THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

Department of Electrical and Electronic Engineering

EEE 3112 EXPERIMENT NO. 04 & 05

TITLE: FAULT FINDING

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LECTURER'S COMMENTS

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1.0 Objective

To get training on how to locate or find faults in electronic circuits and learning fault finding techniques.

2.0 Equipment

i. Fault finding trainer FSC
ii. Oscilloscope a fault
iii. Oscilloscope probes
iv. Digital voltmeter fluke 45
v. Variable load resistor 0 -63Ω,50W
vi. Ammeter 0-1 5A

3.0 Theory

3.1 Fault finding techniques

Various fault finding techniques are usually used by an experienced technician to ensure that the fault is located in an electric or electronic circuit. But that is done if the technician knows the fault at hand and how to find it. Here below is the sequence that might be used to establish the fault.

3.2 A fault finding sequence

3.2.1 What is wrong?

Define the fault; “What is actually wrong?”

Is the fault due to the luck of knowledge on how the work? Is there really a fault?

Be sure to get an accurate description on the fault and how it developed. This will give a clue to the fault. It is important that you how the equipment is supposed to work, in order to establish the nature of the fault.

3.2.2 Is the plug in the socket?

The fault might be severe; perhaps the equipment is all dead. The first you should check is weather the equipment gets power. Is the plug in the socket? Is the fuse blown? Is the ON button pushed?

3.2.3 Look, smell and feel

If the fault persists, open the box. (If you are unsure of how this should be done, get hold of the maintenance handbook. You could quite easily damage the equipment mechanically.)

Use your eyesight.

Do you see any loose ends burned or mechanically damaged components?
Do you detect any “warm” smells? Are any components warmer than they outer to be? Touch the suspected components (be careful with dangerous voltages.)
Such preliminary investigation will often lead you directly to the fault, but remember a burnt component is perhaps more than a symptom of a fault, not the fault itself, so do some thinking and measurements before you replace the damaged components that expensive. Perhaps they will be blown at once when you turn on the equipment.

3.2.4 The halving method

The next step is to roughly locate the fault to certain part of the equipment. If your equipment consists of chain of amplifiers or other blocks where 2 depend on 1 and so on, try to locate the fault to a certain part of the chain. If the fault is in the last part and you start, moving through the whole equipment, you certainly find the fault, but this will be very time consuming.

You could insert a signal at the input and measure half way through the circuit to see whether you have correct signal there. If you have, then the fault is probably in the second half, and you could measure again, ¼ from the end, each time using the principal of halving. In general this is the fastest method when looking for faults and is called the method of halving. To use the method you must have some knowledge on the expected shape and magnitude of the signal along the signal path.

3.2.5 DC measurements

Let us say that you are looking for faults in analogue equipment and are finished with the measurements. You have located the fault roughly to a certain part of the equipment. Now is the time for DC voltages you should ***turn off any analogue signals***, as they could give wrong DC values due to rectifying effects, saturation etc.

3.2.6 Resistance measurements

In the end you may have the to measure resistance. To establish the exact faults when the AC and DC measurements have led you to certain conclusions, but here we have several tumbling stones. When locating the fault using D C measurement, make sure that the following are taken care of:

i. Be sure to switch off the power before start measuring.

ii. Be aware of electrolytic capacitors that are not fully discharged when you measure resistance, as this may give peculiar results. To avoid this you may short circuit the electrolytic capacitors before you measure resistance.

NB: This should be done without power.

Often it is possible to do a lot of "on board" resistance measurements without soldering out the components, but to do this, have look at the circuit diagram to see the possible routes for the current, so that you roughly know what you should get.

Most errors on diodes and transistors can be found by resistance measurements if the AC and DC measurements indicate an error.

3.2.7 Calibration

When you have finished the fault finding and changed the components it will be often be necessary to calibrate the equipment. As the specification for the components admit a certain variation of values, voltages and currents may have changed and need adjustment.

3.2.8 Maintenance and repair log

Each piece of equipment should have maintenance and repair log, keeping track of everything that is done before, including calibration, maintenance, faults and repairs.

Whenever a fault develops or you have problem with calibration, you may see what has been done before, and quite often the same fault will develop again. As the repair technician will change and/ or much time pass, you should not depend on the memory of the technician alone.

