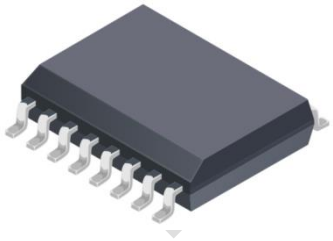
FCS series Current Sensor Ic

The FCS series is a family of integrated ICs for high bandwidth, high speed response and low noise current sensors, suitable for a wide range of applications including automotive, industrial, consumer and communication systems, provides a high speed, high bandwidth integrated solution for current sensing in AC, DC, and inverter high-frequency switching power supplies. The IC family offers various output modes.

Features and Benefits:

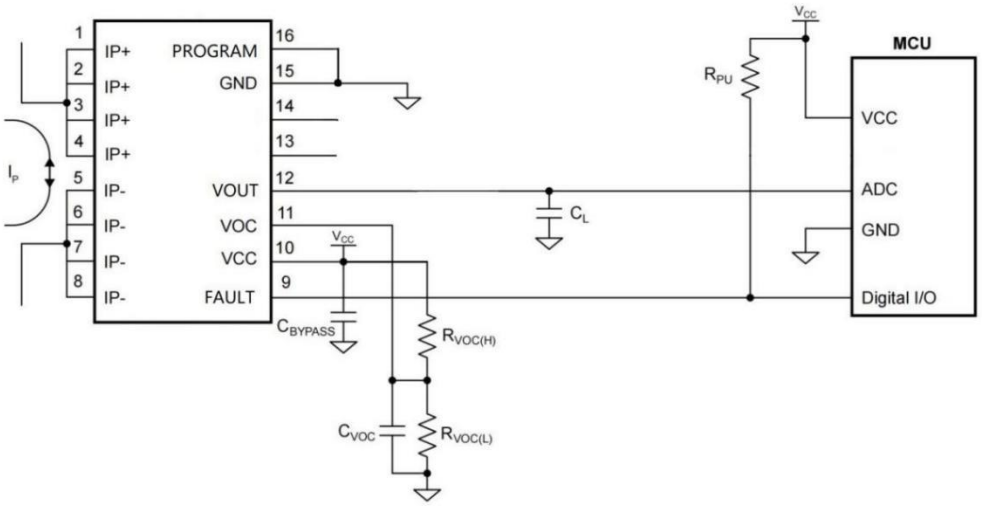


- Open-loop current sensor using the high-sensitivity hall sensing principle
- Single 5V supply
- Support unidirectional, bidirectional output
- Analog signal output
- Current detection range: ±20A - ±75A
- Operating temperature range: -40° C to +125° C
- QVO (Zero current output):
  -xR: QVO ratiometric to supply voltage V_{CC}, Fixed Gain
  V_{QVO}= V_{CC}/2 or V_{CC}/10
- Differential Hall sensors、Good linearity, accuracy and temperature drift
- Low internal resistance, can effectively control the heat dissipation

Applications:

- EV/HEV charger and DC-DC power supply
- Photovoltaic inverter power supply and UPS
- Motor control and frequency converter
- Switching power supply, communication and server power supply

Pinout Table:



Vcc BYPASS capacitor must be close to device Vcc pin

Vout BYPASS capacitor must be close to device Vout pin

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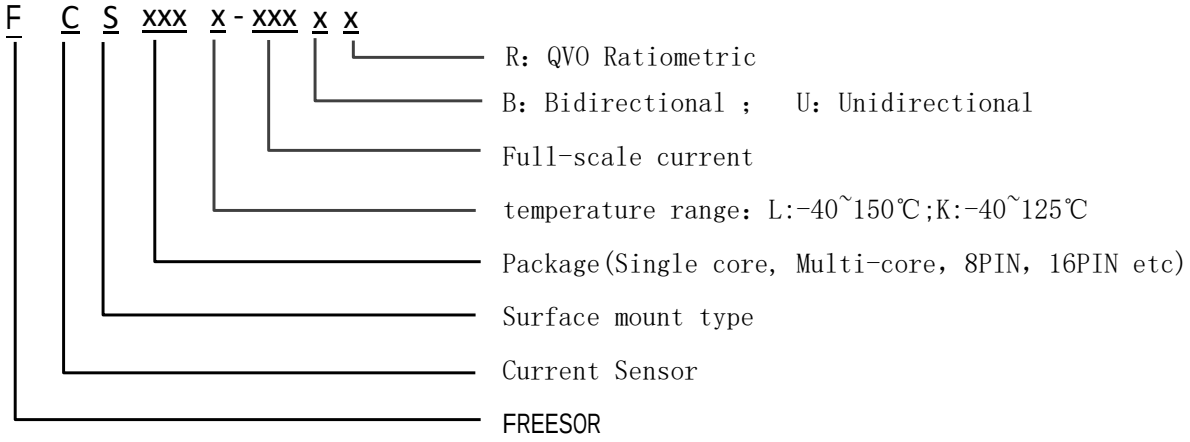
Naming rules:



