TRANSISTOR DAMAGE . . .

the hidden menace of stray voltage on the soldering iron

Most of our readers will already be aware of the potential danger to transistors of excess heat from soldering irons, and the need to take precautions to ensure that overheating does not occur. However, there is another possible source of transistor damage that is not nearly so widely known — the presence of relatively high voltages with respect to earth on the tip of low voltage soldering irons.

This voltage can reach surprising levels, and when the soldering iron is applied to the leads of a semiconductor may cause a damaging amount of current flow through the transistor if a circuit path is established. It has been found that when such an iron is used for soldering a diode matrix, for example, diodes are often found to be defective in subsequent testing. In such cases, the quality of the components have sometimes been called into question, quite unjustly.

The real culprit, the soldering iron, is often not suspected. Perhaps this is not surprising, since it requires some thought to understand how the situation arises where voltage on the tip of the iron can reach destructive levels. Let us firstly consider the construction of such irons, in conjunction with figure 1. The transformer has a 240V primary and, say, 6V secondary. The heat is connected across the secondary, to operate on a nominal 6V. The bit is commonly connected to one side of the secondary, as shown. The real villain of the piece is the voltage coupled from primary to secondary by stray capacitance. The user of this type of iron will probably be very surprised to learn that a stray capacitance of 50pF can result in a voltage of 50V P-P with respect to earth at the soldering iron tip. The purpose of this article is to alert readers to the potential problems which can exist in this context, and to suggest ways of safeguarding against transistor damage.

Soldering transformer with static screen. A transformer without a static screen between the primary and secondary windings has a relatively high capacitance between the two windings, and this leads to the relatively high voltages on the tip already referred to. In figure 1, C represents the stray capacitance between primary and secondary, and R the resistance of the soldering tip to earth, consisting of the insulation resistance of the iron, the cable and the transformer with respect to earth. The potential of this tip with respect to earth is measured across this resistance by means of a voltmeter with a very high input impedance Ri.

The voltage (V) depends on the value of C. If the capacitance between primary and secondary windings is 40pF, and the insulation resistance is 10M, the voltage on the tip will be 40V. Voltages of this order applied to semiconductors are, at the least, a potential source of damage.

It should be noted that we are referring, not to RMS values, but peak-to-peak voltages, which are more significant in this connection. Since this voltage is capable of destroying a sensitive semiconductor if the soldering iron tip comes into contact with it (assuming the existence of a return path, through common earthing arrangements, through common contact, or even through the body of the user) we have to consider ways by which this voltage can be reduced to a safe level, or eliminated entirely.

Earthing the tip. This measure can certainly keep the tip of the iron entirely free from unwanted voltage. The drawback of this simple cure, however, is that the iron cannot then be used for soldering in circuits that are carrying voltages with respect to earth. Moreover, damage can still be caused to semiconductors if the circuit still carries static charges, which would be the case in a circuit with

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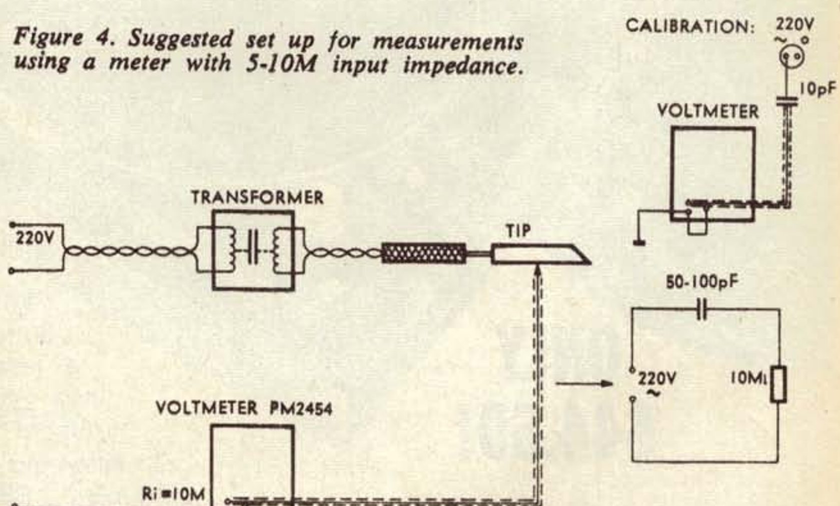
Figure 4. Suggested set up for measurements using a meter with 5-10M input impedance.



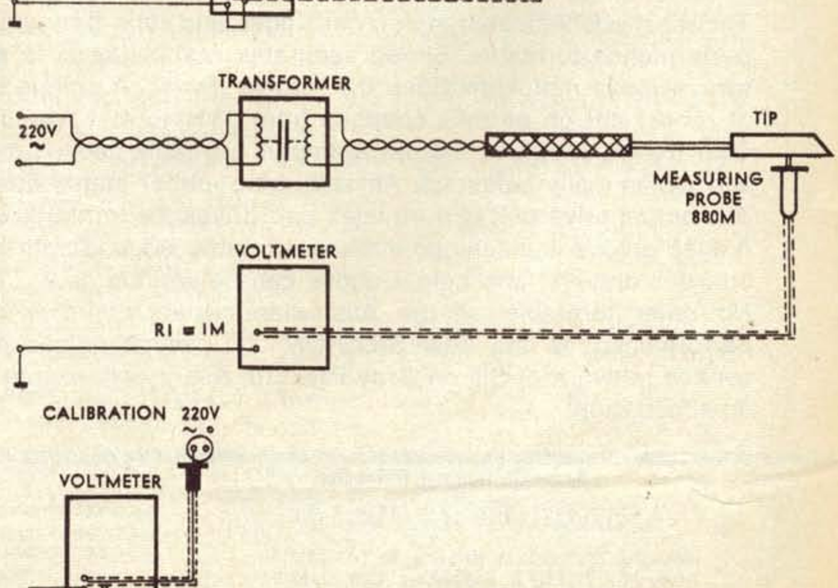


Figure 5. Method of measuring with a high impedance set up.

capacitors, directly after switching off. If the iron is applied to such a circuit, there is the risk of discharging capacitors through the semiconductors with sufficient current flow to cause damage.

