Chapter Ⅲ Thyristor Firing Circuit Exercises

In this chapter students are able to perform exercises about UJT firing circuit, cosine wave crossing control circuit, two linear firing angle control circuits, and Siemens TCA785 firing circuit.

Exp. 3-1 Unijunction Transistor (UJT) Firing Circuit

1. Objectives

(1) To be familiar with the principle of unijunction transistor (UJT) firing circuit and function of each component.

(2) To master the commissioning of the unijunction transistor firing circuit.

2. Equipment

No.	Description	Remark
1	MPE-01 Power control panel	
2	MPE-12 Firing circuit of single-phase converter (Ⅰ)	
3	Dual-channel oscilloscope	Users-self-equipped

3. Principle

Fig.3-1 shows a self-oscillating circuit with frequency adjustable. In this circuit, V_6 is a unijunction transistor (commonly used model: BT33 and BT35); a RC charging circuit is composed of the equivalent resistor V5 and C1; a capacitor discharging circuit consists of C1, V6, and primary winding of pulse transformer; RP_1 is used to change the equivalent resistance of C_1 charging circuit to accordingly change the charging time.

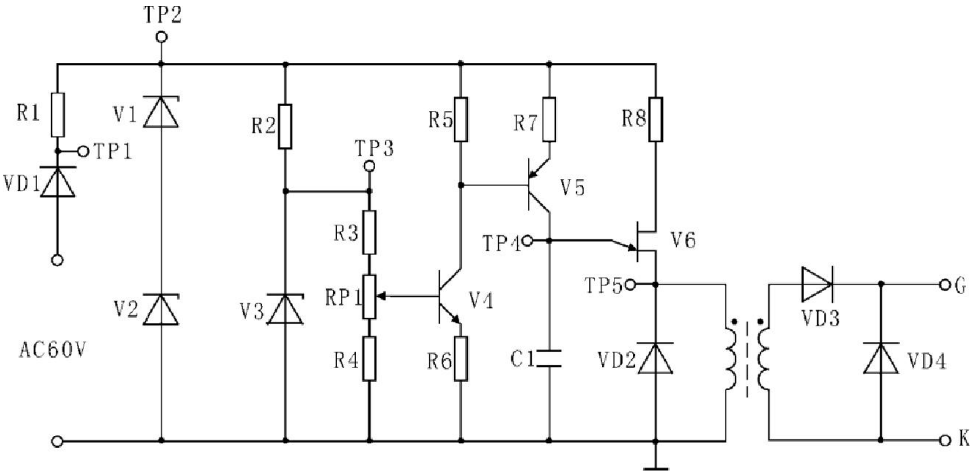

Fig.3-1 Schematic diagram of UJT firing circuit

Operating process: a 60V sync signal from synchronous transformer is applied to the half-wave rectifier VD_1, and is clipped to a trapezoidal wave whose zero crossing point should be in phase with the one of power supply, then C_1 is charged through R_7 and V_5 till the charging voltage reaches to peak voltage of unijunction transistor U_P, now V_6 is conducted and C_1 discharges through the pulse transformer, hence a pulse is output from the secondary side of pulse transformer. However, due to a small discharge time constant, the voltage across C_1 drops quickly to the valley voltage U_V of unijunction transistor to turn V_6 off and recharge C_1. As the charging and discharging moving in cycles, a sawtooth wave is formed across C_1, and a sharp pulse is generated at the secondary side of pulse transformer. Note that the thyristor firing is only affected by the first firing pulse in a cycle. The charging time constant is determined by capacitance of C_1 and equivalent resistance, so RP_1 can be used to change the charging time of C_1 to perform the pulse phase shift control. Waveforms at the test points are shown in Fig.3-2.

RP_1 and all test signals are available on the faceplate, and synchronous signals have been connected inside.