3.2.9 Description of the power supply

The fault finding trainer FSC is a fully operating standard power supply, a series regulator. It is equipped with a row of switches used to set faults, ***one at time.*** First we measure on the faultless power supply to know the normal operating voltages. And then we introduce faults, one at time and try to find the fault component. To do this we use a multi-meter and an oscilloscope. All the necessary measuring points can be reached from outside. There is no need to open the case.

The power supply has a stabilized output and is fed from 220V, 50Hz AC mains. The output voltage E may be adjusted from 9 to 24 V by adjusting the potentiometer P. The output E is stabilized against variations in input voltage and output load. The maximum output current should be 1A DC. In case of overload, the power supply is shut down and will remain down until the overload is removed and button SW_2 is pressed. Functional description of the power supply is shown below:

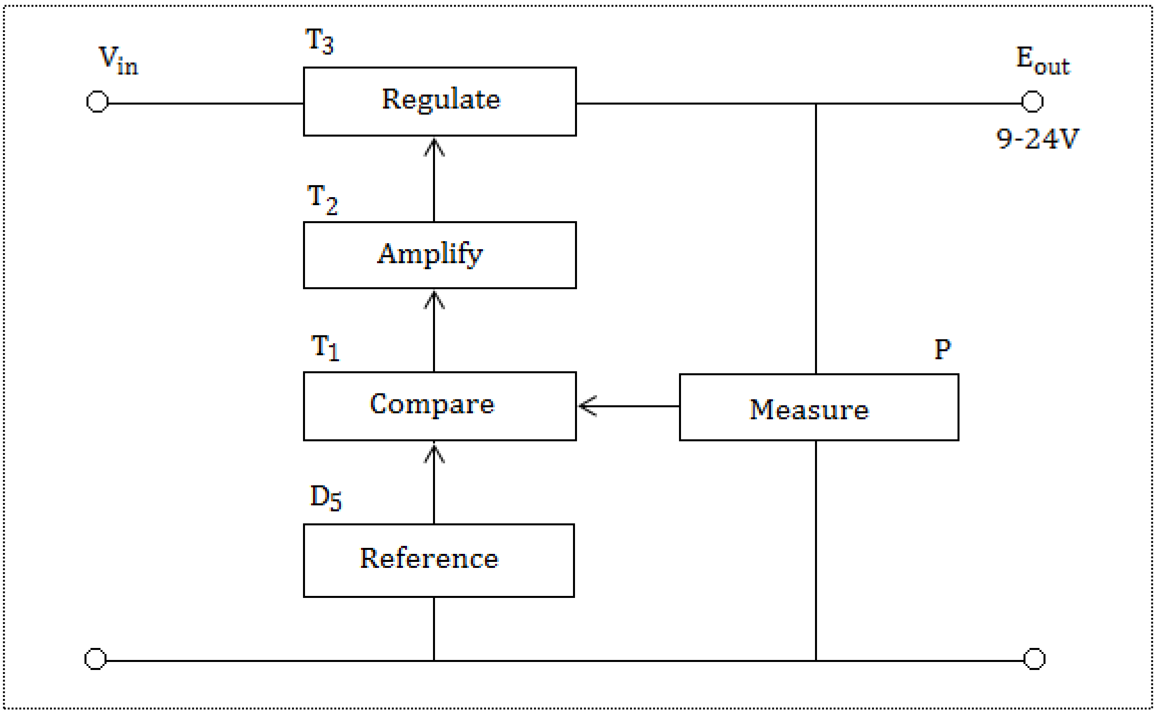

Figure 1 - Block Diagram for the stabiliser part of Power supply

Figure 2 shows a simplified diagram showing the voltages in the voltages in the regular and how they add.

