

R-390A Oscillator output level effects
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This seems to be a popular subject recently and over the past many years, and understandably so, as low output can negatively affect overall gain and sensitivity. So, how do we know when an oscillator output is too low. Well, the big question seems to be, what is really too low. And yes, I'm going to try to answer that. The following are a few signal levels that I found in different R-390A documents. The signal levels are mostly different, hence the source of some confusion.

The TM 11-856A from 1-20-1956 defines the minimum output for them measured at the associated mixer cathode pin 7 as follows:

1. The 1st crystal oscillator is 3.0 V rms or 8.5 V p-p.
2. The 2nd crystal oscillator is 1.8 V rms or 5.1 V p-p.
3. The VFO (PTO) is 1.8 V rms or 5.1 V p-p.

It also says you can test the oscillator outputs by measuring the dc voltage with a high impedance voltmeter with the rx in 'Stand By' on the test points for their respective mixers as follows:

1. The 1st crystal oscillator, test point E209 for -4.5 volts DC or more
2. The 2nd crystal oscillator, test point E210 for between -3.5 and -8.0 volts DC
3. The VFO oscillator, test point E211 for between -2.8 and -4.3 volts DC

I like the above method and this is what the TM 11-5820-358-35 from 12-8-1961 says what the readings should be:

1. The 1st crystal oscillator, test point E209 for approximately -6.8 volts DC
2. The 2nd crystal oscillator, test point E210 for between -3.5 and -8.0 volts DC
3. The VFO oscillator, test point E211 for between -2.8 and -4.3 volts DC

The only difference in the above measurements is the 1st one, for the 1st crystal oscillator. They changed it to read 'approximately -6.8 volts DC'. Well, that is not much of a help. What's important to know is the minimum.

Now for the big difference. The Y2KR3 tech manual that is based on the U.S. Navy Technical Manual from May 15, 1985 also says what the readings should be:

1. The 1st crystal oscillator, test point E209 for between -4.0 and -6.8 volts DC
2. The 2nd crystal oscillator, test point E210 for between -3.0 and -8.0 volts DC
3. The VFO oscillator, test point E211 for between -1.3 and -4.3 volts DC (-0.95 to -1.6 with FC-7)

It looks like the Field Change 7 signal levels are a little lower than without the change. I believe that these new lower numbers are too low for the VFO. Aside from lower overall rx gain, one problem I found is that it can cause low oscillator output on one end of the VFO range compared to the other end. You want it to be about the same, and it can be.

As you can see from the variation in the above specs, the minimum required oscillator output was not understood very well. So why after 29 years is it ok to lower the minimum, especially for the VFO? The problem is that the rx will still work at low output, although probably not to the level that

was originally designed or what we expect of them. I've read through the Pearls a lot on this subject (and there is a lot to read) and believe that the correct minimum specs to go by are from the original TM 11-856A from 1956 as stated above in the 2nd and 3rd paragraphs.

I measured the oscillator outputs of numerous oscillators by measuring the dc voltage with a high impedance calibrated voltmeter in 'Stand By' on the test points for their respective mixers. The averages are as follows:

1. The 1st crystal oscillator, test point E209 for -8.5 volts DC
2. The 2nd crystal oscillator, test point E210 for -7.5 volts DC
3. The VFO oscillator, test point E211 for -3.6 volts DC

Of course, there is a range of output where it is operating normally. The cause of some of this variation is due to differences and changes in components: tubes, crystals, inductors, caps and resistors. And then there are the voltages. One area where varied output is very evident is in the second crystal oscillator when we change bands and peak for max output. Most of the variation in output we see here is due to variations in crystals.

Now enter field change 7 on August 17, 1967. It changed the screen resistors on the 1st crystal and VFO oscillators from 56k to 220k on some rx's. Although this change was not applied to a large number of units and I'm sure it was well tested, it says in the accompanying doc that if the sensitivity does not meet specs after application, it is to be repaired. But, it did not include new minimum oscillator output levels. Further more, it does not take into consideration future minor component changes that may cause incorrect operation at a later date. Because this is not a functional improvement, my feeling on whether you should change it back or not is: if you are working in the subject area, reinstall the 56k ohm resistors. If not working in the area, but you determine that the oscillator output is low for an unknown reason (you tried a new tube, etc), reinstall the 56k ohm resistors. In any case, the oscillators should meet the TM 11-856A minimums, but more on this later. However (you know there's always a however), because there are a lot of factors involved with mixers, low oscillator injection does not mean it is not functioning satisfactorily. If the sensitivity and overall gain are ok, then you could decide that it is ok and leave it as is.

