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1 FEATURES

- Protects relay contacts from damage due to arcing of mains voltage in high load applications
- Relay control does not suffer from the heat dissipation limitations of similar triac control solutions
- Uses a small inexpensive triac to momentarily protect the relay from arcing during switching
- Relay switching can be either temperature sensor triggered or digitally controlled
- Designed to drive resistive and inductive loads up to 2.3kW
- Uses common NTC thermistor temperature sensors
- Significantly reduces Electro-Magnetic Interference (EMI) by zero crossing load switching
- Greatly extends the lifetime of the relay contacts in constant switching applications
- Allows fast relay switching for improved temperature control, without causing early relay failure
- Provides a complete sensing and control solution for resistive and inductive loads

2 GENERAL DESCRIPTION

The HM226 as supplied is an electromechanical thermostat for heating loads up to 10 amps. It can also be configured as a logic controlled switch. It uses a relay and triac to control the load. It is designed to operate from 230Vac mains power, and can be designed to operate from 110/120Vac. It uses the IES5541A Relay Driver with Contact Protection integrated circuit to control the relay and triac.

An electronically switched relay is ideal in situations where heat dissipation from a triac is an issue. However, relays are usually only rated for around 100,000 electrical switching cycles, failing due to contact degradation. Until now this has prevented their use in thermostats, which require regular switching to maintain the desired temperature. The HM226 uses a triac to conduct the initial and final load current of each relay switching cycle, minimizing relay contact arcing.

Using the IES5541A and a triac, the relay life can be extended to over 10 times the relay's rated electrical switching cycles. This enables relay control in constant switching high load applications such as home heating, cooking appliances and fabric care products.

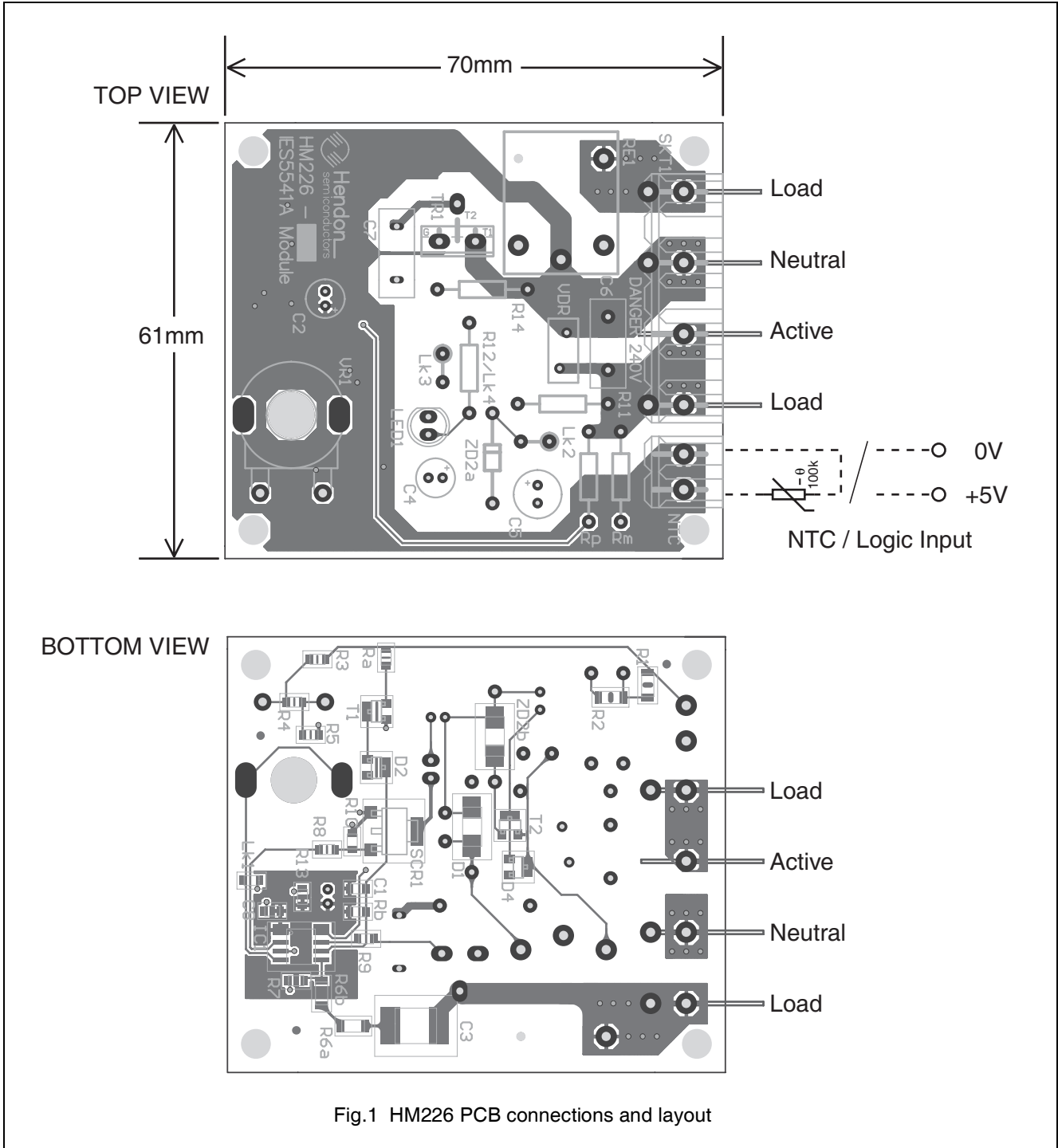
3 QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
VSUP	AC supply voltage	(note 1)	207	230	253	V
ILOAD	load current		–	–	10	A
Tstg	storage temperature range		–25	–	+85	°C
Tamb	operating ambient temperature range	in free air	0	–	+70	°C

