

11/06/2008

## EFRATOM Model FRS-C 10MHz Rubidium Clock.

### Model FRS-C

Most surplus EFRATOM units found today are more than 15 years old. Due to their age and condition of operation, many may be considered by some to be at the end of their life.

I believe that age and period of continuous operation is not the big contributing factor to end of life, scrap the unit to the junk draw.

It is component failure due to long exposures to high heat that causes failure to more than 99% of the 20 units I have repaired.

The following is a result of repairing 20 units over a period of 3 months around 4 years ago. 3 months included some brief study of the Zeeman effect and how Rb resonance works

The main area to consider is within the physics package. There are two essentially 2 blocks that need careful consideration, they are:-

1. The lamp and lamp support board, the support board that holds the Rubidium lamp housing.
2. Resonator cavity and heating ring & circuit.

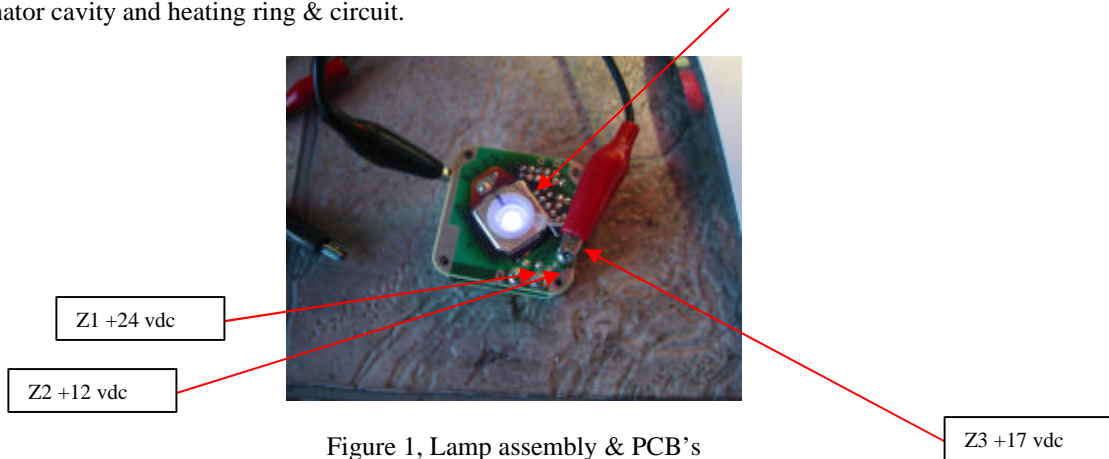


Figure 1, Lamp assembly & PCB's

The Rubidium (Rb) lamp does not have a filament. The function of the lamp assembly is to generate the right Rb Spectral lines  $\sim$  (768nm). Rb light ( Plasma ) is generated as a result of a 80~100 MHz oscillator and heat generated from the lamp support housing.

Figure 1 above shows the lamp ignited as a result of +24 vdc on pin Z3 as shown, the photo shows a blueish discharge. Once ignited, cut back the Z3 voltage to +17 vdc.

Next add +12 vdc to Z2 and then +24vdc to Z1. The current consumption on the +24vdc rail should be approx. 400mA. After about 2 minutes when the housing is temperature stabilized to approx. 84 degrees C, the following should be observed:-

- The current drops to approx. 200mA
- The Plasma discharge colour has an added purple haze around the outside, indicating proper Rb vapour pressure in the lamp envelope.



Figure 2, proper Rb ignition

11/06/2008

Proper ignition and the right housing temperature with maintain the correct Rb vapor pressure resulting in an added purple hazy ring within the lamp and the surrounding Teflon support insulator.

Figure 2 shows the added purple haze, it is important now to check the housing operating temperature. Although the manual states 106°C, in fact 106°C is the temp within the lamp. The emitted light is a combined result of Plasma discharge and heat.

The problem with the lamp assembly.