What I found online did not answer my questions at all. Why are the minimum numbers in the TM 11-856A OK and what happens if any are lower? Well, I devised a simple test to see what happens. I put a T in the output lines of the oscillators and connected a pot to it and the other end of the pot to ground. I used a 2.5k log taper as I did not have a 5k pot to use, but this makes no difference at all. This allowed me to vary the output of each oscillator. I did each one separately to prevent interaction. I then hooked up my sig gen to the bal input with an impedance matching unit so I would know how much signal I was feeding into it. I also hooked up my VTVM to the diode load so I could see the affect on the rx overall gain in MGC mode. I also measured the oscillator output voltage in 'stand by' at the respective mixer test points so I would have a good idea what the oscillator signal level was that was being fed into the mixer. I also set the line level meter for 0 vu with no signal input, so I could see how much the internal noise was reduced (this is also a good gauge of rx gain). Reducing the oscillator signal resulted in what I expected - a similar reduction in rx gain that kept in step with the oscillator voltage. Here's a chart that shows what I saw:

	1 st crystal oscillator -----	2nd crystal oscillator -----	VFO oscillator -----
Bal RF input:	7.7 MH, 2 uv	13.7 MH, 1.5 uv	13.7 MH, 1.5 uv
osc output:	-7.8 to -1.8	-7.7 to -2	-4.2 to -1.2
diode load:	-7 to -1.6	-7.6 to -2.4	-7 to -1.0
line level:	0 to -15	0 to -12	0 to -20

The 'diode load' and 'line level' readings are the result of varying the 'osc output' from normal to it's low point in this test (pot turned all the way). One thing that I get from this is that these low numbers are too low for reasonable operation. Especially drastic is the 20 db drop due to the VFO changing from normal output to -1.2 volts. After seeing this and testimonials from other folks, I don't see how 'field change 7' on the VFO would ever work satisfactorily. My conclusion from this test is that these low numbers are not at all acceptable.

Now to take a look at the operation of the rx at the TM 11-856A documented minimum output levels. I am using the same test setup as for the above readings. I set the oscillator outputs at the minimum, one at a time and took the rest of the readings. Here's the results:

	1 st crystal oscillator -----	2nd crystal oscillator -----	VFO oscillator -----
Bal RF input:	7.7 MH, 1 uv	13.7 MH, 1 uv	13.7 MH, 1 uv
osc output:	-7.2 to -4.5	-7.5 to -3.5	-4.2 to -2.8
diode load:	-7 to -4.8	-7.0 to -3.8	-7 to -4.2
line level:	0 to -5	0 to -7	0 to -6

With the 2nd crystal oscillator at the minimum, it takes an additional 1.4 uv to get the diode load back up to -7, for a total of 2.4 uv. Of course this is without adjusting the gain adjust on the IF deck. That would compensate to some degree. Now the real story, the s/n is 1.0 uv with the reduced 2nd crystal oscillator to the recommended minimum. And, here it is folks, the s/n is .86 uv **without** the reduced 2nd crystal oscillator.

So, it looks like the minimums are just ok for one oscillator to be low. If your rx has 2 or 3 oscillators at the minimum level, I think it is not performing satisfactorily. My opinion is that the oscillators should not be operating close to the minimums. I think **reasonable minimums would be : -5.5, -4.5, and -3.5 vdc** (in the same order as in the above chart).

There's a couple of caveats that I have not talked about. What do I do if the output is above the 'range' specified? What is too high? Is it a problem if it is? If it's the 2nd crystal oscillator, then take a quick look at some of the other bands. They might be higher or lower. There can be quite a large range of outputs. A couple of mine are -9.5 and one is -10.6 vdc. I don't detect any problems on these bands. The TM 11-856A says that the 2nd crystal oscillator maximum should be -8.0 volts DC. I think it should be about -11 vdc. The TM 11-856A also says that the 1st crystal oscillator maximum should be 'or more'. I think it should also be about -11 vdc. I have not heard or read of anyone saying that they're having a problem with too high of an oscillator output, so I assume that there isn't any.

Regards, Larry