

Using the HI7190 with Single +5V Supply

AN9601
Rev 0.00
January 1996

Introduction

The purpose of this application note is to inform the system designer how to use the HI7190 with a single +5V analog supply if a -5V analog supply is not available. An inexpensive low current negative power supply can be generated with the ICL7660S voltage converter. The ICL7660S Voltage Converter is a monolithic CMOS voltage conversion IC. The device performs supply voltage conversion from positive to negative for an input range of 1.5V to 12V, resulting in complementary output voltages of -1.5V to -12V. Only 2 noncritical external capacitors are needed for the charge pump and charge reservoir functions. The conversion chip contains a series DC power supply regulator, RC oscillator, voltage level translator, and four output power MOS switches. For detailed chip information please refer to the ICL7660S datasheet.[1]

Functional Description

The HI7190 single supply circuit is shown in Figure 1. This includes a standard HI7190 application circuit, a ICL7660 voltage converter and two 10μF capacitors. The HI7190 data sheet [2] contains information on the application circuit, therefore, this discussion will focus on the voltage conversion circuit.

ICL7660 Theory of Operation [1]

The ICL7660S contains all the necessary circuitry to complete a negative voltage converter, with the exception of 2 external capacitors which may be inexpensive 10μF polarized electrolytic types. The mode of operation of the

device may be best understood by considering Figure 2, which shows an idealized negative voltage converter. Capacitor C_1 is charged to a voltage, V_+ , for the half cycle when switches S_1 and S_3 are closed. (Note: Switches S_2 and S_4 are open during this half cycle.) During the second half cycle of operation, switches S_2 and S_4 are closed, with S_1 and S_3 open, thereby shifting capacitor C_1 to C_2 such that the voltage on C_2 is exactly V_+ , assuming ideal switches and no load on C_2 . The ICL7660S approaches this ideal situation more closely than existing non-mechanical circuits.

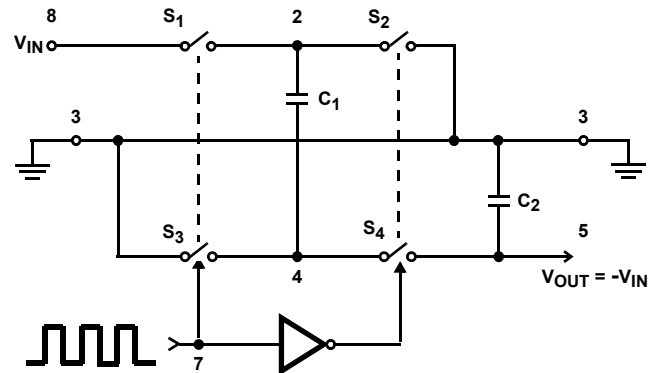


FIGURE 2. IDEALIZED NEGATIVE VOLTAGE CONVERTER

In the ICL7660S, the 4 switches of Figure 2 are MOS power switches; S_1 is a P-Channel devices and S_2 , S_3 and S_4 are N-Channel devices. The main difficulty with this approach is that in integrating the switches, the substrates of S_3 and S_4 must always remain reverse biased with respect to their

