

# LMS8001 Companion Board – A Highly Configurable 4-Channel Frequency Shifter Platform Utilising the LMS8001A RFIC

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*Abstract* – This paper presents the LMS8001-Companion board, which is a highly configurable 4-channel frequency shifter platform utilising the LMS8001A integrated circuit.

*Keywords* – Frequency shifter, RFIC, LMS8001, MIMO, 5G.

## I. INTRODUCTION

The LMS8001-Companion board provides a highly integrated, highly configurable, four-channel frequency shifter platform, utilising the LMS8001A integrated circuit. One of the typical applications is extending Lime Micro transceiver family RF frequency range up to 10 GHz.

Massive MIMO (Multiple Input Multiple Output) technology, which is supported by the latest 3GPP specifications for LTE, will be supported in 5G from the first deployments. Generally, massive MIMO provides both coverage and capacity gains at sub-6GHz frequency and coverage gains at mmWave frequencies for 5G [1].

Highly integrated 4-channel frequency shifter RF IC [2], featured on the presented board, enables compact massive MIMO solutions at any sub-6GHz band, and is paving the way for the above-6GHz applications.

## II. LMS8001-Companion Board

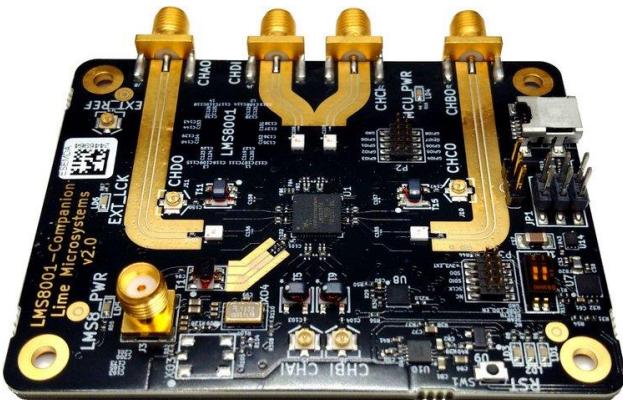


Fig. 1. LMS8001-Companion Board

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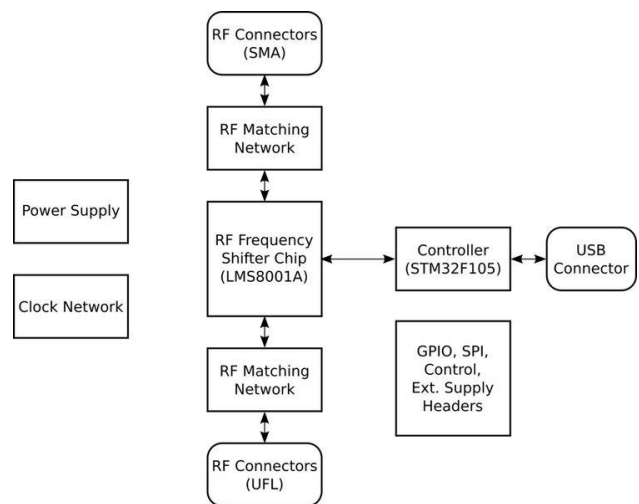


Fig. 2. LMS8001-Companion Block Diagram

LMS8001-Companion board is provided as an open-source hardware, and is available through the Myriad-RF community [3].

Board information, setup and installation instructions, control software basics, as well as basic measurement results are provided in the documentation provided.

### A. LMS8001A Integrated Circuit

Core functionality of the LMS8001-Companion board is provided by the featured LMS8001A integrated circuit [4].

LMS8001A Features:

- Single chip up/down RF frequency shifter with continuous coverage up to 10 GHz RF output range
- Four independent highly reconfigurable RF paths all driven by the same LO
- Fully differential signals
- Few external components
- Low voltage operation, 1.2 and 1.8V. Integrated LDOs to run on a single 1.8 V supply
- 56-pin QFN package
- Serial Port Interface
- Power down control available via ENABLE pins and/or equivalent SPI registers
- Synchronous loading of pre-set operation profiles by

