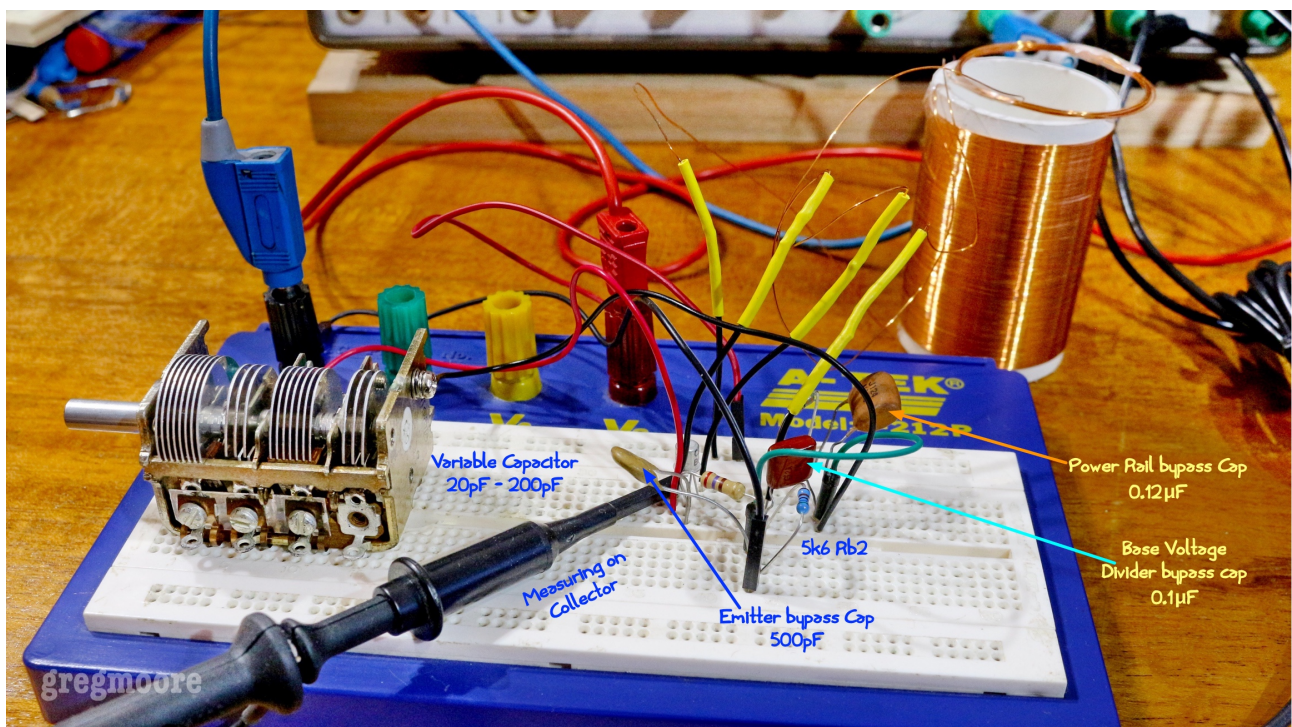
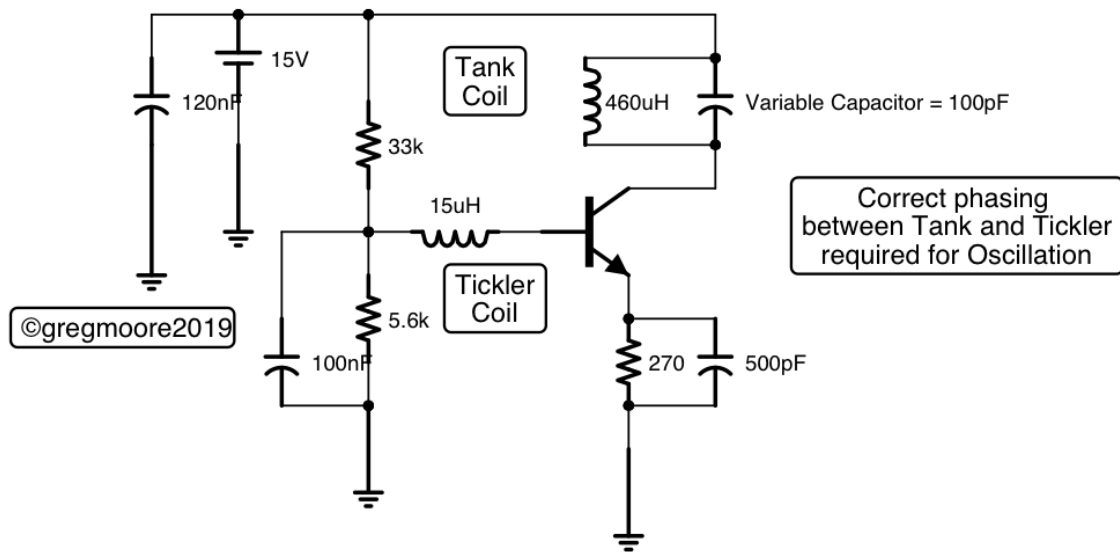


