

# Frequency Adjustment

## Music From The Ether

### MK-1 Theremin Oscillator Board

## WARNING HIGH VOLTAGE

**HIGH VOLTAGES IN EXCESS OF 500 VOLTS AC ARE PRESENT ON THE POWER SUPPLY CHASSIS AND 150 VOLTS DC ON BOTH THE POWER SUPPLY AND OSCILLATOR CHASSIS. TO PREVENT THE POSSIBILITY OF INJURY, SHOCK OR EVEN DEATH USE EXTREME CAUTION WHEN WORKING WITH THESE ASSEMBLIES. YOU HAVE BEEN WARNED!**

There are three oscillators on the Oscillator Board. Two of them control the theremins pitch, one of them controls the theremins volume or expression, not to be confused with the volume of the output amplifier. Everything in a theremin is frequency dependent so for proper operation of the instrument it is essential for the oscillators to be operating at or close to certain specific frequencies. There are two different oscillator tuning techniques presented. The first and most accurate uses a digital frequency counter or an oscilloscope with a frequency measurement function. The second uses a tuning procedure that does not require any instrumentation but will still yield very good results.

#### Analytical Instrument Method:

Measuring the frequency of the oscillators can be a bit tricky because any direct connection to the oscillators even with a 10 Meg oscilloscope probe can load them down and cause frequency readings that are actually lower than the true frequency the oscillator is normally running at. If you have a sensitive frequency counter, oscilloscope with a frequency measurement function or a digital storage oscilloscope (DSO) that has a frequency measurement function, one technique is to affix a short (2"-3") piece of wire to the probe tip of your counter or O'scope and place it inside the oscillator coil using an input range low enough to accurately detect the signal. This technique may alter the actual frequency by a few hundred Hz owing to the wire inside of the coil but is minimal considering that we're using an LC resonant circuit that is already sensitive to variations in temperature, relative humidity, barometric pressure, phase of the moon, etc. Before you begin adjusting oscillators, everything must be installed in the cabinet and connected up as close to the finished product as possible. This includes the aerial coils and the aerials. Power up the theremin with all of the tubes installed for at least one hour prior to making any adjustments to stabilize the electronics and get everything up to operating temperature. Finally, make sure there are NO large metal objects to within at least four feet of the instrument as it may affect the RF fields around the aerials.

#### Initial Tuning Set-up:

##### Fixed Oscillator Tuning:

Remove the power to the oscillator chassis and remove all of the tubes except for the fixed oscillator tube V3-6J5. Don't sweat it, it's perfectly OK to run the oscillator chassis without all of the tubes installed I do it all the time. Restore power to the oscillator chassis. Using a frequency counter or O'scope with the probe wire inserted into coil L4, use a non conductive adjusting tool and adjust the variable trimmer capacitor C6 to a reading of around 192 Khz. Get as close as possible. You will not get it spot on. A tad higher than lower is better.

##### Variable Oscillator Tuning:

Remove the power to the oscillator chassis, remove tube V3-6J5 and install it into the variable oscillator tube socket V5. Adjust the cabinet mounted variable tuning capacitor C11 so that the moving plates mesh 90 degrees to the fixed plates, this will establish the approximate center of it's value. Restore power to the oscillator chassis. Using a frequency counter or O'scope with the probe wire inserted into coil L5, use a non conductive adjusting tool and adjust variable trimmer capacitor C10 to a reading as close as possible to around 192 Khz.

##### Volume Oscillator Tuning:

Using the same procedures as for the pitch oscillators, place the 6J5 tube from the variable pitch oscillator socket into the volume oscillator socket V1 and power it up. Yes, we keep using the same tube. Why not? It's already warmed up... Again this time with the probe wire in the volume oscillator coil L1, adjust variable trimmer capacitor C3 to a reading as close as possible to around 425 Khz.

#### Everything you just endured was merely the buildup to... The BIG Finish:

Remove the power and install all of the tubes back into the oscillator chassis, plug a speaker into the audio output jack, adjust the panel mounted volume control to approximately  $\frac{1}{4}$  turn clockwise and power it up. When all the tubes warm up you should hear a pitch of some kind. Now it's time to finalize the pitch oscillator tuning. Assuming you have not moved the setting on the panel mounted pitch tuning capacitor C11- I haven't mentioned it again so there was no reason to, slowly adjust the variable trimmer capacitor C10 in the variable pitch oscillator. If the pitch starts to increase (go higher) rotate it the opposite direction and it will start to decrease. Continue to adjust C10 decreasing the pitch until no sound comes from the instrument at which point the pitch oscillators will be "neutralized". It may be necessary to repeat this adjustment several times because any proximity of your hand or body to the pitch aerial and pitch aerial coil will detune the variable pitch oscillator. Make a small adjustment to C10- baby steps, and step back a few feet from the instrument if there is still a pitch coming from the speaker make another small adjustment and again step back. Once you have gotten to the point where you can step back from the instrument a few feet and no or minimal pitch is present from the speaker the pitch oscillators are adjusted.

