Multi-Tone Performance of the HI5741

AN9629
Rev 0.00
Jul 1996

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.

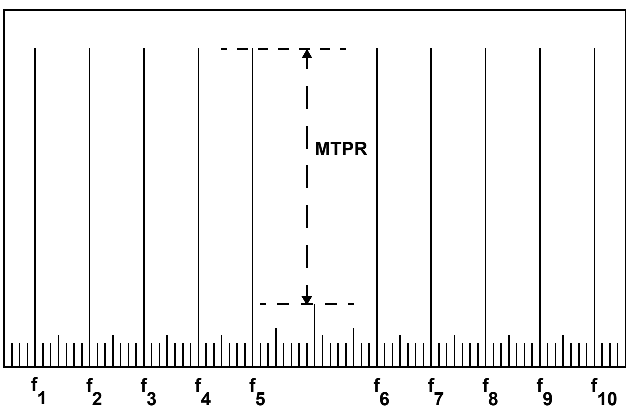

FIGURE 1. DEFINING MTPR

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.

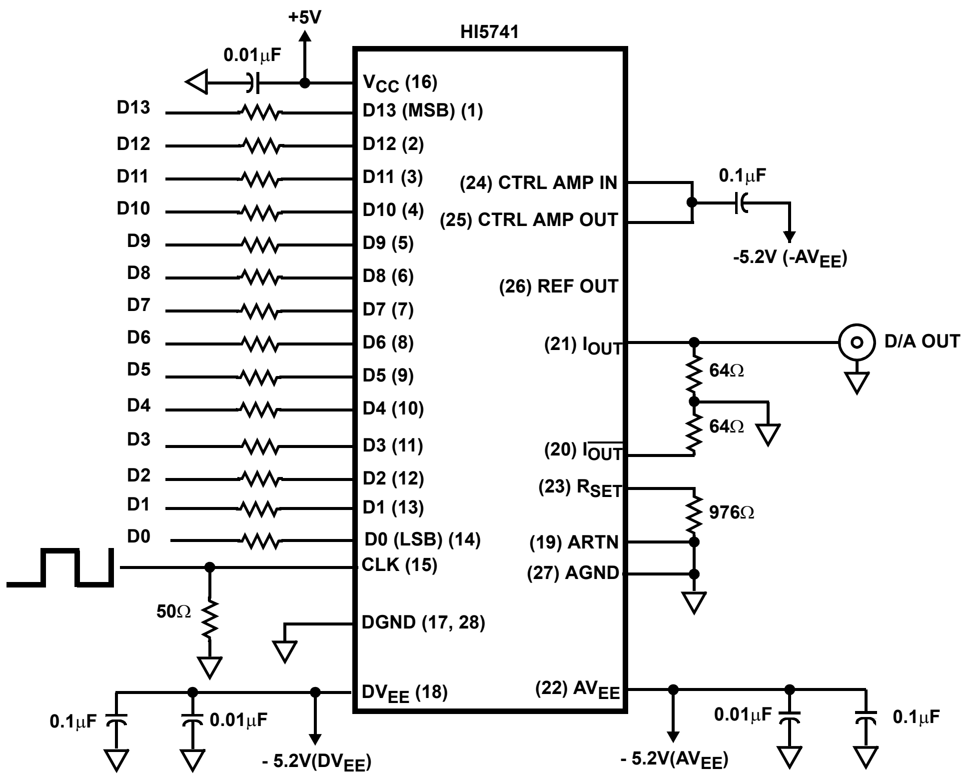

FIGURE 2. HI5741 MTPR EVALUATION CIRCUIT