Ordering Information:

Part number	QVO $V_{OUT}(Q)$ (V)	Primary Current I_P(A)	Sensitivity $Sens_{(Typ.)}$ (mV/A)	T_A (℃)	MPQ (PCS)
FCS202K-020BR	$V_{cc}/2$	±20	100	-40~125	1000
FCS202K-020UR	$V_{cc}/10$	20	200		1000
FCS202K-040BR	$V_{cc}/2$	±40	50	-40~125	1000
FCS202K-040UR	$V_{cc}/10$	40	100		1000
FCS202K-065BR	$V_{cc}/2$	±65	30.8	-40~125	1000
FCS202K-065UR	$V_{cc}/10$	65	61.5		1000
FCS202K-075BR	$V_{cc}/2$	±75	26.7	-40~125	1000
FCS202K-075UR	$V_{cc}/10$	75	53.3		1000

*Please contact factory for currents other than standard current specifications

FCS series Current Sensor Ic

Absolute Maximum Ratings

Characteristic	Symbol	Rating	Unit
Supply Voltage	V_{CC}	-0.3 to 6.5	V
Supply Current	I_{CC}	20	mA
Output Voltage/Reference voltage	V_{OUT}/V_{REF}	0.15 to V_{CC}-0.15	V
Output Current	I_{OUT}	±40	mA
Operating Temperature	T_A	-40 to 125	℃
Max Junction Temperature	T_J	165	℃
Storage Temperature	T_S	-55 to 150	℃

Common Operating Characteristics

Dc operating parameters at VCC = 5.0V (unless otherwise stated), TA within the specified temperature range.

Parameter	Symbol	Condition		Min	Typ.	Max	Unit
Supply Voltage	V_{CC}			4.5	5	5.5	V
Supply Current	I_{CC}	R_L ≥ 10KΩ			16		mA
Power on Delay	T_{PO}	T_A=25°C				1000	μs
QVO Ratiometric Error (-R)	E_r			-0.3		0.3	%
Zero Current Output Voltage	V_{QVO}	FCS-xxxBR	T_A = 25°C	V_{CC}/2			V
		FCS-xxxUR		V_{CC}/10			
Output voltage Range @I_P	V_{OUT}-V_{QVO}	FCS-xxxBR		±2			
		FCS-xxxUR		4			
Output Load Resistance	R_L	V_{OUT} to V_{CC} or GND		5			KΩ
Output Load Capacitance	C_L	V_{OUT} TO GND				10	nF
Response Time	$t_{RESPONSE}$	T_A=25°C, C_L=1nF, I_P step=50% of I_{P+}, 90% input to 90% output			0.7		μs
Response Time	BW	Small signal –3dB, C_L=1nF, T_A=25°C			0.7	1	MHz
DC Output Impedance	R_{OUT}	T_A = 25°C				20	KΩ

ISOLATION CHARACTERISTICS

Characteristic	Symbol	Notes	Rating	Unit
Dielectric Strength Test Voltage*1	VISO	Agency type-tested for 60 seconds per UL standard 60950-1, 2nd Edition	3600	VAC
Working Voltage for Basic Isolation	V_{WVBI}	For basic (single) isolation per UL standard 60950-1, 2nd Edition	870	VDC or V_{pk}
			616	V_{rms}
Electrical distance	D_{CL}	Min distance from IP pin to signal pin(air)	7.5	mm
Creepage distance	D_{CR}	Min distance from IP pin to signal pin (molded body)	7.5	mm

*1: 60-second test is only for UL test; Tested in production against UL60950-1 2nd Edition.

