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## New Trend of Digital Multimeters chip

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## 1. Preface

When repairing machine or conducting experiments, electrical/electronic technicians often use analogue multimeters or digital multimeters (DMM). Previously, the portable digital meter industry usually adopts the analog to digital converter (ADC), provided by large international companies, designed for digital multimeters to convert the inputted analog signals to digital signals and then further process the signals. However, the product has long life cycle, the product also has low demand and various different types; therefore, these large international companies have no longer designed new ADC for digital multimeters, or even leaved the market of the ADCs designed for digital multimeters. A digital multimeter only needs a chip and resistors, capacitors and protection components to finish a product, so the threshold is low and the market of the industry is also limited; therefore, price war must finally take place; further, the profit of the product is also lower than consumable products. For digital multimeters, the core is the analog to digital converter; the large international companies, such as American Fluke, can design the dedicated DCC chips by themselves; on the contrary, as the domestic portable meter industry is smaller the other countries, the domestic companies cannot design the dedicated DCC chips by themselves.

The document will introduce the DMM dedicated chips, including the SiS HY12P-series

Mixed-Signal Microcontroller, and SiS HY313x-series Analog Front End.

## 2. Evolution of Portable Electrical Measurement Instruments

The first kind of portable electrical measurement meter is the analogue multimeters; this electrical measurement meter is of low price, but has low accuracy, low resolution, no input protection and is poor in function.

After the development of IC started, chip providers designed the analog to digital converter, the handheld manual range digital multimeter was developed, which not only had the voltage, resistance and current measurement functions, but also provided the capacitance, frequency and temperature measurement functions; further, DMM manufacturers further added the input protection circuit to this meter; however, almost all functions should be switched by an additional circuit, so users should manually select the range, which is inconvenient in use.

In order to simplify the operation, chip provides designed the analog to digital converter dedicated for the DMM; for the reason, the handheld auto range digital multimeter was developed, which usually designed all functions into the chip, so it only needed to add the resistors and capacitors; further, users did not need to manually select the range.

However, users had new requirements, which were high accuracy, high resolution and special functions, such as computer connection function; thus, chip providers designed a component for the analog front end dedicated for the DMM, or combined the analog front end with the MCU; the chip integrated with the MCU satisfied the new requirements. However, previously, the chip of this kind of product could only provide the voltage, resistance and current measurement functions, but needed additional circuits to realize other functions; thus, the product was not an ideal product.

