RV1S9353A

Optically Isolated Delta-Sigma Modulator

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Summary

This application note describes the features of the RV1S9353A optically isolated delta-sigma modulators and provides usage examples.

Devices on Which Operation Has Been Confirmed

RV1S9353A

Contents

1. Introduction

Demand for delta-sigma modulators has increased in recent years for applications such as high-precision control in motor drive units incorporating general-purpose inverters or AC servos, as well as power conditioner output stabilization control in fields such as solar power and wind power. Delta-sigma modulators are necessary in motor drive units for high-precision detection of the bus voltage or phase currents between inverter and motor, and in power conditioners for high-precision detection of the output voltage and current.

The RV1S9353A is optically isolated delta-sigma modulators that produce digital output ideal for such current and voltage detection applications. They combine high noise tolerance (high CMR) and high linearity (low integral nonlinearity), making them ideal for current and voltage detection applications.

This document describes the features of the RV1S9353A and presents usage examples.

2. Product Overview

Figure 2.1 shows the pin connections of the RV1S9353A. The RV1S9353A is optically isolated A/D converters. Each incorporates a high-precision delta-sigma A/D converter and converts analog voltage input to a one-bit data stream. By connecting the RV1S9353A to a digital filter such as a $Sinc^3$ filter in a later stage, digital signal output with an effective number of bits (ENOB) of 13.8 bits (typ.) can be obtained.

The product features are listed below. For a detailed listing of characteristics, refer to the datasheets of the RV1S9353A.

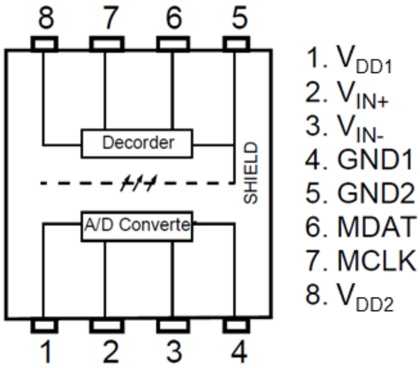


Figure 2.1 RV1S9353A Equivalent Circuit

Features

- Small variation in reference voltage (G_E = ±0.5% max.)
- High resolution (ENOB = 13.8 bits typ.)
- Low integral nonlinearity (INL = 25 LSB max.)
- Low input offset (V_{OS} = 2 mV max.)
- Small input offset drift vs. temperature (|dVos/dTA| = 0.2 µV/°C typ.)
- Operating temperature range (Ta = −40 to 110°C)
- Clock output (f_{CLK} = 10 MHz typ.)
- High common mode transient immunity (CMR = 15 kV/µs min.)
- Package:8-pin SDIP long creepage distance (8 mm) surface mount lead forming
- Conformance with international safety standards: UL, VDE, CSA

3. Operation and Functions

3.1 Operation of RV1S9353A

Figure 3.1 shows an overview of operation. The RV1S9353A accepts an analog input signal and converts it to digital output consisting of a one-bit serial bit stream with a time average proportional to the input signal (Figure 3.2). This signal output can be connected to a digital filter in a later stage or to a microcontroller with in integrated digital filter.