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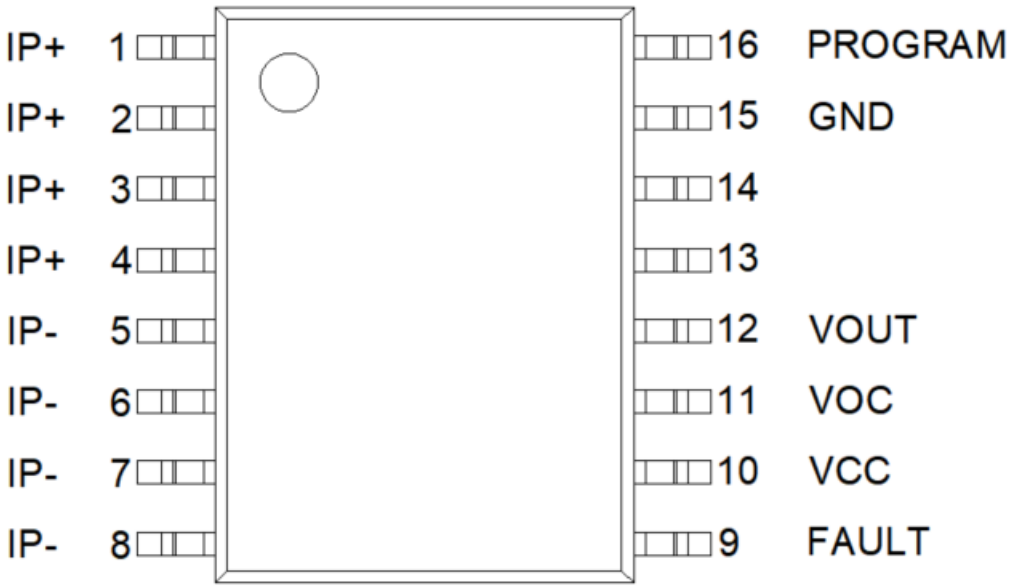
Pin diagram



Pin number	name	description
1, 2, 3, 4	IP+	The positive terminal of the sensed current (in)
5, 6, 7, 8	IP-	Negative terminal of the sensed current (out)
9	FAULT	Overcurrent fault output
10	VCC	Device power supply terminal
11	VOC	Overcurrent fault threshold set pin
12	VOUT	Analog output
13,14		empty
15	GND	Device ground terminal
16	PROGRAM	Factory calibrated feet (ground recommended)

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Overcurrent fault characteristics

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
FAULT Response Time	$t_{RESPONSE(F)}$	the time from Ip>I_{FAULT} to FAULT the foot is pulled below V_{FAULT}; The input current is stepped from 0 to 1.2xI_{FAULT}		1	1.5	μs
FAULT Range [3]	I_{FAULT}	Relative to I_{PR} full-scale； Setable via VOC pin	0.5*I_{PR}	–	2*I_{PR}	A
FAULT Output Low Voltage	V_{FAULT}	In fault condition; RF(PULLUP) = 5 kΩ	–	0.07	0.4	V
FAULT Pull-Up Resistance	$RF_{(PULLUP)}=R_{PU}$		1	–	200	kΩ
FAULT Leakage Current	$IFAULT_{(LEAKAGE)}$		–	±5	–	uA
FAULT Hysteresis[1]	I_{HYST}	Vcc=5V	–	6	–	%FS
		Vcc=3.3V		9		
FAULT Error[2]	EFAULT	Tested at V_{VOC}=0.2×Vcc (I_{FAULT} threshold=100%×I_{PR})	-	±5	-	%
VOC Input Range	V_{VOC}		0.1xVcc	–	0.4xVcc	V
		Vcc=5V	0.5		2	
		Vcc=3.3V	0.33		1.32	
VOC Input Current	I_{VOC}		–	10	100	nA

[1] After Vout is higher than Vout (FAULT), Voutmust be below Vout(FAULT)-VoutHYST, The internal comparator is then reset.

[2] A fault error is defined as the value at which a fault is reported relative to the desired threshold of Vout(FAULT).

[3]

Vvoc(V)			Fault Operation Point %FS
	Vcc=3.3V	Vcc=5V	
0.1xVcc	0.33	0.5	50%
0.15xVcc	0.466	0.75	75%
0.2xVcc	0.661	1	100%
V0.25xVcc	0.826	1.25	125%
0.3xVcc	0.991	1.5	150%
0.35xVcc	1.156	1.75	175%
0.4xVcc	1.321	2	200%