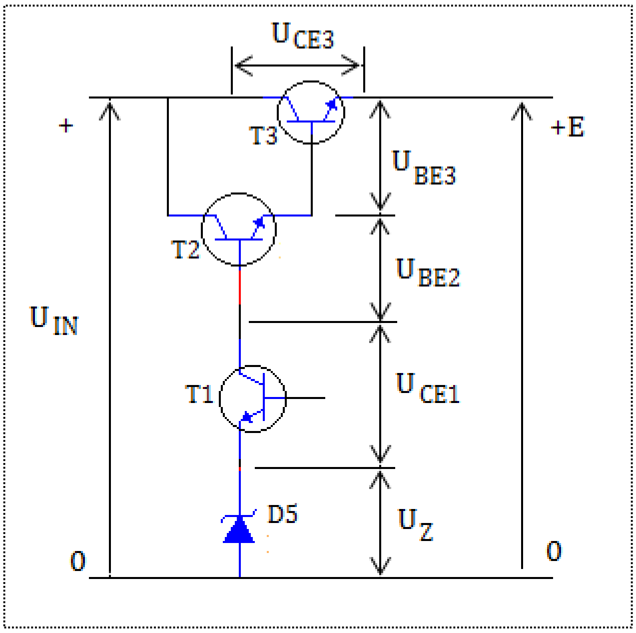

Figure 2 - Simplified Diagram showing Voltages in Regulator and how they add

We may write

E=$U_Z + U_{CE} + U_{BE2} + U_{BE3}$ [1]

Or

E=$U_{IN} + U_{CE3}$ [2]

3.2.10 Lowest output voltage

From equation (1) we get the ***lowest*** value for E that the regular can give.V_{BE} is about 0.7V for a normally biased silicon transistor, and as V_{CE} must be > 0 for normal operation, we get:

E_{min}=U_Z+2+0.7=U_Z + 1.4V. Here U_{CE1}= 0V (The transistor is fully saturated.) In our regulator U_z= 5.6V, so the theoretical minimum output voltage is 7V

3.2.11 Highest output voltage

From equation (2) we get the theoretical ***highest*** value of E.

For the transistor T_3 to work normally, it needs a minimum collector/emmiter remember of the 1V. This gives E_{max} =$U_{IN} - 1$ volt.

Remember that U_{IN} drops with increasing load current, so the value used for U_{IN} should be the input voltage at full load. In this practical design we have not used the theoretical limits E_{min} and E_{max}. By the use of R_7 and R_8 we have got 9V and 24V.

3.2.12 The start and the regulation

When SW1 is operated T_2 and T_3 get their collector voltage from the rectifier. C_2 is charged through R_2, and T_2 gets its base from current from R_3, which also is the collector resistor of T_2 is the base current T_3. Then T_3 is delivering current to the zener diode D_5 with through R_6, thereby giving 5.6V across D_5 with + at the emitter of T_1 ,the transistor T_1 is now “comparing” the voltages at the emitter and the base.

3.2.13 Too high output voltage

The voltage at the test point that joins the base of transistor T1 and the potentiometer is directly related to the voltage, and if it increases, the base current of T_1 will increase, giving an emitter current.

When the emitter current increases, the voltage at test point between the base of transistor T2 and the collector of Transistor T1 decreases, which in turn will give a drop to the voltage at E, the output

The voltage drop at E follows the fact that there is a constant voltage drop 1.4 volt from the base of T_2 to the emitter of T_3 As the output voltage is reduced, the voltage at test point of the base of T1 and the potentiometer is also reduced until the voltage there is U_Z + 0.7 volts, in our case 6.3V, then we have balance.

3.2.14 Too low output voltage

This will make the base voltage of T_1 drop, and if it drops below 6.3V, the base current will decrease, giving a decrease in the emitter current, which in turn will make the voltage at test point between the collector of T1 and base of Transistor T2 higher. Then the output voltage will increase as will, until the voltage at test of the joint of the potentiometer and the base of Transistor T1 is equal to U_Z+ 0.7 =6.3V due to the effect of the negative feedback.

3.2.15 Overload protection

This consists of the thyristor TY, resistors R_1, R_4 and R_5 in addition to the push switch SW2. The load current I_L will create a voltage drop U_4 across the “sampling” resistor R_4 which gives gate voltage to the thyristor. When this voltage reaches about 0.6V, the thyristor is trigged, and champs the base voltage of T_2 and T_3 will be cut off, thereby giving 0 volt output.

Once trigged the current through the thyristor will continue until the current drops below a certain threshold value. Then the output voltage will stay at 0V

To make the circuit work again, we must reduce the current through the thyristor below the threshold current by short circuiting it with the push button switch SW2. When we release SW_2, the circuit will work as normal if the overload at the output is removed.

4.0 Procedure

Measurements on the power supply

4.1 It was ensured that all the faults were turned off by turning the switches down.

4.2 "SET E" was adjusted midway and the circuit was started with SW_1, without load.

4.3 "SET E" was turned to the right as far as it goes and E_{max} was measured and recorded.

