Communications & Power Industries

KLYSTRON TUNING PROCEDURES:

Applicable to 5-Cavity C-Band and Ku-band Klystrons made by CPI Canada.

General.

The channel tuning mechanism, an integral part of the tube, provides for the precise tuning (ie. setting of the bandwidth, gain and amplitude characteristics) for different frequencies and their subsequent retrieval at will by a selection system.

The klystron has been tuned during factory testing to discrete passbands having centre frequencies, Fc, as indicated in the tuner cover decal. These tubes may be factory tuned to any desired frequencies within the operating frequency range (see Specification/Data Sheet) at no extra charge if the required frequencies are specified on the purchase order. The Test Performance Sheet, copies of which accompany each tube, provide operating information and test results for each of the frequency channels to which that particular tube has been set.

Selecting a Pre-set Channel ("Standard" mechanically tuned klystrons):

1. Remove RF drive to the tube.
2. Unlock the tuner mechanism by rotating the Lock-Unlock shaft to its stop, approximately 10 - 18 turns, depending on the model.
3. Select the channel desired by rotating the *Tune* shaft to the selected frequency, F_c, as indicated by its channel number viewed in the window in the tuner cover. A detent in the tuner shaft will locate the new shaft position for the channel selected.
4. Lock the tuner at the new frequency by rotating the *Lock-Unlock* shaft to its stop in a reverse operation to step 2 above.
5. Restore and adjust rf drive to produce output power desired.

Selecting a Pre-Set Channel (DFTS):

In normal use, the KPA controller should be used to change the channel. Consult the relevant section(s) of the KPA operating manual.

It is also possible to use a personal computer to change the channel of the DFTS. It may be possible to disconnect a 9-pin D-connector from the KPA controller and plug this into a COM port on the computer. If this is not possible, consult the wiring diagram in the DFTS operating manual and ensure that 24VDC is applied in the correct way on the 15-pin connector going to the

DFTS and that RS232 is correctly wired. Using either CPI's Freeware FELIX program, or using a terminal emulator, send the command "Cxx" followed by a Carriage Return, where "xx" is the desired channel number. The tuner will respond with an E00 acknowledgement. Current status is found by sending the command "R", followed by a Return, the return string from the tuner lists channel, its defined frequency, and cavity tuner positions.

Alternatively, the tuner can be commanded to tune to a frequency by sending the command "Fnnnnn.n" to tune to a channel centre frequency (eg F06425.5 tunes to 6425.5MHz). See the manual for details.

To Retune a Channel (Standard Mechanically Tuned Klystrons):

When field re-tuning the tube, it is generally a simpler and easier job if the nearest factory tuned channel is used.

The following tools and test equipment are suggested for retuning:

a. Frequency sweeping signal source capable of approx. 0.2 W output power.
b. Oscilloscope
c. Broadband microwave detector
d. Harmonic filter, appropriate to the klystron under test.
e. Allen wrench, 1/16 inch across flats x 13/4 inch minimum length (one wrench supplied with each tube).
f. Frequency standard.

Klystron tuning is achieved by adjusting the resonant frequencies of the cavities of the tube. The adjuster screws in the channel changer mechanism adjust the physical size of the cavity, which changes the resonant frequency. The tube can be tuned in various ways to provide a variety of combinations of output power, gain, and bandwidth. For normal uplink applications, the optimum performance is obtained by tuning the cavities to the pattern shown in figure 1. The cavities are not all tuned to the same frequency: this is what is meant by "stagger tuning".

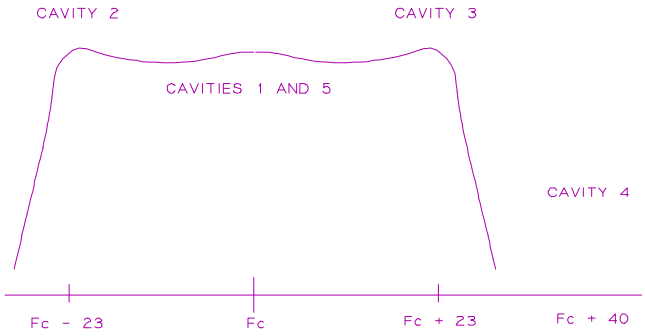

Figure 1

Frequencies of cavities, C-band klystrons.