Resistor R6 fails, resulting in the unit takes a long time to lock, in many cases it may never lock. 100% failure of R6, this is a 1/8 watt 10K resistor. Pure carbon resistors generally increase in value, however 100% have shown that they decrease in value, down to 4.6K.

R6 is located very close to the lamp housing, but so are other resistors. Other resistors have been measured as O.K, within their respective +/- tolerance.

R6 failing forces Q2 to turn on hard .745vdc on the base and therefore stops Q1 from turning on hard enough to heat the lamp assembly to it's correct operating temperature. The correct operation should see approx. 1.3 on Q2 collector.

Check the following things:-

1. Incorrect multiplier freq. injected into cavity ( 60MHz ) to many harmonics
2. Step recovery Diode failed, check diode via diode tester, if measuring .745VDC it's O.K
3. Check R24 & R30 on Multiplier PCB, the following voltages should be checked, if not check and adjust:-  
Junction R25 & R27 it should read 3.38vdc +/-5%  
Junction R30 & R22 it should read 3.38vdc +/-5%  
20MHz input pin 1 at flex board should read 2.5vdc  
Junction C30 & L8 should read 3.38vdc +/-5%  
60MHz output at A5P1 Junction of C30 & L8 should be 2V amplitude and offset 2.5 vdc from ground.  
Check modulated 127Hz at A5J1 pin 5  
Check 5.312MHz signal at A5J1 pin 9
4. Check Lamp oscillator board for the following:-  
Check Plasma colpitts oscillator is set to 80~100 MHz, adjust C11 carefully with non-metallic adjustment tool on Spectrum Analyzer, ensure no harmonics.  
Apply power to Z3 +17vdc and check Plasma lamp, should see blueish glow.  
Check there is no dark spots on lamp, Rubidium has moved from pinch area.  
Check lamp oven, although manual states operating temp. is 106°C, actual Lamp housing should be 84 Degrees C +/- 5%

11/06/2008

5. TP1 on the servo board is the best indicator of good Rb light, if the correct spectral lines are not there then the wave shape below will never be seen, this is the resonance lock null signal, this signal is when Rb spectral lines and step recover multiplier resonate, this is called the Zeeman affect match causing a zero beat, thereby canceling Rb light.

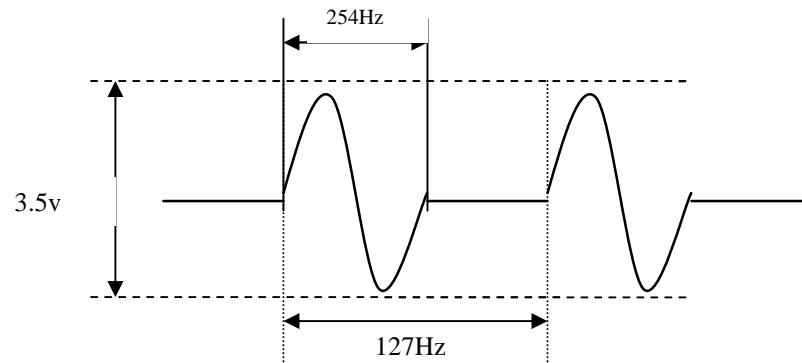


Figure 3, Test point servo waveform.

For those who are interested in Rb lamp rejuvenation, try a trick I have learnt.

First carefully remove the lamp from it's housing and if the Rb material looks like is splattered over the inside wall of the glass, this means Rb material is no longer consolidated in the pinch of the glass lamp. To reconsolidate Rb material use a typical heat gun / paint stripper gun and uniformly rotate the lamp heating the glass, the result will be Rb consolidation at the pinch. I have rejuvenated all 20 lamps with 100% success. The lamp voltage of my FRS made in 44<sup>th</sup> week of 1990 is as strong as ever. The 20 repaired and sold are all perfect, all servo waveforms were a carbon copy of the figure above.

Good luck.