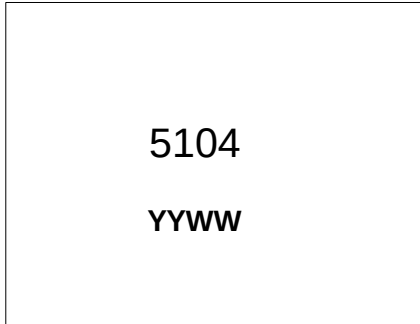


IRL5104FI

Isolated Delta-Sigma Modulator ADC

Key features:



YY -- Year of manufacture
WW – Week of manufacture

- Power supply voltage from 3.0 to 3.6 V;
- Voltage at the INP, INN channel inputs from -50 to +50 mV;
- Signal-to-noise ratio (SNR) 80 dB (data output frequency 4 kHz, INP, INN channels);
- Current consumption 5 mA total;
- Peak insulation voltage 2500 ÷ 5000 V (when applied for 1 minute);
- Maximum working insulation voltage 690 / 1250 V (prolonged exposure);
- Temperature range from -40°C to +85°C.

Package type:

- plastic DFN10 6.5 x 10 mm package.

General description and application of the microcircuit

The IRL5104FI contain a delta-sigma modulator with built-in galvanic isolation for data transmission channels.

The microchips provide the conversion of the voltage drop across "shunt" type current sensors into digital data and the transmission of digital data to the controller.

The microchips are primarily intended for measuring voltage and current values on "shunt" type current sensors in power meters along with general-purpose microcontrollers.