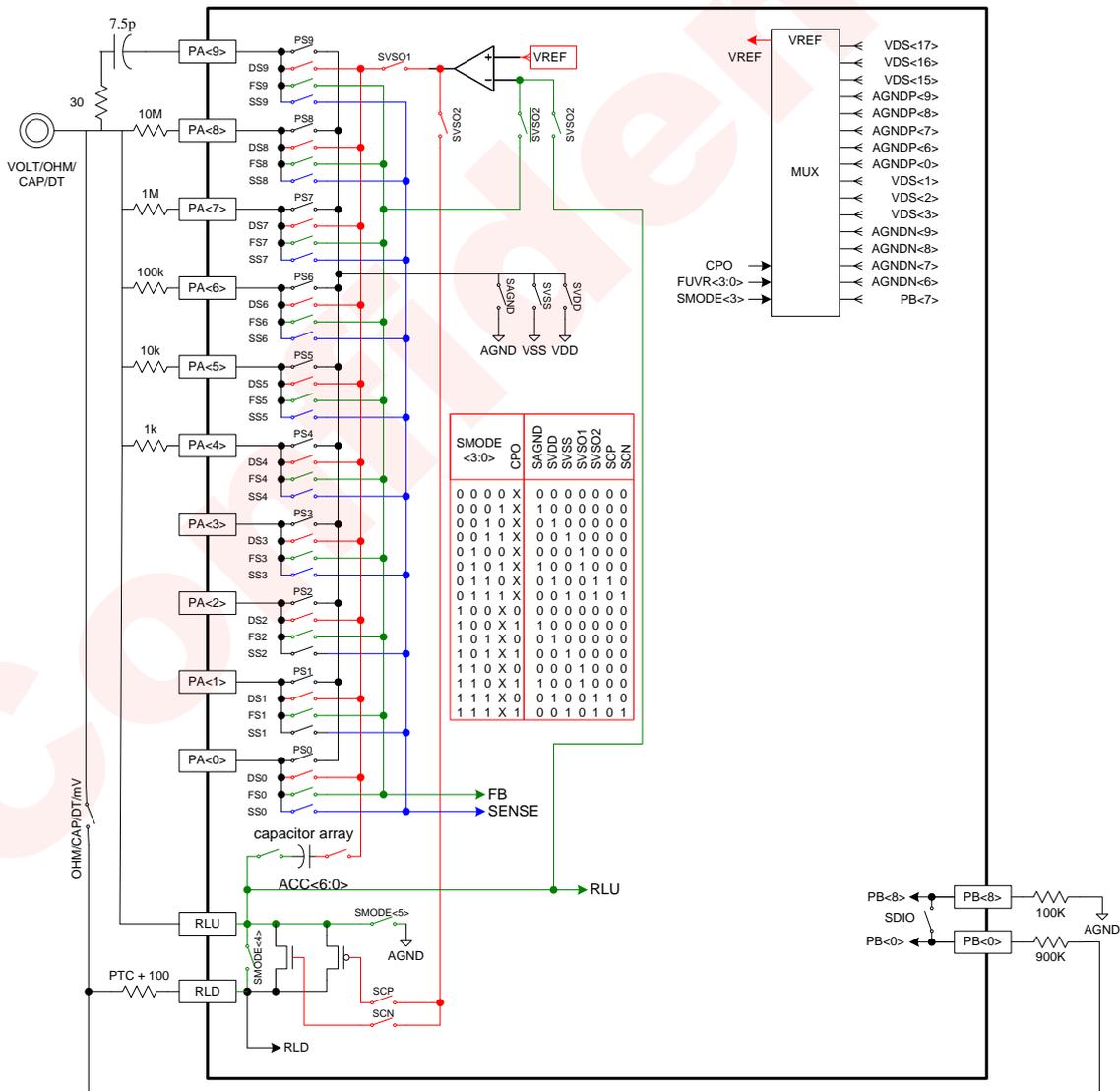
For the purpose of satisfying the above new requirements, SiS provides new-generation DMM dedicated chips, such as HY12P-series and HY313x-series chips to solve the problems.

### 3. Function introduction of new chip trend

The new trend of the portable digital meter industry should have unique product function planning in order to prevent from price war, such as intelligent electrical meter; moreover, more flexible DMM dedicated chip is necessary; the functions of the new chip trend can be classified into the following items.

#### 3.1. Programmable switch network

Previously, the DMM dedicated chips had constant function and range switch networks; the advantages of which were easy to design; however, unique product function planning cannot be realized by flexibly switching multi-function network. All of the DMM dedicated chips introduced by the document have a programmable switch network, such that the portable digital meter can have more space for development. Please refer to HY313x configuration settings and HY12P65 configuration settings for more information about detail function network settings.