Static screen. The use of a transformer with normal layer windings and a static screen gives reasonable results. In tests carried out, using this type of transformer, the amplitude of the unwanted voltage was kept smaller than 4V, which is regarded as safe for use in production and laboratory departments where ultra sensitive devices such as MOSFETS are not involved.

Separated windings on a C core. Separation between the windings is in itself sufficient to keep the stray capacitance between primary and secondary to a low value. If, in addition, the windings are provided with a static screen, the stray capacitance can be reduced to as little as a few tenths of a pF. The arrangement is illustrated in figure 3. The drawback is that it involves the manufacture of special transformers which could be rather expensive.

At this point, it is well to consider a special case, where the static screen cannot be effective. The case arises where a soldering iron is equipped with a thermostatic type of control which will switch the heater on and off, to maintain the tip at constant temperature. It should be noted that when the power is switched off, the

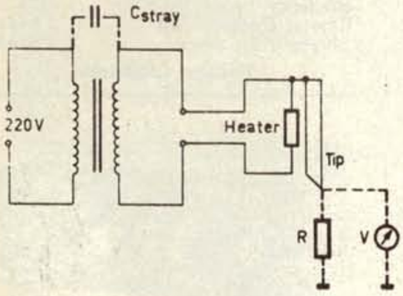


Figure 1. Showing how voltage is capacitively coupled to the soldering iron tip.

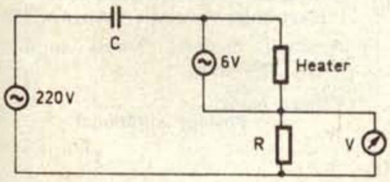


Figure 2. Equivalent circuit of figure 1.

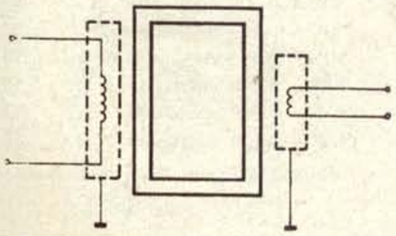


Figure 3. Separated windings on a C-core.

collapse of the field around the transformer windings will give rise to a pulse of voltage of fairly high amplitude. Should a switch-off occur when the iron tip is being applied to a transistor connection, damage to the transistor is almost inevitable.

In cases where it is desirable to prevent overheating of the iron, an acceptable solution has proved to be a combination of a screened transformer and a soldering iron support with a cooling plate to dissipate excess heat.

Tests carried out with screened transformers on C-cores with separated windings showed encouraging results. With the screens not connected to earth, the amplitude of the unwanted voltage was found to lie between 2V and 4V. With the screens connected to earth, the voltage was measured at between 0.3V to 1.5V. In contrast, the normal type of transformer had voltages measured to as high as 50V.

Measuring method. Before deciding that available transformers are not suitable, and need replacing, unwanted voltage at the tip should be measured. It should be realised from the start that any meter with a low input resistance will give a misleading result. Let us assume that the stray capacitance between the primary and secondary is between 50-100pF and represents an impedance at 50Hz of about 30-60M. If the meter has an input impedance of only 1M, the voltage division between the meter and the soldering iron circuit is from 30x to 60x. This means that whereas only 2V might be measured on the iron tip, there can be a potential of up to 120V with the meter not connected. Since such a measurement is virtually valueless, we put forward two alternative methods of measurement.

First method. Taking as a starting point the fact that few semiconductor circuits have an impedance greater than 5M to 10M with respect to earth, we use an electronic voltmeter with an input impedance of 10M, for example, the Philips type PM 2454. The measuring cable to the soldering tip must be screened, and should not exceed about 20in, if possible. (Figure 4, page 67.)

Calibration of the measuring installation:—

Measure the mains voltage with the electronic voltmeter. Connect a capacitor of 10pF to the active side of the mains and measure the mains voltage across this capacitor. If the Ri of the voltmeter is exactly 10M, then the indication will be about 7V for the mains voltage of 220V. If the meter only indicates 5V, then the reading must be multiplied by 7/5 in order to obtain a better approximation of the parasitic voltage on the soldering tip.

This measurement is not absolutely correct, as the multiplications factor changes at capacitance values other than 10pF.

Second method. If a meter with a very high input impedance is available, measurements of much greater accuracy can be made. (Figure 5.) If a probe is used with a series resistance of around 880M (for example, the high voltage probe of a diode voltmeter) the real RMS voltage can be found after calibration. In these circumstances, an electronic voltmeter with an input impedance of only 1M will be satisfactory.

Calibration: After checking the actual value of the mains supply, connect the probe directly to the active side of the mains. If the mains voltage is 220V and the meter reads 0.6V, this indicates an attenuation factor between the probe and the meter of 220/0.6 = 360x. If we now measure the voltage on the tip, the value measured must be multiplied by 360 to obtain the real RMS value of the parasitic voltage. ■