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1 Structural Block Diagram

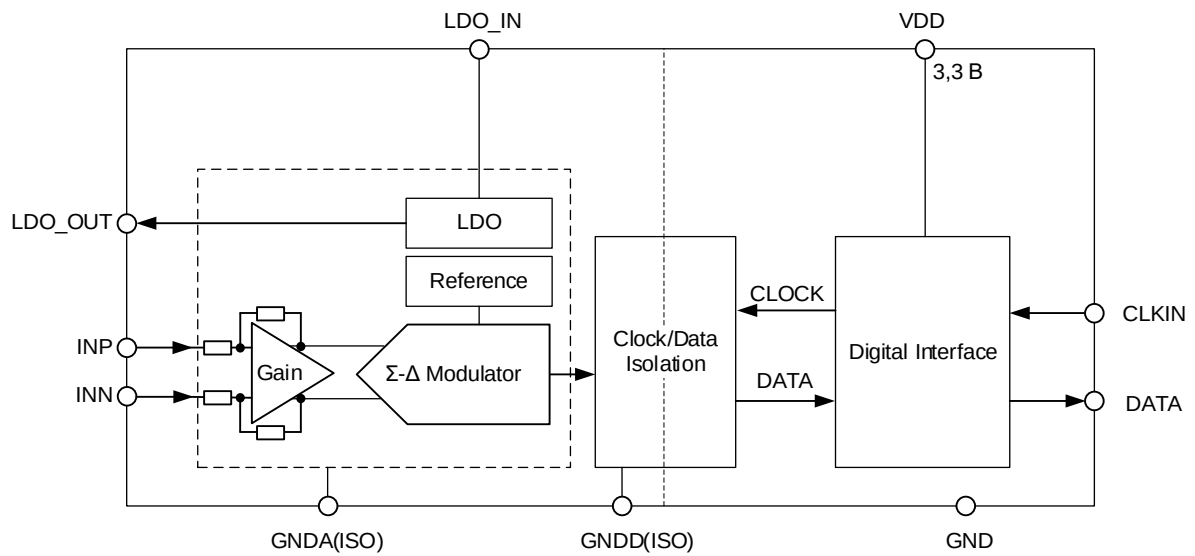


Figure 1 – Microchip block diagram

2 Conventional graphic symbol

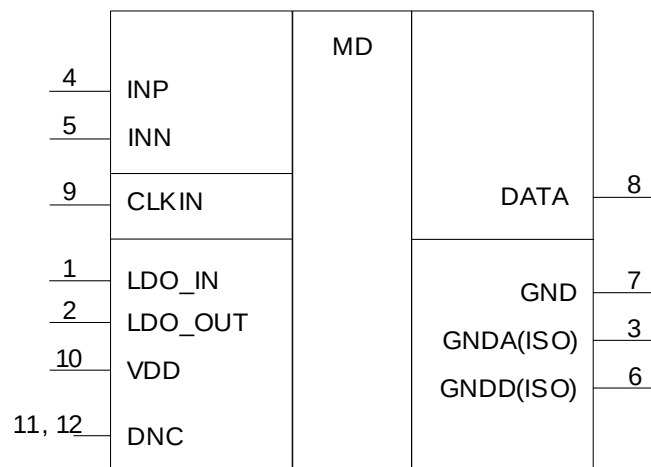


Figure 2 – Schematic representation of the microchip

3 Pin Description

Table 1 – Pin Description

Pin number	Pin indication	Pin Type	Functional purpose of pin
1	LDO_IN	PWR	LDO Power Supply
2	LDO_OUT	PWR	LDO Output 3.1V
3	GNDA(ISO)	PWR	Analog Ground (Isolated)
4	INP	AIN	ADC Input +
5	INN	AIN	ADC Input -
6	GNDD(ISO)	PWR	Digital Ground (Isolated)
7	GND	PWR	Digital Ground
8	DATA	IO	Digital data output
9	CLKIN	IO	Clock signal input
10	VDD	PWR	Digital power supply 3.0 – 3.6 V
11	DNC	TST	Test
12	DNC	TST	Test

4 Functioning Description

4.1 Microchip Architecture

The microchip is a fully differential, isolated delta-sigma ADC modulator that converts analog signal into a single-bit digital stream at an update rate of 1 MHz. The average value of this time-varying digital stream is directly proportional to the input signal voltage.

The stream of digital zeros and ones at the modulator output is transmitted to another part of the microchip, galvanically isolated by a capacitive barrier. This allows microchip output data to be directly accepted by a low-voltage microcontroller, avoiding additional complexities with level conversion. The use of an external microcontroller or FPGA is necessary for digital filtering and decimation of the output stream of the delta-sigma modulator.

A separate power supply is required to power its high-voltage part.

In Figure 1, a typical circuit diagram is shown for connecting an integrated circuit used to measure voltage on a shunt resistor with an amplitude of ± 50 mV.

4.2 Input analog signal

A fully differential operational amplifier (Op-Amp) is installed directly on the INP/INN chip outputs, designed for buffering the input stage of a switched-capacitor modulator. The required gain of this buffer is calculated based on the overall requirements of the path and is set by internal feedback resistors.

The low level of modulator zero offset, as well as zero offset drift, is ensured by an internal chopper stabilization loop that encompasses the operational amplifier. This loop operates at 1/16th of the modulator's sampling frequency. In this regard, the output spectrum may contain spurs at this frequency and its odd harmonics.

Input voltages and currents at the INP/INN pins should not exceed the maximum permissible limits. The chip parameters are guaranteed only if the analog input signal remains within the specified limits.

In a typical application of the microchip, it directly measures the voltage drop across a shunt resistor. The connection can be made through an additional anti-aliasing low-pass RC filter, installed on each of the INP/INN pins.

4.3 Modulator

The microchip implements a second-order delta-sigma modulator with a single-bit quantizer. The external clock signal, supplied to the CLKIN pin, provides all the internal clock signals required for the sampling process, analog-to-digital conversion, and the chip's output interface.

The input analog signal is continuously sampled and compared with an internal reference voltage. The digital stream, accurately representing the original analog signal in time, is fed to a converter output.

The delta-sigma modulation loop shifts quantization noise to the high-frequency region. In this regard, to improve the overall characteristics of the product, an external digital low-pass

filter is necessary. This filter should also convert the high-speed single-bit output stream into a multi-bit stream with a lower refresh rate (decimation).

Specialized microcontrollers for power meters of the IRL1206FI type have similar integrated filters, optimised for use with this particular microchip. As an alternative, third-party microcontrollers can be used if they contain flexible digital filters. For implementing filters, FPGAs can also be utilized.

4.4 Reference voltage source

The microchip has an internal reference voltage source (RVS) which is used in the modulator as a comparison scale. The nominal value of the reference voltage is 1.22 V. The reference voltage value smoothly deviates from its nominal value with changes in ambient temperature as shown in Figure 3.

