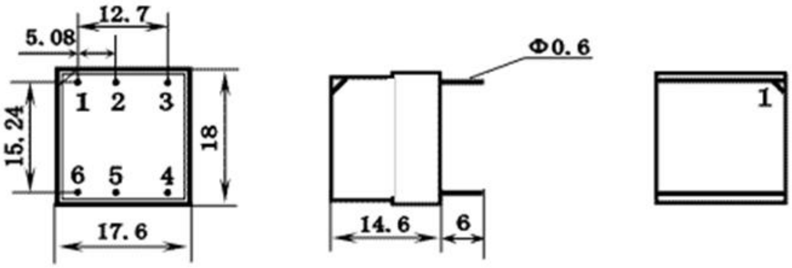


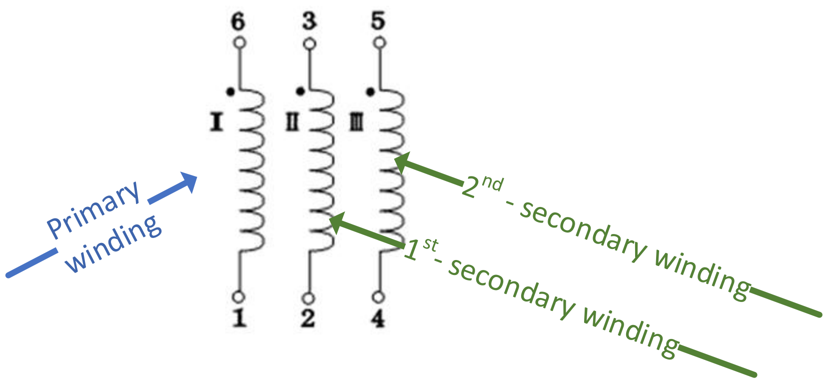
Notes

- The ground point of the firing and the zero-crossing circuits should be connected to the ground of the controller.
- The controller should provide a gate pulse after a specific delay angle (α) from detecting the zero point. In this case the controller will provide two pulses in each cycle. So **same gating signal can be applied to both firing circuits**, where only the forward biased thyristor will be turned on at each gating pulse.
- Although same gating is applied to both firing circuit, it is **recommended** to use **different pins** from the controller to each firing circuit to decrease the burden on the controller pins.
- The gate pulse should be of a suitable time for example 1 ms.
- The resistors should be selected carefully based on the operating voltage and the typical used thyristor, where like the circuit in lab 3, same concept can be applied to select R1, R2, R3, and R4.

The hardware circuit using PULSE transformer KCB473/211B in the firing circuit

In the hardware circuit in order to provide the gate pulse to the thyristor:
two firing circuits (one pulse transformer with three winding configuration – one primary and two secondary winding-) and a zero-crossing detection circuit are needed.

