# CH704

## AEC-Q100 Qualified, 200A Hall Current Sensor IC with 4800$V_{RMS}$ Reinforced Isolation

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## Features

- Reinforced isolation: **4800$V_{RMS}$**
- AEC-Q100 qualified (CH704A)
- Single supply: **4.5-5.5V**
- Output voltage proportional to AC current: **+/-50A, +/-100A, +/-150A, +/-200A**
- Bandwidth: **180 kHz**
- Response time: **< 2μs**
- Wide temperature range: **-40ºC to 150ºC**
- High resolution offset and sensitivity trimming with EEPROM
- Primary conductor resistance: **0.1 mΩ**
- Integrated protections
    - Under-voltage protection
    - Output voltage clamp provides short circuit diagnostic
    - Output spiking suppress during fast current step inputs
- Factory programmed sensitivity and quiescent output voltage TC
- Integrated digital temperature compensation circuitry
- Nearly zero magnetic hysteresis
- Ratio-metric output from supply voltage
- Immunity to external magnetic field

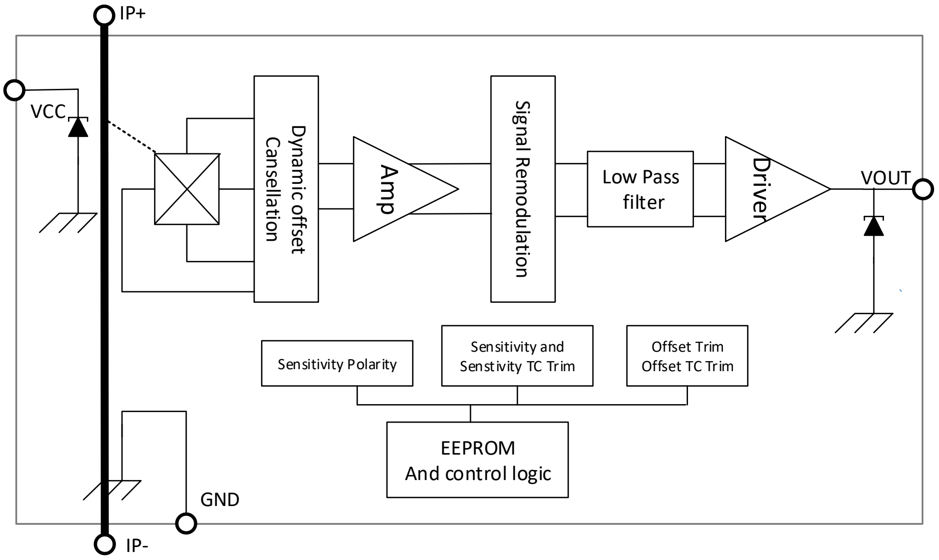
## Package

5-PIN CFF

## Application

- UPS current sensing
- DC-to-DC converter control
- Balance bike motor control
- Overcurrent fault detection

## Functional Block Diagram



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## Description

The device consists of a precise, low-offset, linear Hall sensor circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field which is sensed by the integrated Hall IC and converted into a proportional voltage. A precise, proportional voltage is provided by the low-offset, chopper-stabilized Hall IC, which is programmed for accuracy after packaging. The output of the device has a positive slope when an increasing current flow through the primary copper conduction path, which is the path used for current sensing.

The terminals of the conductive path are electrically isolated from the sensor leads. This allows the CH704 current sensor IC to be used in high-side current sense applications without the use of high-side differential amplifiers or other costly isolation techniques.

The lead-frame is plated with 100% matte tin, which is compatible with standard lead (Pb) free printed circuit board assembly processes. Internally, the device is Pb-free, except for flip-chip high-temperature Pb-based solder balls, currently exempt from RoHS. The device is fully calibrated prior to shipment from the factory.

## Revision History

| Date | Revision | Change |
|---|---|---|
| 10 Oct 2021 | 1.0 | First Released. |
| 29 Dec 2021 | 1.1 | Updated the isolation parameters. |
| 3 March 2022 | 1.2 | Updated bandwidth and packing information |

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# Table of Contents

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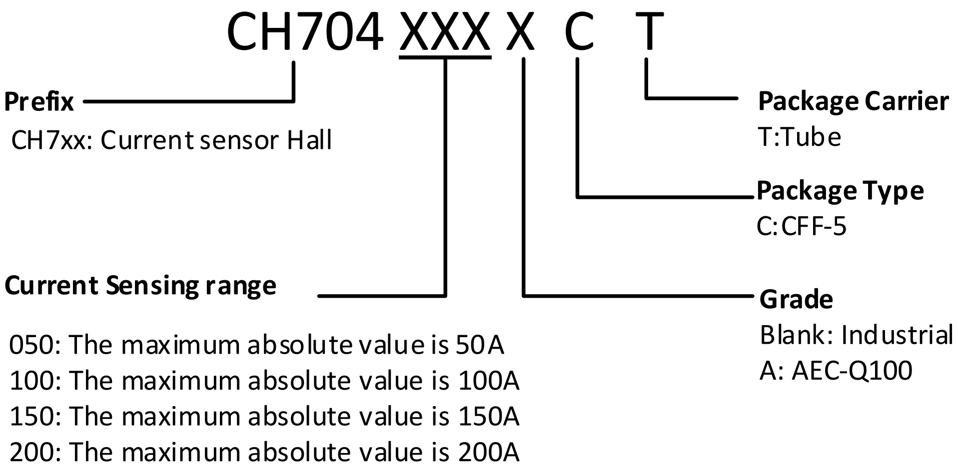
# 1 Product Family Members