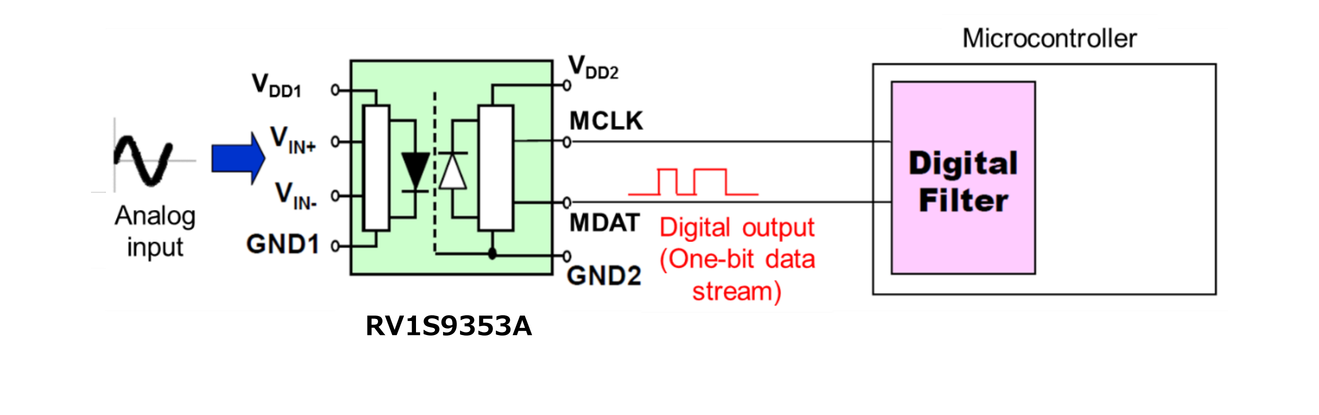


Figure 3.1 RV1S9353A Operation Overview

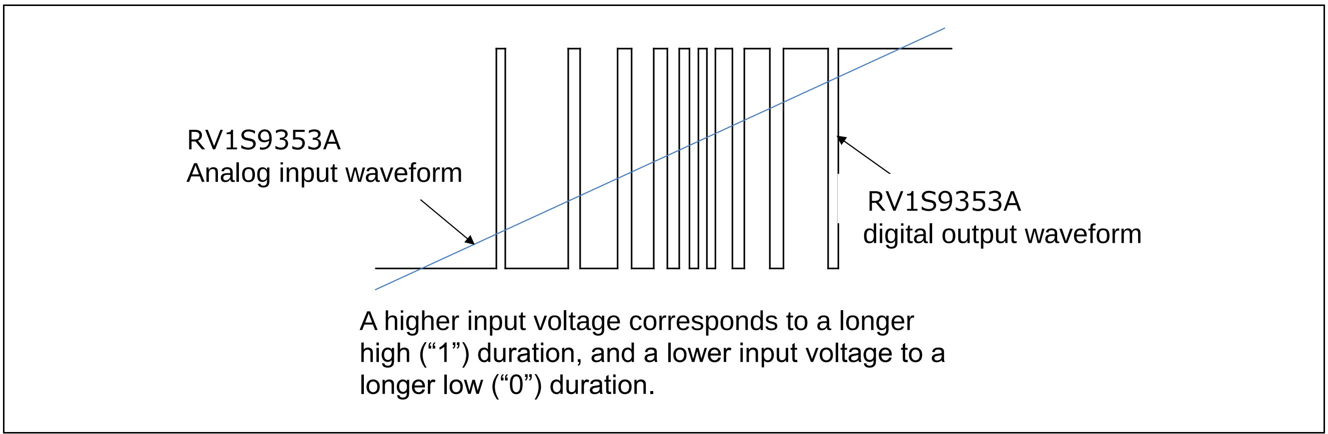
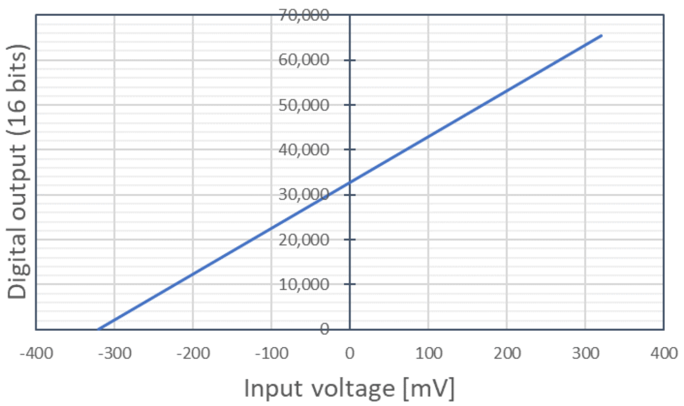


Figure 3.2 RV1S9353A Input / Output

Figure 3.3, below, shows an example of I/O characteristics with 16-bit digital output using the RV1S9353A.