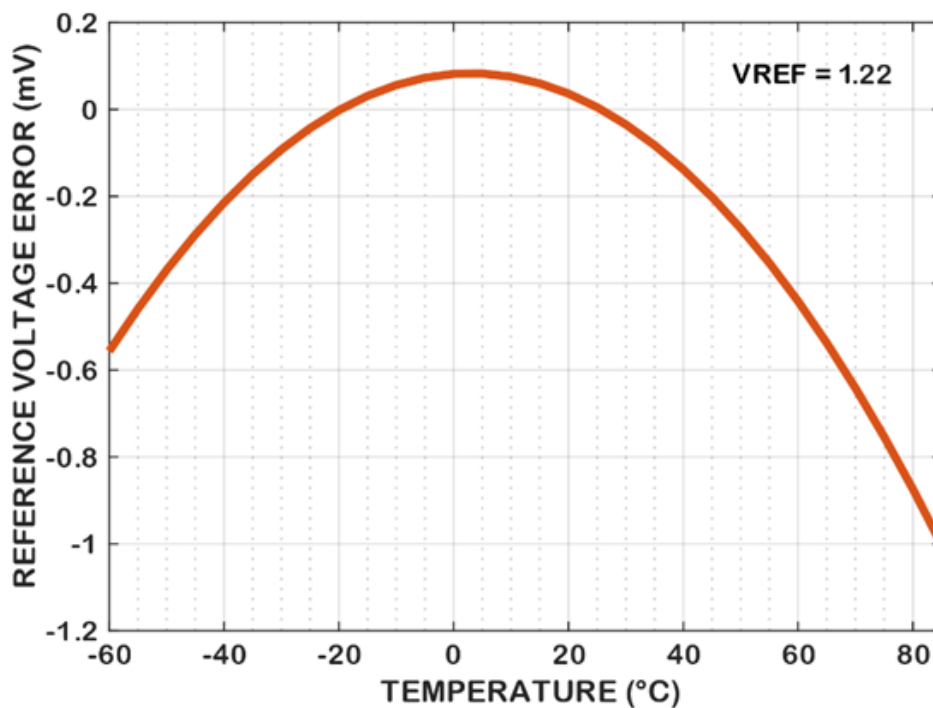


Figure 3 – Deviation of reference voltage from nominal value depending on ambient temperature

The modulator's reference voltage cannot be set by an external source.

4.5 Digital Output

A differential input signal with an amplitude of 0 V ideally generates a sequence of an equal number of zeros and ones at the DATA pin of the microchip. A differential input signal with an amplitude of 50 mV generates a digital stream consisting of ~89% of ones. A differential input signal with an amplitude of minus 50 mV generates a digital stream consisting of ~11% of ones.

These input signal values are the boundaries of the integrated circuit's linear operating range. In case the voltage at the INP/INN terminals goes beyond the specified limits, the nonlinearity at the modulator output may increase and noise may rise.

A continuous stream of ones will appear at the modulator output if the voltage at its input exceeds ~ 55 mV, and, conversely, a digital stream of zeros if it drops below $\sim$ minus 55 mV.

The timing diagram of the microchip operation is shown in Figure 4. The output data is available at the DATA output after t_{PD} seconds from the rising edge of the CLKIN clock signal.