Note

1. The operating voltage range can be set to any desired AC range by selection of power supply resistors. Application circuits are easily designed for 100–120 V, or even an extended voltage range such as 100 to 250 V.

4 CONNECTIONS AND LAYOUT



5 CIRCUIT DIAGRAMS

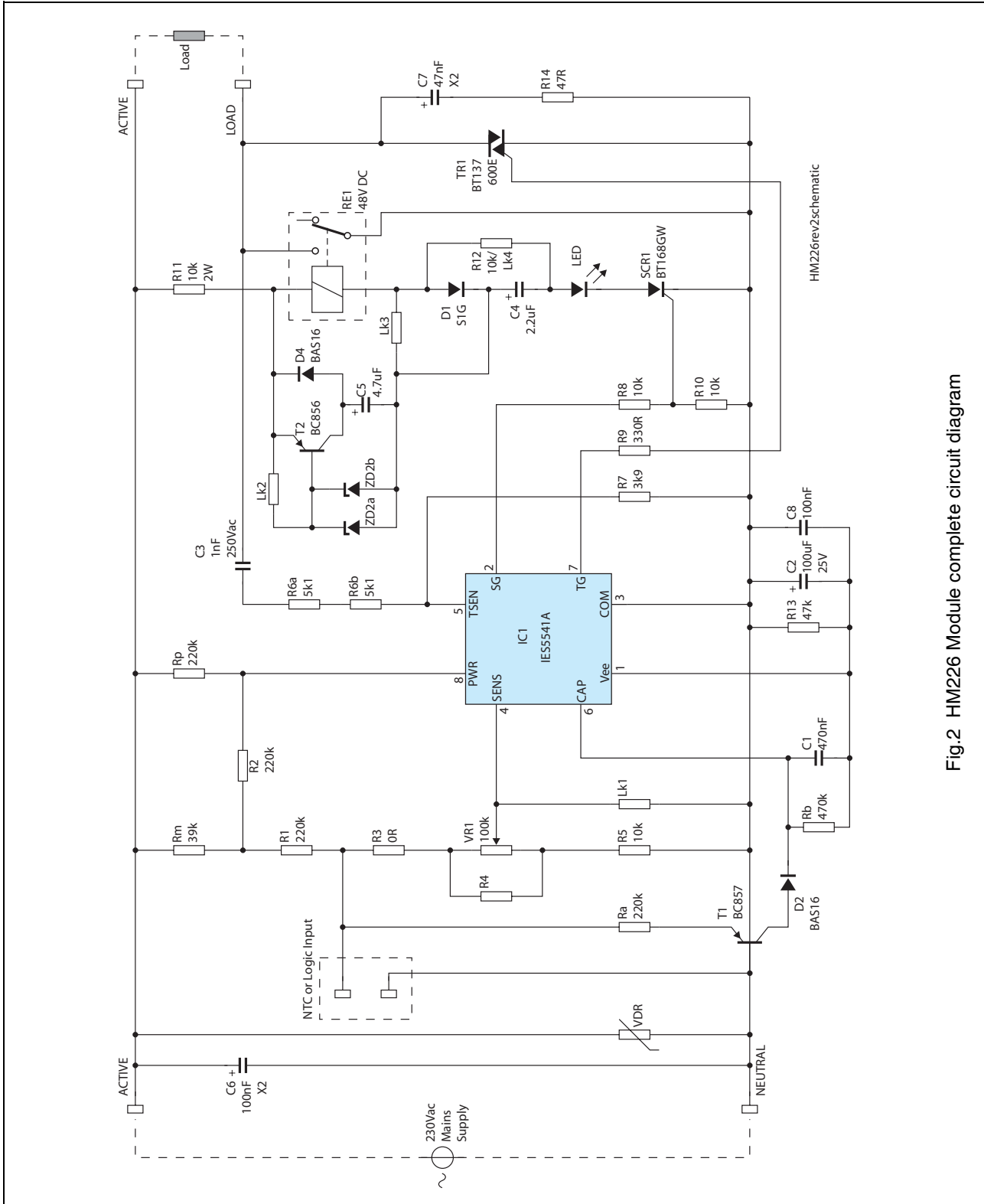


Fig.2 HM226 Module complete circuit diagram

5.1 HM226 - L / Logic Control Schematic

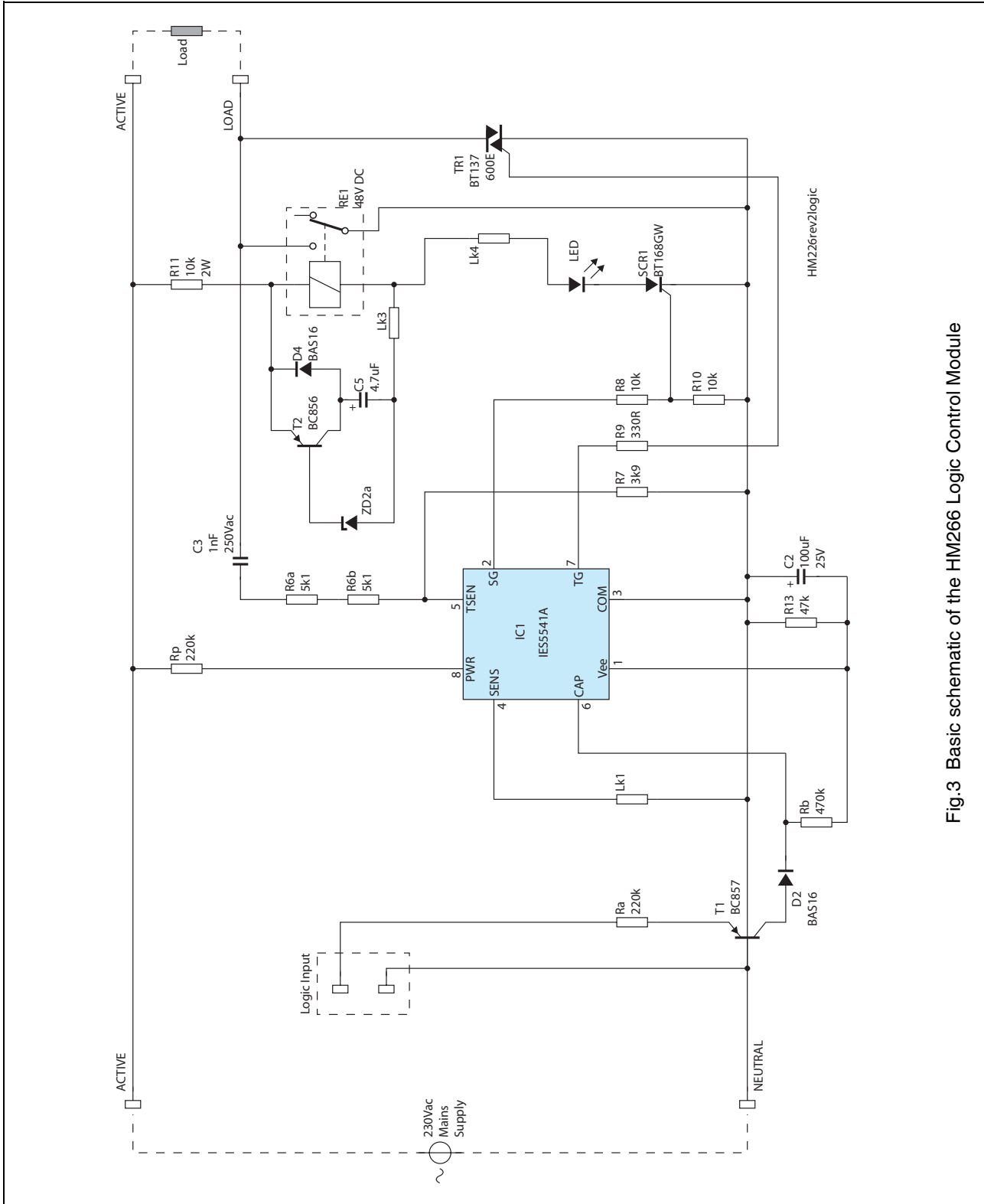


Fig.3 Basic schematic of the HM226 Logic Control Module

6 FUNCTIONAL OVERVIEW

The HM226 Relay switching module with contact protection provides a general purpose platform for relay control of loads up to 10A. The relay can be triggered by a NTC (negative temperature coefficient) thermistor or an external digital logic source. The HM226 is designed around the IES5541A IC and uses a triac to prevent arcing of the relay contacts during switching to extend the relay lifetime.

Two options for controlling the HM226 are included in the design. An NTC can be used to provide an input to the module in order to switch the relay. Alternatively a digital input from such devices as a microcontroller or FPGA (field