Logical values

Analog Input	Digital Output Code
+320 mV (+ full scale)	65,535
0 mV	32,768
–320 mV (– full scale)	0

Figure 3.3 Example RV1S9353A I/O Characteristics

4. Peripheral Circuits

4.1 Current Detection Circuit

Figure 4.1 shows a recommended circuit example for motor current detection using the RV1S9353A. It comprises a shunt resistor, input filter circuit, and digital filter (Sinc^3 filter). The shunt resistor converts the motor current to a voltage, the input filter (anti-aliasing filter) removes unwanted high-frequency components from this signal, and the result is input to the RV1S9353A. The digital output A/D converted by the RV1S9353A is connected to the digital filter.

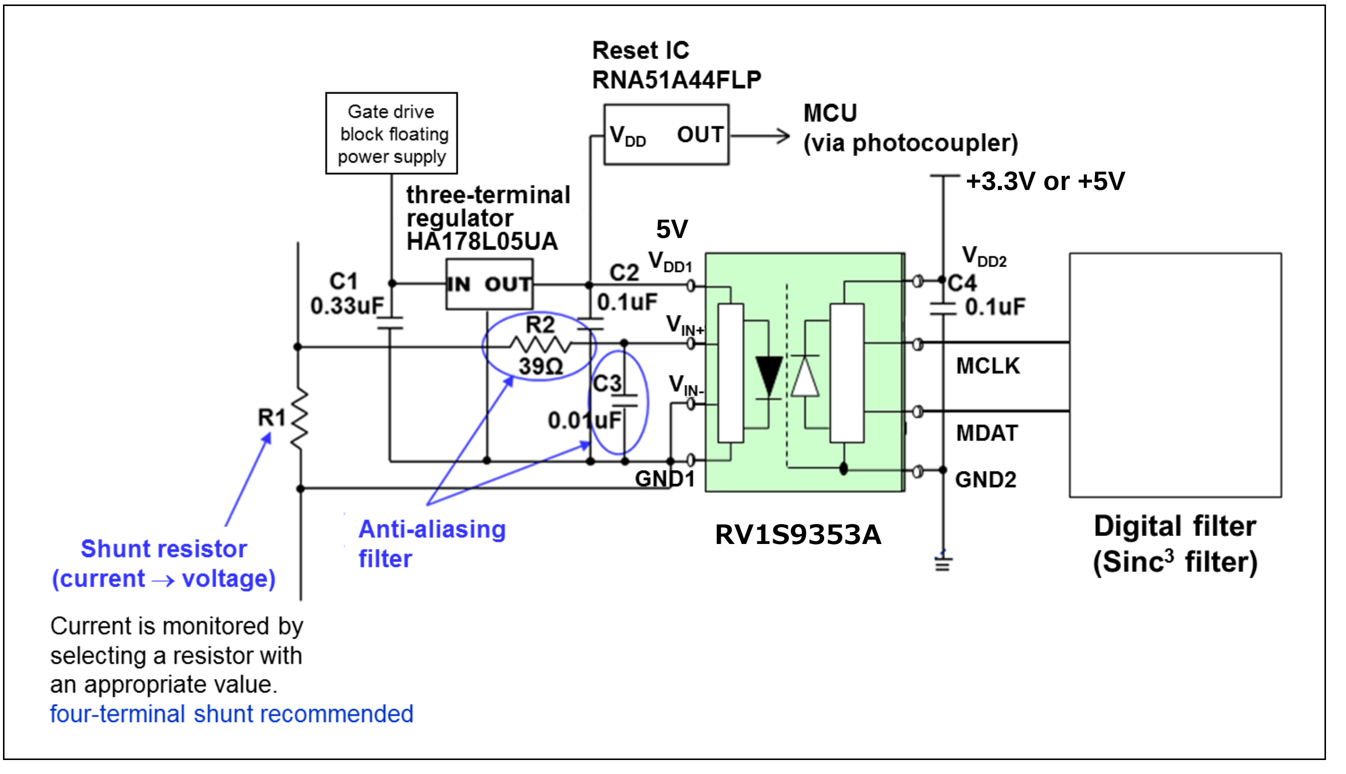


Figure 4.1 Recommended Current Detection Circuit Using RV1S9353A

4.1.1 Shunt Resistor

The shunt resistor converts the motor current to a voltage. The following points should be considered when selecting a shunt resistor for current detection:

(1) Maximum current
(2) Recommended maximum input voltage range of RV1S9353A (200 mV)
(3) Low power consumption (low resistance)
(4) four-terminal shunt (Kelvin connection)
(5) High precision
(6) Low temperature coefficient
(7) Low inductance to minimize the di/dt inductance voltage

Select a shunt resistor that can provide the maximum recommended input voltage of 200 mV from the maximum current used.

Example:

If the maximum effective current value = 20 Arms, and providing an overload tolerance of up to 50% during normal operation:

Peak current = 42.4 A (= 20 Arms × 1.414 × 1.5)

So if the maximum input voltage of the RV1S9353A is 200 mV, the maximum value of the shunt resistor is approximately 5 mΩ (= 200 mV / 42.4 A).

In this case, the maximum power consumption during normal operation is approximately 2 W (= I^2R = 20 Arms × 20 Arms × 5 mΩ).

Also, select the shunt resistor such that the input voltage of the RV1S9353A is kept below the rated value if a short occurs in the motor drive circuit (arm short, load short, short to ground).

When the current value is large the voltage drop in the leads of the shunt resistor can also cause error, so a four-terminal shunt resistor (Kelvin connection) is recommended. Also, resistance accuracy can be affected by ambient temperature and self-heating. Refer to the datasheet of the shunt resistor and if necessary take appropriate measures to disperse heat, such as optimizing the board pattern layout or using a heat sink.

4.1.2 Anti-Aliasing Filter

To avoid the effects of aliasing in the sampling performed internally by the RV1S9353A, do not fail to insert an anti-aliasing filter (RC filter) in the input block of the RV1S9353A, as shown in Figure 4.1, to eliminate frequencies above the required band. In the example shown in Figure 4.1, a filter is inserted with fc = approx. 400 kHz (= 1 / (2 π × 39 Ω × 0.01 µF)) when R2 = 39 Ω and C3 = 0.01 µF. Also, the anti-aliasing filter should be located as close to the input pins of the RV1S9353A as possible due to the high input sensitivity of the RV1S9353A.

Note that caution is necessary when selecting a resistor with a comparatively high value as R2 because the voltage drop due to the input bias current I_{IN+} of the RV1S9353A acts as an offset voltage. In such cases differential input, as described in 4.1.3, should be considered. Using differential input requires resistors for both pin 2 (V_{IN+}) and pin 3 (V_{IN-}) of the RV1S9353A, so the effect of the error of the resistors can be reduced.

4.1.3 Differential Input

If the effects of noise and offset are problematic with the current detection circuit employing the RV1S9353A shown in Figure 4.1, consider the differential input circuit for the RV1S9353A shown in Figure 4.3. By employing symmetrical anti-aliasing filters (R2a, C3a, R2b, and C3b) between the shunt resistor and the V_{IN+} and V_{IN-} pins, respectively, of the RV1S9353A, using twisted-pair wire, and shortening the distances on the board, it is possible to take advantage of the features of differential input and improve the performance characteristics. In addition, C3c reduces noise from the input switched capacitor circuit of the RV1S9353A.