▲ HY3131 Analog Switch Network

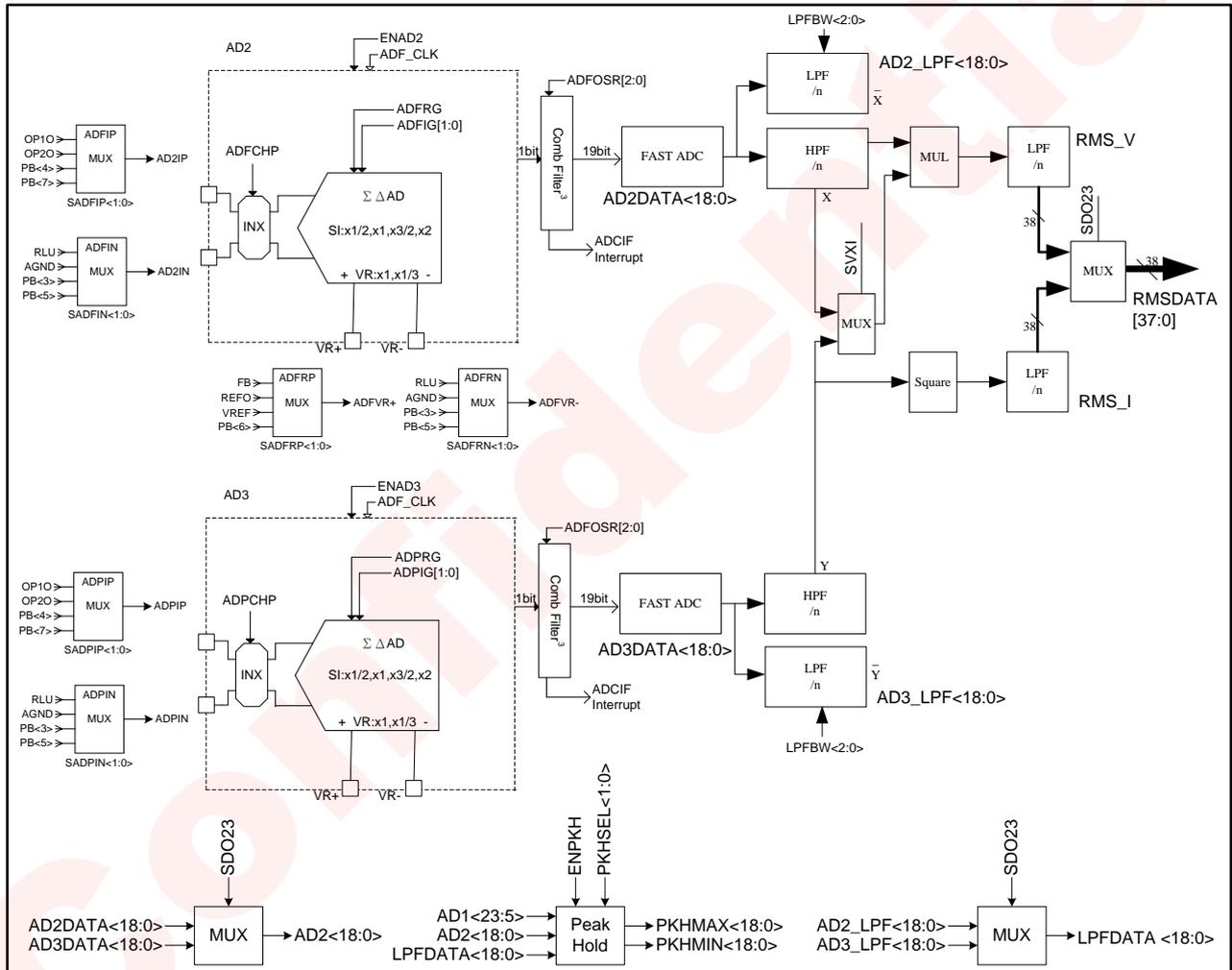
### 3.2. High-resolution $\Sigma$ - $\Delta$ ADC

Previously, the ADCs of the DMM dedicated chips manufactured by large international companies adopted the double slope integrating structure. However, the conversion speed of the analog to digital converter of the structure was slow, and the quality of the integrating capacitor could influence the overall stability and error of the converter. In general, the integrating capacitor needed to use high-cost materials, such as MPE or MPP, and was hard to achieve high resolution.

In recent years, the  $\Sigma$ - $\Delta$ ADC is gradually used for industrial controls and high-class meters; the most important advantage of the ADC is that the ADC has less peripheral circuits and high conversion speed, high resolution and high accuracy; besides, the ADC is not easily influenced by the 50/60 HZ frequency of the power system; moreover, the peripheral cost of the ADC is lower than that of the double slope integrating ADC.

