Technical Service Bulletin 040124

IOT Tuning with Tracking Generator or Network Analyzer: DCX Paragon

This bulletin provides a general procedure for IOT tuning for the DCX Paragon transmitter. When possible, this procedure should be supplemented with specific tuning procedures provided by the IOT manufacturer.

Correct IOT tuning is essential to obtaining adequate gain, efficiency, and signal performance from the IOT. Failure to properly tune the IOT may result in poor output SNR performance due to a skewed output frequency response, poor gain due to the IPA drive power being rejected at a mistuned tube input, or poor efficiency due to poor coupling of the beam power to a mistuned tube output. The output tuning bandwidth also has marked effect on the IMD sidebands created by the tube output saturation level, with wider output bandwidths providing less saturation at the expense of lowered IOT gain.

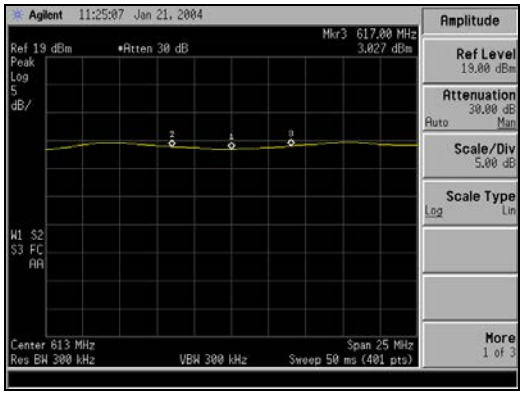
Procedure 040124: IOT Tuning with Tracking Generator or Network Analyzer: DCX Paragon	
Applicability	All DCX Paragon transmitters.
Prerequisites	Correct IOT bias voltage (031208), correct IOT filament voltage (031208), correct IOT beam voltage (031208), correct IOT focus voltage (031208). Transmitter in Beam mode (RF drive off)
Equipment Required	Spec analyzer w/ tracking generator or network analyzer.
Comments	None.

1. For initial installation of new (un-tuned) IOT cavities, set IOT tuning controls to initial tuning settings provided by tube manufacturer.
2. Switch HPA to be tuned to internal control mode via CONTROL button on HPA control panel.
3. Steer HPA to be tuned to a magic tee reject port via following commands on system controller: **SELECT > RF SWITCH > # *(appropriate switch number)* > XFER > ENTER**.
4. Connect sweep output from tracking generator or network analyzer to RF input of IPA drive splitter for HPA cabinet to be tuned.
5. Adjust spectrum or network analyzer to following settings:

   FREQUENCY = center frequency of UHF channel
   SPAN = 20 MHz full screen or 2 MHz / division
   RES BW = 300 kHz
   VIDEO BW = 300 kHz
   VERT SCALE = 5 dB / division
   SWEEP POWER = -20dBm

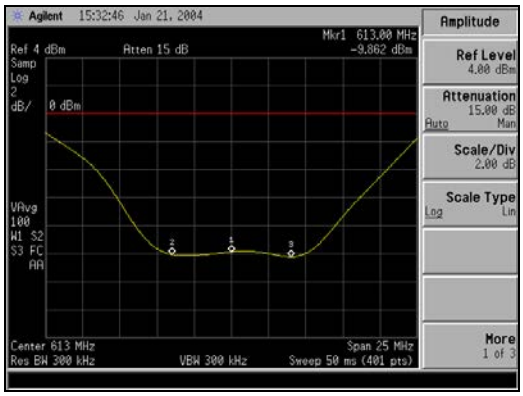
6. Connect RF sample from directional coupler at IPA output to analyzer input.

7. Measure IPA frequency response on analyzer. Verify IPA frequency response is flat to within +/- .5dB across desired six MHz channel bandwidth.



NOTE: Markers in this series of photographs are at +/- 4MHz from channel center. That is, they show an 8 MHz wide frequency band.

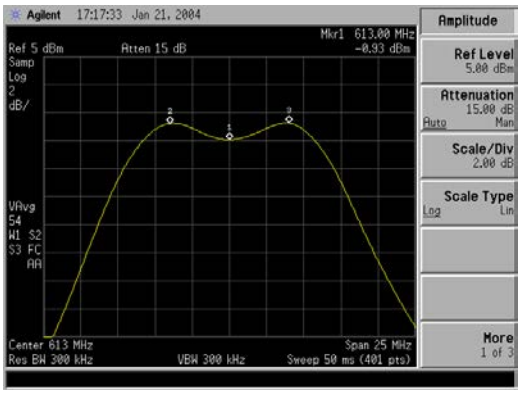
8. Connect RF sample cable to directional coupler on IPA circulator reject port. Spectrum analyzer displays IOT input return loss.



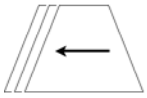
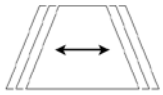
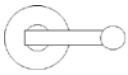
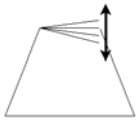
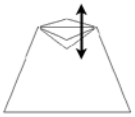
9. Adjust IOT input cavity and input matcher tuning controls for a reasonably low and wide return loss at center of channel. Tighten input matcher set screws to fix tuning (where applicable).
10. Connect RF sample from forward coupler on IOT output stack to input of spectrum analyzer.
11. Adjust the inter-cavity and output coupling controls to mid-range or 45 degrees.