programmable gate array) can be used to control the switching of the load. These control options suit a wide variety of applications in heating element control and the home appliance market.

The HM226 can accommodate a wide temperature sense range. To vary the range the designer only needs alter the resistor values in the temperature sensing part of the circuit. For more accurate temperature control, circuitry can be included external to the HM226. The NTC chosen will also affect the range and sensitivity of the HM226.

A relay driven load is preferable to a triac driven load in situations where heat dissipation is an issue. A triac switching a 10A load requires a large heatsink and may need to be mounted remotely from the PCB. A relay can switch a 10A load with no heat dissipation issues, allowing it to be mounted on the PCB to provide a more compact device.

A relay's main drawback is the arcing that can occur between the contacts of the relay during switching. This leads to burning, pitting and increased resistance, eventually leading to failure of the contacts.

The HM226 all but eliminates arcing of the relay contacts. The IES5541A provides a means for protecting the relay contacts during switching using a small inexpensive triac. When the IES5541A senses the first signs of arcing across the relay contacts during relay open/close, the triac is fired. The triac is also refired 8 times at regular intervals for four full mains cycles when the relay is closed. For a mains frequency of 50Hz for example, this time window where the triac may be triggered will be 80ms.

The HM226 consists of the basic HM226 printed circuit board and comes preassembled with all the components required to implement a logic controlled switch function.

6.1 Technical background

The HM226 contains a relay driver with contact protection IC (IC1); the IES5541A. The module is designed to showcase the relay contact protection that is offered by the IES5541A in constant switching applications. In its most common applications a load is thermostatically controlled by the module using an external NTC as the temperature sensor.

The HM226 uses an inexpensive low coil voltage DC relay rather than an AC driven relay. A network of diodes, resistors and capacitors allow the DC relay to be switched using a SCR from AC mains.