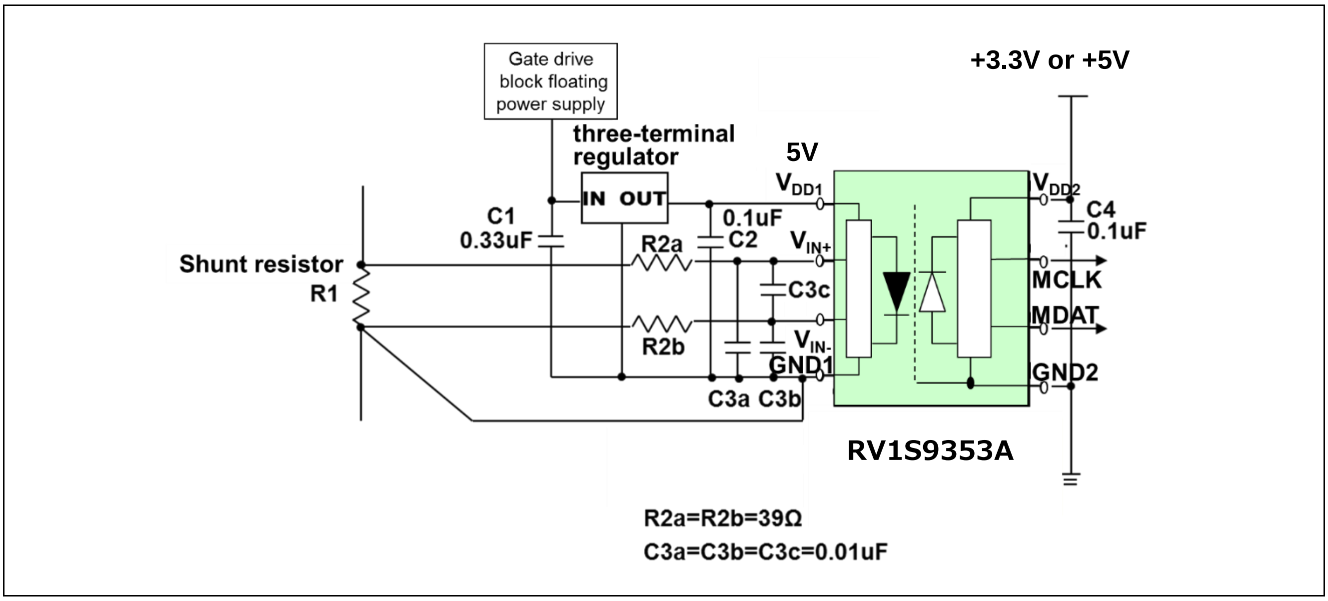


Figure 4.2 RV1S9353A Current Detection Circuit (Differential Input)

4.1.4 Power Supply Block

The primary-side power supply of the RV1S9353A is configured as an isolated DC-DC converter and, in simple terms, can be used with a gate drive circuit floating power supply (V_{CC} = 15 to 18 V) and three-terminal regulator to form a 5 V power supply, as shown in Figure 4.1. Select the capacitor to be inserted at the input side of the three-terminal regulator after consulting the datasheets of the various components.

4.2 Voltage Detection Circuit

For bus voltage detection (DC line: voltage between +HV and −HV) a resistive voltage divider can be used to keep the signal amplitude voltage within the recommended input voltage range of the RV1S9353A and for voltage measurement (Figure 4.3). Voltage divider resistor R8 should have a resistance rating well below the input resistance of the RV1S9353A (R_{IN} = 500 kΩ); for example, 1 kΩ or less. R8 and the internal input resistance (R_{IN}) of the RV1S9353A is configured as parallel resistances, and this can cause gain error due to current division. When the resistance of R7 and R_{IN} is sufficiently greater than R8, the error becomes R8 / R_{IN}. The RV1S9353A has comparatively high input resistance (R_{IN}), making it well suited for voltage detection. Note that due to the voltage divider resistors, the anti-aliasing filter does not require any resistors.