Armstrong Oscillator Lab

There are many variations in all oscillator forms matching Hartley, Colpitts, Armstrong etc.

The circuit I have drawn is just one variant of an Armstrong Oscillator with the tuned tank circuit in the collector and the tickler coil in the base.



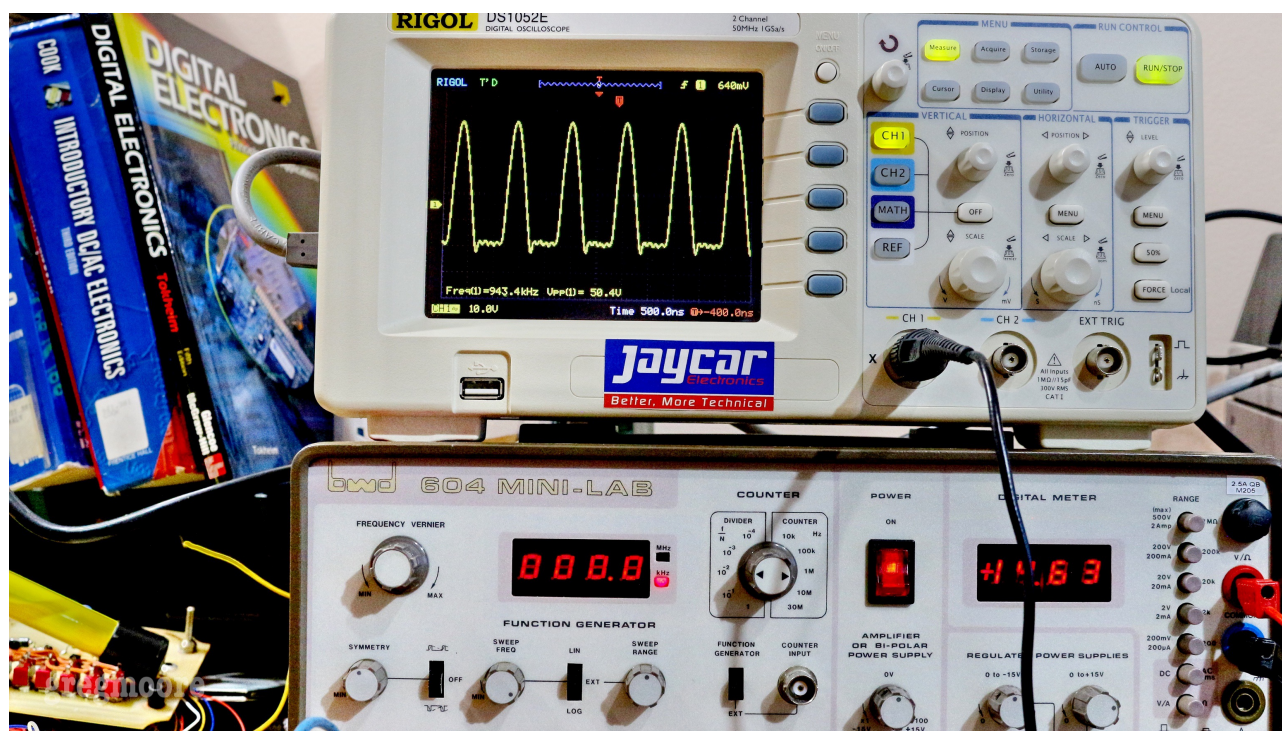
The coils are wound in the workshop class and pigtailed soldered to the cleaned ECW (enamelled copper wire). Note the very tight layout in the above photo.