### 3.3. Digital Root Mean Square(RMS) Circuit

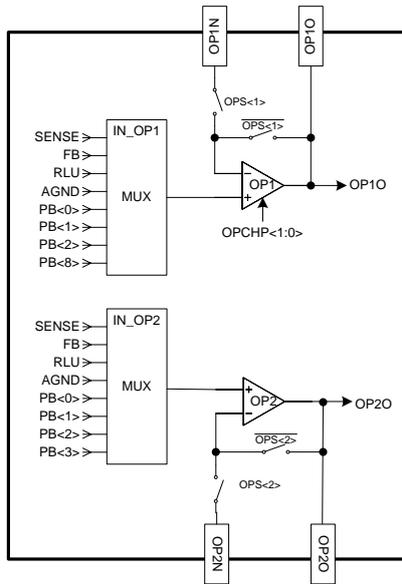
The AC signal measurement is necessary for either voltage or current. However, the AC signal measurement circuit could be divided into the average response circuit measurement circuit and the true RMS conversion dedicated component measurement circuit previously; both of which needed additional components. All of the DMM dedicated chips introduced by the document have a high-precision  $\Sigma$ - $\Delta$ ADC, and the conversion result will be processed by the high-speed calculation of the inner hardware to realize the digital RMS and inrush current measurement functions; besides, which can be integrated with the peak hold measurement to realize higher peak factor signal measurement.



▲ RMS measurement structure block diagram of HY3131

### 3.4. Operational amplifier

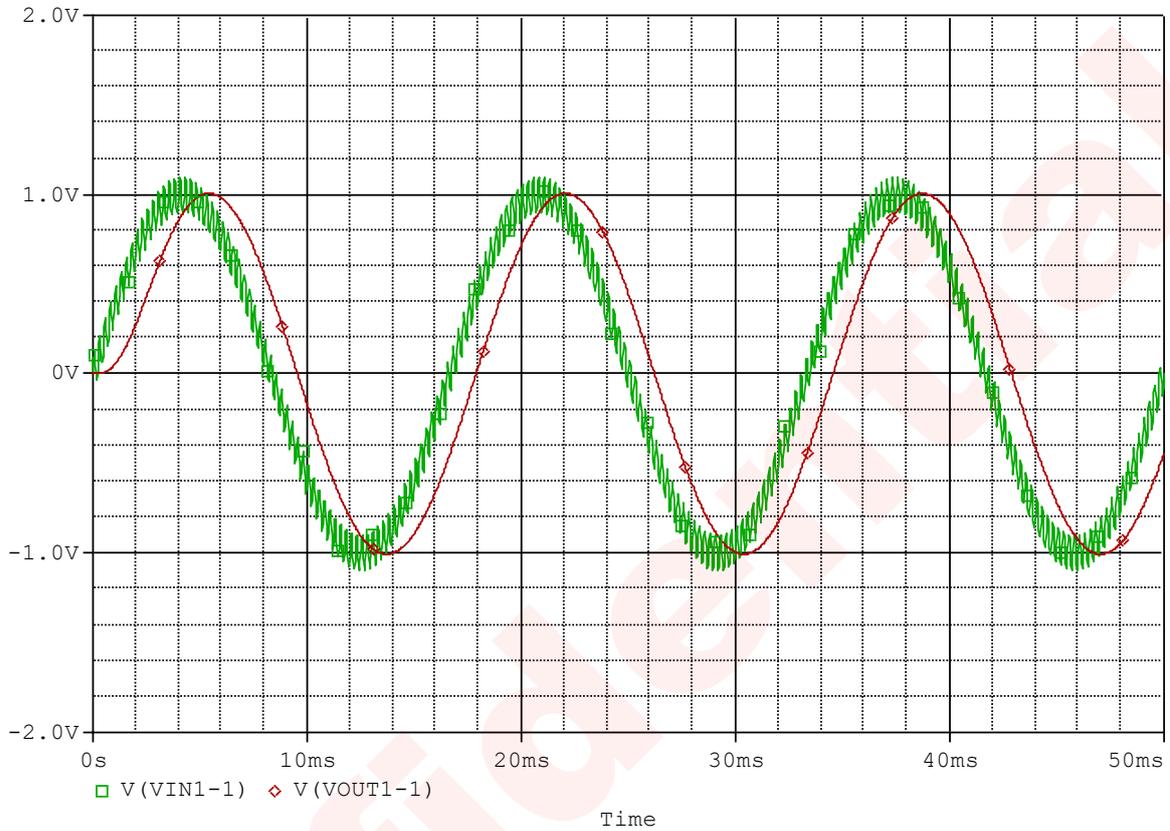
In general, under the lower voltage range, current range and temperature measurement function, small signals are amplified to the allowable range of the converter and then the signal quantization conversion is executed. The DMM dedicated chips introduced by the document can be integrated with the programmable switch network to form a signal buffer or non-inverting amplifying circuit.