4.4 "SET E" was turned to the left as far as it goes and E_{min} was measured and recorded.

4.5 We further adjusted "SET E" until we got 20V output and filled in the table below.

4.6 The "no fault" voltages were measured at the different test points and noted them in the circuit drawings below when the load was 0A and 0.7A.The output voltage set to 20V. These "normal" values were used when finding faults.

4.7 The first fault was turned on using switch 1 and discovered the fault using multi-meter, and/ or oscilloscope. This continued with subsequent switches to turn on fault 2 until fault 16.When a fault component was discovered, we marked and the results were tabulated as shown in the table below.

5.0 Diagrams

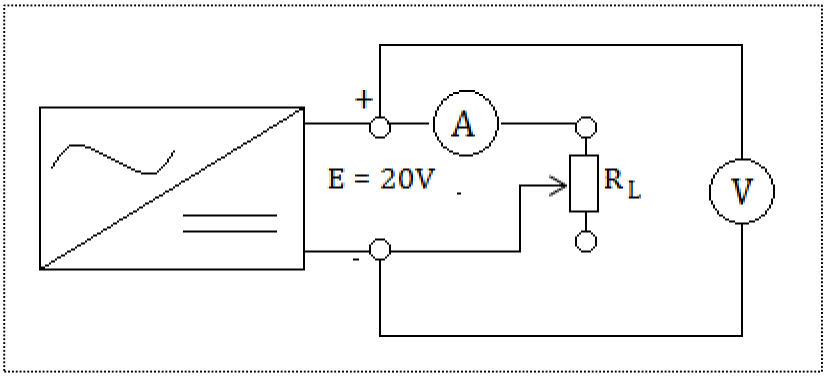

Figure 3 - Measurement of the Power Supply

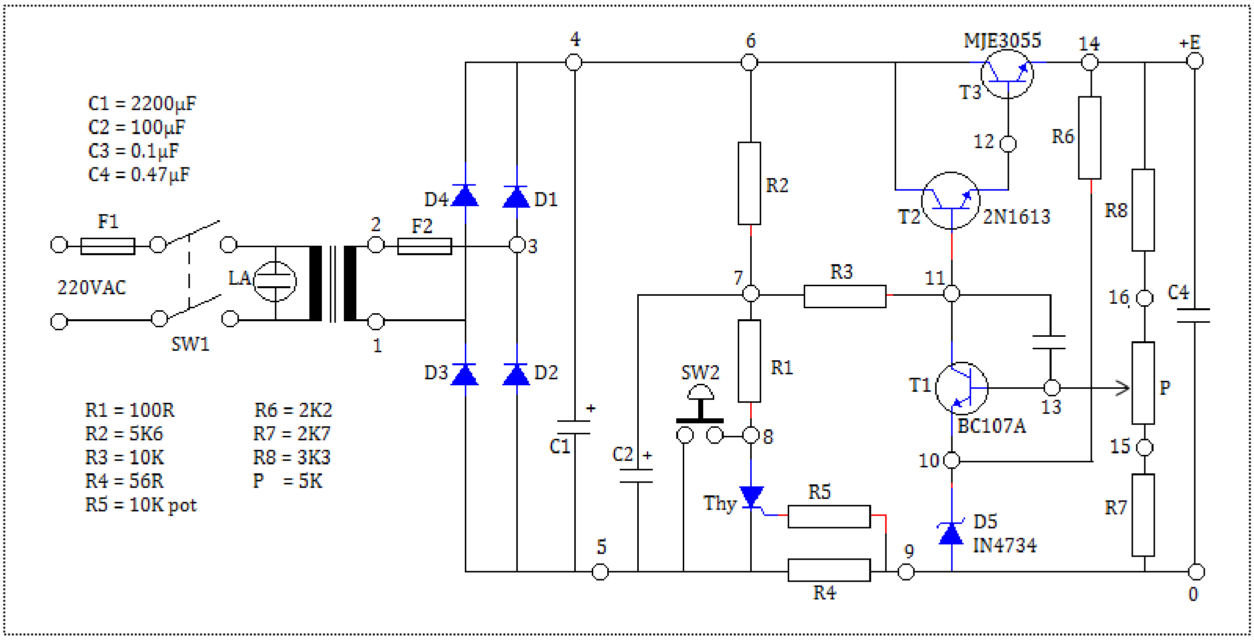

Figure 4 - No Fault, No Load Voltages

6.0 Results

6.1 Data collection/analysis

6.1.1 Without load

$$E_{max} = 27.5V$$

$$E_{min} = 8.8V$$

Table 1 – The Voltage/Current Results

I_L[A]	E[V]
0.0	20.00
0.6	19.87
0.4	19.92
0.8	19.83

Table 2- value of number of fault voltage at 0A and 0.65A

Point number	1	2	3	4	5 mV	6	7	8	9 mV	10	11	12	13	14	15	16
Voltage at 0A[V]	29.8	29.8	29.8	39.5	-5.9	39.5	33	0.0	5.5	21	21.6	21.1	6.2	20	4.5	4
Voltage at load[V] 0.7	26.5	26.5	26.5	30.9	-0.5	30.9	23.3	27.3	-23.6	5.5	20.8	20.7	6.1	19.9	4.4	13

Table 3 - Fault Finding Protocol

FAULT NUMBER	SYMPTOM OR MEASUREMENT RESULTS	CONCLUSION FROM MEASUREMENT
1.	Voltage drops from 29.8 to 1v across fuse 2	Fuse 2 faulty, its resistance increased.
2.	Across fuse 2 was a drop from 29.8 – 0.8v	Fuse 2 faulty, its resistance interest
3.	At point 4, was drop from 39.5 to 0.64v	Diode 1 was affected, its resistance interest.
4.	Voltage drop at point 4	Resistance of R_2 increased
5.	At point 7, was a drop from 35.0 → 0.16mv	Thyristor or SW2 shorted
6.	At point 7, was a drop from 33.0 → 0.7v	Capacitor C_2 shorted
7.	A drop also at point 7	R_2 increased/opened
8.	Voltage drops at point 10 from 5.6 to 5.3mv	Zeno diode not properly working like started
9.	Voltage drop at point at 11 from 20v → 5	T_1 Was fault, reverse biased.
10.	Increase in voltage at 11 from 21.6v to 39v ≈ voltage at 7	R_3 was started
