La Trobe University
Department of Electronic Engineering

ELE1EDP: ELECTRONIC ENGINEERING DESIGN PROJECT

1 Electronic Wiring

1.1 Introduction

Drawing standards play an important role in electronics. Electronics is basically the art of connecting pre-defined components. A circuit diagram is a formal design specifying three main aspects:

1. components
2. connection topology (wiring)
3. labelling

Standardization is important for a quick and clear understanding of circuits. Relevant Australian standards for electronic circuit drawings include:

- AS1100, *Technical drawing*;
- AS1102-1989, *Graphical symbols for electrotechnical documentation;*
- AS3702-1989, *Item designation in electrotechnology*.

These are produced by Standards Australia Limited (http://www.standards.org.au) and are obtainable through the SAI Global WebShop at http://saiglobal.com which provides both PDF and hard copies (at a price of around $50 per document).

The basic structure and size of a circuit diagram is the same as for other engineering drawings. Where several parts are detailed in the diagram, a parts list should be tabulated and this table located above the title block, or, if there is insufficient space, on a separate page.

1.2 Interconnection Lines

Interconnections (wires or conductors) are normally indicated by vertical or horizontal lines.

A junction of three wires is indicated by a tee junction with a solid dot placed at the junction.

A junction of four wires is shown by using two tee junctions as shown in Figure 1. By distributing the connection to two points, this avoids ambiguity with cross overs.

Lines which cross over should not change direction at the cross over point. Lines can cross over diagonally to assist in circuit clarity.

Where lines traverse a large portion of the circuit diagram, it is permissible to omit the line and use arrows to indicate the direction of travel, as shown in Figure 2. It is essential that the arrows are referenced by a unique label. If the connection is to a different page, its sheet number must be given along with the label.

1.2.1 Labelling of Lines

Lines which indicate a connection may optionally be labelled. If the connection is to be referenced, then it needs to be labelled. Labels are placed adjacent to the line or in a gap placed in the line for the purpose of labelling.

1.2.2 Parallel Lines

Where a number of lines run parallel, they can be arranged in groups. The group is defined by leaving increased space outside the group. For readability, it's preferable that no more than three lines run as a group.

When many lines run parallel, they can be bundled into a single line representing the whole group. The order of the lines must be the same at each end of the bundle, as shown in Figure 3. Labels at either end can be redefined, e.g. the terminals of two connectors. If the terminal order (e.g. line numbering) is not consecutive, then the bundle should be expanded in order and each line labelled consistently, as shown.

Where a conductor's line joins a group, it is labelled at the junction, as in Figure 4. Just before the junction, the line is angled to indicate where it enters and leaves the group. This allows easy tracing of the line.

1.3 Symbols for Circuit Elements

AS1102, HB3, and HB8 contain extensive lists of symbols for circuit elements used in electronics. Some of them are shown in the extract from HB3 at the end of these lecture notes.

1.3.1 Positioning symbols

Wherever possible, functional groups of circuit elements should be arranged so that the sequence of events or signal flow is clear. The sequence is shown progressing from left to right, and top to bottom, as in flowcharts.

To assist in referencing circuit elements, a grid system is normally employed, similar to that in a street directory, with letters on one axis, and numbers on the other. (Sometimes only one axis is required to uniquely reference the elements.) A derivative of this scheme is the line referencing system where the circuit elements are placed on a fixed grid, to allow their position to be directly referenced.

Another technique is to list the item designations at one edge of the drawing in a tabular arrangement. The designations are numbered sequentially across the page, and can be classified and organised by type within the table as shown in Figure 5, where the three rows contain capacitors, resistors, and miscellaneous components.

1.3.2 Relationships between symbols

Often a circuit component consists of multiple circuit elements. For example, a relay consists of a coil or actuator, and a number of sets of contacts. The symbols for these elements need to be interrelated so that the reader of the diagram knows that they are parts of the one relay device. See Figure 6.

By drawing the elements in close proximity, they can be drawn in an attached representation. Where the circuit is more complex, this may not be possible, and the mechanical linkage should be indicated by a dashed line. This is called a semi-detached representation.

In a fully detached representation, all elements in a device are labelled with a common item designator but are otherwise quite separately drawn.

Where symbols have multiple states, as e.g. relay contacts do, then they are drawn in the unenergized (or normal or inactive) state. For example, for a bistable switch, it is shown in the normal operating state: such a switch is either normally open or normally closed.