GPIO pins. More options are also available using corresponding SPI registers

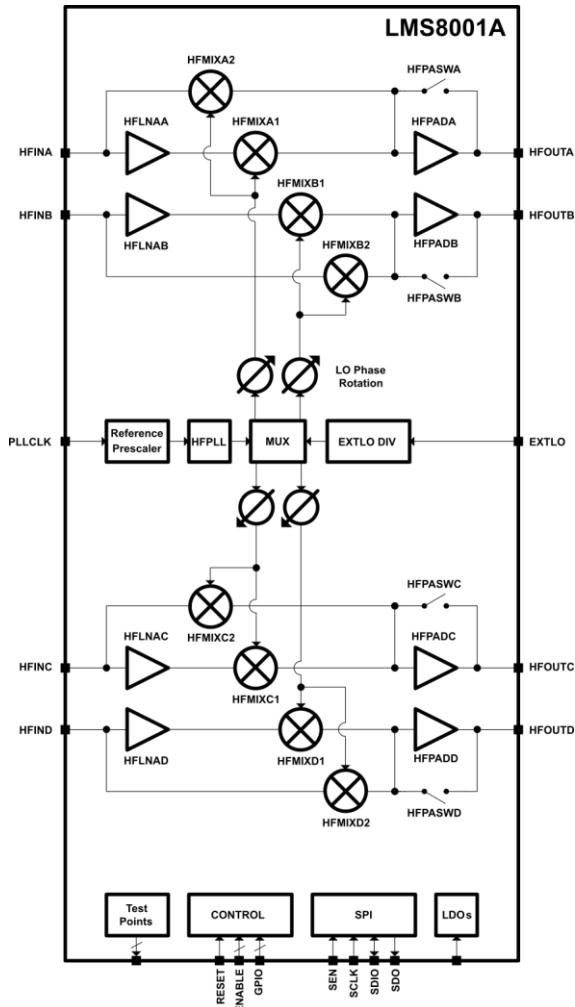


Fig. 3. Structure of LMS8001A up/down RF frequency shifter

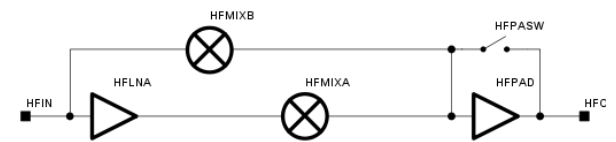


Fig. 4. Channel block diagram

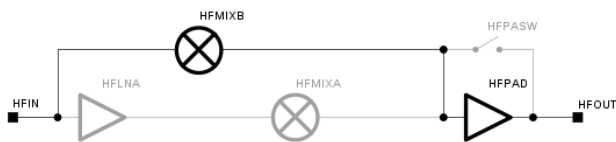


Fig. 5. Example of up-conversion channel configuration

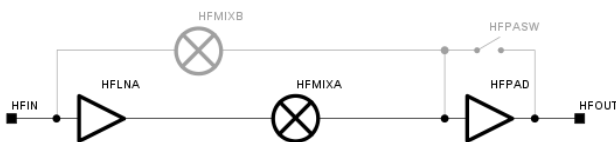


Fig. 6. Example of down-conversion channel configuration

### B. Board Features

Connections:

- 4 x SMA connectors - RF
- 4 x UFL connectors – RF
- 1 x SMA connector – External LO
- 1 x UFL connector – External clock reference

RF Matching:

- Channel A Input (UFL) – 1–3 GHz broadband
- Channel B Input (UFL) – 1–3 GHz broadband
- Channel C Input (SMA) – 10 GHz band
- Channel D Input (SMA) – 5 GHz band
- Channel A Output (SMA) – 10 GHz band
- Channel B Output (SMA) – 5 GHz band
- Channel C Output (UFL) – 1–3 GHz broadband
- Channel D Output (UFL) – 1–3 GHz broadband

USB Interface:

- USB - mini B (STM32 controller STM32F105RBT6)

Clock System:

- 40MHz on board VCTCXO
- Possibility to lock VCTCXO to external clock

Board Size:

- 60mm x 100mm (2.36'' x 3.94'')

### C. Control Software

Utilities for use with hardware based upon LMS8001 RFICs from Lime Microsystems are provided as open-source software [5].

LMS8Suite software provides full control of the LMS8001A integrated circuit.

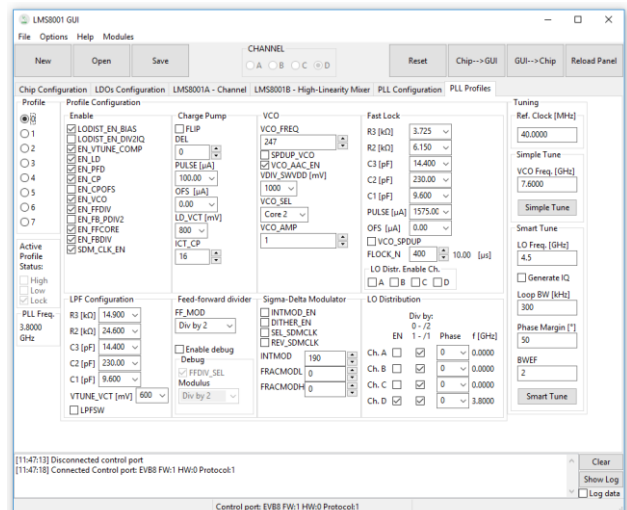


Fig. 7. LMS8Suite Control Software – PLL Profiles Tab

D. LMS8001 PLL-Sim

Lime-Micro LMS8001 PLL-Sim software is intended to provide the user deeper insight into the operation of PLL frequency synthesizer inside the LMS8001 frequency conversion IC. There are many ways to configure LMS8001 PLL Core. In order to somewhat facilitate getting optimal configuration of PLL core for targeted input parameters such as VCO (or LO) frequency, loop crossover frequency, phase margin etc, many functions are implemented to automate the whole optimization process.

This software is also available as the open-source [6].

