Newcomers' Notebook

Making sense of circuits

Jules Perrin VK3JFP

Simple explanation, without complex mathematics.

Making sense of a circuit diagram, for the first time, may seem to be a daunting task. This article breaks down the process of reading a simple circuit diagram into logical steps. After reading this article, my hope is that you will not feel so intimidated by complex drawings and explore the circuits.

Over past Newcomers' Notebook columns, I have written about Ohm's Law, resonant circuits, diodes, transistors, and operational amplifiers. Here, I have tied these articles into a simple Amplitude Modulation (AM) receiver. This little circuit is not intended as a construction project as I pieced it together for this exercise. It will function, nonetheless. There are many excellent circuits for AM receivers in respected amateur radio handbooks and on the internet.

Then there are the confusions that arise in the use of language. Some writers call this type of drawing a "circuit diagram," while others call it a "schematic;" some writers use the terms interchangeably! Never mind, they are generally one and the same thing. However (there's always a 'however'), a mechanical drawing – that is, a drawing of interconnected, or interrelated, mechanical components may also be a "schematic." Let's leave hydraulics out of this.

This simple circuit diagram in **Figure 1** draws together the topics I covered previously and I am using this issue to explain how to read the circuit diagram. I did build the receiver and it worked. A simple crystal radio set is perhaps a better place to start if you are interested in AM radio, *per se*.

I apologise to all the drafting, engineering, and AM radio purists up front. I am sure you will find glaring holes in my circuit. Its principal purpose is to serve as an introduction to reading circuit diagrams for newcomers to both the Amateur Radio Service and electronics generally.

General layout

The general convention for circuit diagrams is that there are five 'focal points' in any circuit you wish to read. These are:

- Left and Right
- Top and Bottom, and
- Centre.

Each focal point has a specific role to play. I am sure there are variations to this convention, but this is a good place to start. I have included these focal points on the drawing to allow you to orientate yourself correctly. These markings would not be on an actual circuit.

This follows the general rule for reading (in the western tradition): from left to right, top to bottom.

Left

This is where a signal enters the circuit. In **Figure 1,** the signal entering the circuit comes from the antenna AE1. Other circuits may have the input coming from a previous stage or circuit.

The left side is generally where you start so you can understand what is coming into the circuit.

Right

This is where signals processed by the circuit exit the circuit. In **Figure 1,** the signal exits via the speaker SP1. In multi-page circuits, this is where the signal would exit and the next destination for the signal would be indicated.

Top

This is where the DC supply for the circuit will be indicated or identified.

Bottom

This where common connections between circuit sections are drawn. Here, the 'earth' for the AM receiver circuit connects to the common connection line.

Centre

The Centre, between the Left and the Right sides, is where the signal is processed and performs the function it was designed to do. Reading the name on the circuit diagram will usually be a good start to understanding the circuit's function.

At a glance

The signal flows Left to Right and is processed by the circuit. Current (electron) flow, for the circuit's power supply, goes from Bottom to Top. I find it convenient to use electron current flow rather than conventional current flow for applications with active components.

Application to Figure 1

Looking at **Figure 1,** the signal input originates at the antenna on a frequency selected by the combination of C1 and L1. You will recognise this as a parallel tuned circuit. If the selected frequency is that of an AM radio station, the output will be an amplitude modulated carrier wave, as shown in **Figure 2,** at A.

The next step in processing the AM signal is to send it through a detector stage. The first component the signal passes through is diode D1. The diode only allows electrons to flow one way, so the output will be one side (half) of the signal as shown in **Figure 2,** at B. To recover the sound, the signal is smoothed by R1 and C2, as illustrated in **Figure 2**, at C. The result is a signal in the audible frequency range but it will be extremely low in strength.

Capacitor C3 is a polarised (electrolytic) coupling capacitor linking the AM detector to the first signal amplifier stage. This capacitor allow the signal to pass while blocking any DC.

Small circuits would not normally have test points shown on them, but I have added three here to introduce the concept. A test point – which might be labelled TP – can have a small drawing next to it or a reference for you to look up in another document.

No matter how it is indicated, the diagram or reference usually shows what size and shape of a signal that should be detected at that point. This is a great tool when fault-finding circuits.

