Application Note

Converting AP60x Ultralam Designs to FR4

This applications note outlines a method to convert our AP60x Ultralam designs to FR4. Currently all WJ AP60x reference designs use Ultralam as the substrate of choice as it provides the highest performance and lower loss. However, FR4 is a perfectly acceptable alternative as many customer applications use this material over Ultralam. An 1800MHz AP602 Ultralam design has been selected to illustrate a possible method to convert to FR4. The FR4 design is compared against the same design implemented in our low loss Ultralam material as detailed in our AP602 datasheets. Both reference designs were implemented to achieve maximum IMD3 performance rather than ACPR as traditionally tested for in our datasheets.

Design Requirements:

Bandwidth: 1805-1880 MHz
Gain: > 11 dB
IMD3: < -60 dBc at 20 dBm/tone
PCB: 21 mil FR4
Note: Minimum PCB space required, so RF choke may be needed.

Summary:

The following key observations were made:

- 15 mil Ultralam is equivalent to 21 mil FR4
- moving AP602 PCB artwork from Ultralam to FR4 requires little to no artwork changes.
- using a ¼ wavelength DC feed line provides for best IMD3 performance while an RF choke will provide for best ACPR performance.

Design Outline:

The same matching network was used for both the Ultralam and FR4 versions of the designs with tuning changes made to maximize IMD3 performance. Figure 1 illustrates the matching network topology used. Using a shunt-series cap (C9 & C6 in Figure 1) network on the input ensures stability of the design.

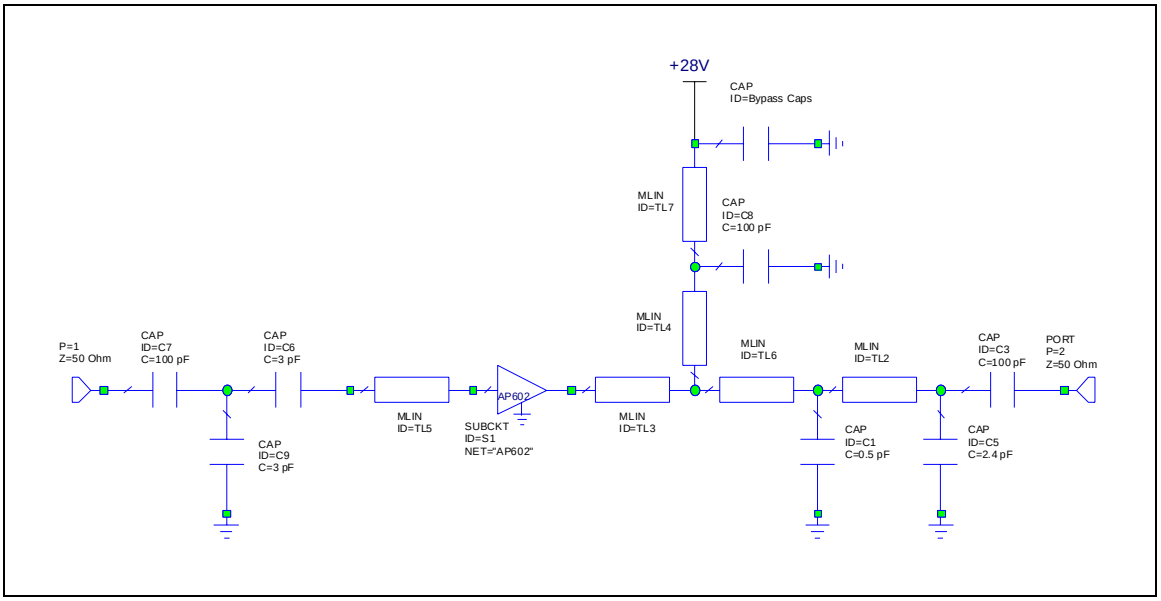

Figure 1: AP602 1800 MHz matching circuit topology

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The design steps used to implement this design in FR4 were as follows:

1. Use AWR simulator to determine initial matching networks for required bandwidth on our traditional Ultralam material.
2. Build circuit on our Ultralam applications board and then tune for IMD3 performance.
3. Re-simulate design using FR4 substrate.
4. Layout and build circuit in FR4 material and then tune for IMD3 performance.
5. Replace ¼ wave bias line with RFC on FR4 PCB and then tune for IMD3 performance.