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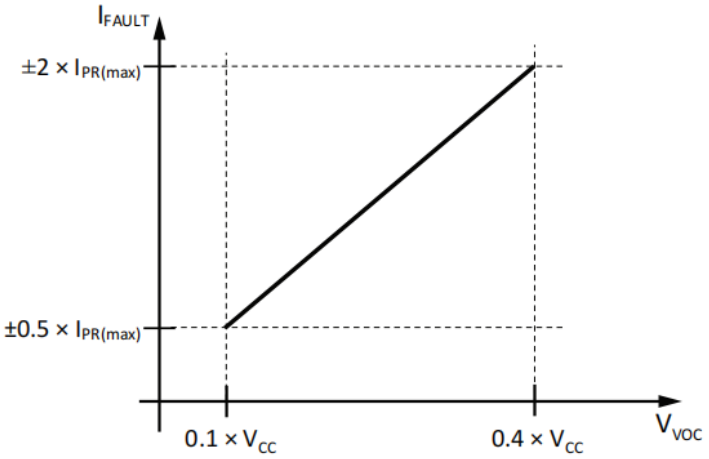
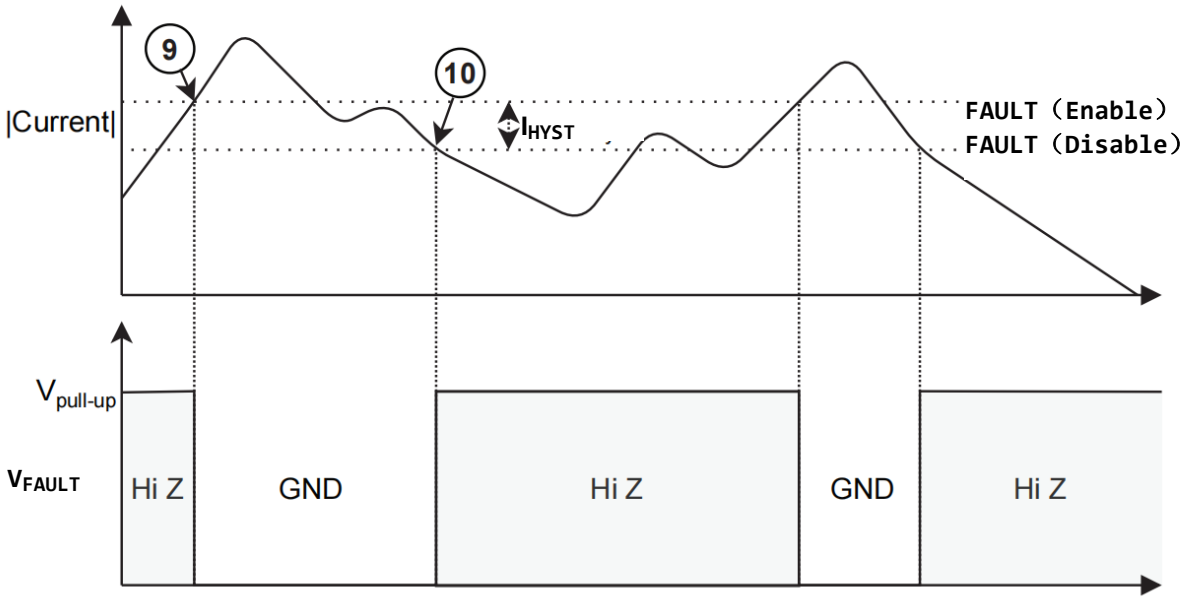
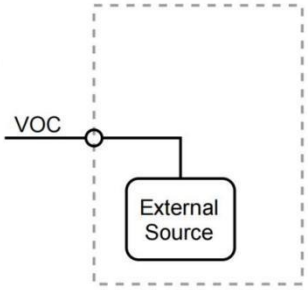


Figure 4: Fault Threshold vs. V_{VOC}



[4] VOCs can be connected to an external voltage source



FCS series Current Sensor Ic

*020BR Performance Characteristics

Dc operating parameters at VCC = 5.0V, T_A=-40°C ~125°C,unless otherwise specified

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal Performance						
Current Sensing Range	I_P		-20		20	A
Sensitivity	$Sens_{TA}$	@V_{CC}=5.0V		100		mV/A
Zero current output voltage	V_{QVO}	Ip=0A		Vcc/2		V
Accuracy Performance						
Sensitivity Error	E_{Sens}	@T_A=25°C;V_{CC}=5.0V	-1		1	%
Zero offset voltage	V_{OE}	I_P=0A, T_A=25°C	-10	±5	10	mV
		I_P=0A, T_A=-40°C ~125°C	-30	±15	30	mV
Linearity Error	Lin_{ERR}	Of full rang	-1	0.5	1	%
Total Output Error	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~125°C	-2		2	%
	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~85°C	-1.5		1.5	%
	$E_{TOT(LT)}$	Full scale of I_P, T_A=-40°C~25°C		±3		%

*020URPerformance Characteristics

Dc operating parameters at VCC = 5.0V, T_A=-40°C ~125°C,unless otherwise specified

