Multi-Tone Performance of the HI5741

Introduction

The HI5741 is a 14-bit 100MHz Digital to Analog Converter. This current out DAC is designed for low glitch and high Spurious Free Dynamic Range operation. As a result of its inherently high dynamic range, the HI5741 allows base station designers to carry a higher degree of dynamic range through the converter. This in turn lowers system cost by reducing board space, power and filtering requirements.

Definition

Originally defined as a figure of merit for applications such as ADSL (Asymmetric Digital Subscriber Line), where groups of tones are input to the device with defined "dead zones" (or separations between groups), an MTPR (or Multi-tone Power Ratio) specification provides system designers with an average level of dynamic range from peak power to peak distortion in the zones void of tones.

Though this definition for MTPR is useful and quite appropriate for ADSL applications, base station requirements are quite different and as a result, require an alternate interpretation of the original definition. As a result, the scope of the MTPR Specification was modified to encompass only one "dead zone", and in turn provide a true dynamic range specification to base station manufacturers.
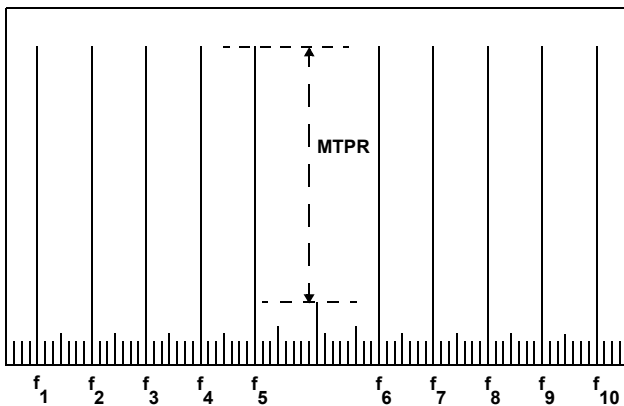

FIGURE 1. DEFINING MTPR

As seen in Figure 1, a series of equally spaced tones is input to the DAC with one tone removed in the center of the range. The worst case converter generated distortion, which is generally a third order harmonic product of the fundamental frequencies ($2f1-f2$ or $2f2-f1$), will appear as the worst case spur at the frequency of the missing tone in the sequence. The resultant dynamic range from peak power to peak distortion in the region of the removed tone is defined as MTPR.

Advantages

Traditionally, Digital to Analog Converter (DAC) spectral specifications have centered around single tone outputs and the corresponding degrees of distortion generated by the DAC itself. Specifications such as Signal to Noise Ratio (SNR), Signal to Noise + Distortion (SINAD), Total Harmonic Distortion (THD) and Spurious Free Dynamic Range (SFDR), all provide system level designers valuable information with respect to the spectral properties of the DAC being evaluated, however the task of determining how the converter responded to multi-tone conditions was still left to the designer. The specification of DAC performance under multi-tone output conditions therefore provides system designers with a key piece of data necessary to determine the applicability of a given converter in their design.

From a system standpoint, the ability to maintain high degrees of dynamic range under multi-tone conditions simplifies the overall design. Traditionally, base-station designs utilized one converter per transmit channel which meant having multiple DACs per board. The ability of the HI5741 to maintain high degrees of dynamic range under a 10 tone condition therefore equates to reduced board space, design complexity and most importantly, cost.

Measuring MTPR

MTPR testing of the HI5741 was performed using the evaluation circuits shown in Figures 2 and 3. In measuring the MTPR performance of the HI5741, a series of 10 tone patterns were created and input to the converter. To truly determine the performance of the converter across frequency, tone spacing was maintained at 200kHz for all frequencies tested, with clock frequencies ranging from 10MHz to 75MHz. These conditions were also repeated for clock to output frequency ratios ($f_{OUT} = f_{CLK}/n$) of 10, 5 and 4. Once the desired frequencies were obtained and observed on the spectrum analyzer, the Multi-tone power ratio of the device was measured as the dynamic range from peak power to peak distortion in the gap between tones 5 and 6. Figures 4 through 6 graphically illustrate the level of performance that can be expected from the HI5741 under the conditions described above. Also included are spectral plots under the three clock to output frequency ratios described above at a clock rate of 22.4MHz.

As can be seen in Figures 4 through 6, the HI5741 exhibits high degrees of dynamic range (>70dBc) under all three clock to output frequency conditions at clock frequencies up to 30MHz. Once past a clock frequency of 30MHz, the full scale settling time of the device begins to dominate the performance of the HI5741, resulting in steadily declining levels of MTPR.

