Application Note
CMX993: Simplified RF Output Match

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1 Introduction

This document contains a series of test results compiled from an evaluation of the CMX993 where simplified alternatives to the recommended 4:1 balun transformer were investigated. See Figure 1 for connection details taken from the EV9930 Evaluation Kit. The use of a balun is the recommended choice as it offers the optimum performance. However the following modifications may be preferred due to lower BOM cost and smaller PCB land requirements.

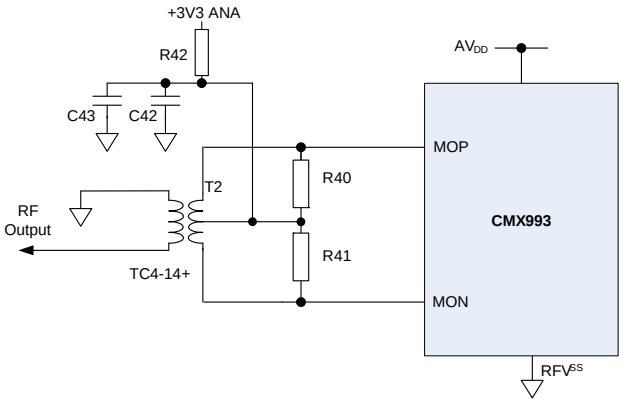

Figure 1 - 4:1 balun attached to CMX993 MON and MOP pins

The following document demonstrates acceptable CMX993 performance at a reduced output level as expected. Two configurations were found to be most practical, one using a single inductor (Figure 4) the other using two inductors (Figure 9) with the second option showing improved performance.

The main compromise of these arrangements is reduced carrier suppression due to the reduced output level. The two-inductor solution (Figure 9) demonstrated better image rejection.

Although these measurements are conducted at 450MHz, a similar solution could be applied to other operating frequencies. Because the L-C circuit is tuned, operation will not be as broadband as with a transformer but acceptable performance should be achieved over 10's of MHz.

These results are also applicable to the CMX998's Up-converter section.

2 History

Version	Changes	Date
1.0	New Issue	08-05-09

3 Operation with default configuration (Using defined balun)

Initial measurements were made of the performance at 450MHz to act as a datum and baseline for results in the following sections. These tests were initially performed on an unmodified EV9930 Evaluation Kit, where a TC4-14M+ balun is connected to the MOP and MON pins.