This is an RF Oscillator and RF grounds are super important, especially close fitting bypass capacitors to keep the circuit 'tame'. In fact without the rail bypass and the voltage divider bypass in the base circuit, the oscillation frequency was quite low and not well behaved at all.

The maths on the tank circuit inductance and 3 points in the range of the variable capacitor calculated to be:

Variable capacitor at:	Inductor in Tank Cct	Calculated Freq.	Measured Freq.
20pF	460 μ H	1.66MHz	943kHz
100pF	460 μ H	742kHz	653kHz
200pF	460 μ H	524kHz	458kHz
It was noted that the output waveform was quite distorted.	The Armstrong oscillator, like the Hartley, only tunes the capacitor.	The large voltage pulses at 50Vpp mean good strong current pulses.	Interesting the error deviation was larger at the higher frequencies.

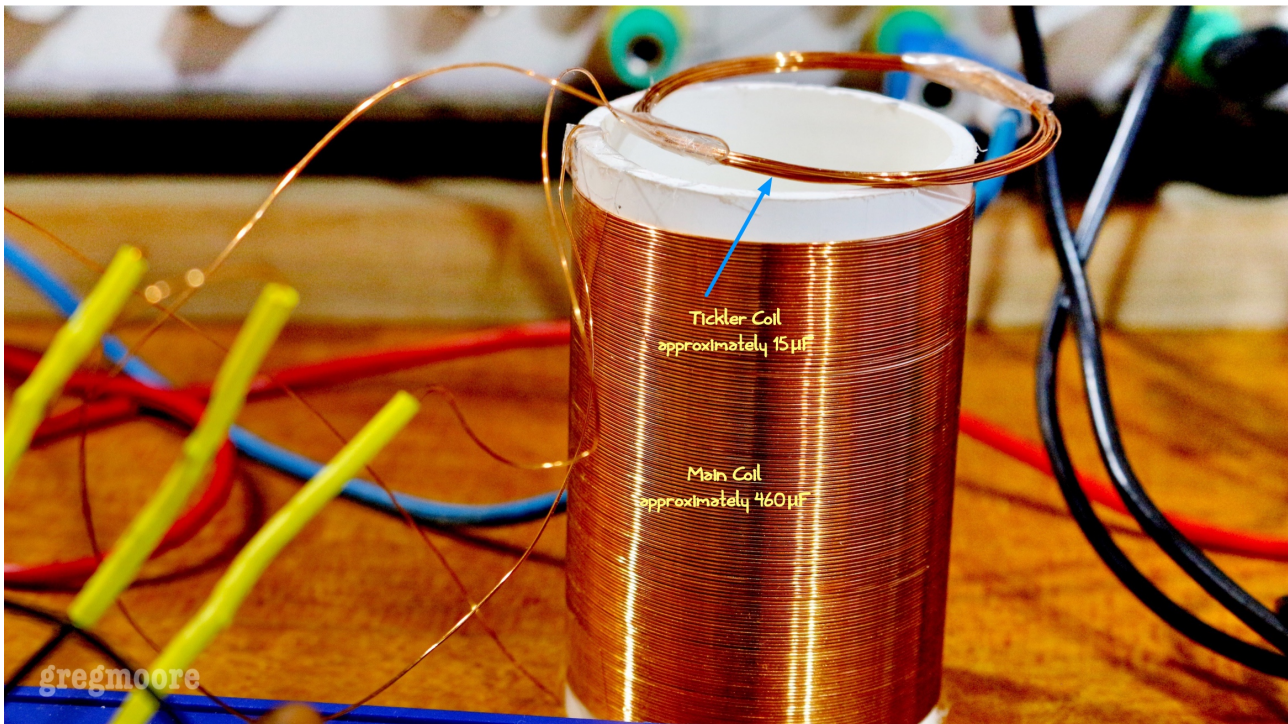
The measured inductance of my coil was 460 μ H and my tickler coil was very small consisting of just 10 looped turns of ECW to make 15 μ H.