**Prefix**
CH7xx: Current sensor Hall

**Current Sensing range**
050: The maximum absolute value is 50A
100: The maximum absolute value is 100A
150: The maximum absolute value is 150A
200: The maximum absolute value is 200A

**Grade**
Blank: Industrial
A: AEC-Q100

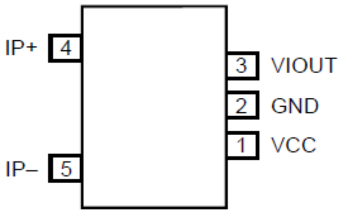
**Package Type**
C:CFF-5

**Package Carrier**
T:Tube

| Part Number | $I_{PR}$ (A) | Sens(Typ) at $V_{CC}$ = 5 V (mV/A) | $T_A$ (°C) | Packing |
|---|---|---|---|---|
| **CH704050CT** | ±50 | 40 | -40 to 125 | 30 pieces per tube |
| **CH704100CT** | ±100 | 20 | | |
| **CH704150CT** | ±150 | 13.3 | | |
| **CH704200CT** | ±200 | 10 | | |
| **CH704050ACT** | ±50 | 40 | -40 to 150 | 30 pieces per tube |
| **CH704100ACT** | ±100 | 20 | | |
| **CH704150ACT** | ±150 | 13.3 | | |
| **CH704200ACT** | ±200 | 10 | | |

# 2 Pin Definitions and Descriptions

| Number | Name | Function |
|---|---|---|
| **5** | IP– | Terminals for current being sensed; fused internally |
| **4** | IP+ | Terminals for current being sensed; fused internally |
| **3** | VIOUT | Analog output signal |
| **2** | GND | Signal ground terminal |
| **1** | VCC | Device power supply terminal |



**Pinout Diagram**

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# 3 Absolute Maximum Ratings

| Parameter | Symbol | Min | Max | Units |
|---|---|---|---|---|
| **Supply Voltage** | $V_{CC}$ | - | 6 | V |
| **Reverse Supply Voltage** | $V_{RCC}$ | -0.1 | - | V |
| **Output Voltage** | $V_{IOUT}$ | - | 6 | V |
| **Reverse Output Voltage** | $V_{RIOUT}$ | -0.1 | - | V |
| **Output Source Current** | Iout(source) | | 2 | mA |
| **Output Sink Current** | Iout(sink) | | 10 | mA |
| **Operating Ambient Temperature** | $T_A$ | -40 | 150 | °C |
| **Storage Temperature** | $T_S$ | -65 | 165 | °C |
| **Junction temperature** | $T_{J(max)}$ | | 165 | °C |

Note 1: Exceeding the absolute maximum ratings may cause permanent damage. Exposure to absolute-maximum- rated conditions for extended periods may affect device reliability.

## Isolation Characteristics

| Characteristic | Symbol | Notes | Rating | Unit |
|---|---|---|---|---|
| **Dielectric Strength Test Voltage** | $V_{ISO}$ | Agency type-tested for 60 seconds per UL standard 60950-1 (edition 2); production-tested at V_ISO for 1 second, in accordance with UL 60950-1 (edition 2). | 4800 | $V_{RMS}$ |
| **Dielectric Surge Strength Test Voltage VSURGE** | $V_{SURGE}$ | Tested ±5 pulses at 2/minute in compliance to IEC 61000-4-5<br>1.2 µs (rise) / 50 µs (width) | 8000 | VAC |
| **Working Voltage for Basic Isolation** | $V_{WVBI}$ | For basic (single) isolation per UL 60950-1 (edition 2) | 1187 | $V_{pk}$ or VDC |
| | | | 840 | $V_{rms}$ |
| **Working Voltage for Reinforced Isolation** | $V_{WVRI}$ | For reinforced (double) isolation per UL 60950-1 (edition 2) | 672 | $V_{pk}$ or VDC |
| | | | 475 | $V_{rms}$ |

## Thermal Characteristics

| Characteristic | Symbol | Test Conditions* | Value | Units |
|---|---|---|---|---|
| **Package Thermal Resistance (Junction to Ambient)** | $R_{\theta JA}$ | Mounted on the evaluation board with 2800 mm2 (1400 mm2 on component side and 1400 mm2 on opposite side) of 4 oz. copper connected to the primary leadframe and with thermal vias connecting the copper layers. Performance is based on current flowing through the primary leadframe and includes the power consumed by the PCB. | 7 | ºC/W |
| **Package Thermal Resistance (Junction to Lead)** | $R_{\theta JL}$ | | 3 | ºC/W |

# 4 ESD Protections

| Parameter | Value | Unit |
|---|---|---|
| All pins 1) | ±6000 | V |
| All pins 2) | ±200 | V |
| All pins 3) | ±750 | V |

1) HBM (human body mode, 100pF, 1.5 kΩ ) according to MIL-STD-883H Method 3015.8
2) MM (Machine Mode C=200pF, R=0Ω) according to JEDEC EIA/JESD22-A115
3) CDM (charged device mode) according to JEDEC EIA/JESD22-C101F

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# 5 Typical Overcurrent Capabilities

| Characteristic | Symbol | Notes | Value | Unit |
|---|---|---|---|---|
| Overcurrent | $I_{POC}$ | TA=25ºC, 1 Second duration, 1% duty cycle | 1200 | A |
| | | TA=85ºC, 1 Second duration, 1% duty cycle | 900 | A |
| | | TA=150ºC, 1 Second duration, 1% duty cycle | 600 | A |