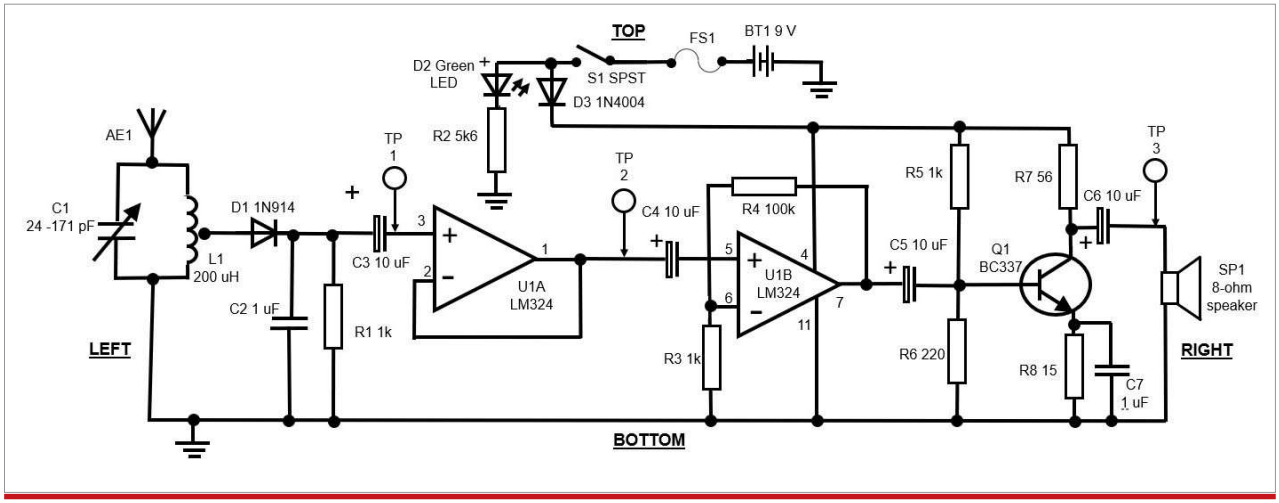

Figure 1. Simple AM receiver circuit diagram.

To boost the signal from the AM detector, I have used two operational amplifiers from an integrated circuit, the widely available low-cost LM-324 (U1). This chip contains four op-amps in a 14-pin dual inline package (DIP).

In my circuit, only two of the four are used (U1A and U1B). U1A is configured as a buffer amplifier. The input and output are the same, but the input to U1A does not impose any drain on the signal from the previous stage, the AM detector.

TP1, at input to U1A, is the first test point. TP2 is another defined test point, at the output of U1A.

Capacitor C4 is a polarised coupling capacitor linking the next signal stage – op-amp U1B. This op-amp is configured to amplify the signal approximately one hundred times. The amplification ratio is determined by R3 and R4. To put this amplification number into perspective, if the input signal is 0.01 V, amplified by one hundred this results in a 1 V output.

Capacitor C5 is a polarised coupling capacitor linking to the next signal stage. Here, Q1 is an NPN bipolar transistor

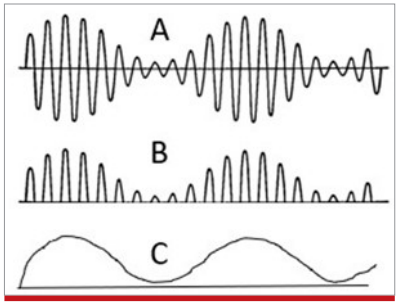

Figure 2. Stages in AM signal detection. At top – signal A – illustrates an AM radio signal, centre – signal B – is the detector output (without smoothing), while the signal at C is the audio recovered by the circuit.

configured as a Class A amplifier, with R5 and R6 providing the bias on the transistor's base. Q1 drives the speaker (SP1) through coupling capacitor C6. Note the last defined test point, TP3.

Capacitor C7 bypasses audio signals across R15 (part of the transistor bias circuit) that would otherwise subtract from the signals amplified by Q1, this yielding more gain.

Power supply

Going back to the circuit's Top, the source of DC supply for the active components in the circuit is a 9 V battery (BT1). FS1 is a fuse that protects the circuit should excessive current be drawn from the battery.

When switch (S1) is closed, electrons will flow from the earth (common line) through the circuit to the positive side of the battery. D3 is a diode designed to prevent current flow if the battery is inserted incorrectly (reverse polarity).

Components R2 and D2 provide an indicator that enables light emitting diode (LED) D2 to glow green when S1 is closed

Well done

Congratulate yourself! You just read your first circuit. By breaking any circuit down to simple stages and individual components, you can begin to understand how the circuit works.

Should you have a topic you would like to nominate to be covered in a future instalment of Newcomers' Notebook, email Jules at jp.bqt@bigpond.net.au.

Have fun and stay safe.