Appendix E

Filter tuning / alignment procedure.

1.0 TECHNICAL NOTE

This technical note describes the assembly and tuning procedures for the 1.03 GHz transponder filter. Before considering these procedures, some general information on the specifications, design and tuning characteristics of the filter are given.

2.0 SPECIFICATIONS

The filter has to meet electromagnetic performance specifications over a range of temperatures and environmental conditions. From a system perspective the key electromagnetic specification is the rejection. Filter parameters such as bandwidth, insertion loss, ripple and return loss are not specifically referenced in the requirements documentation. These have been selected based on the overall system performances and subject to constraints on size, weight and temperature differentials. The filter specifications have been set as follows:

Centre Frequency:	1030 MHz
Bandwidth:	12 MHz
Insertion Loss:	5 dB (maximum)
Return Loss:	12 dB (minimum)
Rejection (± 25 MHz):	60 dB (minimum)

When connected ‘in situ’ the filter is readily accessible from the input side only. This is sufficient to tune the filter but not necessarily to verify all the performance specifications.

3.0 DESIGN APPROACH

The filter is a five section combline design using machined resonators clamped between ground planes. Because of the constraints on size and weight, short resonators have been used with a small ground plane spacing. This reduces the Q of the resonators resulting in relatively high insertion loss. The insertion loss is reduced by silver plating the resonator rods. This also enables the input and output connections to be easily made by standard soldering techniques.

With short resonators (~ $\lambda/8$) capacitive loading at the open circuit end is used to set the resonant frequency. This is done by adjusting the penetration depth of fine tuning screws inside the open end of the resonator. The tuning screws are fitted with a Teflon sleeve. This serves to increase the capacitance, prevents the tuning screw shorting the resonator, acts to damp out any mechanical vibrations and forms part of the temperature compensation.

The filter bandwidth was set relatively narrow (! 12 MHz, 1%) primarily to meet the rejection specification. The bandwidth is controlled by the coupling between the resonators which is not adjustable in this case. Consequently, if the resonators are properly set to the required frequency then the filter bandwidth, return loss and rejection will be as designed with a quite tolerance determined by the mechanical tolerances. The return loss so affected by the neatness of the input/output coupling joints and so it is important to assemble these correctly.

Because of the narrow bandwidth, it is necessary to have good thermal stability. The frequency change due to temperature has been measured at < 15 kHz/°C which is small enough to ensure that the specifications are met with reasonable margin over a temperature range of ± 50° C.

4.0 ASSEMBLY

The filter is assembled in several stages.

The main steps are:

1. Solder ‘wire connectors’ to silver plated fingers.
2. Insert Teflon inserts in end of fingers.
3. Insert fingers in chassis and slide Teflon material in place.
4. Lightly screw tuning screws in place.
5. Place lid over fingers and screw down.
6. Connect input SMA connector and output probe.

The filter is now ready for tuning. Each of these steps is considered in more detail below.

4.1 FINGER ASSEMBLY

The ‘wire connectors’ are actually the .93 mm centre pin of RF142 semi rigid cable. This is used because it is stiff but easily solderable (silver plated steel) and also mates with ‘push on’ SMA connectors.

STEPS

1. Cut the wire to the lengths shown in Figure 1.
2. Insert the wires into the holes in the first and last resonators of the silver plated fingers and solder neatly. Remove all flux.
3. Insert a Teflon ring in each of the five counter bored holes in the resonator finger. (Figure 1).
4. Slide the Teflon sleeve over the input/output probes.