11.	Low output voltage	T_2 was reversed
12.	No element flows from point 11 to point 12	T_2 had its base –emitter opened/reversed
13.	Voltage increased 20v to 25v at point 14 ≈ voltage at 6.	T_3 there was a short between cannon and emitter
14.	Voltage drop at point 11 from 21.6v to 5.3v	$T_{3\text{ is}}$ faulty for 12 and 14 were at same potential instead of to differ with 0.6
15.	Voltage drop at point 13 from 6.1v to ≈ 0V	No contact on P by pointer of SET ‘E’
16.	Voltage drop at point 16 from 14v to 0.6mv	R_8 has its resistivity increased.

6.2 Percentage error calculations

(i) For E_{min}

$$\% \text{ error} = \frac{(8.98 - 8.8)}{8.98} \times 100 = 2\%$$

(ii) For E_{max}

$$\% \text{ error} = \frac{|25.65 - 27.8|}{25.65} \times 100 = 7\%$$

7.0 Discussion

The experiment was a successful as the objectives were met despite minor error of less 20%, otherwise, the obtained results were close to the expected values.

The errors could have been due to loose connections to the measuring instruments and the sensitivity of the overload protection relay. When the load resistance was changed i.e. when the load was connected, it was observed that the current stopped increasing when it was 0.84A instead of at 1.0A.This presumably suggested to us that the overload protection failed or was activated.

The thyristor was triggered when the voltage across R4 which reached 0.4V, once triggered the current through the thyristor continued flowing until it reached its threshold thereby removing the overload from the circuit. This is done in order to prevent some components from burn out.

8.0 Conclusion

The objectives of the experiment were met and it can be concluded that faults may occur in electrical and electronic circuits and it is possible to locate the faults and resolve them in order to restore the equipment into service. The experiment enhanced my understanding of fault finding using measuring instruments.

9.0 Application

Fault finding is applied in rectification of causes of electrical/electronic equipment failure by analysing the circuit driving that equipment..

10.0 REFERENCES

1. Henry C Mulle, **TROUBLE SHOOTING OF ELECTRIC CIRCUITS** , 4th Edition
2. **EEE3112 ENGINEERING PRACTICE LAB MANUAL;** University of Zambia, Lusaka, Zambia.