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal Performance						
Current Sensing Range	I_P		0		20	A
Sensitivity	$Sens_{TA}$	@V_{CC}=5.0V		200		mV/A
Zero current output voltage	V_{QVO}	Ip=0A		Vcc/10		V
Accuracy Performance						
Sensitivity Error	E_{Sens}	@T_A=25°C;V_{CC}=5.0V	-1		1	%
Zero offset voltage	V_{OE}	I_P=0A, T_A=25°C	-10	±5	10	mV
		I_P=0A, T_A=-40°C ~125°C	-30	±15	30	mV
Linearity Error	Lin_{ERR}	Of full rang	-1	0.5	1	%
Total Output Error	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~125°C	-2		2	%
	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~85°C	-1.5		1.5	%
	$E_{TOT(LT)}$	Full scale of I_P, T_A=-40°C~25°C		±3		%

FCS series Current Sensor Ic

*040BR Performance Characteristics

Dc operating parameters at VCC = 5.0V, T_A=-40°C ~125°C,unless otherwise specified

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal Performance						
Current Sensing Range	I_P		-40		40	A
Sensitivity	$Sens_{TA}$	@V_{CC}=5.0V		50		mV/A
Zero current output voltage	V_{QVO}	Ip=0A		Vcc/2		V
Accuracy Performance						
Sensitivity Error	E_{Sens}	@T_A=25°C;V_{CC}=5.0V	-1		1	%
Zero offset voltage	V_{OE}	I_P=0A, T_A=25°C	-10	±5	10	mV
		I_P=0A, T_A=-40°C ~125°C	-30	±15	30	mV
Linearity Error	Lin_{ERR}	Of full rang	-1	0.5	1	%
Total Output Error	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~125°C	-2		2	%
	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~85°C	-1.5		1.5	%
	$E_{TOT(LT)}$	Full scale of I_P, T_A=-40°C~25°C		±3		%

*040UR Performance Characteristics

Dc operating parameters at VCC = 5.0V, T_A=-40°C ~125°C,unless otherwise specified

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal Performance						
Current Sensing Range	I_P		0		40	A
Sensitivity	$Sens_{TA}$	@V_{CC}=5.0V		100		mV/A
Zero current output voltage	V_{QVO}	Ip=0A		Vcc/10		V
Accuracy Performance						
Sensitivity Error	E_{Sens}	@T_A=25°C;V_{CC}=5.0V	-1		1	%
Zero offset voltage	V_{OE}	I_P=0A, T_A=25°C	-10	±5	10	mV
		I_P=0A, T_A=-40°C ~125°C	-30	±15	30	mV
Linearity Error	Lin_{ERR}	Of full rang	-1	0.5	1	%
Total Output Error	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~125°C	-2		2	%
	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~85°C	-1.5		1.5	%
	$E_{TOT(LT)}$	Full scale of I_P, T_A=-40°C~25°C		±3		%

FCS series Current Sensor Ic

*065BR Performance Characteristics

Dc operating parameters at VCC = 5.0V, T_A=-40°C ~125°C,unless otherwise specified

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal Performance						
Current Sensing Range	I_P		-65		65	A
Sensitivity	$Sens_{TA}$	@V_{CC}=5.0V		30.8		mV/A
Zero current output voltage	V_{QVO}	Ip=0A		Vcc/2		V
Accuracy Performance						
Sensitivity Error	E_{Sens}	@T_A=25°C;V_{CC}=5.0V	-1		1	%
Zero offset voltage	V_{OE}	I_P=0A, T_A=25°C	-10	±5	10	mV
		I_P=0A, T_A=-40°C ~125°C	-30	±15	30	mV
Linearity Error	Lin_{ERR}	Of full rang	-1	0.5	1	%
Total Output Error	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~125°C	-2		2	%
	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~85°C	-1.5		1.5	%
	$E_{TOT(LT)}$	Full scale of I_P, T_A=-40°C~25°C		±3		%

*065UR Performance Characteristics

Dc operating parameters at VCC = 5.0V, T_A=-40°C ~125°C,unless otherwise specified

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal Performance						
Current Sensing Range	I_P		0		65	A
Sensitivity	$Sens_{TA}$	@V_{CC}=5.0V		61.5		mV/A
Zero current output voltage	V_{QVO}	Ip=0A		Vcc/10		V
Accuracy Performance						
Sensitivity Error	E_{Sens}	@T_A=25°C;V_{CC}=5.0V	-1		1	%
Zero offset voltage	V_{OE}	I_P=0A, T_A=25°C	-10	±5	10	mV
		I_P=0A, T_A=-40°C ~125°C	-30	±15	30	mV
Linearity Error	Lin_{ERR}	Of full rang	-1	0.5	1	%
Total Output Error	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~125°C	-2		2	%
	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~85°C	-1.5		1.5	%
	$E_{TOT(LT)}$	Full scale of I_P, T_A=-40°C~25°C		±3		%

