CCS801

Ultra-Low Power Analog VOC Sensor for Indoor Air Quality Monitoring

General Description

ams micro-hotplate technology provides a unique silicon platform for the CCS80x range of Metal Oxide (MOX) gas sensors. These devices enable sensor miniaturization, have ultra-low power consumption and provide fast response times due to the ability to heat the micro-hotplate very quickly.The micro-hotplates are fabricated using a robust silicon dioxide membrane and include an embedded tungsten heating element to heat the MOX based sensing material. The MOX sensing material can be heated up to 500°C to allow the electrical resistance of the MOX sensor to be monitored to detect the target gas. By exploiting the fast heater cycling times, temperature modulation techniques can be used to reduce the device power consumption and implement advanced gas sensing methods.

Software libraries containing proprietary algorithms and example Android applications are available for indoor air quality monitoring.

Product Overview

CCS801 is an ultra-low power analog sensor for monitoring indoor air quality including Carbon Monoxide (CO) and a wide range of Volatile Organic Compounds (VOCs) such as Ethanol. CCS801 can be used as an equivalent carbon dioxide (eCO2) sensor to represent eCO2 levels in real world environments, where the main source of VOCs is from humans.

For CCS801 a supply voltage (V_H) is provided to the integrated micro-heater and the gas concentration can be correlated to the change in resistance of the MOX sensing layer (Rs).

V_H can be set using a low-dropout (LDO) regulator or operated in constant or pulsed PWM mode to reduce power consumption. The sensor resistance (R_S) is typically determined using a series load resistor (R_L), a reference voltage (V_{REF}), and by reading an output voltage (V_{OUT}) with an Analogue-to-Digital Converter (ADC). The reference voltage (V_{REF}) must only be enabled during the sensor reading.

CCS801 is supported in a compact 2mm x 3mm x 1mm DFN (Dual Flat No lead) package as standard.

Ordering Information and Content Guide appear at end of datasheet.

Key Benefits & Features

The benefits and features of CCS801, Ultra-Low Power Analog VOC Sensor for Indoor Air Quality Monitoring are listed below:

Figure 1:
Added Value of Using CCS801 Sensor

Benefits	Features
• Extend battery life for portable applications	• Optimized low-power modes
• Sensitive to target gases	• Reduced cross sensitivity
• Fast heating time <15ms	• Quick response to target gases
• Suitable for small form factor designs	• Compact 2mm x 3mm x 1mm DFN package

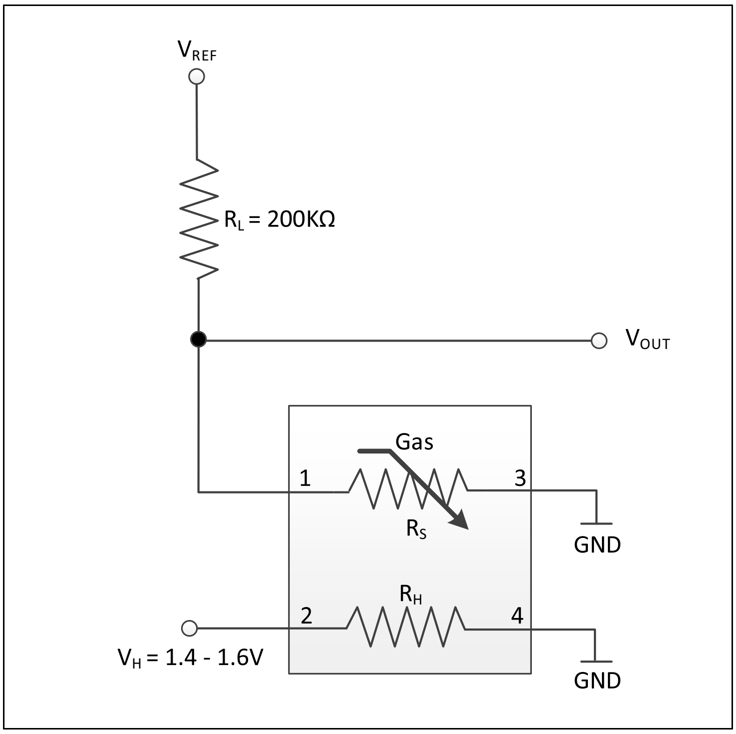
Applications

CCS801 can be used to detect VOCs for indoor air quality monitoring.