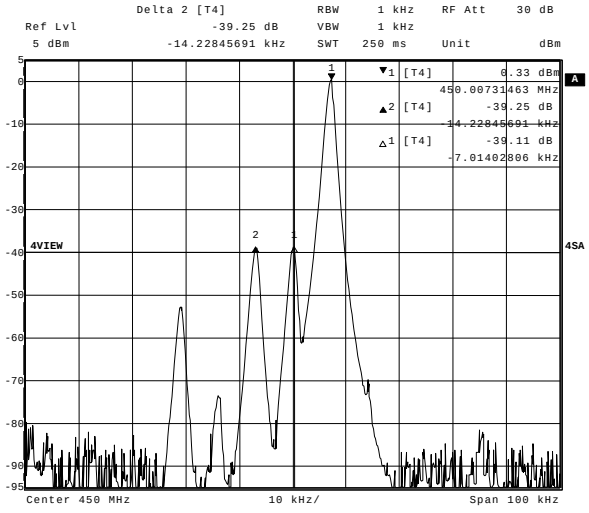

Figure 2 – Initial performance, 7kHz, 250mV amplitude tone, 450MHz

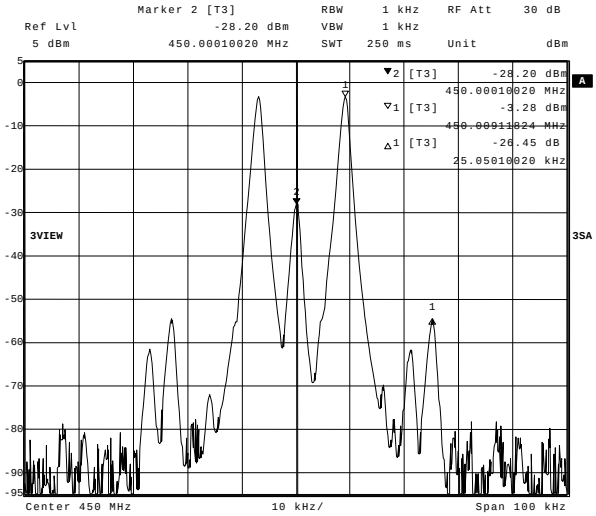

Figure 3 - Initial performance, 7kHz, & 9kHz 175mV amplitude tones, 450MHz

4 Operation with non-differential LC match

4.1 MOP to VCC

The first test configuration evaluated that avoids the use of a balun, is shown in Figure 4 below. All component references are from the EV9930. All other components are as the EV9930 default design. Test results are shown in the following figures.

In this mode current drawn was 103mA (same as the default configuration).