Reversing the tickler coil did not stop the oscillation but reduced the collector RF voltage to 3Vpp and oscillated at 7.6MHz. Putting the tickler very close to the tank in this incorrect phase position did almost stop the oscillation completely. Because my tickler was very small, the amount of feedback is quite limited. This was intentionally done to have better control over amplifier / oscillator operation.

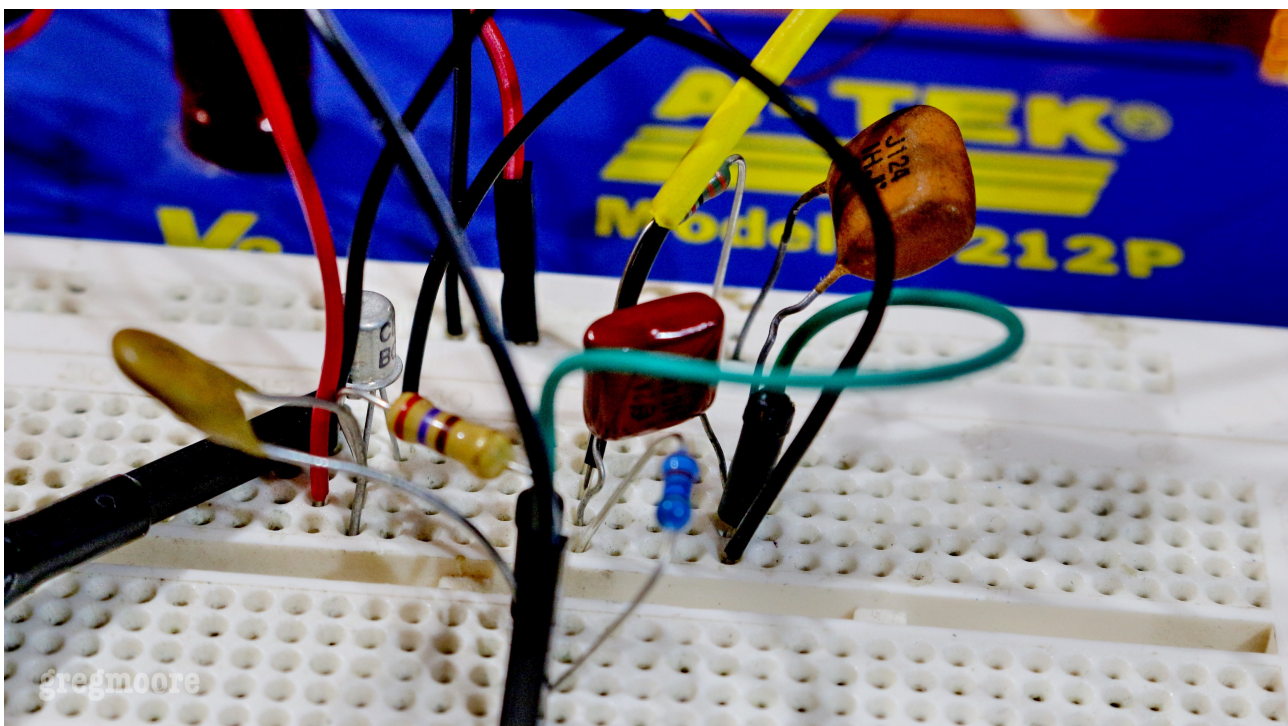
The distorted output waveform is acceptable and possibly has a bit to do with the capacitance between breadboard columns. The inter column capacitance is approximately 15pF, so the collector has an additional 15pF coupling to the emitter which was in the very adjacent column. I did not experiment with the base bias, as

the 2.1 Volts DC is considered fine for a small signal amplifier such as this. The



quiescent emitter voltage and currents would be 1.5V and 5.6mA respectively.