Where circuit elements are connected in parallel, their comparative significance can be indicated by their position relative to the interconnecting lines, as shown in Figure 7.

1.3.3 Relationship with Supplies

In a schematic, (power) supply to a circuit is normally shown by horizontal conductors above and below a circuit. Alternatively, connections to the supply can be labelled using the polarity and magnitude of the supply, as in Figure 9.

1.3.4 Groups of Symbols

Where groups of circuit elements form a sub-assembly, they can be surrounded by a long chain boundary line. This line can be labelled with the sub-assembly's reference identifier.

If the sub-assembly is not fully drawn, it can be labelled with a diagram number that refers to its full detail drawing.

1.3.5 Symbol Orientation

To fit in with the horizontal and vertical requirement for lines, the symbols are usually also oriented horizontally or vertically. However, where it improves circuit clarity, diagonal orientation of symbols may be used. Bridge circuits are typically drawn diagonally, as shown in Figure 8.

1.4 Symbol Designation

Generally symbols relating to particular items are designated by:

1. Kind of item (normally indicated by a letter) corresponding to its graphical representation.
2. Ordinal number of the item.
3. Function - additional optional information.

A list of Australian (and European) Standard conventions for the alphanumeric representation of various kinds of items is given in Table 1.

For additional information, the value or type of an item can also be given as a separate designation, as shown in Figure 9. This information is normally found in the tabulated parts list, when such a list is included.

An example of symbol designation is a resistor designated R4 with a part type (actually value) of 10k.

1.5 References

Aside from the Standards Australia documents, a useful brief reference is http://en.wikipedia.org/wiki/Circuit_diagram which also has links to informative sites on circuits and schematics.

Geoffrey Tobin
Version 2.1
Monday 23 July 2007

(based on EPM 1 notes by Erich Stumpf 1992)