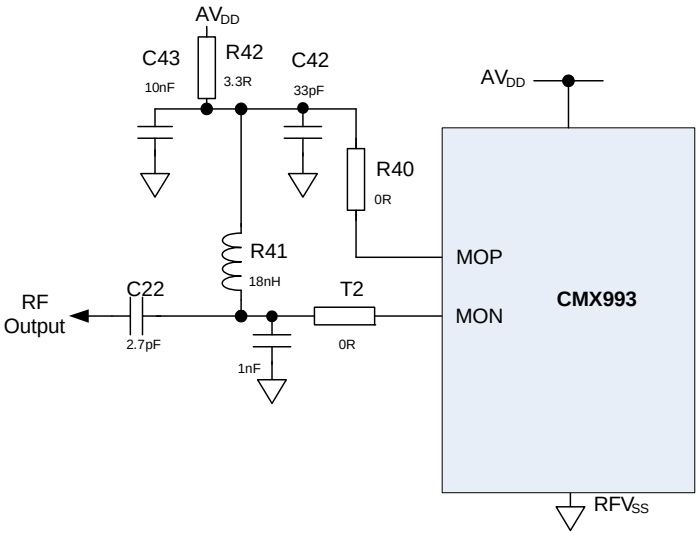

Figure 4 - Modified output configuration

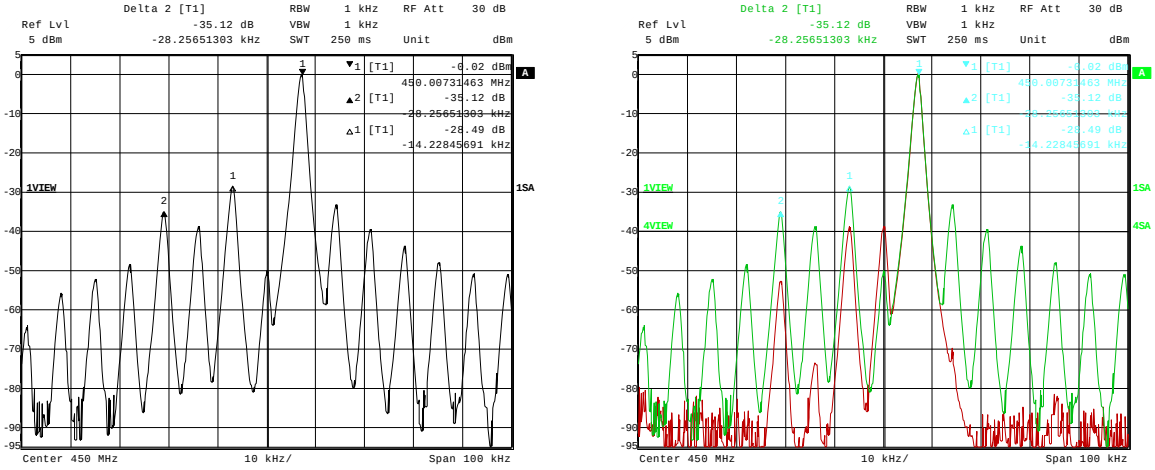

Figure 5 - 7kHz, 250mV amplitude tone, 450MHz

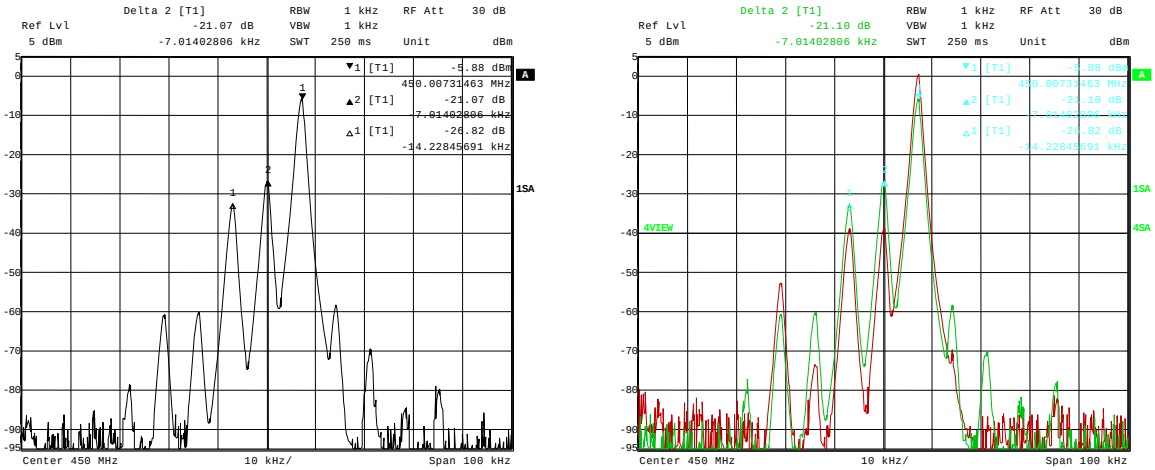

Figure 6 - 7kHz, 175mV amplitude tone, 450MHz

The CMX993 is useable in this configuration; the output level has to be backed off by about 6dB to get a reasonable spectrum. Note that with the same input level on I/Q the spurious products are excessive (Figure 5) but with input level halved (Figure 6) operation is satisfactory. Some degradation is observed in carrier leakage and phase / amplitude balance leading to slightly degraded image rejection. The carrier leakage can be nulled with suitable application of a small dc bias on I and Q (note: it is expected that this will vary from device to device).

The following corrections were applied to obtain Figure 7

- Phase imbalance = 3 deg
- Amplitude imbalance = 0.6dB
- DC offsets: -14mV and –9mV

A two-tone plot is shown in Figure 8.

It was observed that with a 1nF decoupling capacitor to ground on the transformer (T2) pin for MOP, the I/Q balance was slightly improved (Phase imbalance = 2 deg, amplitude imbalance = 0.6dB).