The photo above shows the quite small, 10 winding tickler coil. It's just used for feedback and is not a frequency determining element.



Here above is a close up photo of the transistor, BC109C and all the other components. Note the possible RF problem with only one column spacing between collector tank coil connection (red wire foreground) and the emitter pin

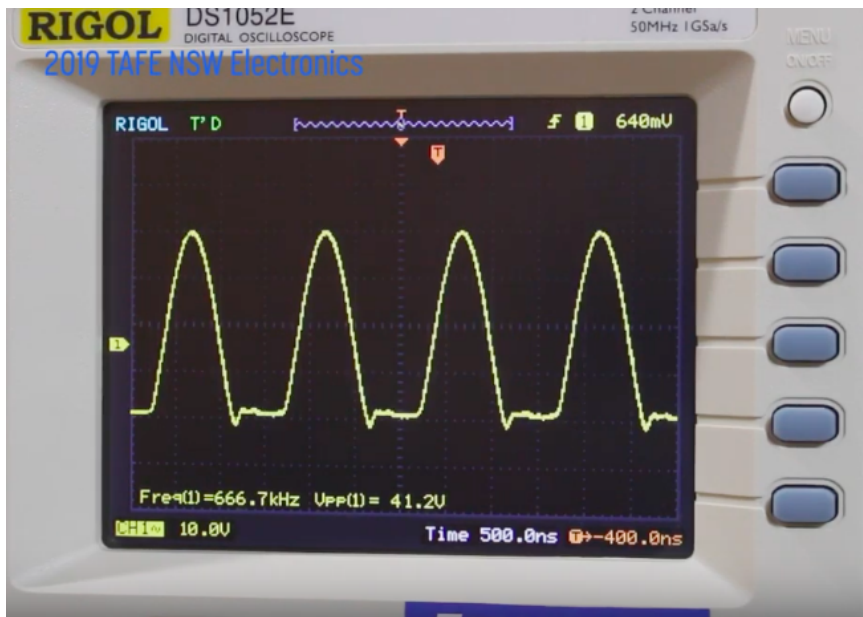
with 270Ω resistor and 500pF bypass capacitor. Luckily it's still at quite low RF frequency. If this was at 10MHz , many more problems would exist. Breadboards are not really suitable for RF work :)

In the small video for this circuit I demonstrate the Broadcast band frequency by using a Transistor radio in the AM Broadcast band. Any amplification of our RF signal at these frequencies would be illegal and incur the wrath of the Spectrum Management Department.

Tank Coil in Base Circuit Variant (Tuned Base)

With a FET vs BJT there are some differences in how to do this. BJT has low input impedance and FET has high input impedance. Placing any resistance across our tank coil will lower the Q, and that is undesirable.

In the Tuned Base circuit, I have kept the base bias the same as in the first circuit, but have capacitively coupled the tank coil and variable capacitor to the Base. The tickler coil is in the collector circuit with R_c . **See circuit later in notes.**