Design Results:

IMD3 and gain performance for the 3 AP602 1800MHz design variants is illustrated in figures 2 and 3. Photos of the final module assemblies are shown in figures 4,5 and 6. In each case, while the circuit topology for each module is the same a small amount of re-tuning was required to improve IMD3 performance. In the case of the RF choke design; while you reduce the total area of the design on the PCB, IMD3 performance is greatly reduced.

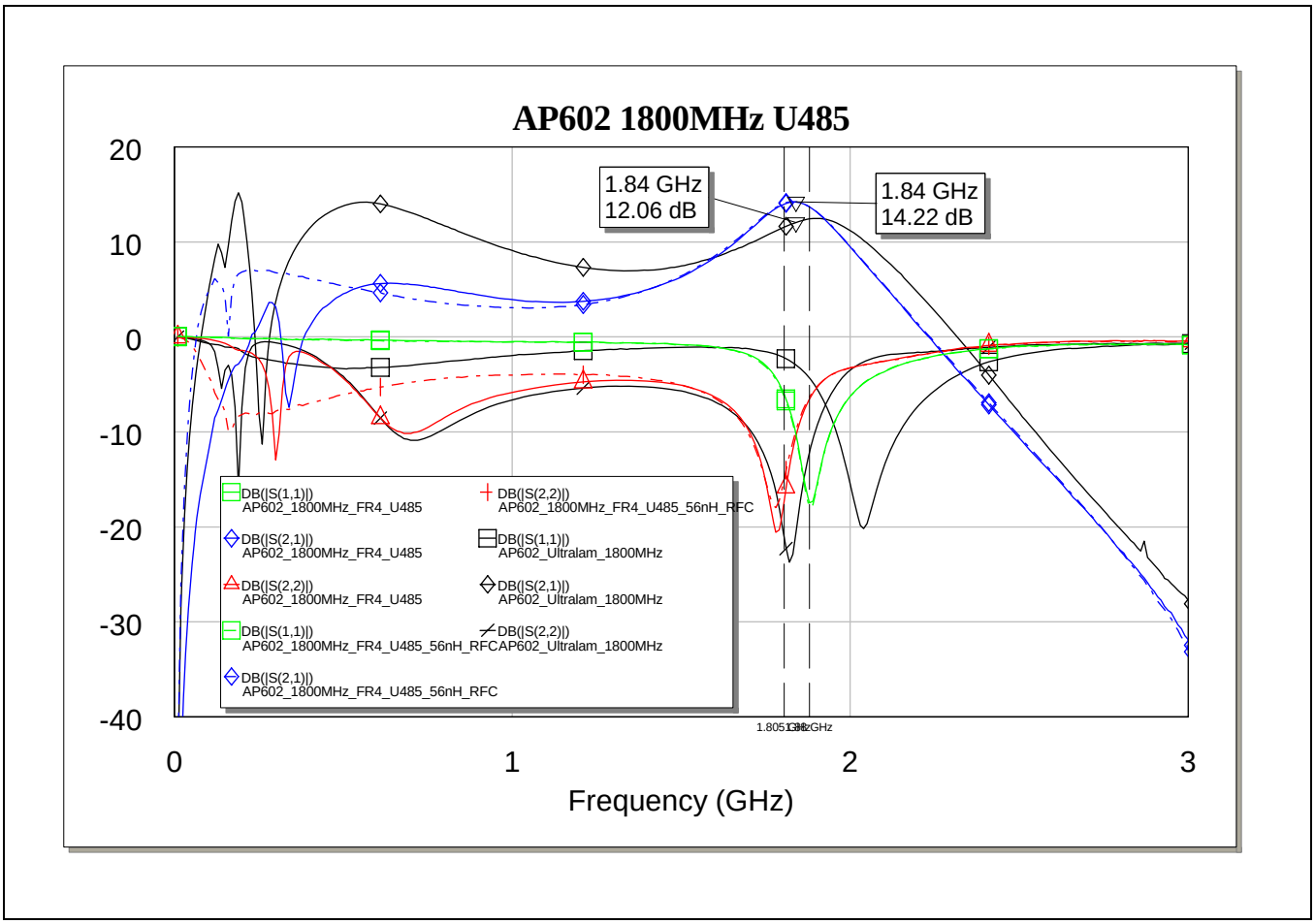

Figure 2: S-Parameters for AP602 on FR4, Ultralam and FR4 with RF Choke.