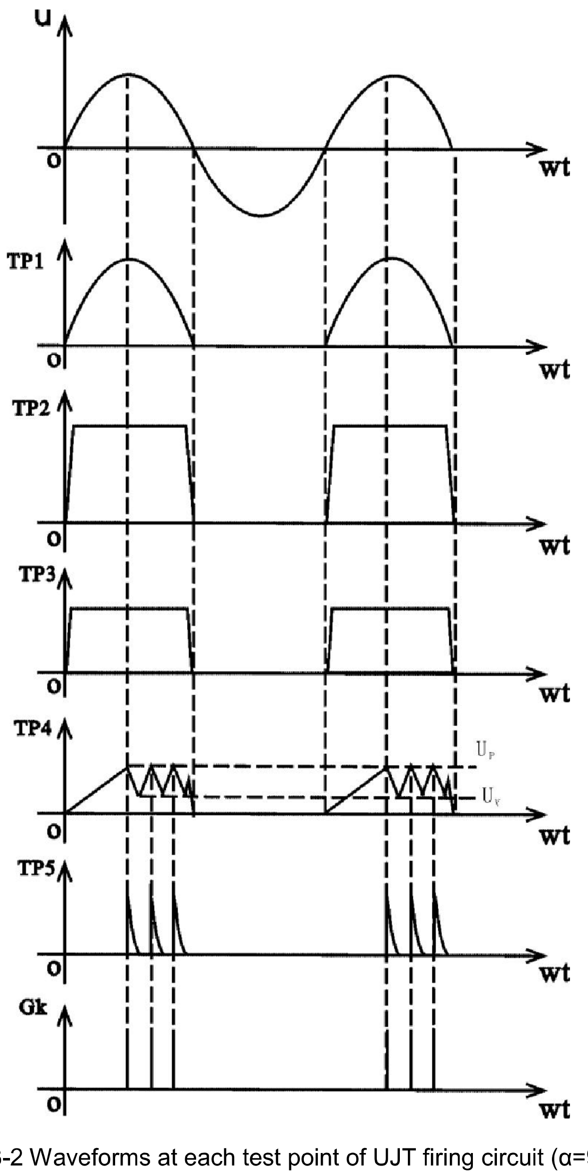

Fig.3-2 Waveforms at each test point of UJT firing circuit (α=90°)

4. Experimental contents

(1) Commissioning of UJT firing circuit

(2) Observation of waveforms at each test point of UJT firing circuit

5. Pre-lab

Review the knowledge about unijunction transistor, and master the principle of a UJT firing circuit.

6. Questions

(1) What is the relationship between the oscillating frequency and capacitance of C1 in the UJT firing circuit?

(2) Can the phase shift range of UJT firing circuit reach to 180°?

7. Operating instructions

(1) Observation of waveforms at each test point of UJT firing circuit

Apply a line voltage output from the power control panel to the “IN~220V” terminal on MPE-12. Press down “Start” button on power control panel, and switch on MPE-12 unit to activate all the firing circuits. Monitor the 60V sync signal with one channel of dual-channel oscilloscope, leaving the other channel for observing waveform at TP1, TP2, TP3, TP4, and TP5 respectively. Observe the waveform variation at TP4 and TP5 during adjusting RP1. Check whether the firing voltage at terminals G and K can shift in range of 30°~170°.

(2) Recording the waveforms at each test point of UJT firing circuit

Adjust RP1 to change the firing angle α, and record the waveforms at each test point when α=30°/60°/90°/120°, then compare with waveforms in Fig.3-2.

8. Laboratory report

Record the waveforms and amplitude at each test point when α=60°.

9. Notes

(1) The two probes of a dual channel oscilloscope should be connected to common ground to avoid an electric short circuit fault.

(2) To reduce the observation error caused by capacitance, it is required to connect terminals G and K to gate and cathode of thyristor respectively when observing the waveforms of output pulse voltage.

(3) Make sure the calibration knobs, the small knob in the center of both the volts/div and time/div knobs, that are always in the fully CW position when measuring the amplitude and period of a signal using oscilloscope.

Exp. 3-2 Linear Firing Angle Control Circuit

1. Objectives

(1) To be familiar with the principle of a linear firing angle control circuit, and the function of each component.

(2) To master the commissioning of a linear firing angle control circuit.

2. Equipment

No.	Description	Remark
1	MPE-01 Power control panel	
2	MPE-12 Firing circuit of single-phase converter (Ⅰ)	
3	Dual-channel oscilloscope	Users-self-equipped

3. Principle

The linear firing angle control circuit include synchronous detection, sawtooth wave generation, pulse generation, pulse amplification, etc., as shown in Fig.3-3.