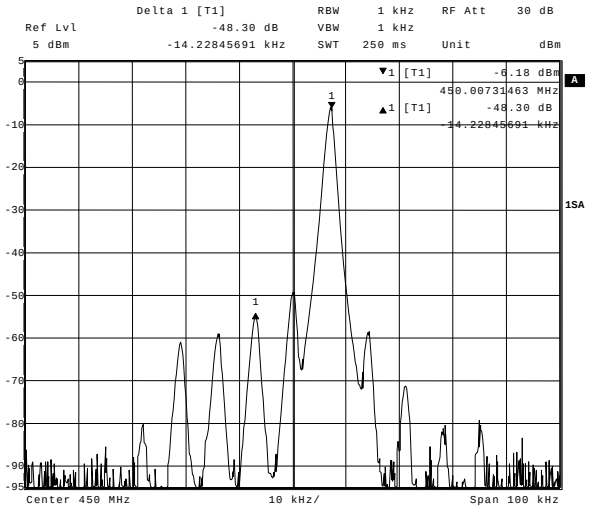

Figure 7 - Operation with corrected I/Q and DC Offsets

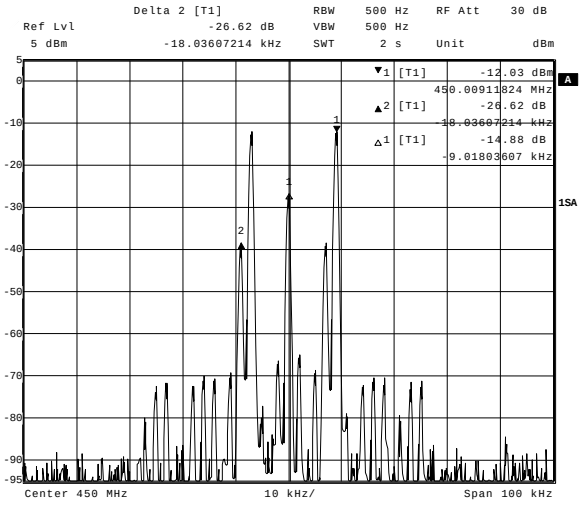

Figure 8 - 7kHz and 9kHz tones, 87.5mV amplitude

4.2 MOP to VCC via Inductor

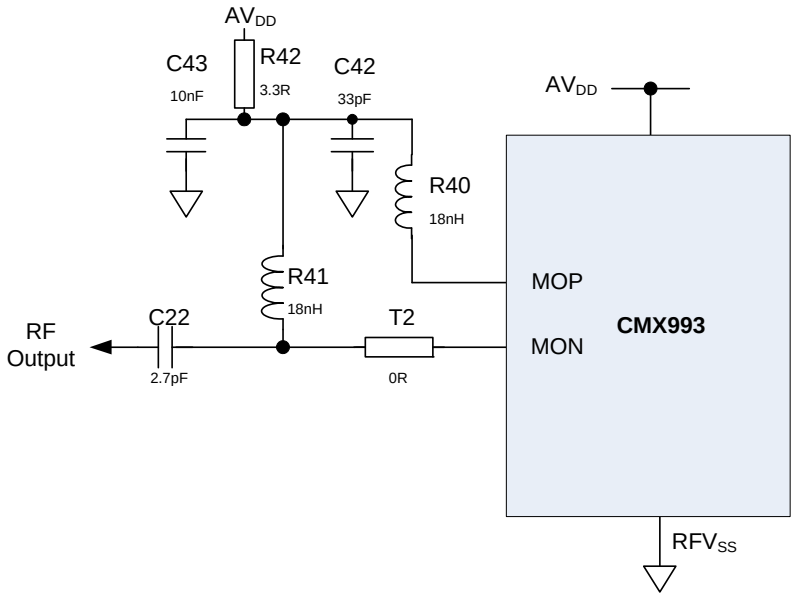

Figure 9 – Matching using a second inductor

Using an inductor to MOP pin (Figure 9) improves the I/Q phase amplitude balance as can be seen in Figure 10.

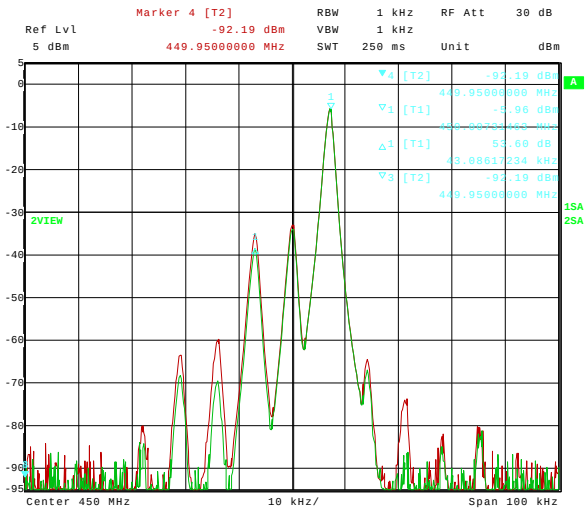

Figure 10 - 7kHz, 175mV amplitude tone, Green: with inductor to MOP; Red: as Figure