# 6 Electrical Characteristics[1]:

## Common operating characteristics:

**Valid through the full range of $T_A$, VCC = 5 V, $C_{BYP}$ = 0.1uF, unless otherwise specified**

| Characteristic | Symbol | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Supply Voltage | $V_{CC}$ | | 4.5 | 5 | 5.5 | V |
| Supply Current | $I_{CC}$ | $V_{CC}$ = 5 V, output open | – | 7 | 10 | mA |
| Supply Zener Clamp Voltage | $V_z$ | $T_A$ = 25°C, $I_{CC}$ = 30mA | 5.7 | 6.4 | – | V |
| Power-On Time | $t_{po}$ | Output reaches 90% of steady-state level, $T_A$ = 25°C, $I_P$ = $I_{PR}$(max) applied | – | 30 | – | μs |
| Under voltage Threshold | $V_{UVLOHI}$ | $T_A$ = 25°C, $V_{CC}$ rising | 2.8 | 2.9 | 3 | V |
| | $V_{UVLOLOW}$ | $T_A$ = 25°C, $V_{CC}$ falling | 2.5 | 2.6 | 2.7 | V |
| Rise Time | $t_r$ | $I_P$ = $I_P$(max), $T_A$ = 25°C, $C_L$ = 1 nF | – | 3.6 | – | μs |
| Propagation Delay | tpd | $I_P$ = $I_P$(max), $T_A$ = 25°C, $C_L$ = 1 nF | – | 2.2 | – | μs |
| Response Time | tRESPONSE | $I_P$ = $I_P$(max), $T_A$ = 25°C, $C_L$ = 1 nF | – | 3.6 | – | μs |
| Bandwidth | BW | Small signal –3 dB; $C_L$ = 1 nF | – | 180 | – | kHz |
| Output Capacitance Load | $C_L$ | VIOUT to GND | – | – | 10 | nF |
| Output Resistive Load | $R_L$ | VIOUT to GND | 4.7 | – | – | kΩ |
| Primary Conductor Resistance | $R_{IP}$ | $T_A$ = 25°C | – | 0.1 | – | mΩ |
| Quiescent Ouput voltage | $V_{IOUT(QBI)}$ | Ip=0, $T_A$=25ºC | | Vcc/2 | | |
| Ratiometry | $V_{RAT}$ | Vcc=4.5 to 5.5V | | 100 | | % |
| Hall Coupling Factor | G | $T_A$ = 25ºC | – | 11 | – | G/A |
| Hall Plate Sensitivity Matching | $Sens_{match}$ | $T_A$ = 25ºC | – | ±1 | – | % |
| Noise Density | IND | Input-referenced noise density; $T_A$ = 25°C, $C_L$ = 1 nF | – | 150 | – | $\mu A_{(rms)}$/ √Hz |
| Noise | IN | Input-referenced noise: $C_F$ = 4.7 nF, $C_L$ = 1 nF, BW = 18 kHz, $T_A$ = 25°C | – | 20 | – | $mA_{(rms)}$ |
| Nonlinearity | ELIN | Through full range of $I_P$ | –1.5 | – | +1.5 | % |
| Sensitivity Ratiometry Coefficient | SENS_RAT_COEF | $V_{CC}$ = 4.5 to 5.5 V, $T_A$ = 25ºC | – | 1.3 | – | – |
| Zero-Current Output Ratiometry Coefficient | QVO_RAT_COEF | $V_{CC}$ = 4.5 to 5.5 V, $T_A$ = 25ºC | – | 1 | – | – |
| Saturation Voltage[3] | VOH | $R_L$ = 4.7 kΩ | – | $V_{CC}$ – 0.3 | – | V |
| | VOL | $R_L$ = 4.7 kΩ | – | 0.3 | – | V |

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## CH704050 Performance Characteristics:

**Valid at $T_A$ = –40°C to 150°C, unless otherwise specified**

| Characteristic | Symbol | Test Conditions | Min. | Typ.[1] | Max. | Unit |
|---|---|---|---|---|---|---|
| **Nominal Performance** | | | | | | |
| Current-Sensing Range | $I_{PR}$ | | -50 | – | 50 | A |
| Sensitivity | Sens | $I_{PR(min)} < I_P < I_{PR(max)}$ | – | 40 | – | mV/A |
| Noise | $V_{NOISE}$ | $T_A$ = 25°C, 10nF on VIOUT pin to GND | | 10 | | mV |
| Nonlinearity | $E_{LIN}$ | Measured using full-scale and half-scale Ip | -1 | | 1 | % |
| **Accuracy Performance** | | | | | | |
| Total Output Error[2] | $E_{TOT}$ | $I_P = I_{PR(max)}$, $T_A$ = 25°C to 150ºC | –2 | ±1.5 | 2 | % |
| | | $I_P = I_{PR(max)}$, $T_A$ = –40°C to 25ºC | –3 | ±2 | 3 | % |
| **Total Output Error Components[3] $E_{TOT} = E_{SENS} + 100 \times V_{OE}/(Sens \times I_P)$** | | | | | | |
| Magnetic Offset Error | $I_{ERRM}$ | Ip=0, $T_A$ = 25°C, after excursion 50A | | 100 | 250 | mA |
| Offset Voltage | $V_{OE}$ | $I_P$ = 0 A, $T_A$ = 25°C to 150ºC | –10 | ±3 | 10 | mV |
| | | $I_P$ = 0 A, $T_A$ = –40°C to 25ºC | –20 | ±5 | 20 | mV |
| **Lifetime Drift Characteristics** | | | | | | |
| Sensitivity Error Lifetime Drift | $E_{sens\_drift}$ | | –0.8 | ±0.2 | 0.8 | % |
| Offset voltage Drift Over Lifetime | $\Delta V_{OE}$ | AEC-Q100 Grade 0 | -5 | 1.5 | 5 | mV |
| Total Output Error Lifetime Drift | $E_{tot\_drift}$ | | –2 | ±0.5 | 2 | % |