#### Volume Oscillator Final:

With the probe wire placed back into the volume oscillator coil L1, adjust the variable trimmer capacitor C3 to get as close to 425 Khz as possible. As with the variable pitch oscillator the frequency of the volume oscillator will also be affected by the proximity of your hand and body to the volume aerial and volume aerial coil so again make a small adjustment and step back a few feet and take a reading then go back and do it again- remember, baby steps, until you get as close as possible to 425 Khz. Again a bit over is slightly better than a bit under 425 Khz. All of the harmonics have to be right for this little technological terror to work! Now it's time to adjust potentiometer VR1. Basically VR1

controls volume aerial proximity or how close your hand gets to the volume aerial before no sound comes out of the speaker. So, with you hand at your side the maximum volume will come out of the instrument and the closer you move your hand to the aerial the softer it will play until there is no sound at all... I typically like the instrument to fall silent about ½" before I touch the volume aerial but this is an adjustment based totally on personal preference so, you may end up making a largish number of trips between adjusting VR1 and the front of the instrument to test it out before you arrive at a volume range you are happy with.

## **No instrument Method (Winging it by ear):**

### **Initial Tuning Set-up:**

This procedure is performed with all of the vacuum tubes installed and the instrument fully powered up. Before you begin adjusting oscillators, everything must be installed in the cabinet and connected up as close to the finished product as possible. This includes the aerial coils and the aerials. Adjust the fixed oscillator tuning capacitor C6, variable oscillator tuning capacitor C11, volume oscillator tuning capacitor C3, and Bias potentiometer VR1 to their approximate center of value. Also, adjust the cabinet mounted variable tuning capacitor C11 so that the moving plates mesh 90 degrees to the fixed plates, this will also establish the approximate center of it's value. Power up the theremin with all of the tubes installed for at least one hour prior to making any adjustments to stabilize the electronics and get everything up to operating temperature. Finally, make sure there are NO large metal objects to within at least four feet of the instrument as it may affect the RF fields around the aerials.

### **Oscillator Tuning:**

Begin by plugging a speaker capable of handling approximately 10 watts into the Audio Output jack on the Power Supply/Audio Amplifier Chassis and turn the front panel mounted volume control approximately ¼ turn clockwise. You may or may not hear a pitch coming from the speaker. Use a non conductive adjusting tool, slowly adjust the variable trimmer capacitor C10 in the variable pitch oscillator. If the pitch starts to increase (go higher) rotate it the opposite direction and it will start to decrease. Continue to adjust C10 decreasing the pitch until no sound comes from the instrument at which point the pitch oscillators will be "neutralized". It may be necessary to repeat this adjustment several times because any proximity of your hand or body to the pitch aerial and pitch aerial coil will detune the variable pitch oscillator. Make a small adjustment to C10- baby steps, and step back a few feet from the instrument, if there is still a pitch coming from the speaker make another small adjustment and again step back. Once you have gotten to the point where you can step back from the instrument a few feet and no or minimal pitch is present from the speaker the pitch oscillators are adjusted. If you reach a point in the adjustment of C10 where the pitch is as low as it will go and will still not "neutralize", adjust the fixed oscillator variable tuning capacitor C6 to a point where the oscillators are neutralized and then go slightly past it and then readjust C10 as per the previous procedure.

### **Volume Oscillator Tuning:**

Potentiometer VR1 controls volume aerial proximity or how close your hand gets to the volume aerial before no sound comes out of the speaker. Standing in front of the instrument, move your left hand slowly towards the volume aerial. As your hand approaches the aerial the volume should start to decrease and the instrument should go completely silent just before your hand touches the aerial. If not adjust potentiometer VR1 slightly on one direction and retry. If you can not accomplish the adjustment within the range of VR1, make a small adjustment to the volume oscillator variable trimmer capacitor C3 and redo the adjustment procedure. I typically like the instrument to fall silent about ½" before I touch the volume aerial but this is an adjustment based totally on personal preference so be prepared to possibly make a lot of trips between the back and front of the instrument adjusting VR1 and C3 until you get to the volume response you are happy with.