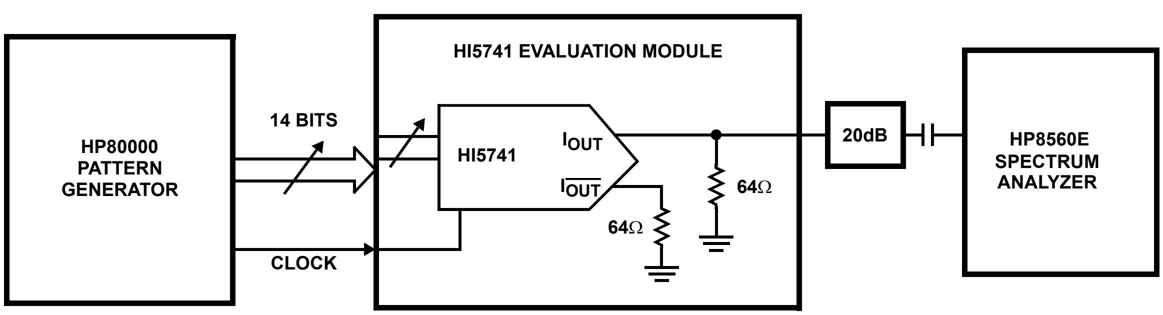

FIGURE 3. LAB SETUP FOR HI5741 EVALUATION

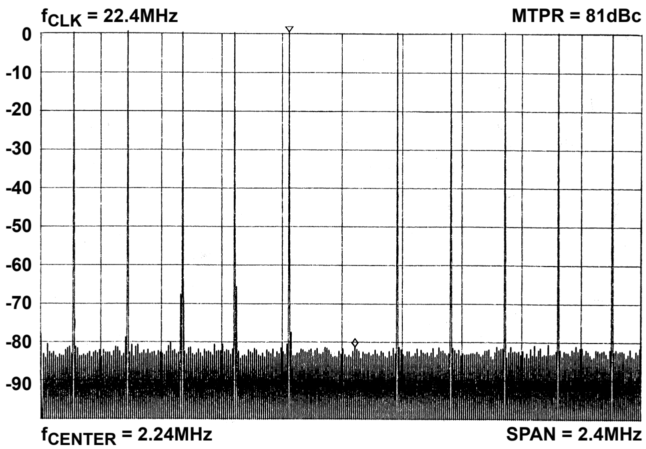

FIGURE 4A.

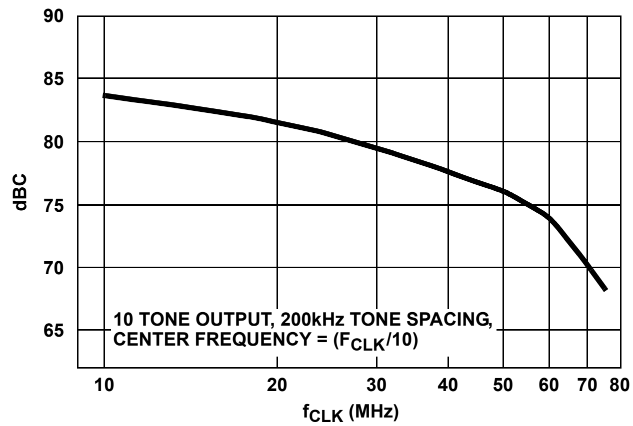

FIGURE 4B. HI5741 MTPR PERFORMANCE vs CLOCK FREQUENCY

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

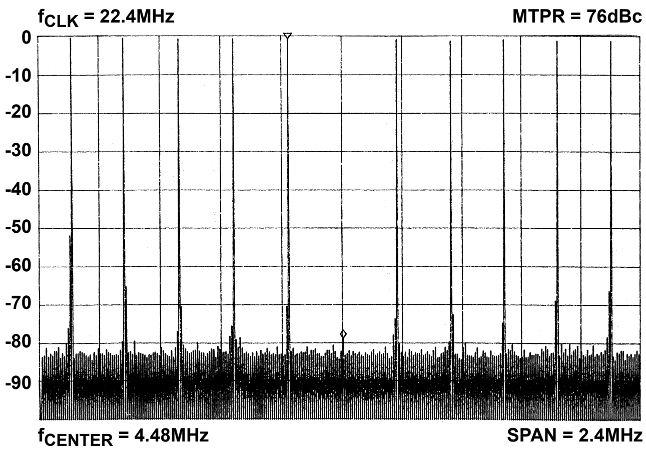

FIGURE 5A.