Youtube link for Armstrong Oscillator video: <https://youtu.be/9cds82zuEWw>

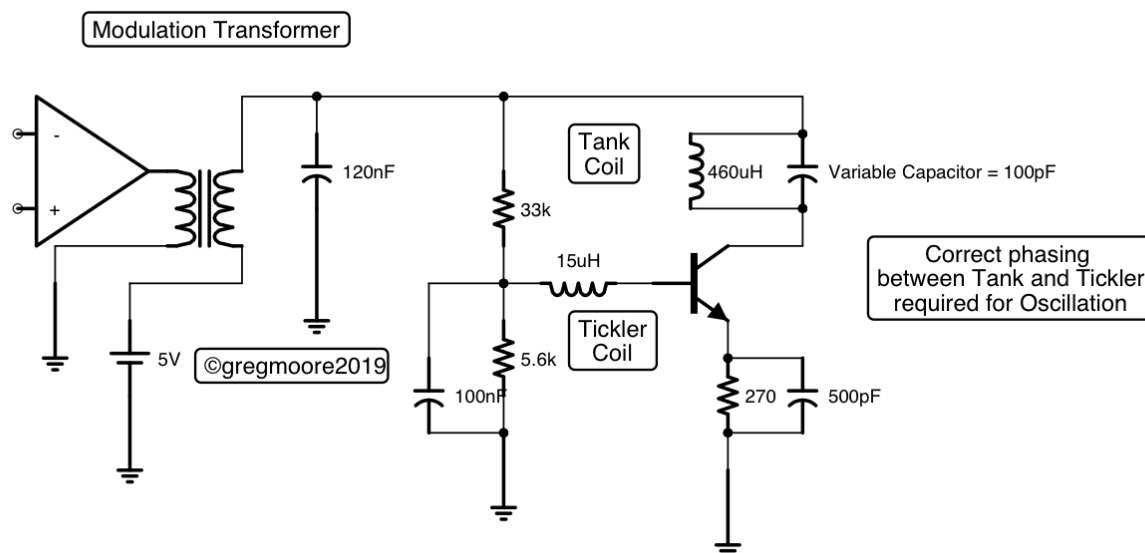
In fact with the series fed tickler winding to the base of the BJT, this first circuit is almost a bastardised blocking oscillator circuit with a tuned output, but sans the large negative spikes associated with blocking oscillators.

Here above is a frame snipped from the video. Using DC coupling for waveform on the collector, it was seen that the flat portion of the waveform is sitting on zero volts indicating that transistor saturation is occurring. Certainly there is ample output here to feed a PA directly or via a buffer. Especially if running a PA for RF in class C or class E operation, the shape of the oscillator output waveform is not important as the final PA is also non linear.

Modulation to the Oscillator

This was an interesting thing to try with this circuit. It then becomes an oscillator / PA running in not A0 / A1 mode but A2 mode modulated CW, popular many years before but not very efficient. A2 mode means the receiver does not need to use heterodyne mixing in the way of a Beat Frequency Oscillator to extract the audio

keying information from the morse code which was used. Today we call the BFO a Product Detector and it's often achieved with a balance modulator mixer such as the NE602A ic. Never forget that during both the WW2 and Korean and Vietnam wars, morse code in cipher groups was the predominant form of radio



transmission in the field. Many war time field radios did not have the option for a BFO or did not want to be reliant on it so A2 transmission was common, even though it's very power wasteful as the carrier is on for the entire time of the morse transmission. Point to point communications using ASCII and Frequency Shift Keying for Radio Teletype was available during the Second World War but only in very large installations. Moreover RTTY with FSK was seen more in the Korean and Vietnam wars. As a matter of interest, the Australian Army Special Air Services and 126 Special Forces Signal Squadron still learn and use morse code.

USE	OLD	NEW	
Pure carrier	A0,F0	N0N	
Morse telegraphy (by ear)	A1	A1A	
Modulated CW Morse	A2	A2A	Bingo, this is what we heard in the receiver, modulated morse code.
AM voice	A3	A3E	
SSB, suppressed carrier	A3J	J3E	
SSB, reduced carrier	A3R	R3E	