[1] Typical values with +/- are 3 sigma values

[2] Percentage of $I_P$ , with $I_P = I_{PR(max)}$.

[3] A single part will not have both the maximum/minimum sensitivity error and maximum/minimum offset voltage, as that would violate the maximum/minimum total output error specification. Also, 3 sigma distribution values are combined by taking the square root of the sum of the squares. See Application Information section.

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# CH704100 Performance Characteristics:

**Valid at $T_A$ = –40°C to 150°C, unless otherwise specified**

| Characteristic | Symbol | Test Conditions | Min. | Typ.[4] | Max. | Unit |
|---|---|---|---|---|---|---|
| **Nominal Performance** | | | | | | |
| Current-Sensing Range | $I_{PR}$ | | -100 | – | 100 | A |
| Sensitivity | Sens | $I_{PR(min)} < I_P < I_{PR(max)}$ | – | 20 | – | mV/A |
| Noise | $V_{NOISE}$ | $T_A$ = 25°C, 10nF on VIOUT pin to GND | | 6 | | mV |
| Nonlinearity | $E_{LIN}$ | Measured using full-scale and half-scale Ip | -1 | | 1 | % |
| **Accuracy Performance** | | | | | | |
| Total Output Error[5] | $E_{TOT}$ | $I_P = I_{PR(max)}$, $T_A$ = 25°C to 150ºC | –2 | ±1.5 | 2 | % |
| | | $I_P = I_{PR(max)}$, $T_A$ = –40°C to 25ºC | –3 | ±2 | 3 | % |
| **Total Output Error Components[6] $E_{TOT} = E_{SENS} + 100 \times V_{OE}/(Sens \times I_P)$** | | | | | | |
| Magnetic Offset Error | $I_{ERRM}$ | Ip=0, $T_A$ = 25°C, after excursion 50A | | 120 | 300 | mA |
| Offset Voltage | $V_{OE}$ | $I_P$ = 0 A, $T_A$ = 25°C to 150ºC | –10 | ±3 | 10 | mV |
| | | $I_P$ = 0 A, $T_A$ = –40°C to 25ºC | –20 | ±5 | 20 | mV |
| **Lifetime Drift Characteristics** | | | | | | |
| Sensitivity Error Lifetime Drift | $E_{sens\_drift}$ | | –0.5 | ±0.15 | 0.5 | % |
| Offset voltage Drift Over Lifetime | $\Delta V_{OE}$ | AEC-Q100 Grade 0 | -5 | 1.5 | 5 | mV |
| Total Output Error Lifetime Drift | $E_{tot\_drift}$ | | –2 | ±0.5 | 2 | % |

1 Typical values with +/- are 3 sigma values
2 Percentage of $I_P$ , with $I_P = I_{PR(max)}$.
3 A single part will not have both the maximum/minimum sensitivity error and maximum/minimum offset voltage, as that would violate the maximum/minimum total output error specification. Also, 3 sigma distribution values are combined by taking the square root of the sum of the squares. See Application Information section.

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## CH704150 Performance Characteristics:

**Valid at $T_A$ = –40°C to 150°C, unless otherwise specified**

| Characteristic | Symbol | Test Conditions | Min. | Typ.[7] | Max. | Unit |
|---|---|---|---|---|---|---|
| **Nominal Performance** | | | | | | |
| Current-Sensing Range | $I_{PR}$ | | -150 | – | 150 | A |
| Sensitivity | Sens | $I_{PR(min)} < I_P < I_{PR(max)}$ | – | 13.33 | – | mV/A |
| Noise | $V_{NOISE}$ | $T_A$ = 25°C, 10nF on VIOUT pin to GND | | 4 | | mV |
| Nonlinearity | $E_{LIN}$ | Measured using full-scale and half-scale Ip | -1 | | 1 | % |
| **Accuracy Performance** | | | | | | |
| Total Output Error[8] | $E_{TOT}$ | $I_P = I_{PR(max)}$, $T_A$ = 25°C to 150ºC | –2 | ±1.5 | 2 | % |
| | | $I_P = I_{PR(max)}$, $T_A$ = –40°C to 25ºC | –3 | ±2 | 3 | % |
| **Total Output Error Components[9] $E_{TOT} = E_{SENS} + 100 \times V_{OE}/(Sens \times I_P)$** | | | | | | |
| Magnetic Offset Error | $I_{ERRM}$ | Ip=0, $T_A$ = 25°C, after excursion 50A | | 120 | 300 | mA |
| Offset Voltage | $V_{OE}$ | $I_P$ = 0 A, $T_A$ = 25°C to 150ºC | –10 | ±3 | 10 | mV |
| | | $I_P$ = 0 A, $T_A$ = –40°C to 25ºC | –20 | ±5 | 20 | mV |
| **Lifetime Drift Characteristics** | | | | | | |
| Sensitivity Error Lifetime Drift | $E_{sens\_drift}$ | | 0.25 | ±0.1 | 0.25 | % |
| Offset voltage Drift Over Lifetime | $\Delta V_{OE}$ | AEC-Q100 Grade 0 | -5 | 1.5 | 5 | mV |
| Total Output Error Lifetime Drift | $E_{tot\_drift}$ | | –2 | ±0.5 | 2 | % |

[1] Typical values with +/- are 3 sigma values

[2] Percentage of $I_P$ , with $I_P = I_{PR(max)}$.