FCS series Current Sensor Ic

*075BR Performance Characteristics

Dc operating parameters at VCC = 5.0V, T_A=-40°C ~125°C,unless otherwise specified

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal Performance						
Current Sensing Range	I_P		-75		75	A
Sensitivity	$Sens_{TA}$	@V_{CC}=5V		26.7		mV/A
Zero current output voltage	V_{QVO}	Ip=0A		Vcc/2		V
Accuracy Performance						
Sensitivity Error	E_{Sens}	@T_A=25°C;V_{CC}=5V	-1		1	%
Zero offset voltage	V_{OE}	I_P=0A, T_A=25°C	-10	±5	10	mV
		I_P=0A, T_A=-40°C ~125°C	-30	±15	30	mV
Linearity Error	Lin_{ERR}	Of full rang	-1	0.5	1	%
Total Output Error	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~125°C	-2		2	%
	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~85°C	-1.5		1.5	%
	$E_{TOT(LT)}$	Full scale of I_P, T_A=-40°C~25°C		±3		%

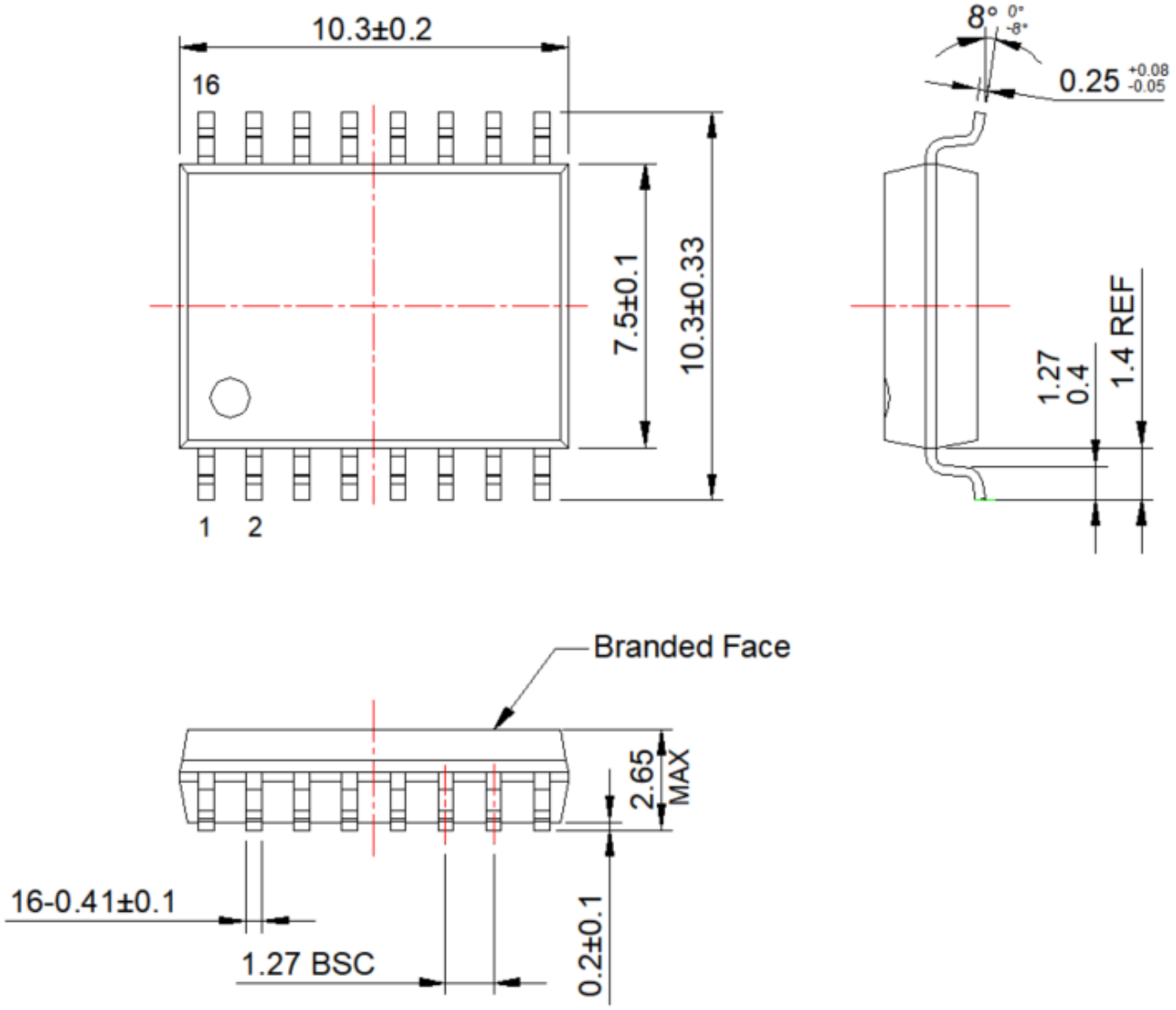
*075UR Performance Characteristics

Dc operating parameters at VCC = 5.0V, T_A=-40°C ~125°C,unless otherwise specified

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Nominal Performance						
Current Sensing Range	I_P		0		75	A
Sensitivity	$Sens_{TA}$	@V_{CC}=5V		53.3		mV/A
Zero current output voltage	V_{QVO}	Ip=0A		Vcc/10		V
Accuracy Performance						
Sensitivity Error	E_{Sens}	@T_A=25°C;V_{CC}=5V	-1		1	%
Zero offset voltage	V_{OE}	I_P=0A, T_A=25°C	-10	±5	10	mV
		I_P=0A, T_A=-40°C ~125°C	-30	±15	30	mV
Linearity Error	Lin_{ERR}	Of full rang	-1	0.5	1	%
Total Output Error	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~125°C	-2		2	%
	$E_{TOT(HT)}$	Full scale of I_P, T_A=25°C~85°C	-1.5		1.5	%
	$E_{TOT(LT)}$	Full scale of I_P, T_A=-40°C~25°C		±3		%

FCS series Current Sensor Ic

Package size drawing



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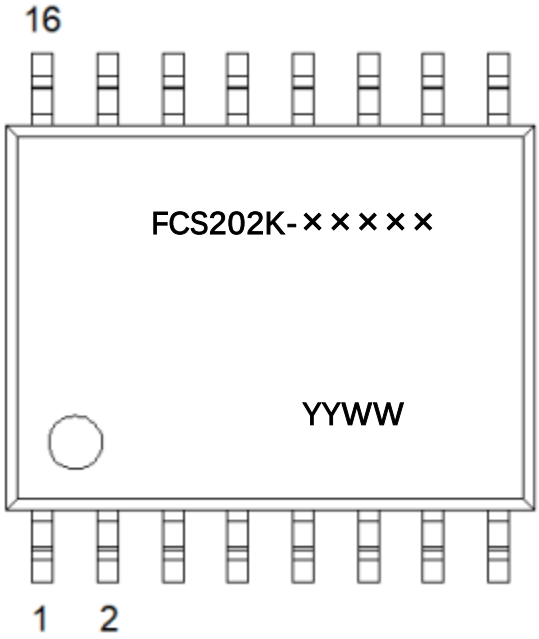
