

TD1316 Application Charge Pump Settings for Optimal Phase Noise Performance

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Abstract

This report aims to characterize the phase noise performance of the TD1316 that uses the new TDA6650/1 MOPLL IC. This IC, though regarded as best in its class for DVB-T has its own share of problems and limitations as we have discovered from numerous feedback from our designers as well as from the customers.

Ultimately, after weighing its phase noise performance and all other known weaknesses in the tuner and the IC, this report will recommend certain application solutions to which maximizes its performance in the field.

Introduction

The TD1316 is a full band tuner utilizing the new TDA6650/1 IC from Philips Semiconductors. The real main feature of this product is the MOPLL itself where it has been specially tailored to suit DVB-T application where phase-noise is critical factor.

The MOPLL is highly configurable in terms of charge pump settings (8 current settings ranging from 600uA to 40uA) and divider ratio sizes. When designed properly with an external loop filter, ideally the tuner utilizing this IC can achieve phase noise performance of up to -90dBC and above, which is basically unheard of from the last generation of MOPLL or PLL ICs.

The Issue

The TD1316 has a channel-locking problem where the user cannot lock into a high-end channel from a low-end channel within the same band. This occurs with the usage of the recommended charge pump settings from Philips Semiconductors as shown below.

| LO1 | LO2 | Ch Freq | Ch Freq | Band | Charge Pump |
|-----|-----|---------|---------|------|-------------|
| 80 | 136 | 44 | 100 | LOW | 90 |
| 136 | 160 | 100 | 124 | LOW | 130 |
| 160 | 164 | 124 | 128 | LOW | 190 |
| 164 | 176 | 128 | 140 | LOW | 280 |
| 176 | 184 | 140 | 148 | LOW | 410 |
| 184 | 196 | 148 | 160 | LOW | 600 |
| 196 | 284 | 160 | 248 | MID | 90 |
| 284 | 324 | 248 | 288 | MID | 130 |
| 324 | 364 | 288 | 328 | MID | 190 |
| 364 | 408 | 328 | 372 | MID | 280 |
| 408 | 444 | 372 | 408 | MID | 410 |
| 444 | 484 | 408 | 448 | MID | 600 |
| 484 | 500 | 448 | 464 | HIGH | 90 |
| 500 | 524 | 464 | 488 | HIGH | 130 |
| 524 | 560 | 488 | 524 | HIGH | 190 |
| 560 | 712 | 524 | 676 | HIGH | 280 |
| 712 | 868 | 676 | 832 | HIGH | 410 |
| 868 | 904 | 832 | 868 | HIGH | 600 |

As there is a phase noise requirement that we need to fulfill, the aim of this report will be to find the optimal settings for charge pump current that avoids the above problem, while providing the best possible phase noise performance.

The next section will deal with an exhaustive set of measurement data and how the optimal settings can be achieved just by analyzing it.

Phase Noise Measurement and Analysis

Specification states -86dBc at 1kHz and 10kHz. Yellow filled cells denotes area that passes this requirement. Refer to Appendix A for the detailed plots.

| 1kHz | 40uA | 60uA | 90uA | 130uA | 190uA | 280uA | 410uA | 600uA |
|---------------|-------------|-------------|-------------|--------------|--------------|--------------|--------------|--------------|
| 480MHz | -75.9 | -78.1 | -81.7 | -85.2 | -87.3 | -88 | -89.4 | OUT |
| 600MHz | -73 | -74.2 | -77.6 | -81.2 | -84.8 | -86 | -87.3 | -88.2 |
| 700MHz | -53 | -74.5 | -78 | -80.5 | -82.5 | -84 | -86.2 | -87 |
| 850MHz | -64.2 | -66.1 | -71.7 | -73.9 | -76.3 | -78.2 | -82.4 | -84.3 |
| 180MHz | -81 | -86.5 | -89 | -86.6 | -84.7 | -83.3 | OUT | OUT |
| 300MHz | -78.6 | -82.5 | -86 | -88 | -90.8 | -92.6 | -92 | OUT |
| 420MHz | -72.5 | -75 | -78.5 | -82.4 | -83.8 | -87 | -90.4 | -91.5 |
| 10kHz | | | | | | | | |
| 480MHz | -81.4 | -84.2 | -85.5 | -87.6 | -91.8 | -92.8 | -95.5 | OUT |
| 600MHz | -81.5 | -84 | -85.4 | -86.6 | -88.8 | -91.3 | -93 | -96 |
| 700MHz | -82.6 | -82.9 | -83.5 | -85 | -86.8 | -88 | -91.8 | -94.3 |
| 850MHz | -85 | -85 | -85.1 | -84.5 | -84.8 | -84.9 | -86.2 | -87.9 |
| 180MHz | -87.8 | -90.9 | -94 | -97.8 | -100 | -102 | OUT | OUT |
| 300MHz | -85.5 | -86.7 | -89.8 | -93.3 | -95.9 | -97.9 | -99.8 | OUT |
| 420MHz | -87.2 | -87.5 | -88.1 | -88.8 | -89.5 | -91 | -94.1 | -98 |

For UHF in particular, care has to be taken so that the best combination of charge pump setting are chosen to ensure that the performance meets or exceed the specifications. There is however, a catch in the design of the TD1316. When the recommended settings of the MOPLL is used (it calls for 600uA for 800MHz and above and 130uA for 500MHz and below), the tuner cannot tune from 480MHz to 800MHz directly. This is due to the massive difference in the charge pump current causing a lock-out situation in the PLL which is irrecoverable.

To counter this, an alternate set of settings were recommended in place of the one recommended by Philips Semiconductors, that is to have the entire original recommended settings down by 2 charge pump settings. This simply means that what was previously using 600uA will use now 280uA and what was previously 130uA will now use 60uA.

Compare those settings and the phase noise measurements above and you will find that there is an issue; almost all the phase noise readings do not adhere to the specification.

Recommendation/Conclusion

With this, we have come up with a better setting table for this particular MOPLL for optimal field performance as below.

| LO1 | LO2 | Ch Freq | Ch Freq | Band | Original CP | New CP |
|------------|------------|----------------|----------------|-------------|--------------------|---------------|
| 80 | 136 | 44 | 100 | LOW | 90 | 280 |
| 136 | 160 | 100 | 124 | LOW | 130 | 280 |
| 160 | 164 | 124 | 128 | LOW | 190 | 280 |
| 164 | 176 | 128 | 140 | LOW | 280 | 410 |
| 176 | 184 | 140 | 148 | LOW | 410 | 410 |
| 184 | 196 | 148 | 160 | LOW | 600 | 600 |
| 196 | 284 | 160 | 248 | MID | 90 | 280 |
| 284 | 324 | 248 | 288 | MID | 130 | 280 |
| 324 | 364 | 288 | 328 | MID | 190 | 280 |
| 364 | 408 | 328 | 372 | MID | 280 | 410 |
| 408 | 444 | 372 | 408 | MID | 410 | 410 |
| 444 | 484 | 408 | 448 | MID | 600 | 600 |
| 484 | 500 | 448 | 464 | HIGH | 90 | 280 |
| 500 | 524 | 464 | 488 | HIGH | 130 | 280 |
| 524 | 560 | 488 | 524 | HIGH | 190 | 280 |
| 560 | 712 | 524 | 676 | HIGH | 280 | 410 |
| 712 | 868 | 676 | 832 | HIGH | 410 | 410 |
| 868 | 904 | 832 | 868 | HIGH | 600 | 600 |

Appendix A

Phase noise plots