Although the triac may carry the load current during switching the heat dissipated in the triac is not significant in this application as the triac only conducts the load current for very short periods of time during relay opening and closing operations.

For a detailed description of the functioning of the IES5541A integrated circuit refer to the Data Sheet "IES5541A Relay Driver with Contact Protection".

7 CIRCUIT DESCRIPTION

This section describes the circuit design approach used in application of the IES5541A relay driver IC. In the HM226 there are options to satisfy different application needs and temperature ranges.

7.1 Mains Supply Voltage

The HM226 circuit using the IES5541A have been designed for Australian standards, where the normal supply voltage is 230 Volts. However the IES5541A is interfaced to the mains supply by a number of high voltage resistors which can be selected to suit the design supply voltage range.

The considerations involved in choosing the power supply, SCR and triac drive components are the current draw of the IES5541A, SCR and triac.

At the lowest value of the supply voltage there must be sufficient supply current to power the IES5541A, and to provide the gate current drive for the triac and SCR. When the supply is at its highest, then the power dissipation of the power supply resistor(s) must not be excessive.

7.2 Mains Rated Resistors

The power supply resistors, and those resistors in the temperature sensing circuit which carry most of the mains supply voltage should be chosen to give guaranteed performance with high ac voltages. Mains rated resistors, such as the Vishay VR37 and VR25 series or the Phoenix Passive Components HVR25 and HVR37 series are strongly recommended. Although standard metal film resistors may be able to withstand the nominal supply voltage they can become unreliable when subject to the normal mains transients which are known to occur.

7.3 Temperature Control Shaft Rotation

The clip-in potentiometer shaft for adjusting the set temperature or duty cycle can be either inserted through a hole in the printed circuit board, or directly into the potentiometer from the component side. Depending on how the board is mounted and which surface faces forward, the direction of rotation of the potentiometer will vary.

7.4 Choice of Thermistor

It is necessary to choose a thermistor which has a resistance of at least 1,000 Ω at the operating temperature, otherwise the voltage across the thermistor will be too small to provide accurate and adequate sensitivity. It is also important to ensure that the thermistor can be mounted in a way that is electrically safe, is protected from the access of moisture, and which provides good thermal contact to the intended thermal measuring point.

7.5 Thermistor Mounting Considerations

As the thermistor is electrically live to mains voltages it must be adequately insulated for use in each application. A range of insulated thermistors are available, and there are a number of important issues which must be considered in mounting them.

The best way in which to mount the thermistor is to clamp along the length of the lead for about 50 mm starting just clear of the sensing "head" of the lead. Ideally the plastic head of the leaded thermistor should all be clear of the mounting clamp by a distance of at least 1 to 5 mm. The sensing head of an insulated leaded thermistor should never be clamped.

7.6 Thermistor/Potentiometer Failure Table

As the thermistor is remote from the HM226, there is a possibility that these wires may either short, or may become open circuit. Table 1 below shows the result with such a failure. It also shows what occurs if the wiper on the potentiometer becomes open circuit through contamination from dust etc.

Table 1 Sensor - Potentiometer Failure Table

MODE	HEATING
NTC open	Continuous heating
NTC short	No heating
Pot wiper open	No heating
Pot wiper short	Heat to highest set point

7.7 Accuracy

Due to the broad temperature control range, accuracy for the typical application circuit (i.e. Figure 3 of IES5541A data sheet) is of the order of $\pm 20^{\circ}\text{C}$. This is not unusual for a simple thermostat controlling over the range of 25°C to $+300^{\circ}\text{C}$. Accuracy is also affected by mains supply voltage variations. However using the bridge input circuit configuration (Figure 5 of IES Application Note AN004) much more accurate control is possible.

Using thermistors chosen from the Vishay range, the typical best thermistor accuracy is 5 % (a little over 1°C error/spread) although more accurate thermistors are available (3%, 2%). With the choice of 1% resistors in the measuring section of the circuit (R1 to R7), the total temperature error will be less than 2°C . In a production batch most units will be much closer to the nominal value (say 80% or more within 1°C).