[3] A single part will not have both the maximum/minimum sensitivity error and maximum/minimum offset voltage, as that would violate the maximum/minimum total output
error specification. Also, 3 sigma distribution values are combined by taking the square root of the sum of the squares. See Application Information section.

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## CH704200 Performance Characteristics:

**Valid at $T_A$ = –40°C to 150°C, unless otherwise specified**

| Characteristic | Symbol | Test Conditions | Min. | Typ.[10] | Max. | Unit |
|---|---|---|---|---|---|---|
| **Nominal Performance** | | | | | | |
| Current-Sensing Range | $I_{PR}$ | | -200 | – | 200 | A |
| Sensitivity | Sens | $I_{PR(min)} < I_P < I_{PR(max)}$ | – | 10 | – | mV/A |
| Noise | $V_{NOISE}$ | $T_A$ = 25°C, 10nF on VIOUT pin to GND | | 3 | | mV |
| Nonlinearity | $E_{LIN}$ | Measured using full-scale and half-scale Ip | -1 | | 1 | % |
| **Accuracy Performance** | | | | | | |
| Total Output Error[11] | $E_{TOT}$ | $I_P = I_{PR(max)}$, $T_A$ = 25°C to 150ºC | –2 | ±1.5 | 2 | % |
| | | $I_P = I_{PR(max)}$, $T_A$ = –40°C to 25ºC | –3 | ±2 | 3 | % |
| **Total Output Error Components[12] $E_{TOT} = E_{SENS} + 100 \times V_{OE}/(Sens \times I_P)$** | | | | | | |
| Magnetic Offset Error | $I_{ERRM}$ | Ip=0, $T_A$ = 25°C, after excursion 50A | | 200 | 450 | mA |
| Offset Voltage | $V_{OE}$ | $I_P$ = 0 A, $T_A$ = 25°C to 150ºC | –10 | ±3 | 10 | mV |
| | | $I_P$ = 0 A, $T_A$ = –40°C to 25ºC | –20 | ±5 | 20 | mV |
| **Lifetime Drift Characteristics** | | | | | | |
| Sensitivity Error Lifetime Drift | $E_{sens\_drift}$ | | 0.25 | ±0.1 | 0.25 | % |
| Offset voltage Drift Over Lifetime | $\Delta V_{OE}$ | AEC-Q100 Grade 0 | -5 | 1.5 | 5 | mV |
| Total Output Error Lifetime Drift | $E_{tot\_drift}$ | | –2 | ±0.5 | 2 | % |

[1] Typical values with +/- are 3 sigma values

[2] Percentage of $I_P$, with $I_P = I_{PR(max)}$.

[3] A single part will not have both the maximum/minimum sensitivity error and maximum/minimum offset voltage, as that would violate the maximum/minimum total output error specification. Also, 3 sigma distribution values are combined by taking the square root of the sum of the squares. See Application Information section.

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# 7 Function Description

## 7.1 General Function

The CH704 is factory-programmed Hall-Effect Linear current sensor. The current flowing through the primary side current path induces a corresponding magnetic field measured by a build-in Hall plate. The magnetic flux through the Hall plate is proportional to the primary current. And the output signal amplified and filtered from Hall voltage induced is proportional the sensed current. The output signal also can be proportional to the supply voltage (ratio-metric behavior) as long as the analog output mode is selected.

The sensitivity and offset is factory-programmed into the EEPROM registers. And the temperature characteristics of sensitivity and offset of Hall plate will be compensated by the coefficients stored in the EEPROM memory. Then the output voltage signal will have a good linear and temperature characteristic with the sensed current.

# 8 Application Information

## 8.1 Estimating Total Error vs. Sensed Current

The Performance Characteristics tables give distribution (±3sigma) values for Total Error at $I_{PR(max)}$; however, one often wants to know what error to expect at a particular current. This can be estimated by using the distribution data for the components of Total Error, Sensitivity Error, and Offset Voltage. The ±3 sigma value for Total Error ($E_{TOT}$) as a function of the sensed current ($I_P$) is estimated as:

$$E_{TOT}(I_P) = \sqrt{{E_{SENS}}^2 + \left(\frac{100 \times V_{OE}}{Sens \times I_P}\right)^2}$$

Here, $E_{SENS}$ and $V_{OE}$ are the ±3 sigma values for those error terms. If there is an average sensitivity error or average offset voltage, then the average Total Error is estimated as:

$$E_{TOT_{AVG}}(I_P) = E_{SENS_{AVG}} + \frac{100 \times V_{OE_{AVG}}}{Sens \times I_P}$$

The resulting total error will be a sum of $E_{TOT}$ and $E_{TOT\_AVG}$.