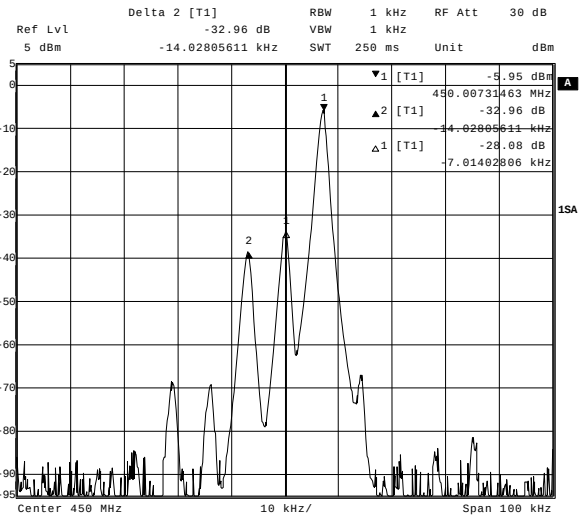

Figure 11 - 7kHz, 175mV amplitude tone with inductor to MOP

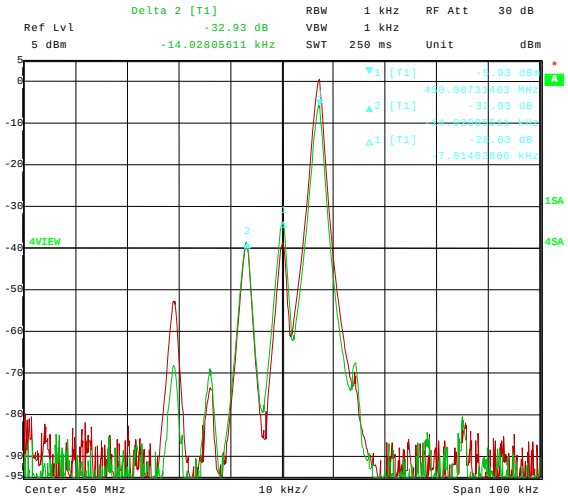

Figure 22 - 7kHz, 175mV amplitude tone, Green: with inductor to MOP; Red: as Figure 2

The performance improvement is more obvious by comparing the two-tone test in Figure 13 with the previous results in Figure 8.