When a potentiometer is used to adjust to the required temperature an error is introduced from the tolerance of the potentiometer (usually 10 to 20%), and the designer will allow for this by making the adjustment range wider than that specified). However, it obviously becomes possible to set the temperature to any desired point within its range.

7.8 Digital Control

To digitally control the module, 5 extra components must be installed. The module can then be controlled from any 5V digital logic device such as a microcontroller. The SENS input is tied to neutral with LK1 to negate the temperature sense network. The logic signal can then be input through the NTC connector. The logic signal drives transistor T1 which feeds the Cap input through D2.Rb drains a portion of the current to protect the input. This is exemplified in figure 5.

7.9 Relay Drive Circuit

The relay drive rectification circuit is controlled when the IES5541A switches the SCR. For each type of relay used different component values for the supply resistors and capacitor will be needed. Further information on selecting these values can be found in application note AN005.

7.10 RFI and EMC Compatibility

The IES5541A has been designed to be especially insensitive to interference. Even when the thermistor is mounted remotely from the HM226 control module, the signal is an attenuated mains voltage, and not a signal which might provide radio frequency interference (rfi). This is important in view of recent changes to the law with respect to Electromagnetic Compatibility (EMC compliance) in Australia.

In addition to appliances needing to be insensitive to external sources of interference, these standards also require appropriate measures to be taken to ensure no appliances generate radio frequency interference (rfi) beyond prescribed limits.

When controlling a resistive load the IES5541A employs zero crossing load switching to minimise emitted rfi.

8 HM226 -L LOGIC CONTROL MODULE

8.1 Description

In this basic variant of the HM226, a simple logic controlled application is described. The application circuit is as shown in Figure 4. The circuit accepts a 5V logic level input to turn the relay ON and OFF.

In Table 2 the parts list of the HM226 Digital Control Module is given. This unit is normally supplied as a fully assembled kit for evaluation purposes. The digital logic control signal is input to the module through the NTC connector.

8.2 Materials

Table 2 Parts list for the HM226 Logic Control Module

PART	VALUE	DESCRIPTION
R6a	5k1	Resistor, SM, 1%, 1206
R6b	5k1	Resistor, SM, 1%, 1206
R7	3k9	Resistor, SM, 1%, 0805
R8	10	Resistor, SM, 1%, 0805
R9	330R	Resistor, SM, 1%, 0805
R10	10k	Resistor, SM, 1%, 0805
R11	10k	Resistor, axial, 1%, PR01(0.7)
R13	47k	Resistor, SM, 1%, 0805
Rp	270k	Resistor, axial, 1%, VR25(0.6)
Ra	220k	Resistor, SM, 1%, 0805
Rb	470k	Resistor, SM, 1%, 0805
Lk1	0R	Resistor, SM, 0 ohm link, 0805
Lk3	0R	0R Link
Lk4	0R	0R Link
C2	100uF, 16V	Capacitor, ELCO, radial
C3	1nF, 250Vac	Capacitor, SM, C2220
C5	4.7uF, 100V	Capacitor, Electrolytic, radial
IC1	IES5541A	IES5541A Relay Driver with Contact Protection
TR1	BT137 600E	triac, axial, SOT186AGENHS
T1	BC857	transistor, SM, SOT23T
T2	BC856	transistor, SM, SOT23T
D2	BAS16	diode, SM, SOT23
D4	BAS16	diode, SM, SOT23
ZD2a	BZV85-C56	Zener Diode, 56V
LED	5mm	LED, axial, 5mm
SCR1	BT168GW	SCR, SM, SOT223T
RE1	HRS4E	Relay, HRS4E 48V DC
Plug		4 pos 10 mm pitch mains connector
SKT1		4 pos screw mount socket for mains/load
NTC		2 way screw in connector for Logic Input

9 HM226 - T THERMOSTAT MODULE

9.1 Description

In this basic variant of the HM226, a simple thermostat application is described. The application circuit is as shown in Figure 3. The control range with the supplied 100k NTC is 80°C to 180°C. In Table 3 the parts list of the HM226 Temperature Sense is given. This unit is normally supplied as a fully assembled module for evaluation purposes.