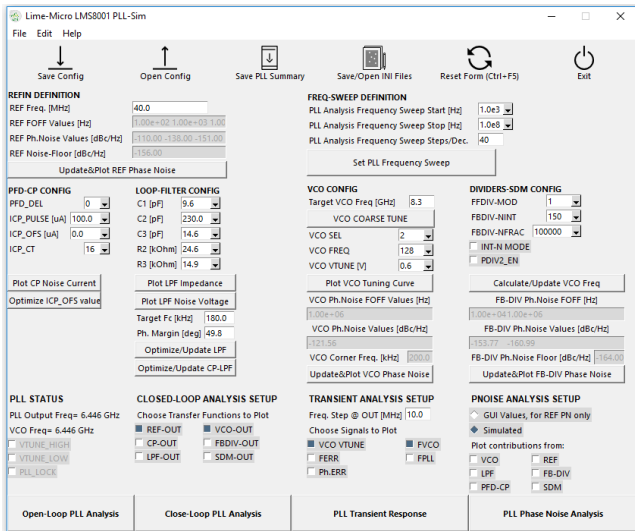


Fig. 8. LMS8001 PLL-Sim – Main Window

III. MEASUREMENT RESULT EXAMPLE

In the following the measurement results of the channel D configured for downconversion (Fig. 6) are presented. The input frequency was swept between 5 and 6 GHz, and output frequency was set to 1.2 GHz, unless otherwise stated.

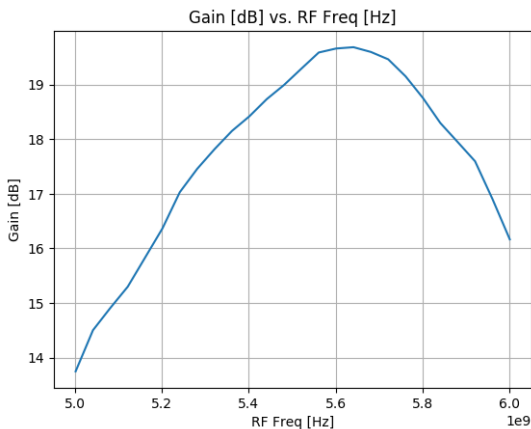


Fig. 9. Conversion Gain

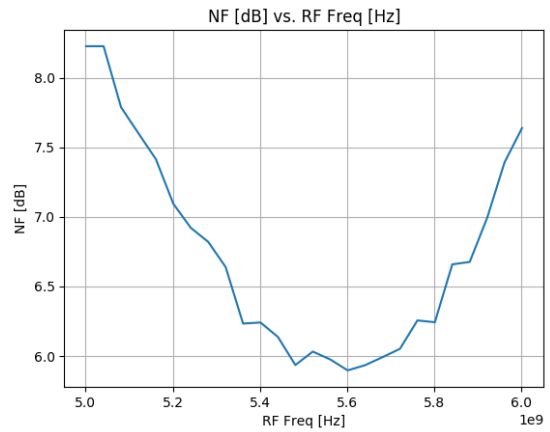


Fig. 10. Noise Figure

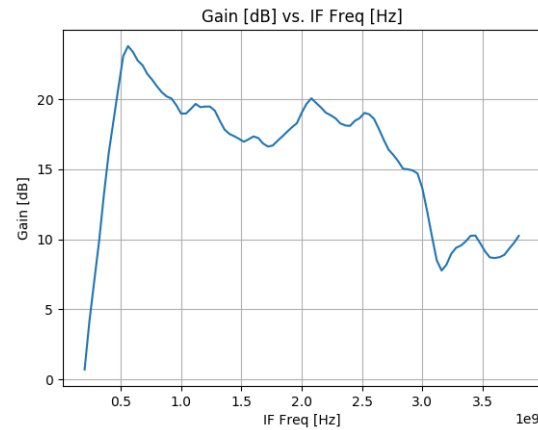


Fig. 11. Gain vs. IF Frequency, RF Frequency = 5.5 GHz

IV. CONCLUSION

This paper presented the LMS8001-Companion board, which is a highly configurable 4-channel frequency shifter platform utilising the LMS8001A integrated circuit from Lime Microsystems.

REFERENCES

- [1] Nokia, "Beamforming for 4.9G/5G Networks – Exploiting Massive MIMO and Active Antenna Technologies", White Paper, Available at: [https://onestore.nokia.com/asset/201377/Nokia\\_5G\\_Beamforming\\_mMIMO\\_White\\_Paper\\_EN.pdf](https://onestore.nokia.com/asset/201377/Nokia_5G_Beamforming_mMIMO_White_Paper_EN.pdf)
- [2] Litovski, V., Zvolinski, M., "VLSI Circuit Simulation and Optimization", Chapman and Hall, London, 1997.
- [3] Lime Microsystems, "LMS8001-Companion", available at: <https://github.com/myriardr/LMS8001-Companion>
- [4] Lime Microsystems, "LMS8001 Documentation", available at: <https://github.com/myriardr/LMS8001-docs>
- [5] Lime Microsystems, "LMS8Suite", available at: <https://github.com/myriardr/LMS8Suite>
- [6] Lime Microsystems, "LMS8001 PLL-Sim", available at: <https://github.com/myriardr/LMS8001-PLL-Sim>