## 8.2 Definitions of accuracy characteristics

**Sensitivity (Sens).** The change in sensor IC output in response to a 1 A change through the primary conductor. The sensitivity is the product of the magnetic circuit sensitivity (G/A) (1 G = 0.1 mT) and the linear IC amplifier gain (mV/G). The linear IC amplifier gain is programmed at the factory to optimize the sensitivity (mV/A) for the full-scale current of the device.

**Nonlinearity ($E_{LIN}$).** The nonlinearity is a measure of how linear the output of the sensor IC is over the full current measurement range. The nonlinearity is calculated as:

$$\mathrm{E}_{LIN} = \left\{1 - \left[\frac{V_{IOUT}\left(I_{PR(max)}\right) - V_{IOUT_{(Q)}}}{2 \times \left(V_{IOUT}\left(\frac{I_{PR(max)}}{2}\right) - V_{IOUT_{(Q)}}\right)}\right]\right\} \times 100(\%)$$

where $V_{IOUT}(I_{PR(max)})$ is the output of the sensor IC with the maximum measurement current flowing through it and $V_{IOUT}(I_{PR(max)}/2)$ is the output of the sensor IC with half of the maximum measurement current flowing through it.

**Zero-Current Output Voltage ($V_{IOUT(Q)}$).** The output of the sensor when the primary current is zero. For a unipolar supply voltage, it nominally remains at 0.5 × $V_{CC}$ for a bidirectional device and 0.1 × $V_{CC}$ for a unidirectional device. For example, in the case of a bidirectional output device, $V_{CC}$ = 5 V translates into $V_{IOUT(Q)}$ = 2.5 V. Variation in $V_{IOUT(Q)}$ can be attributed to the resolution of the linear IC quiescent voltage trim and thermal drift.

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**Offset Voltage ($V_{OE}$).** The deviation of the device output from its ideal quiescent value of 0.5 × $V_{CC}$ (bidirectional) or 0.1 × $V_{CC}$ (unidirectional) due to nonmagnetic causes. To convert this voltage to amperes, divide by the device sensitivity, Sens.

**Total Output Error ($E_{TOT}$).** The difference between the current measurement from the sensor IC and the actual current ($I_P$), relative to the actual current. This is equivalent to the difference between the ideal output voltage and the actual output voltage, divided by the ideal sensitivity, relative to the current flowing through the primary conduction path:

$$E_{TOT}(I_P) = \frac{V_{IOUT\_ideal}(I_P) - V_{IOUT}(I_P)}{Sens_{ideal}(I_P) \times I_P} \times 100(\%)$$

The Total Output Error incorporates all sources of error and is a function of $I_P$ . At relatively high currents, $E_{TOT}$ will be mostly due to sensitivity error, and at relatively low currents, $E_{TOT}$ will be mostly due to Offset Voltage ($V_{OE}$ ). In fact, at $I_P = 0$, $E_{TOT}$ approaches infinity due to the offset. This is illustrated in Figures 2 and 3. Figure 2 shows a distribution of output voltages versus $I_P$ at 25°C and across temperature. Figure 3 shows the corresponding $E_{TOT}$ versus $I_P$ .

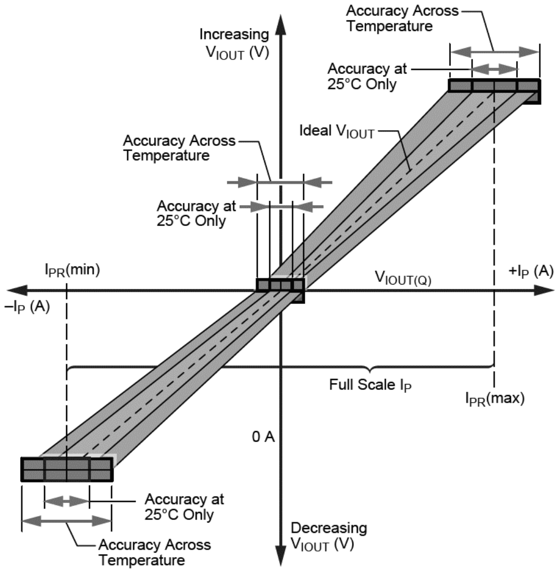

Figure 2: Output Voltage versus Sensed Current

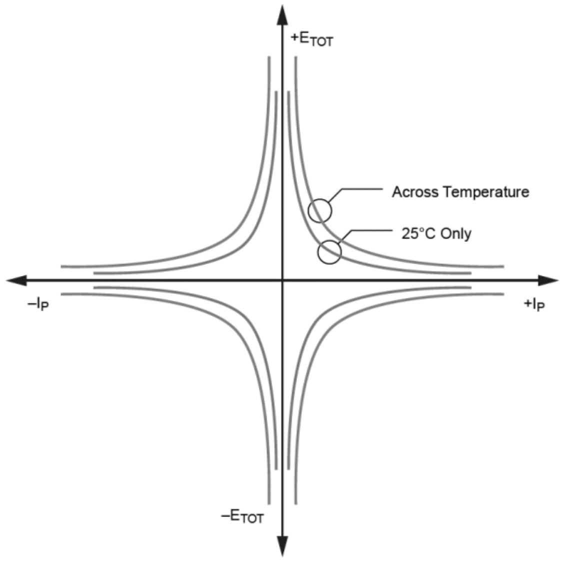

Figure3: Total Output Error versus Sensed Current

**Sensitivity Ratiometry Coefficient (SENS_RAT_COEF).** The coefficient defines how the sensitivity scales with $V_{CC}$. The ideal coefficient is 1, meaning the sensitivity scales proportionally with $V_{CC}$. A 10% increase in $V_{CC}$ results in a 10% increase in sensitivity. A coefficient of 1.1 means that the sensitivity increases by 10% more than the ideal proportionality case. This means that a 10% increase in $V_{CC}$ results in an 11% increase in sensitivity. This relationship is described by the following equation:

$$\mathrm{Sens}(V_{CC}) = Sens(5V)\left[1 + \frac{(V_{CC} - 5V) \times SENS\_RAT\_COEF}{5V}\right]$$