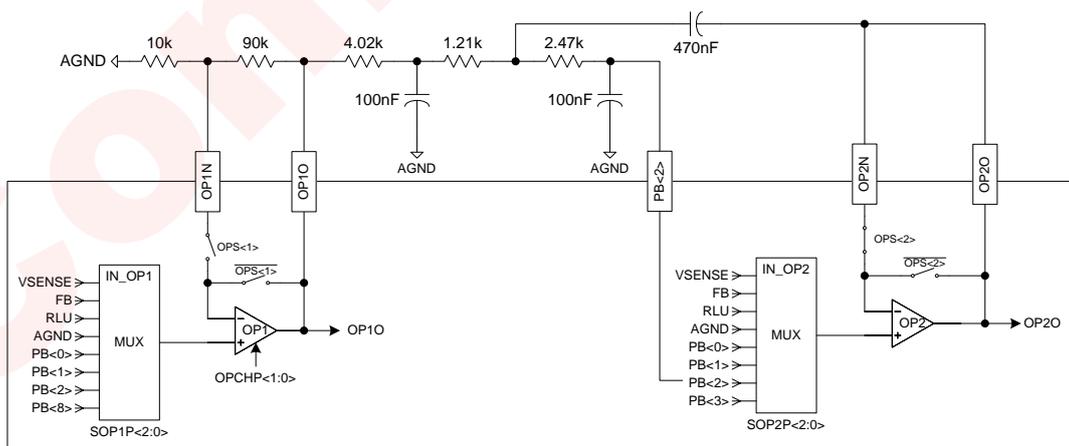
◀ HY3131 OPAMP Switch Network

## 3.5. Low-pass filter

In some electromechanical measurement applications, the signals to be measured may include surges or other high-frequency signals. The low pass filter can be used to filter out the high-frequency signals, and HY313x can use the OP inside the chip to realize the function of the third-order LPF.



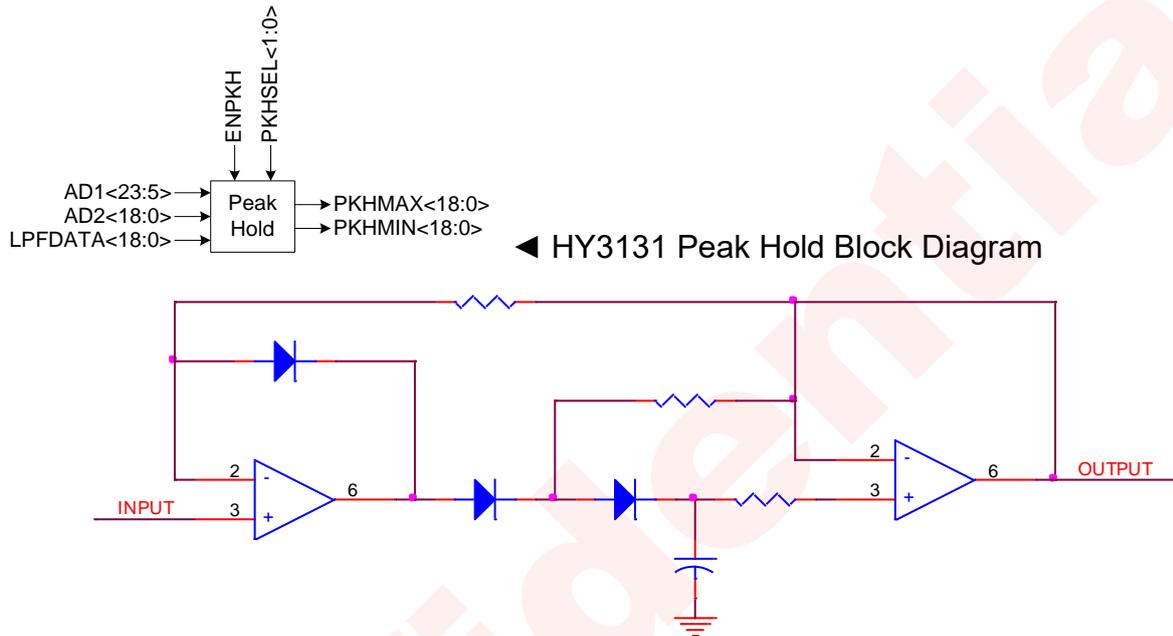
▲ According to the above figure, the original waveform is 1V/60Hz plus 0.1V/4KHz; after the waveform passes through the low pass filter, the waveform is filtered to be 1V/60Hz.