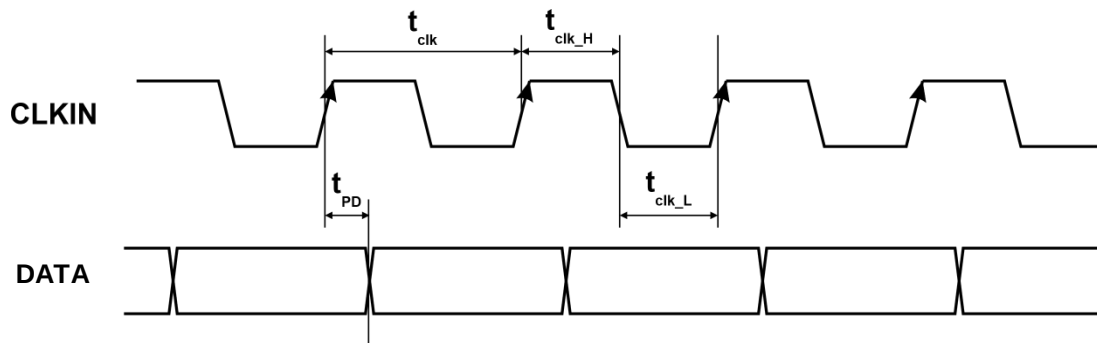


Figure 4 – Timing diagram of the microchip operation

4.6 Power supply structure

For operation the microchip requires two power sources: 3.3 V, connected on the low-voltage side to the VDD pin, and 3.0 – 5.5 V, connected on the high-voltage side to the LDO_IN pin.

5 Standard connection diagram

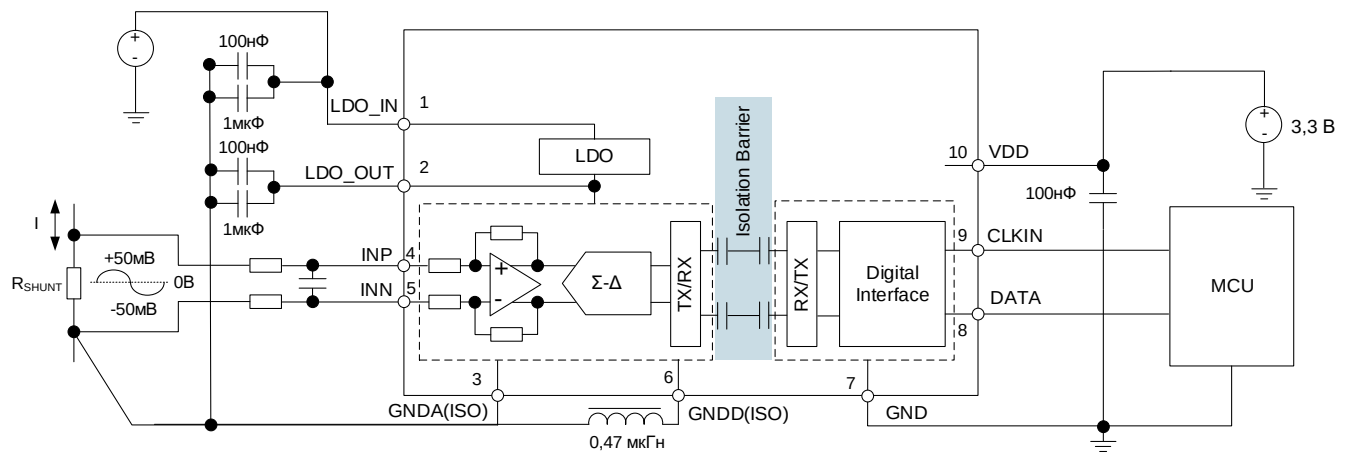


Figure 5 – Typical circuit diagram of the microcircuit

6 Electrical parameters

Table 2 – Electrical parameters of the microcircuits upon acceptance and delivery

Parameter name, unit of measurement, measurement mode	Letter indication of the parameter	Parameter Normal Value		Ambient temperature, °C
		at least	not more	
Consumption current on VDD, mA	I _{OCC}	–	2.5	25, 85, – 40
Consumption current on LDO_IN, mA	I _{OCCISO}	-	2.5	
Low-level output voltage, V, in the DATA pin	U _{OL}	–	0.2 • U _{CC}	
High-level output voltage, V, in the DATA pin	U _{OH}	0.8 • U _{CC}	–	
Low-level input leakage current, µA, in CLKIN pin	I _{ILL}	-2	2	
High-level input leakage current, µA, in CLKIN pin	I _{ILH}	-2	2	
Input differential resistance between INP INM, kOhm	R _{IN_DIF}	1.6	2.8	

7 Maximum permissible and limit parameters

Table 3 – Maximum permissible electrical operating modes and limiting electrical modes of the microcircuits