This can be rearranged to define the sensitivity ratiometry coefficient as:

$$SENS_{RAT_{COEF}} = \left[\frac{\mathrm{Sens}(V_{CC})}{Sens(5V)} - 1\right] \times \frac{5V}{V_{CC} - 5V}$$

**Zero-Current Output Ratiometry Coefficient (QVO_RAT_ COEF).** The coefficient defines how the zero-current output voltage scales with $V_{CC}$. The ideal coefficient is 1, meaning the output voltage scales proportionally with $V_{CC}$, always being equal to $V_{CC}/2$. A coefficient of 1.1 means that the zero-current output voltage increases by 10% more than the ideal proportionality case. This means that a 10% increase in $V_{CC}$ results in an 11% increase in the zero-current output voltage. This relationship is described by the following equation:

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$$\mathrm{VIOUTQ}(V_{CC}) = \mathrm{VIOUTQ}(5V)\left[1 + \frac{(V_{CC} - 5V) \times QVO\_RAT\_COEF}{5V}\right]$$

This can be rearranged to define the zero-current output ratiometry coefficient as:

$$QVO\_RAT\_COEF = \left[\frac{\mathrm{VIOUTQ}(V_{CC})}{\mathrm{VIOUTQ}(5V)} - 1\right] \times \frac{5V}{V_{CC} - 5V}$$

## 8.3 Definitions of dynamic response characteristics

**Power-On Time ($t_{PO}$).** When the supply is ramped to its operating voltage, the device requires a finite time to power its internal components before responding to an input magnetic field. Power-On Time, $t_{PO}$ , is defined as the time it takes for the output voltage to settle within ±10% of its steady-state value under an applied magnetic field, after the power supply has reached its minimum specified operating voltage, $V_{CC(min)}$, as shown in the chart at right.

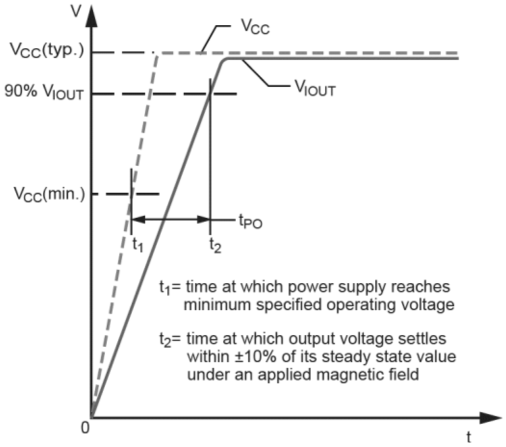

Figure 4: Power-On Time

**Rise Time ($t_r$).** The time interval between a) when the sensor IC reaches 10% of its full-scale value, and b) when it reaches 90% of its full-scale value. The rise time to a step response is used to derive the bandwidth of the current sensor IC, in which $f(-3\text{ dB}) = 0.35 / t_r$. Both $t_r$ and $t_{RESPONSE}$ are detrimentally affected by eddy-current losses observed in the conductive IC ground plane.

**Propagation Delay ($t_{pd}$ ).** The propagation delay is measured as the time interval a) when the primary current signal reaches 20% of its final value, and b) when the device reaches 20% of its output corresponding to the applied current.

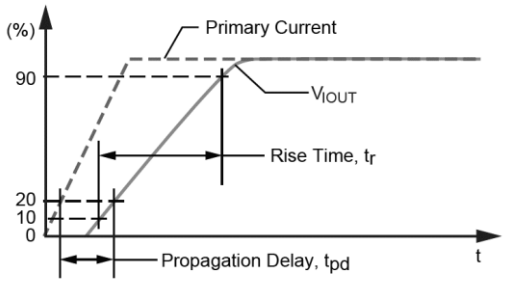

Figure 5: Rise Time and Propagation Delay

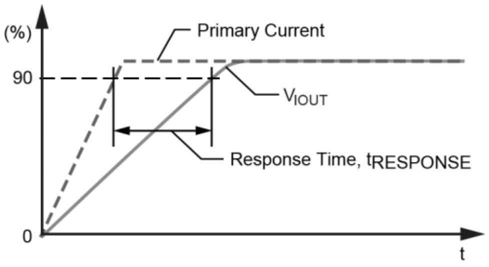

Figure 6: Response Time

**Response Time ($t_{RESPONSE}$).** The time interval between a) when the primary current signal reaches 90% of its final value, and b) when the device reaches 90% of its output corresponding to the applied current.

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## *8.4 Thermal Rise vs. Primary Current*

Self-heating due to the flow of current should be considered during the design of any current sensing system. The sensor, printed circuit board (PCB), and contacts to the PCB will generate heat as current moves through the system.

The thermal response is highly dependent on PCB layout, copper thickness, cooling techniques, and the profile of the injected current. The current profile includes peak current, current “on-time”, and duty cycle. While the data presented in this section was collected with direct current (DC), these numbers may be used to approximate thermal response for both AC signals and current pulses.