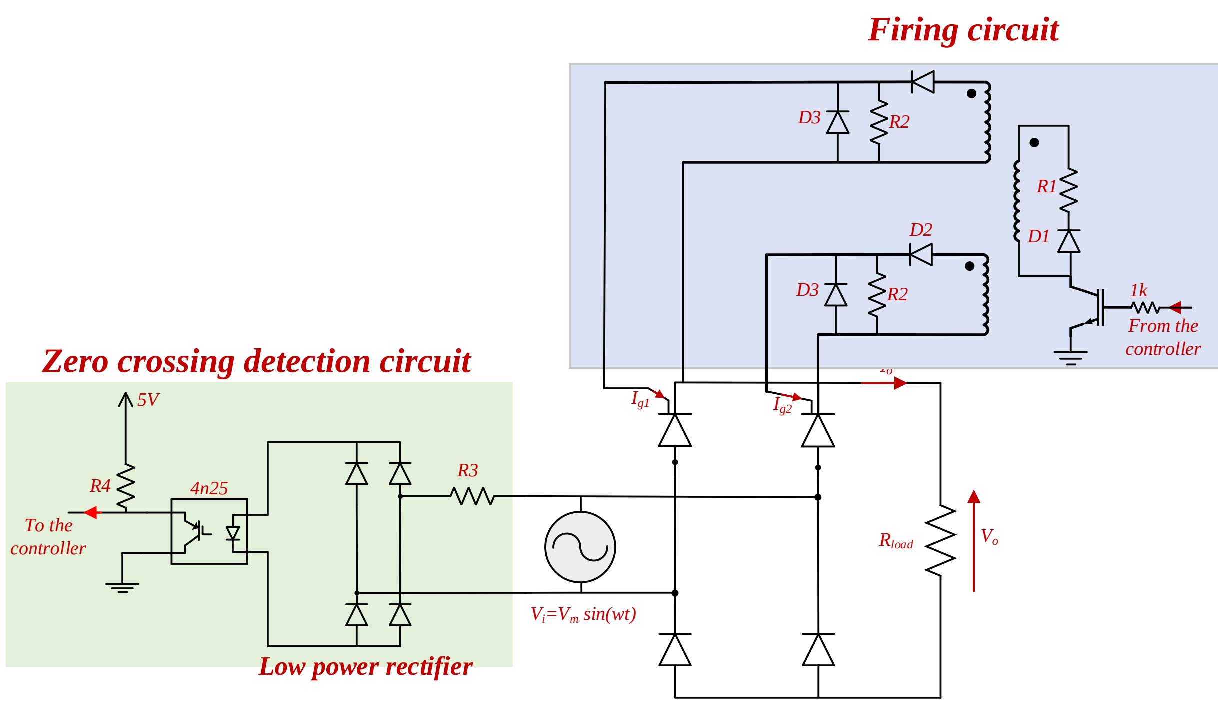




Model	u	Vp (KV)	Triggering Mode	Fp (HZ)	∫ udt (μVS)	V_1 (V)	tn (μs)	V_2 (V)	R_L (Ω)
KCB473/211B	2:1:1	3.1	Pulse Train	3KHz	750	15	50	5	50

***The meaning of the parameters:**

u - transformer ratio = I : II : III : IV
Vp - effective voltage value of testing dielectric strength imposed on between coils, its duration is 60 seconds.
Fp - testing pulse frequency (Tp: cycle time).100Hz is referred to single pulse, the others referred to pulse train, assuming that width of pulse train (equivalent width) is td=2ms
∫udt - rated product of volt-microsecond V1·tn , which basically dose not change in certain range of frequencies
V1-input pulse amplitude (primary pulse voltage)
tn - rated pulse width transferred under the related V1 and fp (50 ~ 1000 us)
V2 - output pulse amplitude (secondary pulse voltage)



Notes

- In this pulse transformer: you have three winding: 1 primary and two secondaries
  you could control the two secondary with only one signal on the primary.
- Hence: using one pulse transformer with only one firing pulse, make you able to control two thyristors at a time.
- The ground point of the firing and the zero-crossing circuits should be connected to the ground of the controller.
- The controller should provide a gate pulse after a specific delay angle (α) from detecting the zero point. In this case the controller will provide <u>two pulses in each cycle</u>. So **same gating signal can be applied to both firing circuits**, where only the forward biased thyristor will be turned on at each gating pulse.
- Although same gating is applied to both firing circuit, it is **recommended** to use **different pins** from the controller to each firing circuit to decrease the burden on the controller pins.
- The gate pulse should be of a suitable time for example 50u ~1 ms.
- R1 and D1 act as current continuing components.
  D1 normally is 1N4007,R1 is selected between 1K Ω ~ 2K Ω
- D2,D3,R2 act as shaping components.
  D2,D3 can be 1N4007,R2 is optional from a few tens ohms to several hundreds ohms.(200 ohm)

Requirements

- MATLAB Simulation on the single phase full-wave semi-controlled rectifier (Screen shots of the simulated circuit, measurements of the output voltage and input current).
- PCB board for single phase full-wave semi-controlled rectifier.
- It is required to design the circuit with any firing circuit (either using MOC or pulse transformer).
- **Three push buttons** are required: 1: increase (α) 2: Decrease (α) 3: Reset (α) to zero (remember that $0 \leq \alpha \leq 180$; assume the range has 11 points)

Instructions

- Only 5-6 students are allowed per team.
- All PCB boards should have the number of the team written on it. Otherwise, the board will be held until the end of the submission week.
- At the submission day, the mark is given based on the PCB board, simulation, and a few oral questions

What each student should have learnt by the end of lab 4

- How the single phase full-wave semi-controlled rectifier works.
- How to build a zero-crossing detector circuit.
- How to fire a thyristor
- How to design an experimental circuit of a single phase full-wave semi-controlled rectifier
- Debugging a PCB circuit.