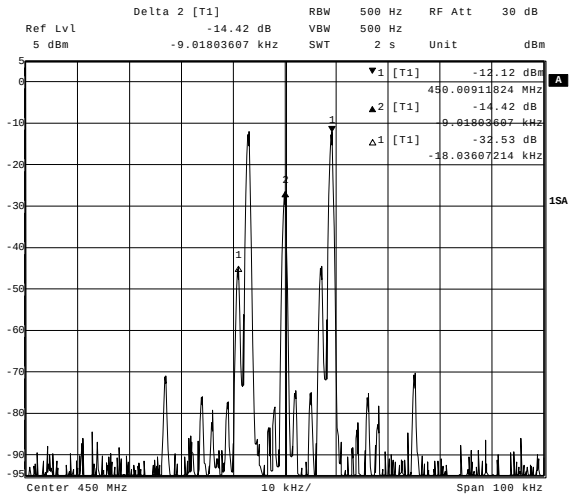

Figure 13 - 7kHz and 9kHz tones, 87.5mV amplitude with inductor to MOP

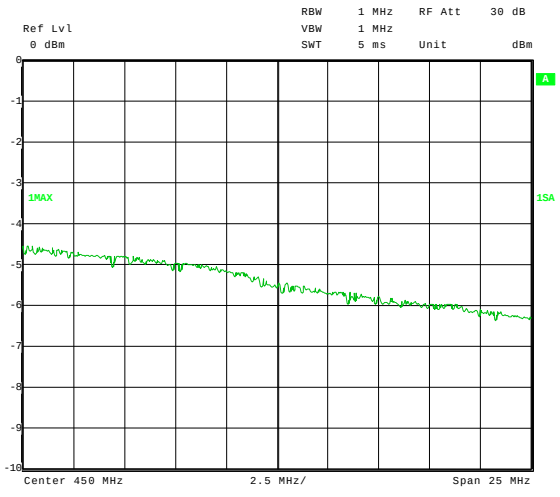

Figure 14 – Output level variation

4.3 MOP to Open Circuit

With MOP open circuit or de-coupled to ground the output level drops significantly and spurious are unacceptably poor. The current is still 104mA. Operation in this configuration is not recommended.

4.4 Improved Matching Circuit

With the series capacitor changed to 1.8pF the match to 50 ohms is improved (before and after plots are shown in Figure 15) and the resulting spectrum, shown in Figure 16. It will be seen that the output level increased but the rise in spurious products is also significant. Although the input level can be backed-off there appears little advantage in the 'improved' circuit and the 2p7 matching seems a good compromise.

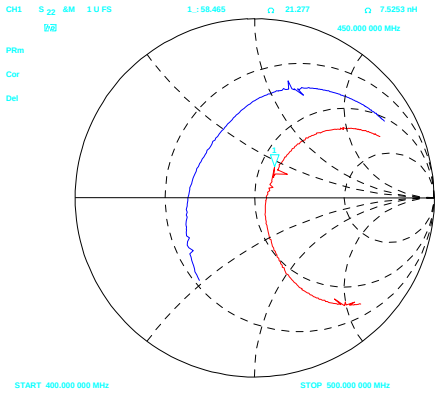

Figure 15 - Output impedance with 1p8 (red) or 2p7 (blue) series matching capacitor.

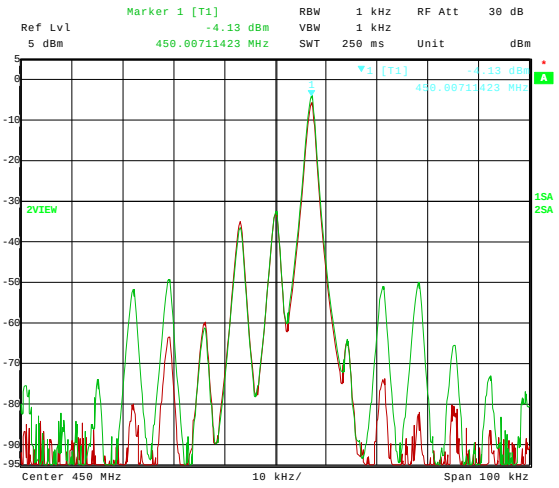

Figure 16 - 7kHz, 175mV amplitude tone, Green: with 1.8pF matching; Red: as earlier tests

CML Microcircuits (UK) Ltd COMMUNICATION SEMICONDUCTORS	CML Microcircuits (USA) Inc. COMMUNICATION SEMICONDUCTORS	CML Microcircuits (Singapore) Pte Ltd COMMUNICATION SEMICONDUCTORS
Tel: +44 (0)1621 875500 **Fax:** +44 (0)1621 875600 **Sales:** sales@cmlmicro.com **Tech Support:** techsupport@cmlmicro.com	**Tel:** +1 336 744 5050 800 638 5577 **Fax:** +1 336 744 5054 **Sales:** us.sales@cmlmicro.com **Tech Support:** us.techsupport@cmlmicro.com	**Tel:** +65 67450426 **Fax:** +65 67452917 **Sales:** sg.sales@cmlmicro.com **Tech Support:** sg.techsupport@cmlmicro.com
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