Conclusion

The inclusion of dynamic range specifications for Digital to Analog converters under multi-tone conditions can provide base station designers with key information with respect to the anticipated performance of a given converter in their system. For cellular applications, high degrees of dynamic range under multi-tone conditions can reduce system cost by allowing greater throughput (by passing more information through each converter) from each individual DAC, thus reducing board space, power consumption, filtering requirements, and overall system cost.
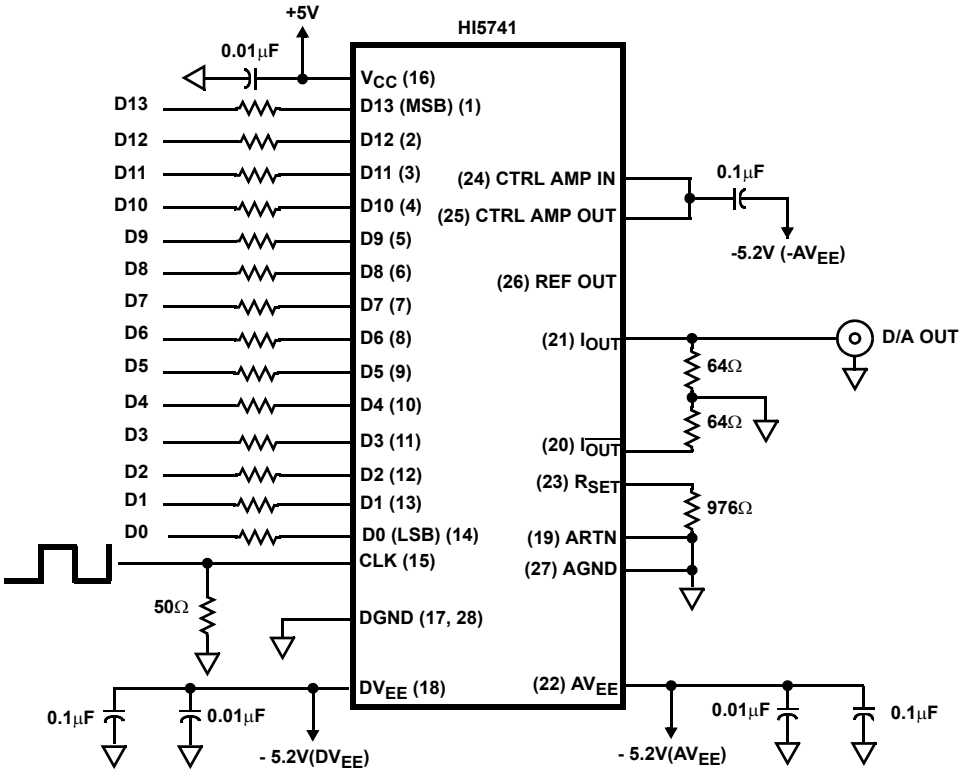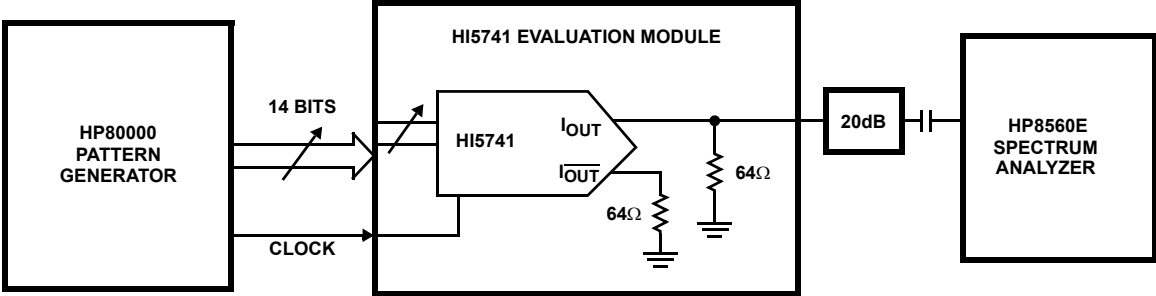

FIGURE 2. HI5741 MTPR EVALUATION CIRCUIT

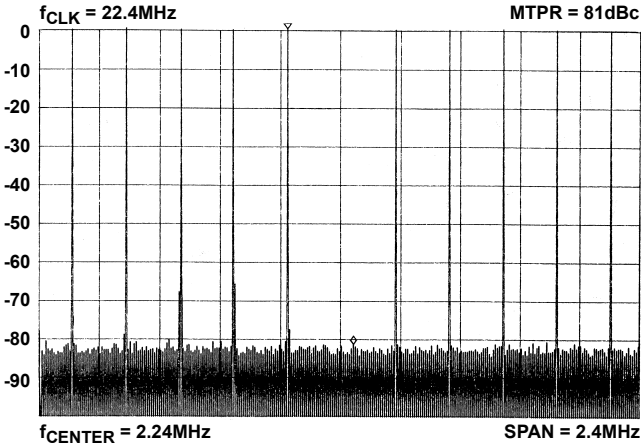FIGURE 3. LAB SETUP FOR HI5741 EVALUATION

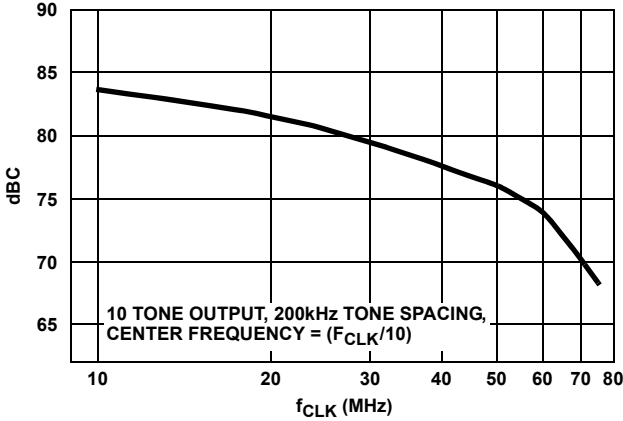RENESAS

FIGURE 4A.