Figure 7 shows the maximum continuous current at a given TA. Surges beyond the maximum current listed in Figure 7 are allowed given the maximum junction temperature, $T_{J(MAX)}$ (165℃), is not exceeded.

The thermal capacity of the CH704 should be verified by the end user in the application’s specific conditions. The maximum junction temperature, $T_{J(MAX)}$ (165℃), should not be exceeded.

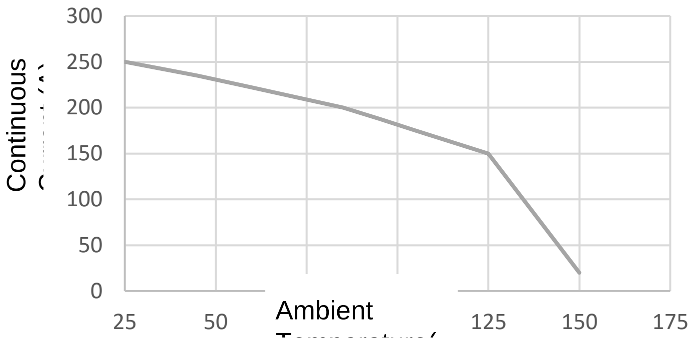

**Figure 7: Maximum Continuous Current at a Given TA**

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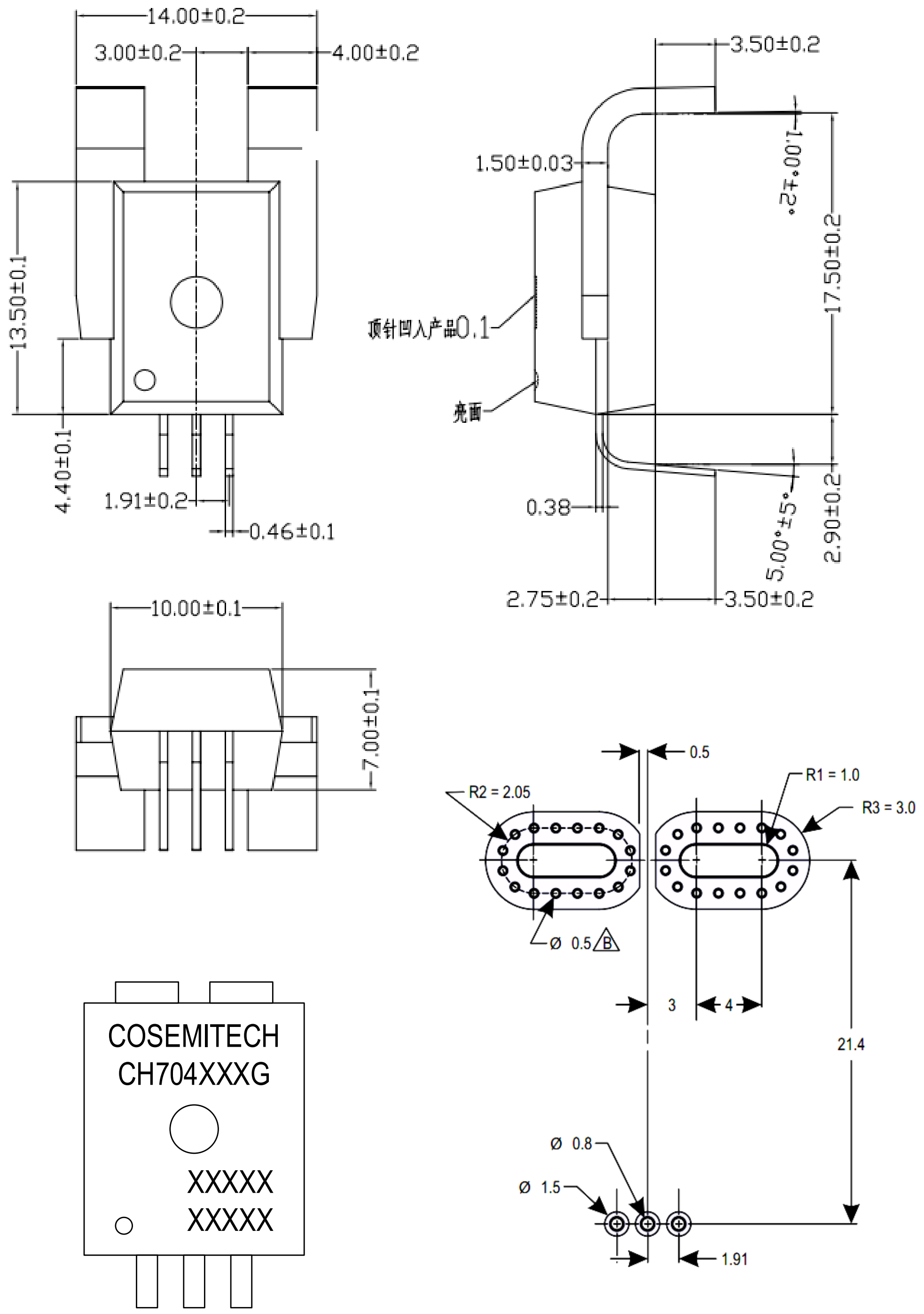
# 9 Package Information:

**For Reference Only – Not for Tooling Use**



*1 CH704XXXG: XXX= Current level, G = Grade
*2 XXXXX: Factory tracking number
*3 XXXXX: Factory tracking number

Figure 8: Package CB, 5-pin Lead-form CFF

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