9.2 Materials

Table 3 Parts list for the HM226 Thermostat Module

PART	VALUE	DESCRIPTION
R1	220k	Resistor, SM, 1%, 1206
R2	220k	Resistor, SM, 1%, 1206
R3	0R	Resistor, SM, 1%, 0805
R5	10k	Resistor, SM, 1%, 0805
R6a	5k1	Resistor, SM, 1%, 1206
R6b	5k1	Resistor, SM, 1%, 1206
R7	3k9	Resistor, SM, 1%, 0805
R8	10k	Resistor, SM, 1%, 0805
R9	330R	Resistor, SM, 1%, 0805
R10	10k	Resistor, SM, 1%, 0805
R11	10k	Resistor, axial, 1%, PR01(0.7)
Rm	39k	Resistor, axial, 1%, VR25(0.6)
VR1	100k	Potentiometer, linear, PT15 + Shaft
Lk3	OR	0R Link
Lk4	OR	0R Link
NTC1	100k	NTC sensor - leaded
C1	470nF	Capacitor, SM, 0805
C2	100uF, 16V	Capacitor, ELCO, radial
C3	1nF, 250Vac	Capacitor, SM, C2220
C5	4.7uF 100V	Capacitor, Electrolytic, radial
IC1	IES5541A	IES5541A Relay Driver with Contact Protection
TR1	BT137F 600E	triac, axial, SOT186AGENHS
T2	BC856	Trasistor
D4	BAS16	Diode, SM, SOT23
ZD2a	BZV85-C56	Zener Diode, 56V
LED	5mm	LED, axial, 5mm
SCR1	BT168GW	SCR, SM, SOT223T
RE1	HRS4	Relay, HRS4 48V DC
Plug		4 pos 10 mm pitch mains connector
SKT1		4 pos screw mount socket for mains/load
NTC		2 way screw in connector for NTC, Logic input