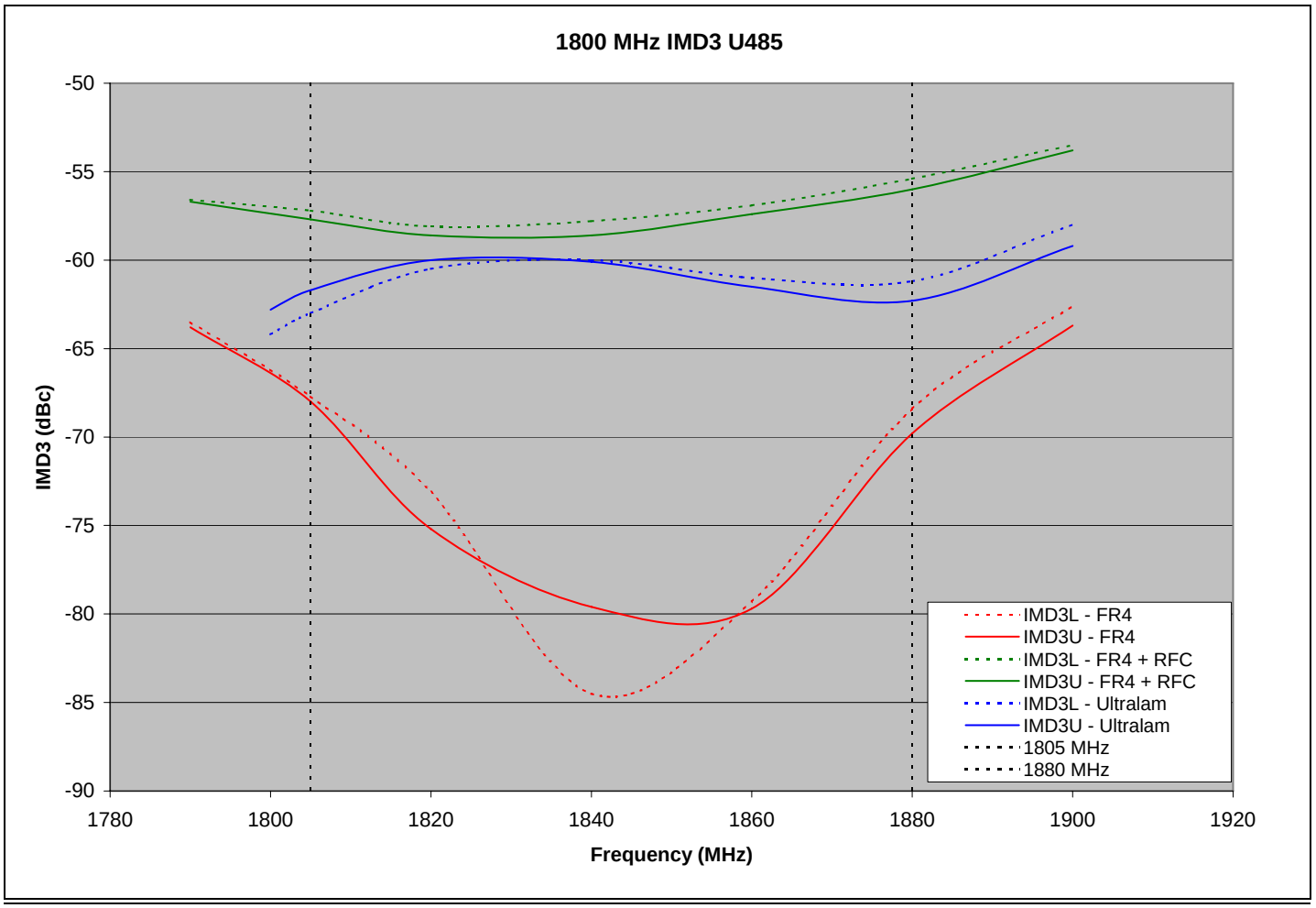

Figure 3: IMD3 for AP602 on FR4, Ultralam and FR4 with RF Choke.