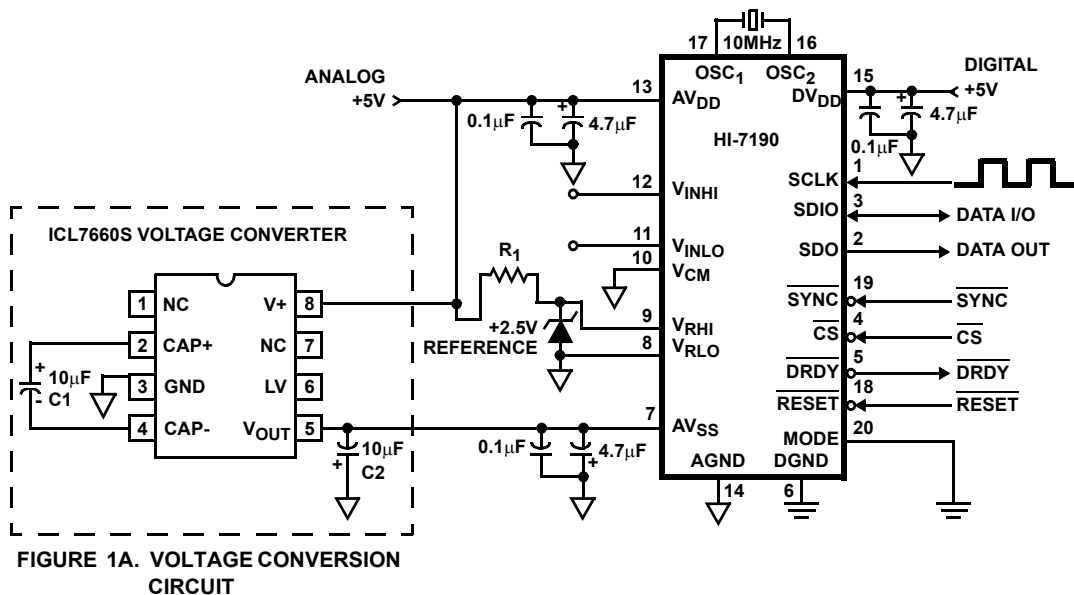


FIGURE 1A. VOLTAGE CONVERSION CIRCUIT

FIGURE 1. SINGLE SUPPLY APPLICATION CIRCUIT

sources, but not so much as to degrade their “ON” resistances. In addition, at circuit start up, and under output short circuit conditions ($V_{OUT} = V+$), the output voltage must be sensed and the substrate bias adjusted accordingly. Failure to accomplish this would result in high power losses and probable device latchup.

This problem is eliminated in the ICL7660S by a logic network which senses the output voltage (V_{OUT}) together with the level translators, and switches the substrates of S_3 and S_4 to the correct level to maintain necessary reverse bias.

The voltage regulator portion of the ICL7660S is an integral part of the anti-latchup circuitry, however its inherent voltage drop can degrade operation at low voltages. Therefore, to improve low voltage operation “LV” pin should be connected to GND, disabling the regulator. For supply voltages greater than 3.5V the LV terminal must be left open to insure latchup proof operation, and prevent device damage.

ICL7660 Application Discussion

The output characteristics of the voltage converter (Figure 1A) can be approximated by an ideal voltage source in series with a resistance as shown in Figure 3. The voltage source has a value of $-(V+)$ with a slight ripple voltage due to the ICL7660S switching between C_1 and C_2 . The output impedance (R_O) is a function of the ON resistance of the internal MOS switches (shown in Figure 2), switching frequency, the value of C_1 and C_2 , and the equivalent series resistance (ESR) of C_1 and C_2 .

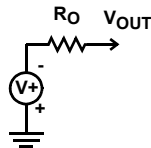


FIGURE 3. ICL7660S EQUIVALENT CIRCUIT

Below is an analysis of this application at 25°C. From the datasheet the MOS switch resistance is typically 23Ω, switching frequency is 10kHz. The capacitors C_1 and C_2 are 10μF, 16V Kemet Solid Tantalum capacitors type number “T350106K016AS” with ESR of 1Ω at 10kHz. The typical supply current into the HI7190 negative supply is 1mA. The low current requirement of the HI7190 is critical since the conversion chip is ONLY designed for low current applications. As defined in the ICL7660S datasheet, the inverted output voltage drops significantly from -5V to -4.25V when 10mA of current is required. If additional current is needed to drive supplementary devices, multiple ICL7660S units can be placed

in parallel [1]. Below are the theoretical calculations for output impedance and ripple voltage.

$$R_O \cong 2 \times R_{SW} + \frac{1}{0.5f_{OSC} \times C_1} + 4 \times ESR_{C1} + ESR_{C2} \Omega$$

$$R_O \cong 2 \times 23 + \frac{1}{(5 \times 10^3 \times 10 \times 10^{-6})} + 4 \times ESR_{C1} + ESR_{C2}$$

$$R_O \cong 46 + 20 + 5 \times 1 \Omega \cong 71 \Omega$$

$$V_{RIPPLE} \cong I_{OUT} \left(\frac{1}{2 \times f_{PUMP} \times C_2} + 2ESRC_2 \right)$$

$$V_{RIPPLE} \cong I_{OUT} \left(\frac{1}{2 \times 10kHz \times 10\mu F} + 2 \right)$$

$$V_{RIPPLE} \cong 7mV$$

Measured Performance

The circuit in figure 1A was added to the evaluation platform to determine performance. The testing consisted of both noise and linearity with the standard -5V supply and a -5V supply derived from the ICL7660S. Noise data was derived from 100 readings while linearity involved single measurements in 0.5 volt increments. Comparison of the performance data showed no degradation of either noise or linearity while using the ICL7660S voltage converter.

References

- [1] ICL7660S Datasheet, File Number 3179, Intersil Corporation, Melbourne, Florida, 1994.
- [2] HI7190 Datasheet, File Number 3612, Intersil Corporation, Melbourne, Florida, 1995.

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)



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