The response can be visualised as follows:

Cavity #2 sets the lower band edge.

Cavity #3 sets the upper band edge.

Cavity #1 should be set close to the centre frequency of the channel, and controls flatness.

Cavity #5 should also be tuned to centre frequency and controls tilt.

Cavity #4 is positioned above the upper edge of the channel, and controls gain.

Cavity numbering is from input to output: cavity #1 is at the cathode (bottom) end of the tube, while #5 is at the collector (heat exchanger) end of the device.

NOTE

Turning the wrench in a CLOCKWISE direction will INCREASE the cavity frequency. This is UP in the case of DFTS.

A COUNTER-CLOCKWISE rotation of the wrench will DECREASE the frequency. This is DOWN for DFTS.

Tuning.

a) Equipment required.

In order to tune the device, you need a tunable input source. The ideal is a sweep generator, but a tunable CW source is also adequate. The sweep generator will save hours even on a six channel device. Some measure of input power is an advantage: there is usually an input power meter provided by the system manufacturer and this is adequate. For monitoring the output response shape, either a crystal detector and oscilloscope, or a scalar network analyser, is the best case. A spectrum analyser is adequate, but slower, while the output power meter on the KPA will suffice in emergencies. A method of measuring output power is essential: the KPA meter is sufficient.

b) Preparation.

Check that the following are in order:

Body current trip set to 30mA or less. If the trips are not readily adjustable then extra care will be required.

The lock-unlock adjuster is in the fully locked position.

Make sure that the ratings of the monitoring equipment cannot be exceeded. Verify that the input to the IPA (if present) cannot exceed its ratings: insert attenuators between the sweeper and the amp as required. Also check that the crystal, network analyser, and/or spectrum analyser cannot be overloaded. If no attenuators are available, extra care will be required during the process. Be aware also that too much output can damage isolators and other output waveguide components and may damage the tube as a result.

c) Evaluate where you are and what you need to do.

If you are checking the tuning on an existing channel or are retuning by less than about 60MHz, then the process is much easier than for retuning by a long way or for starting from scratch.

Apply input power over a range of twice the bandwidth of the device around the centre frequency of the channel. If you can see no response on the scope, increase the input power. Watch the

body current of the tube: if it starts to rise appreciably, there is probably output, and the monitoring should be re-examined. Check another channel for proper response if doubt continues.

For minor re-tuning operations, all cavities are to be adjusted by approximately the same amount and in the same direction.

- If the cavity frequencies are being increased, then start the adjustment with cavity #4, which will reduce gain. Then adjust cavities #5, #3, #2 and #1 respectively, and finally bring #4 back.
- If the cavity frequencies are being decreased, then perform the adjustments on cavities #1, #2, #3 and #5 respectively first. Adjust cavity #4 last.

d) For larger re-tuning jobs, start to synchronously tune the klystron. This means all cavities are tuned to the same frequency. In this mode, bandwidth is small but gain and output power are far more than rated conditions.

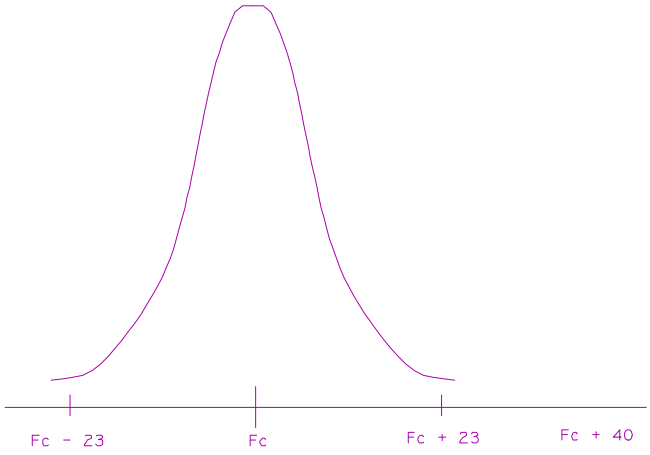

Figure 2

Synchronously tuned gain response.

When synchronously tuning, carefully watch output power and body current: be cautious.