▲ The function of the third-order LPF is realized by HY3131.

### 3.6. Peak Detection Circuit

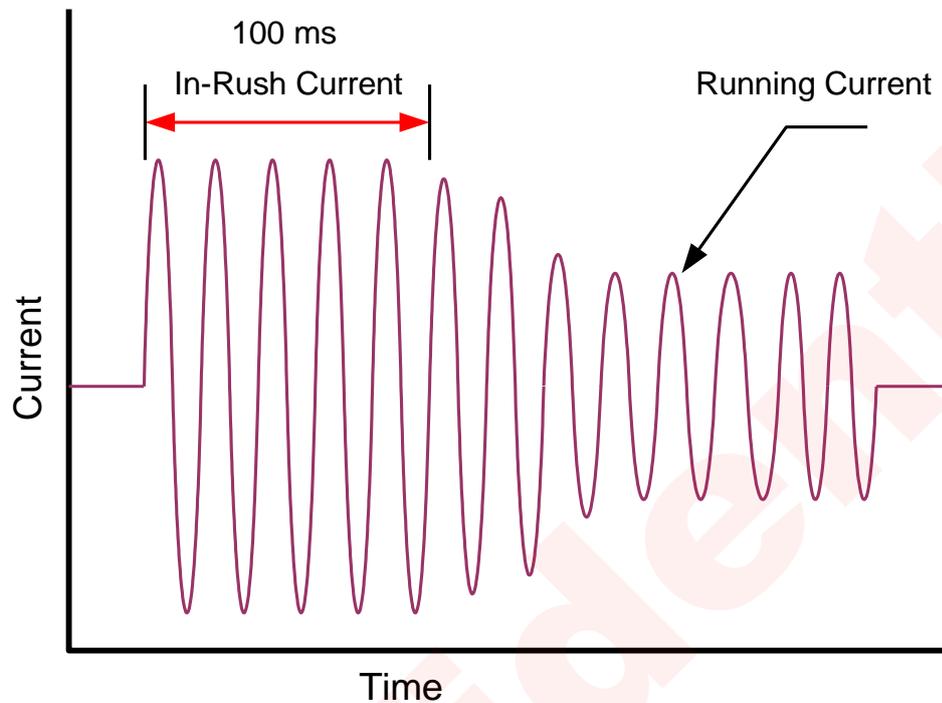
Some electromechanical measurement applications need to measure the peak value; then, it is necessary to use the peak hold circuit to lock the voltage, and the use the analog to digital converter to convert the voltage. However, the capacitor used by this kind of circuit to lock the voltage tends to be influenced by the external environment. All of the DMM dedicated chips introduced by the document have the digital peak hold function to compare the analog-to-digital conversion results so as to achieve higher accuracy.