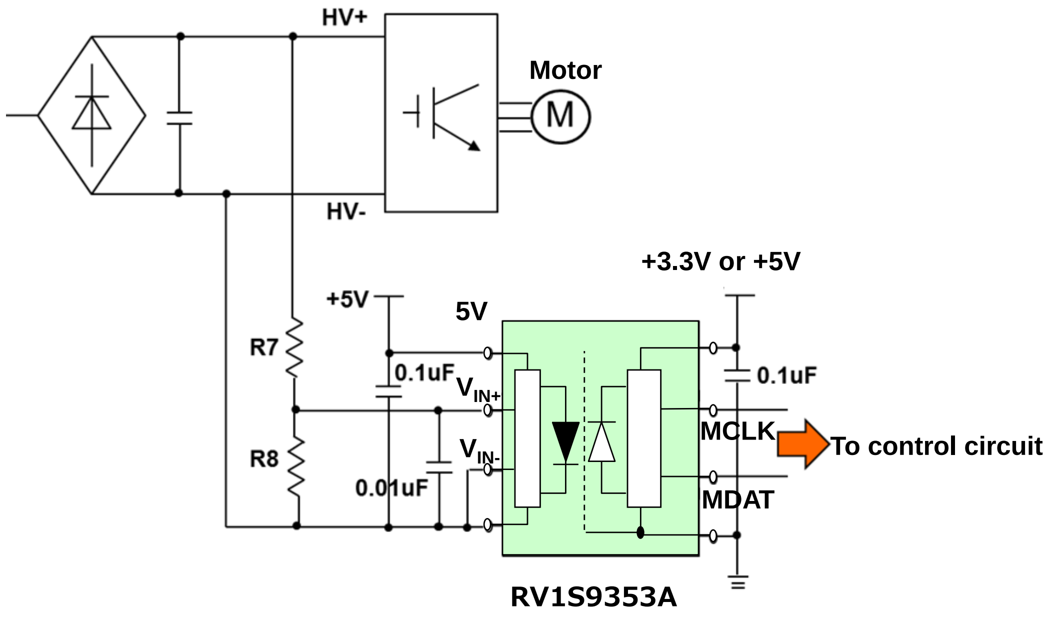


Figure 4.3 Voltage Detection Circuit

5. Conclusion

This concludes the description of the characteristics of and presentation of usage examples for the RV1S9353A delta-sigma modulators. It is hoped that this document will serve as a reference for customers designing their own systems. Renesas Electronics believes that this product category will contribute to the emergence of even more highly precise inverter systems, an area where future market growth is anticipated. Renesas Electronics will continue to aggressively market these products and to develop new ones offering even higher precision.

Caution GaAs Products	These products contain gallium arsenide (GaAs). GaAs vapor and powder are hazardous to human health if inhaled or ingested, so the following points should be observed without fail. • Dispose of the product as recommended below: 1. Commission a disposal company qualified to collect, transport, and dispose of materials that contain arsenic and other such industrial waste materials. 2. Exclude the product from general industrial waste and household garbage, and ensure that the product is properly managed (as industrial waste subject to special control) up until final disposal. • Do not burn, destroy, cut, crush, or chemically decompose the product. • Do not lick the device or allow it to enter the mouth.

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General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Handling of Unused Pins

   Handle unused pins in accordance with the directions given under Handling of Unused Pins in the manual.

   — The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible. Unused pins should be handled as described under Handling of Unused Pins in the manual.
2. Processing at Power-on

   The state of the product is undefined at the moment when power is supplied.

   — The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the moment when power is supplied.
   In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the moment when power is supplied until the reset process is completed.
   In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the moment when power is supplied until the power reaches the level at which resetting has been specified.
3. Prohibition of Access to Reserved Addresses

   Access to reserved addresses is prohibited.

   — The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.
4. Clock Signals

   After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has stabilized.

   — When the clock signal is generated with an external resonator (or from an external oscillator) during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Moreover, when switching to a clock signal produced with an external resonator (or by an external oscillator) while program execution is in progress, wait until the target clock signal is stable.
5. Differences between Products

   Before changing from one product to another, i.e. to a product with a different part number, confirm that the change will not lead to problems.

   — The characteristics of Microprocessing unit or Microcontroller unit products in the same group but having a different part number may differ in terms of the internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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