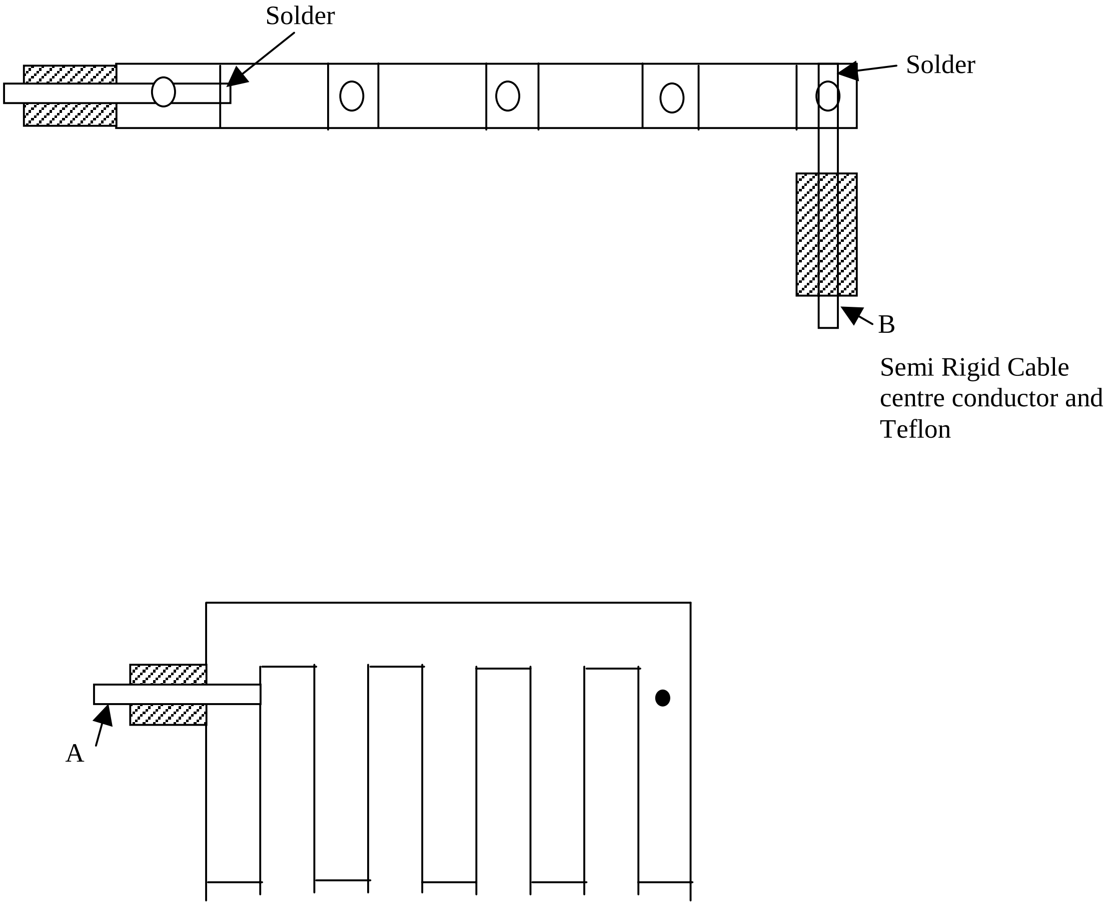
4.2 ‘IN CHASSIS’ ASSEMBLY

This stage describes the insertion of the silver plated resonator fingers into the chassis. Before proceeding, make sure all items are clean and free from oil, grit, flux etc.

STEPS

5. Position the resonator section and slide into place taking care not to bend either of the probes , and ensure both of the Teflon sleeves on the probes are in situ.
6. Screw in each of the resonator tuning screws ensuring that the screws slide neatly through the Teflon inserts.
7. Position the lid over the resonator fingers and screw in place.
8. Slide the SMA (F) push on connector over the input probe. If the filter is to be checked for ‘through loss’ then the coaxial probe should be connected to the output. If it is to be tuned on return loss only, then the filter output can be connected directly to the receiver circuit.

The filter is now ready for tuning/testing.