Application Diagram

The recommended configuration of this device is shown below:

Figure 2:
Recommended Sensor Configuration



Pin Assignment

Figure 3:
Pin Diagram

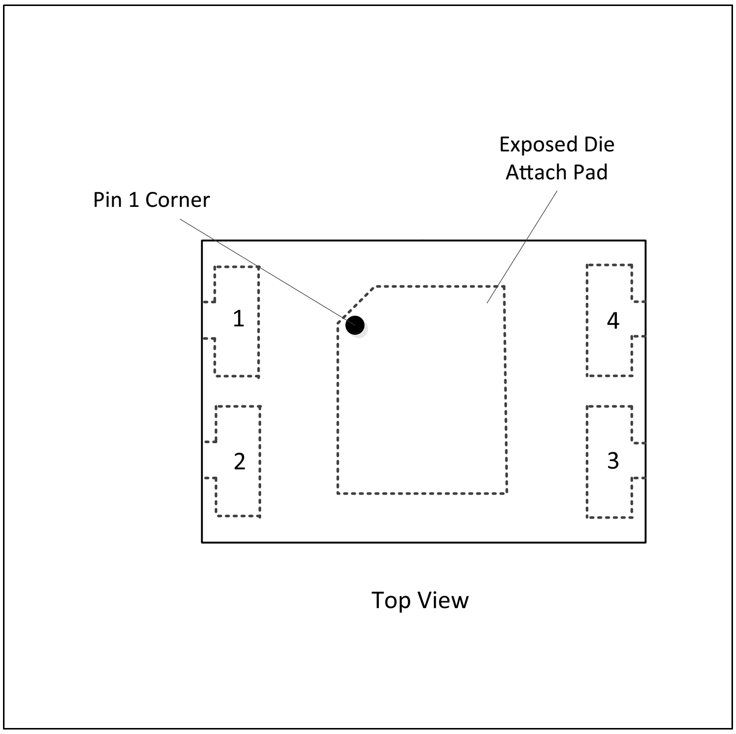


Figure 4:
Pin Description

Pin Number	Pin Name	Description
1	Sensor+	Sensor output (V_{OUT})
2	Heater+	Heater Input (V_H)
3	Sensor-	Connect to Ground or 0V
4	Heater-	Connect to Ground or 0V

Absolute Maximum Ratings

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated under Electrical Characteristics is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Figure 5:
Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Units	Comments
Electrical Parameters					
V_H	Maximum Heater Voltage (V_H) (1)		1.8	V	
Electrostatic Discharge					
ESD_{HBM}	Human Body Model	±1000		V	
Environmental Conditions					
T_{AMB}	Ambient Temperature for Operation	-5	50	°C	
T_{Strg}	Storage Temperature	-40	125	°C	
RH_{NC}	Relative Humidity (non-condensing)	10	95	%	
MSL	Moisture Sensitivity Level	1			Represents an unlimited floor life time

Note(s):

1. When V_H is produced by PWM of a V_{DD} above 1.8V the duty cycle (%) must not exceed $1.8V^2 / V_{DD}^2$

Electrical Characteristics

Figure 6:
Electrical Characteristics

Parameters	Conditions	Min	Typ	Max	Units
Recommended Heater Voltage (V_H)	In constant power mode		1.4		V
Average Power Consumption (P_{AV})	Pulsed heating mode [1]		0.9		mW
Peak Power Consumption (P_{DC})	Constant power mode V_H = 1.4V		33		mW
Heater Resistance (R_H)	V_H = 1.4V @ 50% RH	50	58	66	Ω
Sensor Resistance In Clean Air (R_a)	V_H = 1.4V @ 50% RH	10		1600	kΩ
Lifetime	V_H = 1.4V		>5		years