NOTE: IOTs produced by Thales Electron Devices do not have an inter-cavity coupling adjustment. The degree of inter-cavity coupling on Thales IOTs is preset to an optimal value by the inherent output cavity design. Users of Thales IOTs should disregard all references to inter-cavity coupling adjustments.

12. Turn primary cavity tuning control five turns in counter-clockwise direction.
13. Turn secondary cavity tuning control five turns in clockwise direction.
14. Turn primary cavity tuning control clockwise until a sharp resonance peak is stationed at center of desired channel bandwidth.
15. Turn secondary cavity tuning control counter-clockwise until primary cavity resonance peak softens and symmetrical humped (or dimpled) response develops in center of desired channel bandwidth.
16. Adjust primary cavity, secondary cavity, inter-cavity coupling, and output coupling controls in iterative fashion to achieve desired response. While exact tuning recommendations may change from tube manufacturer to tube manufacturer, a frequency flat to +/- .5db across the desired six MHz channel is generally considered acceptable.



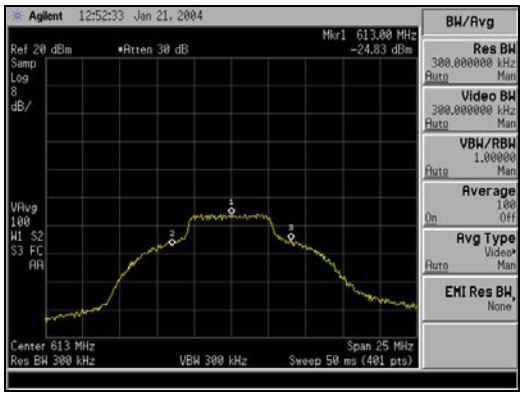
The reference table below describes the action of the various IOT tuning controls

CONTROL	ROLE		EXPLANATION
PRIMARY CAVITY	**CENTER**		Primary cavity tuning adjusts center position of entire "mound" of resonant response. Focus on lower slopes of resonant response, and center mound relative to channel markers at band edges.
INTERCAVITY COUPLING	**WIDTH**		Intercavity coupling adjusts bandwidth of entire resonant response. Focus on distance between two humps at channel edge relative to frequency markers and/or distance between lower slopes of resonant response (width of entire mound). Start with tube manufacturer's recommended bandwidth as given in tube manual. Adjust final bandwidth as necessary according to tube linearity and efficiency requirements.
 SECONDARY CAVITY	**TILT**		Secondary cavity tuning adjusts tilt of in-channel resonant response, but does not change center frequency of entire resonant mound. Focus on in-channel response tilt from lower edge to upper edge (ignore saddle or haystack). Re-trim response primary cavity or intercavity coupling as necessary afterwards.
OUTPUT COUPLING	**FLATNESS**		Output coupling adjusts depth of saddle or haystack in center of in-band response. Focus on desired depth of saddle while ignoring tilt that inevitably results ("tilt your eyeballs!"). Re-trim secondary cavity afterwards to eliminate tilt. Some tube manufacturers recommend leaving in a slight response saddle. A saddled response of a given total bandwidth requires less output and intercavity coupling, thereby raising efficiency.

NOTE: Contrary to a widely held belief, both the primary and secondary output cavities are tuned to the SAME frequency when the IOT is correctly tuned. The widened bandwidth comes from the over-coupling of the (synchronously tuned) cavities, not from stagger tuning. Do not attempt to visualize the primary cavity as being a hump at one end of the band and the secondary cavity as a hump at the other end. This is incorrect and will result in confusion.

17. Steer HPA output in question away from magic tee reject port and back to antenna via appropriate commands on system controller. If possible, switch off RF output of all other HPAs.
18. Re-adjust secondary cavity and output coupling controls to re-optimize IOT frequency response while connected to antenna.
19. Gently rock all tuning controls to relieve any residual mechanical strain.

20. Disconnect analyzer and restore RF drive connections to original condition.
21. Re-establish RF drive to transmitter by pressing RF mode button on HPA control panel.
22. Increase HPA power to 100%, checking power calibration as necessary with average power meter(s) in RF output system.
23. Connect RF cable to directional coupler on IPA circulator reject port and readjust IOT input match and tuning controls, as necessary, to re-establish good return loss null. Relieve mechanical strain. If signal is NTSC, it will be necessary to apply a pseudo-wideband video signal, such as sinx/x or multiburst, to properly observe location of return loss null.



24. Connect RF sample to forward coupler on IOT output stack and verify that IOT output frequency response has not significantly changed. Trim frequency response with secondary cavity and output coupling controls, as necessary. Relieve mechanical strain.
25. Recheck tuning (previous two steps) after thirty minutes of full power operation.
26. Remove tuning handles (where applicable), tighten set screws on input tuner (where applicable), and return equipment to original condition.
27. Procedure complete.

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