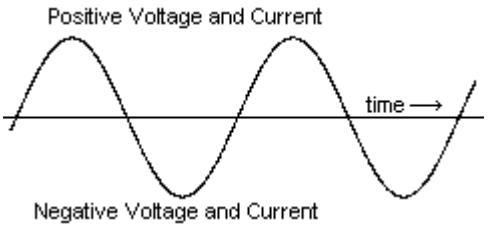
Diamond Valley Railway Inc.

Using AC Track Circuits for Signal Control

What is AC?

A.C. stands for 'Alternating Current'. This is a term used to describe one of the two common forms of supplying electrical power. The other common form is 'Direct Current' (D.C.). Current is a measure of the rate of flow of electricity. Direct current describes current that flows in one direction. Alternating current describes current in which the direction of flow alternates. It flows in one direction, then reverses and flows in the other direction. In Australia, the number of reversals occurring per second for mains power (240V A.C.) is 50 per second. These reversals are smooth and can be represented as a sine wave.



Using AC for Track Circuits

In the previous page, the operation of D.C. track circuits was described. Those track circuits used D.C. (direct current) to power track circuit relays. An A.C. track circuit uses the same principle. The voltage used is around 12V A.C. One side of the A.C. supply is applied to the 'power' rail via a ballast resistor (in the same way as the +ve side of the D.C. supply is applied to the 'power' or 'positive' rail in D.C. track circuits). At the other end, a relay is powered by the voltage present across the rails. When a train occupies the track, the circuit is shorted to ground and the relay turns off. The ballast resistor is set such that the minimal current required to energise the relay can pass along the rail (this is the same current that will run straight to ground when a train occupies the track, and is around 0.3A, depending on the length of rail).

The reason for using A.C. track circuits is that A.C. can be used to encode a small amount of data. Consider D.C. track circuits - the D.C voltage is either strong enough to energise the relay or it isn't - the relay is on or off. That's two 'bits' of data, or two 'states'. A.C. on the other hand can be used to represent four bits or data, or four states. This is done by using each polarity of the A.C. waveform as a separate signal - one positive, one negative. Each polarity can be on or off. In combination, that gives four unique states.

The following table illustrates the waveform of the AC signal for each of the four states:

State	Positive	Negative	Waveform
1	Off	Off	
2	Off	On	
3	On	Off	
4	On	On	

Automatic Signals

Some sections of the mainline contain signals which are not controlled by any signal box. In fact, they operate automatically using track circuit states. These are called Automatic Signals. The sections they protect are commonly referred to as 'automatic sections'.

Most of the automatic sections at Diamond Valley Railway employ 'three-position' signalling. For automatic signals, two lights are displayed, each light being one of three colours - red, yellow and green. There are two styles of three-position automatic signalling in use at Diamond Valley Railway - 3-aspect and 4-aspect.

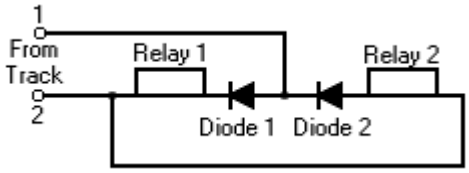
3-aspect automatic signals show one of the following three combinations:

Aspect	Name	Meaning
RED/RED	Stop	Section ahead occupied
YELLOW/RED	Normal speed warning	Next signal at stop
GREEN/RED	Clear normal speed	Next signal at proceed aspect

4-aspect automatic signals show one of the following four combinations:

Aspect	Name	Meaning
RED/RED	Stop	Section ahead occupied
RED/YELLOW	Medium speed warning	Next signal at stop
YELLOW/GREEN	Reduce to medium speed	Next signal at medium speed aspect (such as medium speed warning)
GREEN/RED	Clear normal speed	Next signal at a proceed aspect

Automatic signals use the A.C. waveform of the track circuit ahead (the one they are protecting) to determine the coloured aspect to show. This is simply done by powering two separate relays with the two polarities (positive and negative) from the A.C. waveform. The following circuit diagram shows how the track is connected to the two relays.



The separate polarities are split using the two diodes. When current flows in from the track via terminal 1, it is blocked by Diode 2, but carried by Diode 1, allowing Relay 1 to energise. When current flows in the other direction (in from the track via terminal 2), it is blocked by Diode 1, but carried by Diode 2, allowing Relay 2 to energise. Assuming 'positive' flow means current coming into the circuit via terminal one, Relay 1 will be energised whenever the A.C. waveform contains a 'positive' component. Relay 2 will be energised whenever the A.C. waveform contains a 'negative' component. When both components exist in the waveform, both relays are energised. Note that either A.C. relays are used, or D.C. relays and capacitors.

The two relays are used to select one of four (or three) aspect for the signal protecting the track circuit.

Our table of states (from above) can now be extended to show relay operation and signal aspects:

State	Positive	Negative	Waveform	Relay 1	Relay 2	Aspect (3-aspect)	Aspect (4-aspect)
1	Off	Off		Off	Off	RED/RED	RED/RED
2	Off	On	-	Off	On	YELLOW/RED	RED/YELLOW
3	On	Off	+	On	Off	GREEN/RED	YELLOW/GREEN
4	On	On	+ -	On	On	GREEN/RED	GREEN/RED

Note that 3-aspect and 4-aspect signals work using the same concept - the difference is that for 3-aspect signals, the last two states are the same.

We've seen how the A.C. track circuit waveform is 'decoded' into aspects, but what creates the waveform in the first place? The waveform represents the state of the next signal - hence the next signal is used to generate the waveform. When an automatic signal receives a waveform for a particular state, it applies to the preceding track section the waveform for the next state.

For example, if a signal receives the state 1 waveform (no voltage) from the track section ahead, it displays the matching aspect (RED/RED) and applies the state 2 waveform ('negative' polarity only) to the previous track section. The signal in the rear receives this waveform (assuming no train is in the section), and displays the matching aspect (RED/YELLOW for a 4-aspect signal or YELLOW/RED for a 3-aspect signal).

The following diagram shows all of the states and aspects for five consecutive track sections. Note that 3-aspect signals are shown at the top, and 4-aspect signals on the bottom (of course, only one or the other would actually be installed trackside).