SSB, full carrier

A3H

H3E

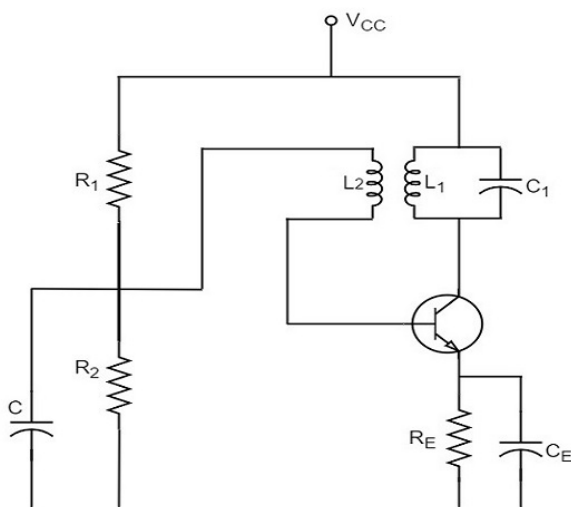
By feeding high level audio sine wave at 500Hz into the power supply current path, the oscillator circuit was being fed by a new voltage which varies at the audio rate. Again, this is quite bastardised because the frequency shift from the oscillator would be seriously horrible as it's voltage changed but for demonstration purposes it worked fine. In fact the PA would be modulated and the oscillator would be voltage regulated and temperature compensated / protected in real operation.

Tuned Collector Oscillator (Armstrong Oscillator)

Tuned collector oscillators are called so, because the tuned circuit is placed in the collector of the transistor amplifier. The combination of L and C form the tuned circuit or frequency determining circuit.

Building the Circuit

The resistors R_1 , R_2 and R_E are used to provide d.c. bias to the transistor. The capacitors C_E and C are the by-pass capacitors. The secondary of the transformer provides a.c. feedback voltage that appears across the base-emitter junction of R_1 and R_2 is at a.c. ground due to by-pass capacitor C . In case, the capacitor was absent, a part of the voltage induced in the secondary of the transformer would drop across R_2 instead of completely going to the input of transistor.

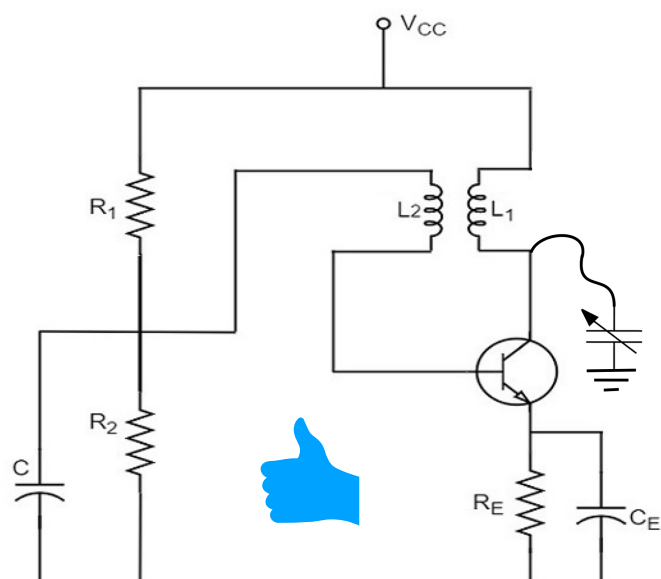


As the CE configured transistor provides 180° phase shift, another 180° phase shift is provided by the transformer, which makes 360° phase shift between the input and output voltages. The following circuit diagram shows the arrangement of a tuned collector circuit.

How it works

Once the supply is given, the collector

current starts increasing and charging of capacitor C takes place. When the capacitor is fully charged, it discharges through the inductance L_1 . Now oscillations are produced. These oscillations induce some voltage in the secondary winding L_2 . The frequency of voltage induced in the secondary winding is same as that of the tank circuit and its magnitude depends upon the



Armstrong and Variants

Oscillators

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number of turns in secondary winding and coupling between both the windings. The voltage across L2 is applied between base and emitter and appears in the amplified form in the collector circuit, thus overcoming the losses in the tank circuit. The number of turns of L2 and coupling between L1 and L2 are so adjusted that oscillations across L2 are amplified to a level just sufficient to supply losses to the tank circuit.