FIGURE 4B. HI5741 MTPR PERFORMANCE vs CLOCK FREQUENCY

FIGURE 4. HI5741 MTPR PERFORMANCE WITH f_{OUT} = (f_{CLK}/10)

FIGURE 5A.
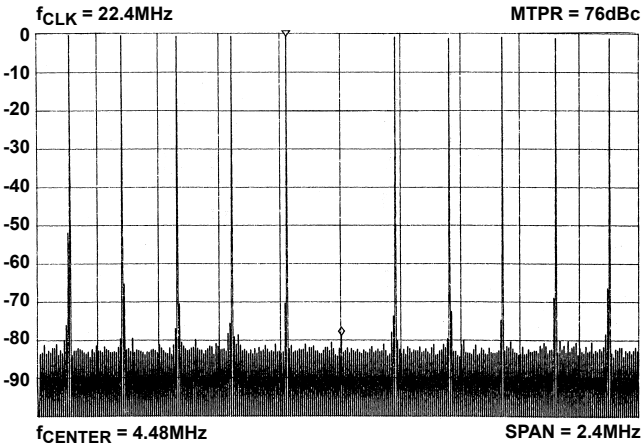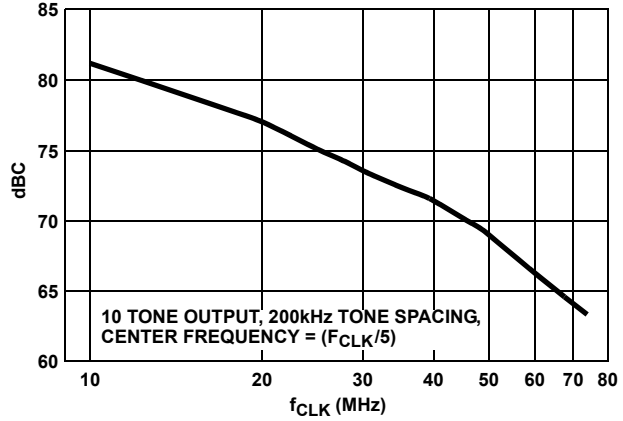
FIGURE 5B. HI5741 MTPR PERFORMANCE vs CLOCK FREQUENCY

FIGURE 5. HI5741 MTPR PERFORMANCE WITH f_{OUT} = (f_{CLKT}/5)

FIGURE 6A.
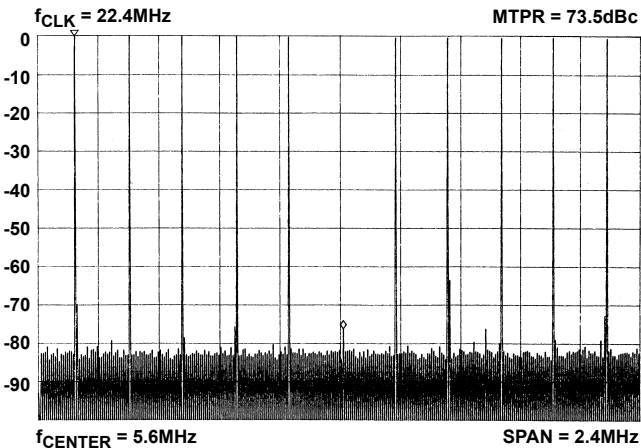
FIGURE 6B. HI5741 MTPR PERFORMANCE vs CLOCK FREQUENCY

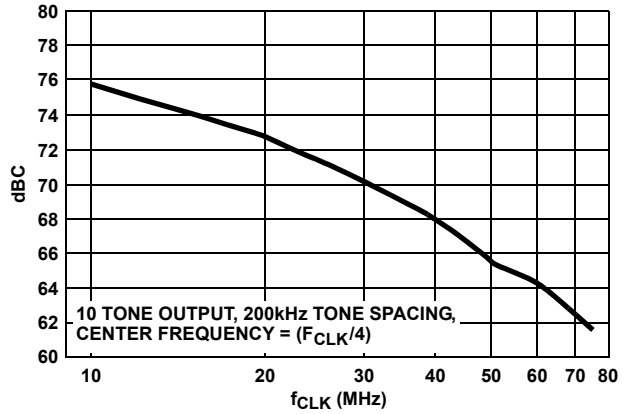**FIGURE 6. HI5741 MTPR PERFORMANCE WITH f_{OUT} = (f_{CLK}/4)**

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