A: 16 mm   Teflon: 9 mm

B: 22 mm   Teflon: 22 mm

Figure 1:   Dimensions for Input/Output Probes

FILTER TUNING

The filter can be tuned in situ using return loss only. This can be done with either a vector or a scalar analyser but it is important that the frequency of the sweeper be accurate (within ± 500 kHz) so that the filter frequency can be set precisely. With a vector analyser, tuning can be done using the group delay of the reflected signal. The advantage of this technique is it allows the filter coupling parameters to be measured. However, since these are set by the mechanical dimensions and are not adjustable, knowledge of the actual coupling values is not essential. The method is described for return loss (amplitude) tuning.

Step 1

- The resonators should all be thoroughly 'detuned' by inserting the tuning screws the minimum (or maximum) depth.
- The 'reflection test set' is connected to the SMA connector on the filter in. (See Figure 2)
- Now, tune the input (first) resonator until a sharp dip in the return loss is observed at 1.03 GHz (See Plot 1). Inserting the tuning screw reduces the resonant frequency.

  NOTE: If the response is not symmetrical it usually means that the second resonator is not 'detuned' enough. Detune more if necessary.

- Now, tune the second resonator to resonance. The correct response is shown in Plot 2. Some points to note:

  9. The response should be symmetrical about 1.03 GHz. If not slightly adjust Resonator 1 and/or 2 to get the centred symmetrical response.

  10. The minimum return loss should be < 5 dB. Values in excess of this indicate higher loss than acceptable in the first two resonators.

- Then tune the third resonator to resonance again ensuring that the response is symmetrical and centred at 1.03 GHz. (See Plot 3) Note: Some differences in the return loss nulls is acceptable as these nulls are due not only to the filter but to interactions with the test equipment.

  If the first two resonators have been properly set, it should be necessary to fine tune 2 and 3 only to get a symmetrical response.

- Tune resonator four to resonance and again re-adjust resonator 3 if necessary to get the symmetrical, centred response (See Plot 4). The return loss at the centre frequency should be less than 8 dB and the 'bandwidth' of the outside nulls should be about 12 MHz.
- The final (fifth) resonator can be tuned by at least two methods:

Method 1: Return Loss

This method assumes that the input to the detector circuit is reasonably well matched. In this case, the final resonator is tuned to give the best return loss symmetrical and centred about 1.03 GHz.

NOTE: The filter was not designed for good return loss (only ~ 12 dB) but rather for higher rejection loss below about 12 dB over the 12 MHz pass band.

Method 2: Maximum Power

In this method, the detector voltage is monitored as the fifth resonator is tuned and the optimum is when the voltage is a maximum at 1.03 GHz.

The detector voltage can be monitored on a CRO as the RF input is swept and both the shape and loss of the filter optimised. The set up for this is shown in Figure ….

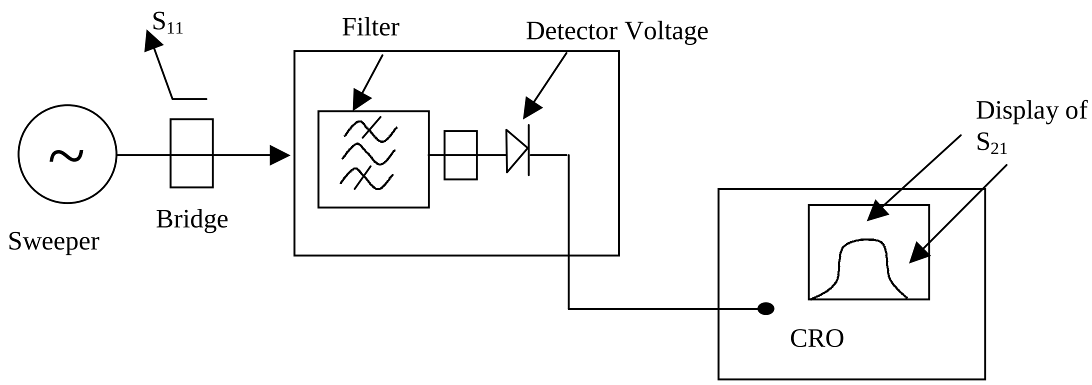


Figure 2: Test Set Up