Tuned collector oscillators are widely used as the local oscillator in radio receivers.



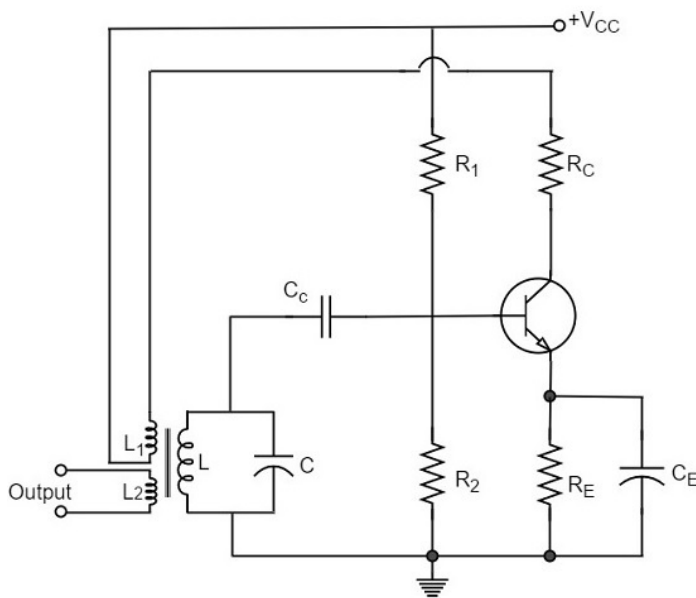
Note the second circuit I have drawn with the Variable capacitor going to ground is identical RF wise to the first circuit as ground and rail are both the same point as far as RF is concerned. This allows the rotor of the capacitor to be grounded.

Tuned Base Oscillator

Tuned base oscillators are called so, because the tuned circuit is placed in the base of the transistor amplifier. The combination of L and C form the tuned circuit or frequency determining circuit.

Building the Circuit

The resistors R1, R2 and RE are used to provide d.c. bias to the transistor. The parallel combination of RE and CE in the emitter circuit is the stabilising circuit. CC is the blocking capacitor. The capacitors CE and C are the by-pass capacitors. The primary coil L and the secondary coil L1 of RF transformer provides the required feedback to collector and base circuits.



As the CE configured transistor provides 180° phase shift, another 180° phase shift is provided by the transformer, which makes 360° phase shift between the input and output voltages. The following circuit diagram shows the arrangement of a tuned base oscillator circuit.

How it works

When the circuit is switched on, the collector current starts rising. As the collector is connected to the coil L1, that current creates some magnetic field around it. This induces a voltage in the tuned circuit coil L. The feedback voltage

produces an increase in emitter base voltage and base current. A further increase in collector current is thus achieved and the cycle continues until the collector current becomes saturated. In the meanwhile, the capacitor is fully charged. When the collector current reaches saturation level, there is no feedback voltage in L. As the capacitor has been charged fully, it starts discharging through L. This decreases the emitter base bias and hence IB and the collector current also decreases. By the time the collector current reaches cutoff, the capacitor C is fully

charged with opposite polarity. As the transistor now gets off, the condenser C begins to discharge through L. This increases the emitter-base bias. As a result, the collector current increases.

The cycle repeats so long as enough energy is supplied to meet the losses in L.C. circuit. The frequency of oscillation is equal to the resonant frequency of L.C. circuit.

Disadvantage

The main disadvantage of tuned-base oscillator circuit is that, due to the low base-emitter resistance, which appears in shunt with the tuned circuit, the tank circuit gets loaded. This reduces its Q which in turn causes drift in oscillator frequency. Thus stability becomes poorer. Due to this reason, the tuned circuit is not usually connected in base circuit. Essentially, why would you put the tank circuit anywhere except in the collector circuit here - where it is the most efficient.

Some notes here extracted from:

https://www.tutorialspoint.com/sinusoidal_oscillators/sinusoidal_oscillators_quick_guide.htm

To be continued.