Parameter name, unit of measurement	Letter indication of the parameter	Parameter Normal Value			
		Maximum permissible mode		Limit mode	
		not less	not more	not less	not more
Supply voltage, V	U_{CC}	3.0	3.6	–	4.0
Supply voltage of the isolated part, V	U_{CC_ISO}	3.0	5.5	–	6.0
Temperature, °C	T	-45	85	-50	125
Low-level input voltage at CLKIN input, V	U_{IL}	0	$0.2 \cdot U_{CC}$	-0.3	–
High-level input voltage at CLKIN input, V	U_{IH}	$0.8 \cdot U_{CC}$	U_{CC}	–	$U_{CC} + 0.3$
Input voltage at INP, INM inputs, mV	U_{I_VIN}	-50	50	-0.3	$U_{CC} + 0.3$
Input differential voltage at INP, INM, B inputs	U_{ID_VIN}	-50	50	–	–
Low-level output current at DATA pin, mA	I_{OL}	–	2	–	4
High-level output current at DATA pin, mA	I_{OH}	-2	–	-4	–
Load capacity, pF	C_n	-	30	-	–
Clock frequency, MHz	F_{CLK}	0.9	1.1	–	–
CLK Signal Duty Cycle, %	F_{CLK_DC}	45	55	–	–
Note – Simultaneous exposure to two or more limiting modes is not allowed.					

8 Reference parameters

Table 4 – Reference parameters of the microchips

Parameter name, unit of measurement, measurement mode	Letter indication of the parameter	Parameter Normal Value		Ambient temperature, °C
		at least	not more	
ADC gain error, % at $U_{CC} = 3.3$ V, and an external 3rd-order filter with OSR = 256	G_{error}	-1*	1*	25, 85, – 40
ADC internal reference voltage, V	U_{REF}	1.2	1.25	
ADC bias voltage, mV, at $U_{CC} = 3.3$ V, and an external 3rd-order filter with OSR = 256	U_{OFFSET}	-0.15	0.15	
ADC intrinsic noise, μ V RMS, when inputs are shorted, $U_{CC} = 3.3$ V, and an external 3rd-order SINC filter with OSR = 256	U_{N_RMS}	–	5	
THD, dB at an input frequency of 57 Hz, amplitude $U_{ID_VIN} = 50$ mV, $U_{CC} = 3.3$ V, and an external 3rd-order SINC filter with OSR = 256	THD	80	–	
Breakdown voltage of insulation, kV	U_{ISO}	2-6*	–	
Common-mode noise immunity, kV/ μ s	CMTI	25*	–	
* Meaning to be clarified during R&D				

9 Dimensional drawing of the microchip

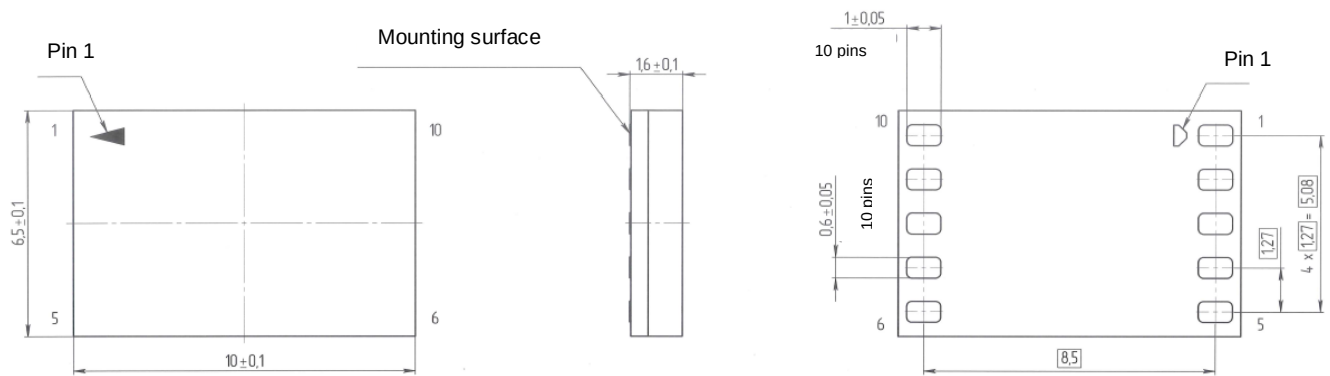


Figure 6 – Microcircuit in DFN10 6.5×10 package

10 Order Information

Part number	Marking	Package type	Temperature range, °C
IRL5104FI	5104FI	DFN10	from – 40 to +85