Marking drawings



XXXXX represents a specific model
YY represents the year
WW represents the month

FCS series Current Sensor Ic

Performances Parameters Definitions:

- **Quiescent Voltage Output (QVO)**

In the quiescent state (no significant magnetic field, B=0G), Current Sensor Output Voltage V_{QVO}

-xR: V_{QVO} has a constant ratio to the supply voltage;

$$V_{QVO} = V_{CC}/2 \text{ or } V_{QVO} = V_{CC}/10$$

- **Sensitivity(Sens)**

Sens is the slope of the reference output line ; $V_{OUT} = V_{QVO} + 2 \times I_P / I_{P\_MAX}$ which refers to the following, the change of current, the change of output, its relationship with current is : $\mathbf{Sens} = 2/I_{P\_MAX}$

- **Offset with Temperature**

Due to internal component tolerances and thermal considerations, the Quiescent Voltage Output (QVO) may drift from its nominal value through the operating ambient temperature (TA).

- **Sensitivity with temperature**

Due to the influence of internal temperature compensation coefficient, the sensitivity will change through the whole working temperature, and be different from the expected value at room temperature.

- **offset voltage**

The zero offset voltage is the output voltage when the primary current is zero, with ideal value: $V_{QVO} = V_{CC}/2$ (or Vcc/10)。Therefore, the difference between V_{QVO} and the ideal value is called the total zero offset voltage error. This offset error can be attributed to the zero electrical offset voltage (due to the resolution of the ASIC's internal QVO adjustment), temperature drift.

- **Response Time**

The response time of the sensor refers to when the applied current reaches the final 90% input to the sensor The time interval between outgoing and the corresponding value of the applied current.