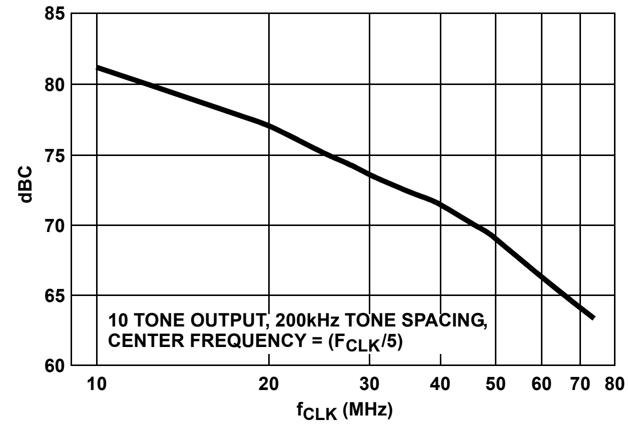

FIGURE 5B. HI5741 MTPR PERFORMANCE vs CLOCK FREQUENCY

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

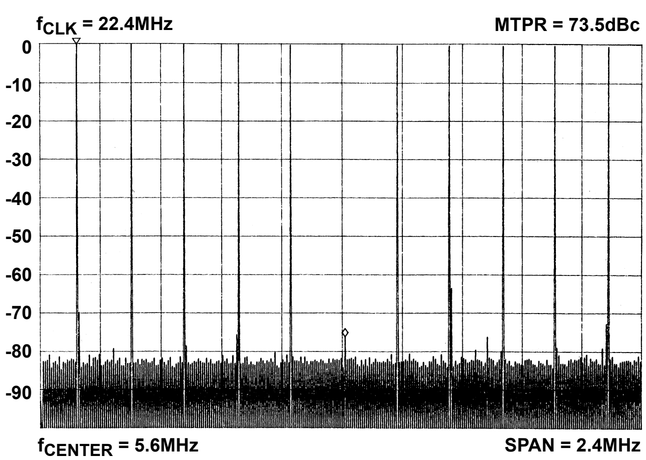

FIGURE 6A.

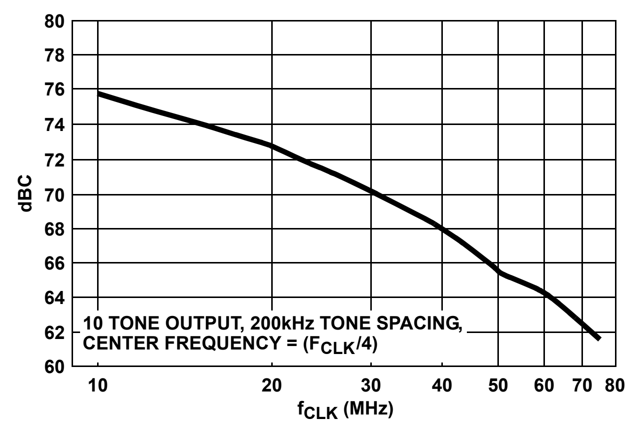

FIGURE 6B. HI5741 MTPR PERFORMANCE vs CLOCK FREQUENCY

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

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
5. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.
   "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.
   "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.
   Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.
6. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
7. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
9. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
10. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
11. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.

(Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.4.0-1 November 2017)

RENESAS

SALES OFFICES Renesas Electronics Corporation http://www.renesas.com

Refer to "http://www.renesas.com/" for the latest and detailed information.

Renesas Electronics America Inc.
1001 Murphy Ranch Road, Milpitas, CA 95035, U.S.A.
Tel: +1-408-432-8888, Fax: +1-408-434-5351

Renesas Electronics Canada Limited
9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3
Tel: +1-905-237-2004

Renesas Electronics Europe Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-651-700, Fax: +44-1628-651-804

Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.
Room 1709 Quantum Plaza, No.27 ZhichunLu, Haidian District, Beijing, 100191 P. R. China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, 200333 P. R. China
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

Renesas Electronics Hong Kong Limited
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2265-6688, Fax: +852 2886-9022

Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

Renesas Electronics Singapore Pte. Ltd.
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

Renesas Electronics Malaysia Sdn.Bhd.
Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

Renesas Electronics India Pvt. Ltd.
No.777C, 100 Feet Road, HAL 2nd Stage, Indiranagar, Bangalore 560 038, India
Tel: +91-80-67208700, Fax: +91-80-67208777

Renesas Electronics Korea Co., Ltd.
17F, KAMCO Yangjae Tower, 262, Gangnam-daero, Gangnam-gu, Seoul, 06265 Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5338

Colophon 7.0