Remember that INDICATED OUTPUT POWER is an average over the sweep. Run CW at centre frequency to find out the true level at that point.

Try and tune at a peak power of 1kW or less: remember the average power on the meter will read less than the peak value. Start by applying input power of about 200mW (that's output from the IPA if present) and observe the response.
Start with cavity 1, tuning it until the highest response is obtained in the centre of the band. Now tune cavities 2, 3 and 5 to do the same, tuning cavity #4 last. Keep adjusting the input power downwards to avoid damaging the output run components, especially while adjusting cavity #4.
Once the cavities are all apparently tuned together, verify each one is really tuned to the band centre (Fig 2).

e) Widen the gain response.

Now widen the response to obtain the desired chracteristics.

Cavity #4 should be raised in frequency to a value higher than its final value. It is normally difficult to see cavity 4 on the reponse, so turn the tuning screw for cavity 4 clockwise by two turns. The gain will drop off: increase input power and/or monitoring sensitivity as required.

Cavity #2 is now reduced in frequency by 23MHz (C-band) or 40 MHz (Ku-band). This means adjusting the cavity to maximise the gain at that frequency.

Cavity #3 is now tuned up in frequency to its final value in the same way.

Trim cavities 1 and 5 for maximum output in the centre of the band.

Tune cavity 4 down in frequency and the gain will increase. Keep going until the response flattens out, as in Fig 1. Note that cavity 1 may or may not be visible as a peak in the centre of the band, depending on the device type, the frequency of the channel, etc.

NOTE

Manual Tuners: Always end each tuning operation in a COUNTER-CLOCKWISE direction to assure repeatability.

DFTS: Always end tuning with an UPWARDS movement.

IMPORTANT TUNING NOTE

Be aware that the body current may rise beyond safe levels during some tuning conditions at large RF output levels, so it is safer to perform retuning at low levels of RF power until a reasonably wide and flat response has been attained. The RF drive power may then be raised to achieve the desired output power.

f) Checking small to large signal behaviour.

Check the peak output power (ie CW at FC). Raise the input power so that output is close to the rated power of the product and then back it off by 10dB or so. Watch the shape of the response. If there is insufficient gain, check positions of the cavities. Cavity #4 may still be tuned too high. If there is a definite change of tilt with output power then cavity 4 is too close and should be moved up in frequency slightly. Adjust the other cavities to obtain the correct response shape, tuning 3dB to 10dB backed off from rated power. Keep checking the change in shape with power, until the correct behaviour is observed. Small signal response should be as Figure 1, large signal may appear as Figure 3 (frequency marking on Fig 3 is for C-band 45MHz).

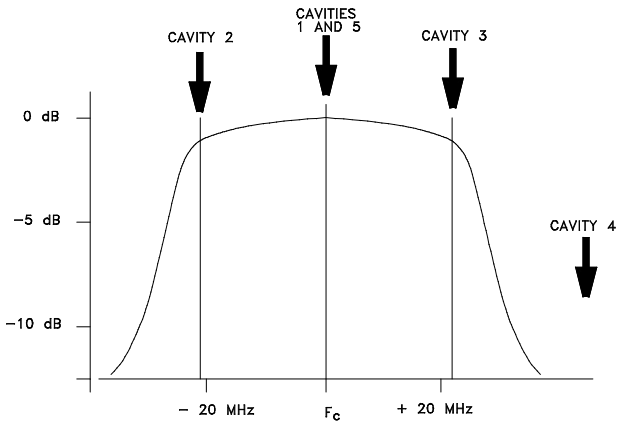

Figure 3

Large Signal, Broadband Tuned (C-band)

g) Remove tuner backlash.

To ensure repeatability, turn each screw clockwise by a quarter turn or so, and bring it back to its correct position. It is important to finish the adjustment by turning counter-clockwise to eliminate the effects of backlash. In the case of DFTS, each cavity must be finished with an UPWARDS movement.

Hint.

It may be easiest to obtain the optimum bandpass by trim tuning cavities 2, 3 and 4 at small signal (ie. < 200 Watts) and trim tune cavities 1 and 5 at rated power. The large signal response should look similar to Figure 3.

Once retuning is complete, indicate the new frequency in the appropriate space on the tuner cover by overpasting the old frequency notation with a new tab.