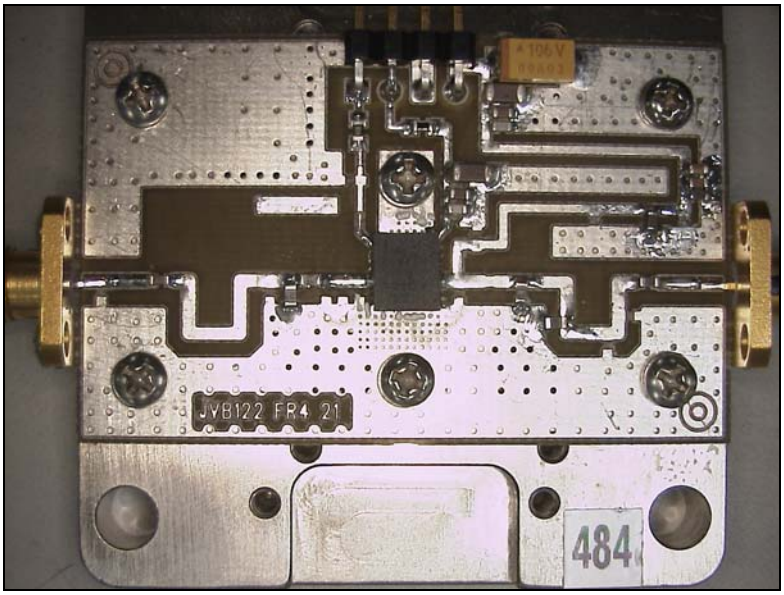

Figure 4: AP602 1800MHz design on FR4.

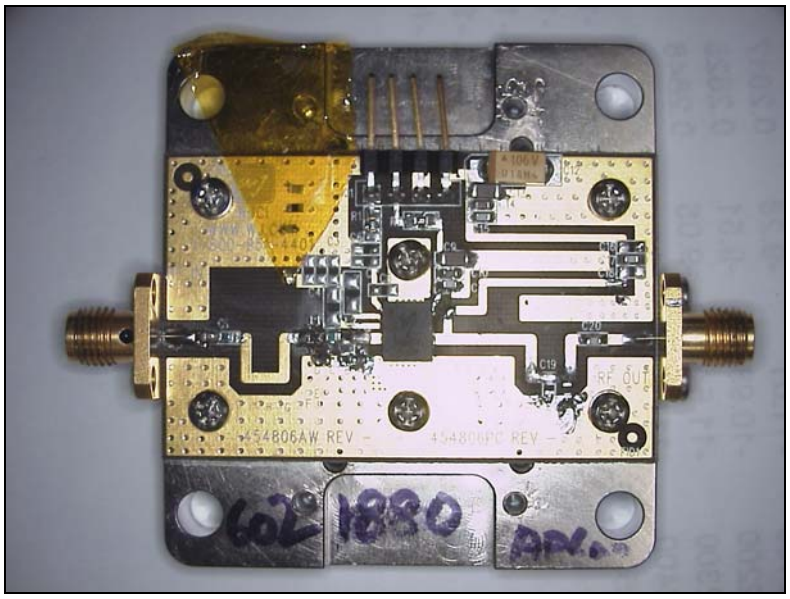

Figure 5: AP602 1800MHz design on Ultralam.

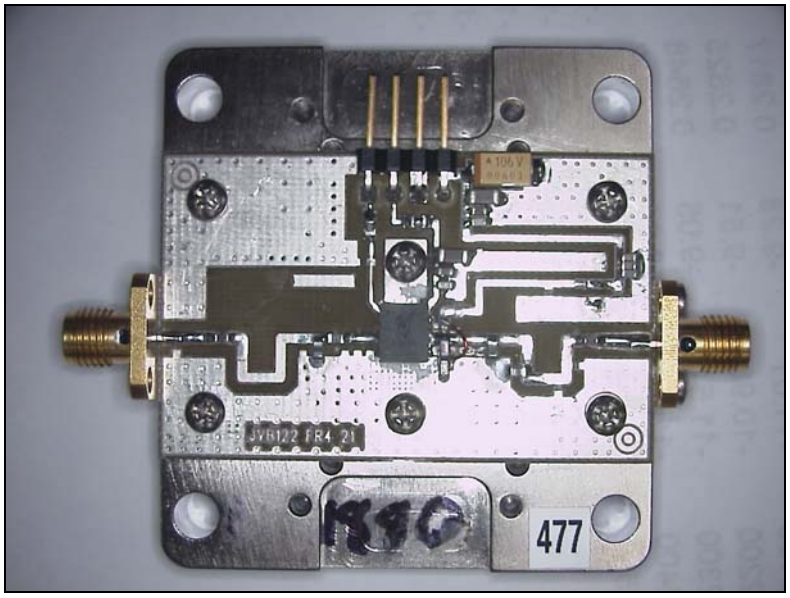

Figure 6: AP602 1800MHz design on FR4 with RF choke.