9.3 HM226 - T / Thermostat Schematic

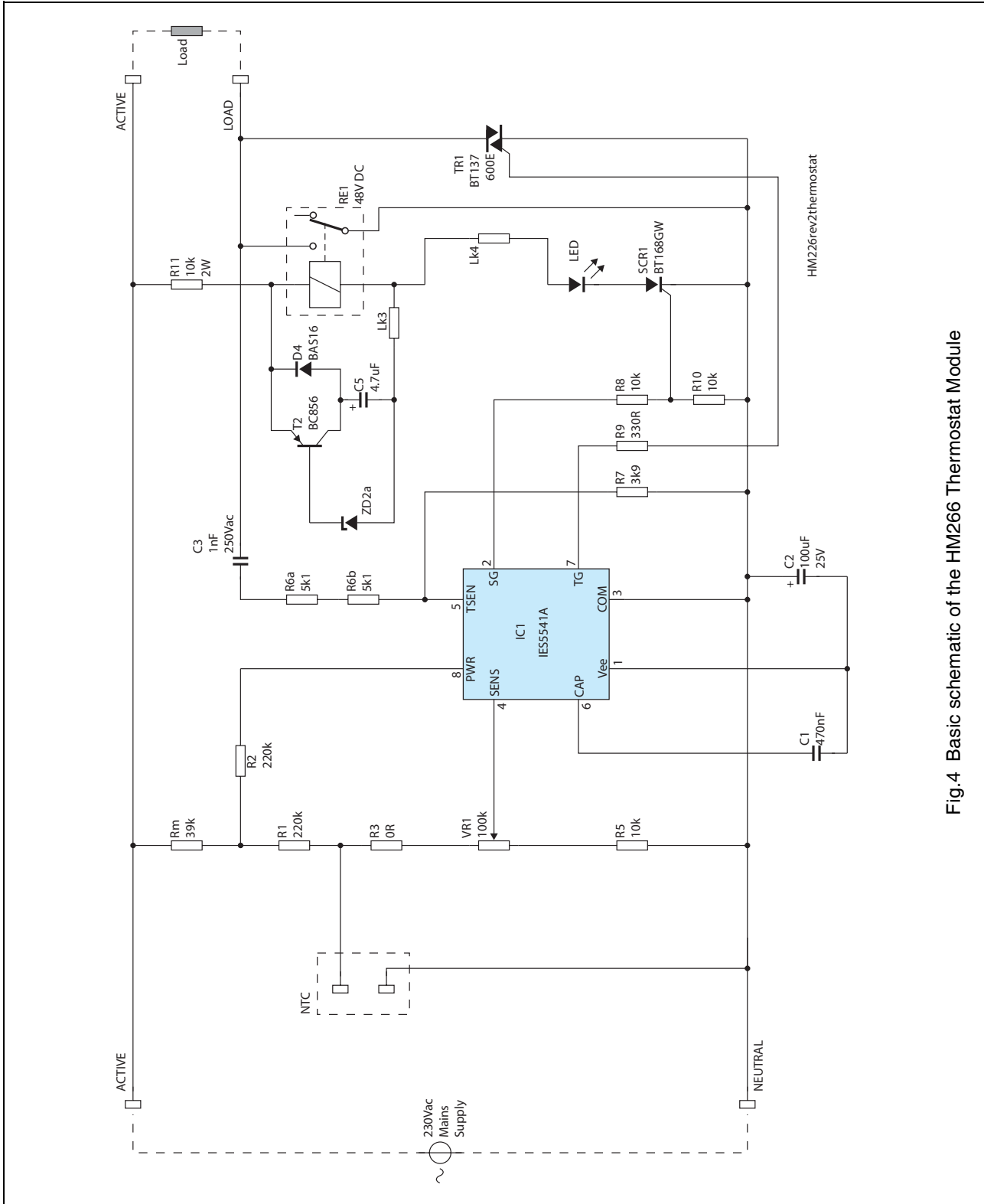


Fig.4 Basic schematic of the HM226 Thermostat Module

10 IMPORTANT ELECTRICAL SAFETY WARNING

The HM226 circuit is connected to the mains electrical supply and operates at voltages which need to be protected by proper enclosure and protective covering. While it has been designed to conform to relevant Australian and overseas Standards (such as IEC60335), it should only be used in a manner that ensures the appliance in which they are used complies with all relevant safety and other requirements.

The board must be mounted with non-conductive clips, and positioned such that the minimum creepage distances from the circuit assembly to earth, and between high voltage points is not transgressed.

The NTC element is electrically live and connected to the mains, and must therefore be electrically insulated. Also creepage distances must be maintained for all live parts in the circuit and its wiring, especially with respect to the NTC thermistor.

It should be noted that there are Mains Voltages on the circuit board. Adequate labelling should be attached to warn service personnel, and others, that this danger exists.

The board should be mounted in a place that is clean and dry at all times, not subject to condensation or the accumulation of dust and other contaminants.

11 REFERENCES

- Data Sheet - IES5541A Relay Driver and Contact ProtectionIC
- Application Note - AN005 Relay Drive Circuit

12 DOCUMENT HISTORY

REVISION	DATE	DESCRIPTION
0.1	09 May 2006	First Issue
0.2	07 June 2006	1. Minor corrections made to document body. 2. Company address updated (section 15). 3. Revision level added to document. 4. Document history added (section 13).
0.3	28 June 2006	1. Included CRO trace and explanation section 6 2. Changed format to new IES datasheet format
0.4	14 August 2007	1. Removed CRO trace and explanation section 6 pending update 2. Changed format to new Hendon datasheet format 3. Update to new layout and schematics
0.5	19 November 2007	1. Changed mains voltages for consistency 2. Swapped Logic/Thermostat order

13 DEFINITIONS

Data sheet status	
Engineering sample information	This contains draft information describing an engineering sample provided to demonstrate possible function and feasibility. Engineering samples have no guarantee that they will perform as described in all details.
Objective specification	This data sheet contains target or goal specifications for product development. Engineering samples have no guarantee that they will function as described in all details.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later. Products to this data may not yet have been fully tested, and their performance fully documented.
Product specification	This data sheet contains final product specifications.
Limiting values	
Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.	
Application information	
Where application information is given, it is advisory and does not form part of the specification.	

14 COMPANY INFORMATION

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