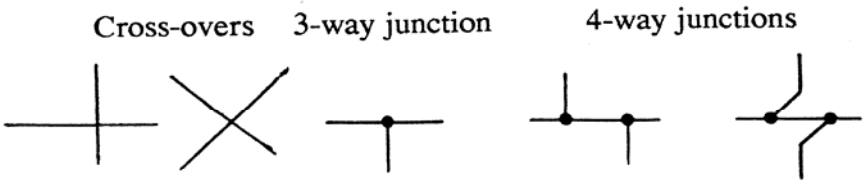


Figure 1 Cross-overs and Junctions

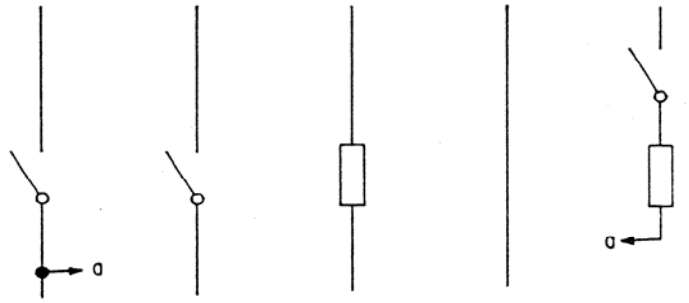


Figure 2 Omitted line referenced by arrows

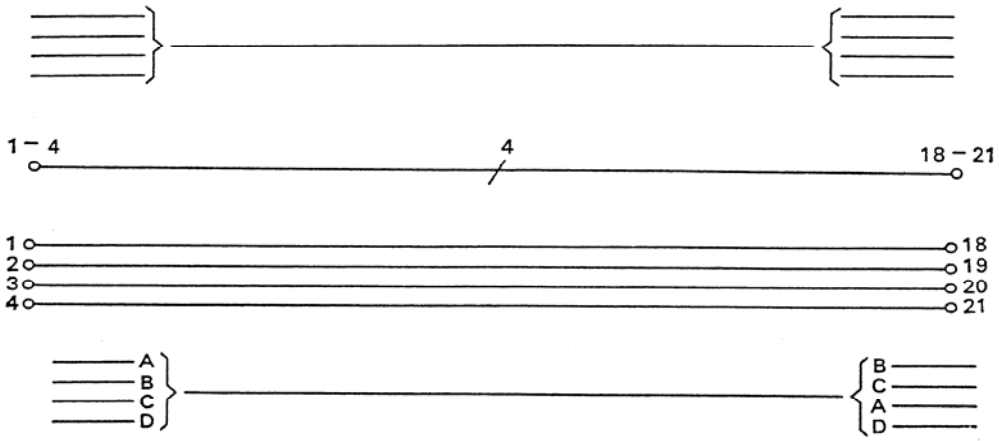


Figure 3 Single line representations of parallel lines

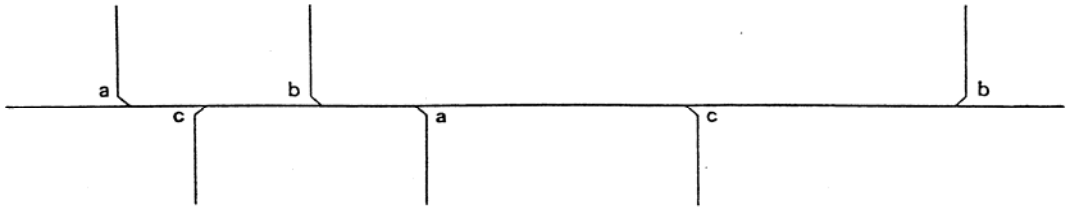


Figure 4 Group wiring

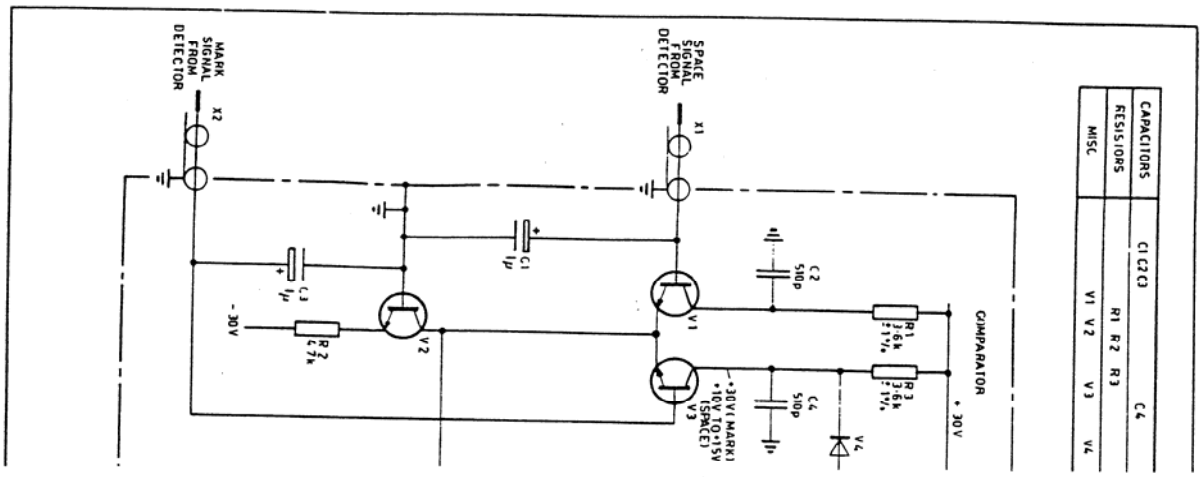


Figure 5 Tabular referencing of circuit elements

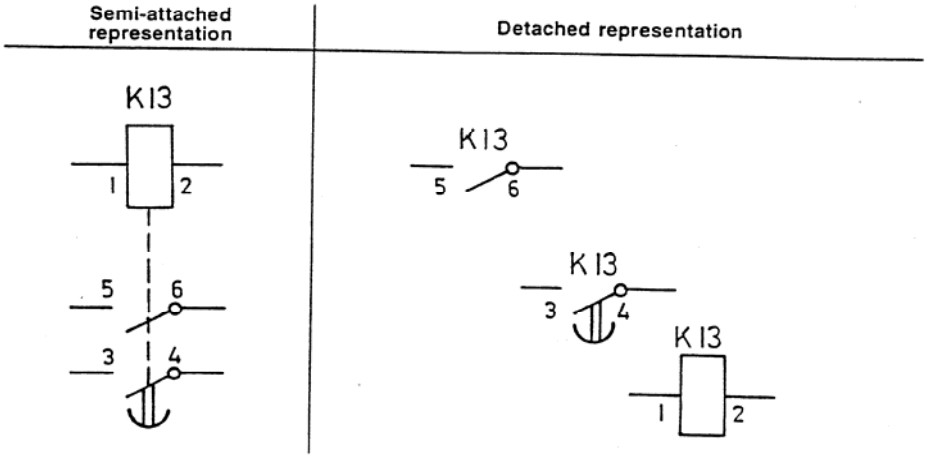
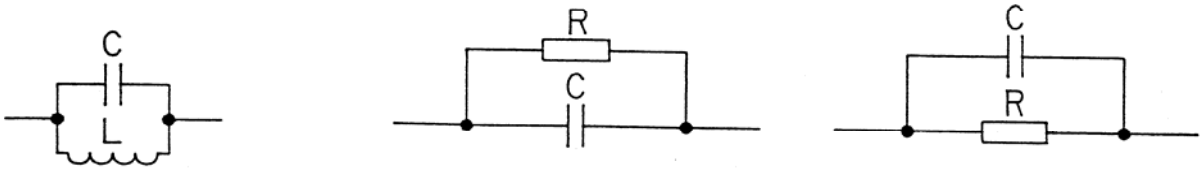