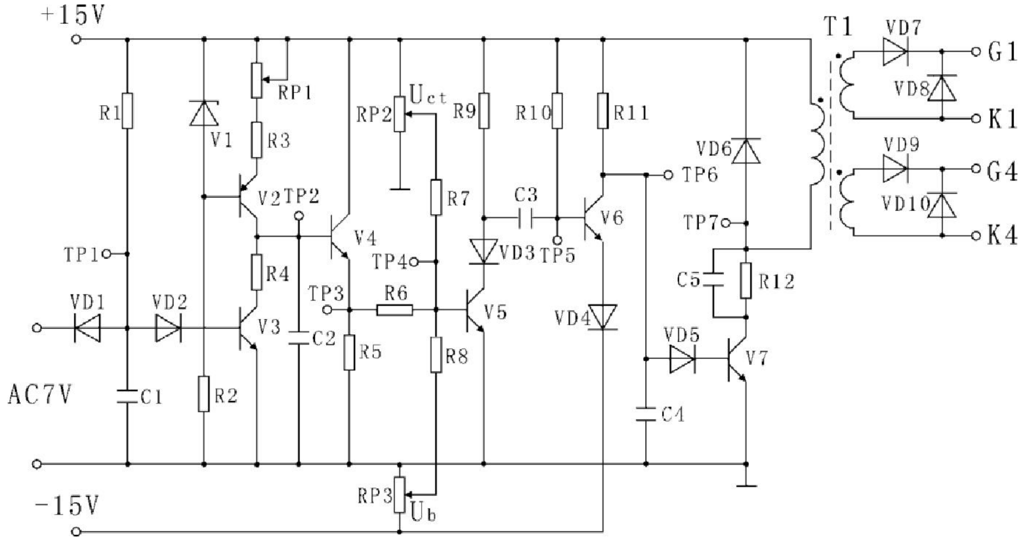

Fig.3-3 Schematic diagram of linear firing angle control circuit

Components V_3, VD_1, VD_2, and C_1 form a synchronous detection circuit to control the generating time of sawtooth wave and its width. V_1 and V_2 make a constant current source, C_2 is charged to generate sawtooth wave when V_3 is off while C_2 is discharged through R_4 and V_3 when V_3 is on. To change the current level of constant current source, adjust RP_1, then the ramp of sawtooth wave is also changed. A phase-shift control circuit is formed by U_{ct} (controlled by RP_2), U_b (controlled by RP_3), and sawtooth voltage at the base of V_5. V_6 and V_7 function pulse generation and amplification, the firing pulse is output from the pulse transformer. Waveforms at each test point of linear firing angle control circuit are shown in Fig.3-4.

MPE-12 unit has linear firing angle control circuits I and Ⅱ which are the same but there is a phase difference of 180° between their output pulses.

RP_1, RP_2, RP_3, and all test signals are available on the faceplate, and the secondary winding of synchronous transformer has been connected inside.

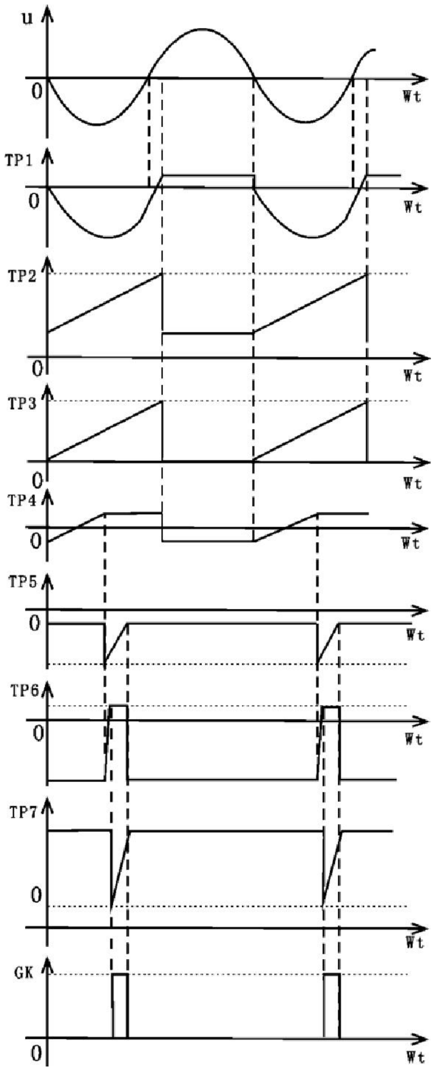

Fig.3-4 Waveforms at each test point of linear firing angle control circuit I (α=90°)

4. Experimental contents

(1) Commissioning of linear firing angle control circuit

(2) Observation of waveforms at each test point of linear firing angle control circuit

5. Pre-lab

(1) Review the knowledge about linear firing angle control circuit, and master its principle.

(2) Master how to determine the initial phase of firing pulse in a linear firing angle control circuit.

6. Questions

(1) What are the features of a linear firing angle control circuit?

(2) Which parameters will affect the phase-shift range of linear firing angle control circuit?

(3) The phase-shift range of linear firing angle control circuit is wider than the one of cosine wave crossing control circuit, why?

7. Operating instructions

(1) Apply a line voltage output from the power control panel to the “IN~220V” terminal on MPE-12. Press down “Start” button on power control panel, and switch on MPE-12 unit to activate all the firing circuits, then:

1) Simultaneously observe the waveforms of synchronous voltage and the voltage at point “1” to study how the waveform at point “1” generate.

2) Observe the waveform at points “1” and “2” to study the relationship between the waveform at point “1” and sawtooth wave width.

3) Observe the variation of sawtooth wave ramp at point “2” when adjusting RP_1.

4) Observe and record the waveforms of output voltage and the voltages at points “3”~“7”, then analyze the relationship between the voltages at points “4” and “7”.

(2) Phase-shift range determination of firing pulse

Adjust RP_2 CCW to the end (U_{ct}=0), observe the waveforms of test point 7 and synchronous voltage with a dual-channel oscilloscope, then adjust RP_3 for a firing angle of 170°.

(3) Adjust RP_2 till α=60°, then observe and record the waveforms at each test point and terminals G and K

	U_1	U_2	U_3	U_4	U_5	U_6	U_7
Amplitude (V)							
Width (ms)							

8. Laboratory report

(1) Record every experimental waveform, and mark its amplitude and width.

(2) Summarize method for phase shift range adjustment in linear firing angle control circuit. For example, how to enable α=90° if U_{ct}=0?

9. Notes

Please refer to the notes in Exp.3-1.