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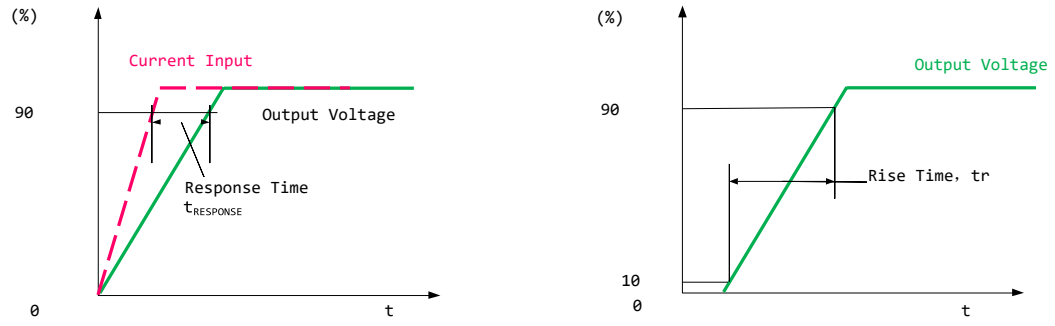
- **Rise time**

The time between when the sensor output reaches 10% of its final value, and when it reaches 90% of its final value.



- **QVO Ratiometricity error**

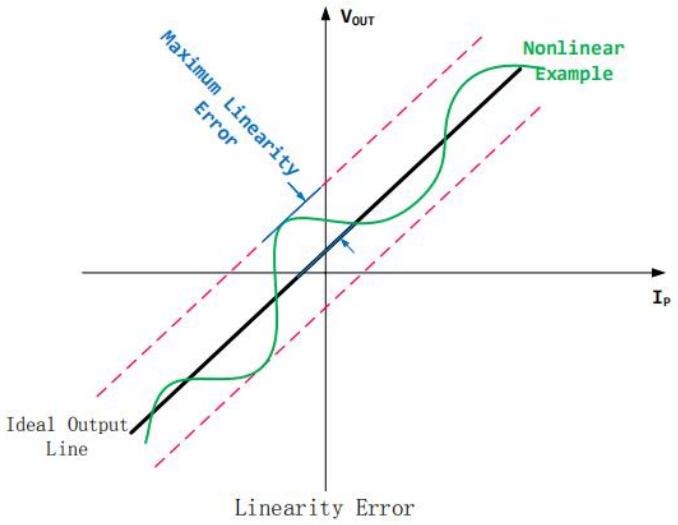
When the supply voltage VCC changes from 5.0V to 4.75<VCC1<5.25V , the deviation between the sensor zero output and the theoretical value, the formula is defined as follows:

$$Er = V_{QVO(Vcc1)} - V_{QVO(5V)} \times (Vcc1/5)$$

- **Linearity**

The maximum Positive and Negative error comparing with ideal output line.

(-BR mode: $Vout = {}^{Vcc}/_{2} + 2 \times {}^{Ip}/_{P(MAX)}$),



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- **Total Output Error E_{TOT}**

Error between the device measurement current and Applied current (I_P), which is defined as the difference between the ideal output voltage and the actual output voltage divided by the ideal sensitivity:

$$E_{TOT(I_P)} = \frac{V_{I_{OUT(I_P)}} - V_{I_{OUT(ideal)(I_P)}}}{Sens_{(ideal)} \times I_P}$$

$$V_{I_{OUT(ideal)(I_P)}} = V_{I_{OUT(Q)}} + (Sens_{(ideal)} \times I_P)$$

At relatively high currents, E_{TOT} is mainly due to sensitivity errors; while at relatively low currents, E_{TOT} is mainly due to offset voltage errors (V_{OE}).

Actually, when the I_P approaches zero, the E_{TOT} approaches infinity due to offset voltage error.

Notes:

1. Wrong wiring may cause sensor damage. After the sensor is connected to the 5V power supply, the measured current passes through the direction of the sensor current terminal, and the corresponding voltage value can be measured at the output end.
2. -BR mode:

   $V_{OUT} = {}^{V_{CC}}/_{2} + 2 \times {}^{I_P}/_{I_{P(MAX)}}$,

   Supply voltage change will cause V_{OUT} change by ratio.

   For example: V_{CC} range:4.75V~5.25V:

   V_{QVO} output range at 0A: 2.375V~2.6255V.

   $V_{OUT(IPMAX)}$ output range at Ipmax: 4.275V~4.725V.

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Version history:

Version number	Date of change	remark
V1	2023/03/20	first edition
V1.2	2023/07/06	Fixed some parameters
V1.3	2023/08/09	Add marking information