Figure 6 Representing symbols within a component



(a) Paths of equal importance (b) C is more important (c) R is more important

Figure 7 Parallel circuit paths

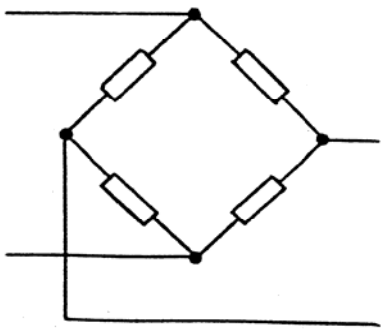


Figure 8 Diagonal orientation

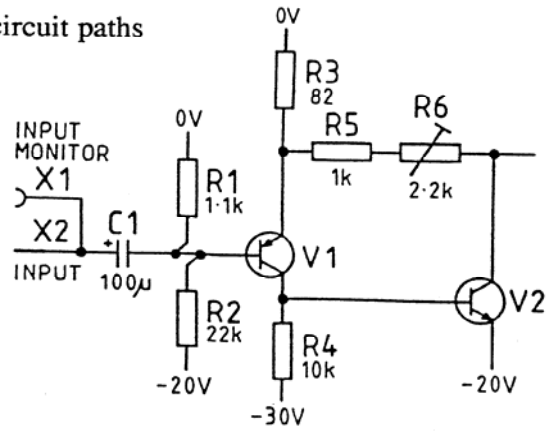


Figure 9 Item designation

Letter code	Class of item	Examples
A	Assemblies, subassemblies	Composite circuits and subcircuits, PCBs
B	Transducers	Microphones, speakers, strain gauges
C	Capacitors	
D	Digital ICs and storage devices	Delay lines, flip-flops, registers, monostable devices, tape recorders, disc recorders
E	Miscellaneous	Lamps, heaters, anything else not classified by another letter code
F	Protective devices	Fuses, surge diverters
G	Generators, power supplies	Rotating generators, batteries, oscillators
H	Signalling devices	LEDs, buzzers, sirens, bells
I	NOT USED	
J	NOT USED	
K	Relays, contactors	
L	Inductors	Induction coils
M	Motors	
N	Analog ICs	Operational amplifiers, DACs, low power voltage regulators
O	NOT USED	
P	Measuring/Test equipment	Meters, recording devices, signal generators, clocks, counters
Q	Mechanical switching devices for power circuits	Circuit-breakers, isolators, fault interrupters, earthing switches
R	Resistors	Static and variable resistors, potentiometers, thermistors
S	Switches, selectors	Push buttons, selector switches, dials
T	Transformers, high power voltage regulators	
U	Modulators	Discriminators, demodulators, frequency changers, coders, modems
V	Vacuum tubes, semiconductors	Diodes, transistors, thyristors, opto-isolators
W	Waveguides, aerials, transmission paths	Conductors, cables, busbars, waveguides, dipoles, parabolic dishes
X	Terminals, joins	Plugs, sockets, jacks, terminal boards, soldering terminal strips, links, cable joints
Y	Electrically operated mechanical devices	Brakes, clutches, pneumatic valves
Z	Network devices	Cable-balancing networks, compandors, crystal filters, hybrid transformers, filters, equalizers, limiters

Table 1: Electronic Parts' Reference Designator letter codes.