#### ▲ Low Drift Peak Detector

## 3.7. Inrush Current Measurement

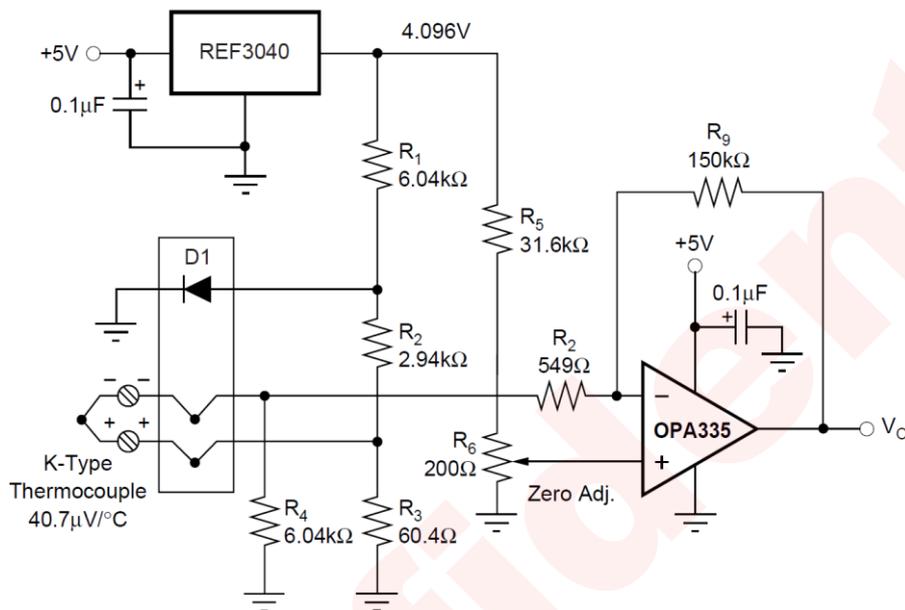
In recent years, some long-test ammeter providers proposed the in-rush current measurement, which means “in a three-phase motor, the in-rush current usually lasts 75~150mS and has a current peak between 500%~1200%, which is short but the instantaneous increase will result in some problem”. All of the DMM dedicated chips introduced by the document have the swift AC signal conversion function, which can capture the in-rush current.



▲ In-Rush Current

## 3.8. Temperature Sensor

Some portable electrical measurement devices have the temperature measurement function in addition to the electricity measurement and component measurement functions. The most frequently-used temperature detectors are the following 4 types: the thermocouple detector, the resistance temperature detector (RTD), the thermistor detector and IC detector. In general, the portable electrical measurement devices adopt the thermocouple measurement structure; its principle is that the contact of two metals will result in the voltage caused by Seebeck effect. However, as the voltage is 0 when the temperature to be measured is equal to the environmental temperature, it is necessary to perform “Cold-Junction Compensation”. All of the DMM dedicated chips introduced by the document have a temperature sensor.



▲ Temperature Measurement Circuit. (摘自 Texas Instruments OPAX235 Datasheet)

### 3.9. Standard Serial Interface

HY12P-series chips have the UART (Universal Asynchronous Receiver/Transmitter) interface. The new-generation portable digital meters usually have the UART interface and the computer communication function, which can achieve the automatic test and the automatic calibration functions to reduce the cost of the manpower. The UART interface can completely change the usage habit of users; for example, the product can be integrated with the wireless communication module, such as Bluetooth or WiFi module to communicate with a smart phone or tablet computer to separately perform measurement, displaying and data statistics analysis.

HY313x-series chips have the SPI interface; the component is a DMM analog front end dedicated chip, which can be integrated with the MCU control chip to realize the products with special displaying screens, such as the following products. The SPI is the standard serial transmission interface most frequently used in microcomputer systems, and can provide higher transmission speed.

### 3.10. Microcontroller

HY12P-series chips not only have the DMM dedicated analog front end circuit, but also is integrated with the MCU having the 80bit RISC, which is suitable for middle-class or low-class meters, and can save the circuit layout space for the products in order to reduce the size of the products.

### 3.11. Wider Operating Temperature Range

Previously, the operation temperature of the DMM dedicated chips manufactured by the large international companies is about 0°C~50°C; however, some users need wider usage range; thus, the operation temperature of all products of SiS is -40°C~85°C.

#### 4. Reference

- HY3131(50,000 counts DMM Analog Front End) Datasheet
- HY12P65(DMM Specialized IC Embedded Digital T-RMS) Datasheet
- HY12P(Digital Multimeter) Family User's Guide
- HY313x Configuration Settings
- HY12P65 Configuration Settings

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## 5. Revisions

The following describes the major changes made to the document, excluding the font and punctuation changes.

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Version	Page	Date	Revision Summary
V01	All	2016/08/20	First edition