Note(s):

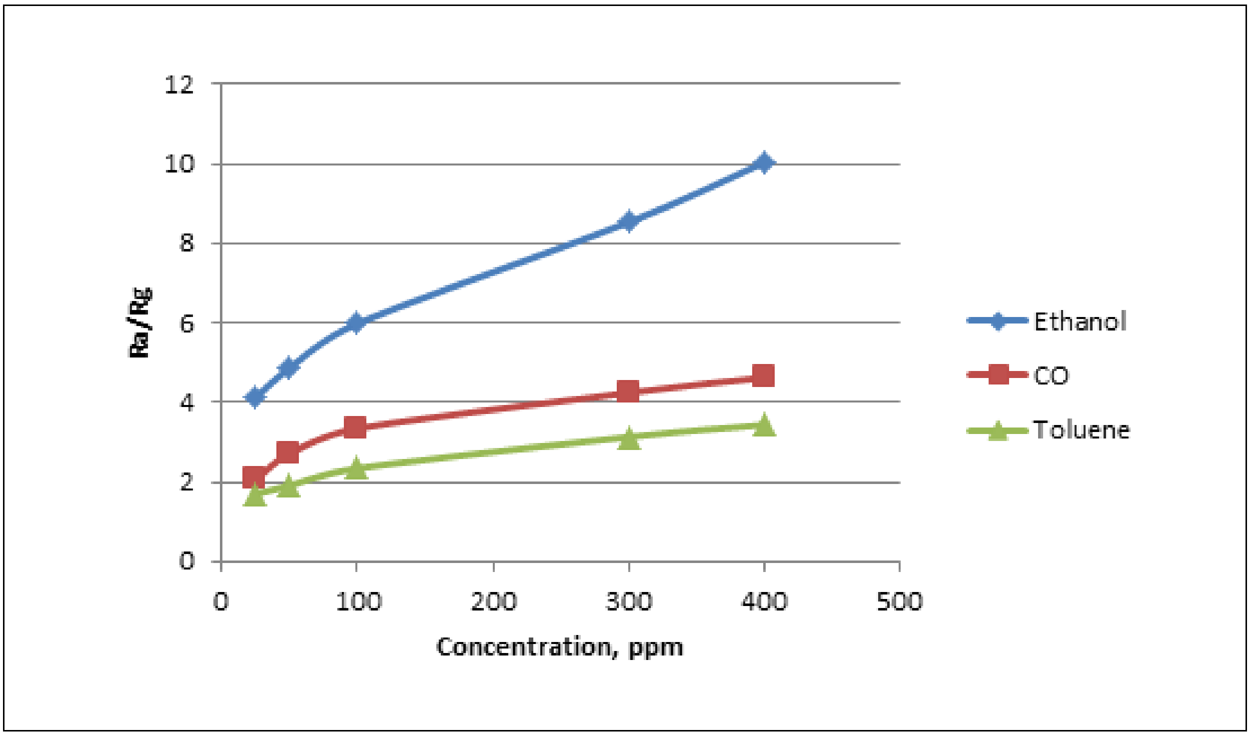
1. Based on a sensor measurement duty cycle of 2.5%, heater ON for 1.5s (0.5s @ 1.6V, 1s @ 1.4V) and then heater OFF for 58.5s (0V).

Detailed Description

Sensor Performance

Sensitivity is defined as the sensor's resistance in clean air (Ra) divided by the sensor's resistance at a specific gas concentration level at 50% relative humidity and 25°C ambient temperature (Rg). The following chart shows the typical sensitivity of CCS801 to CO, Ethanol and Toluene (as an example VOC gas) in constant power mode with a heater voltage (V_H) of 1.4V.

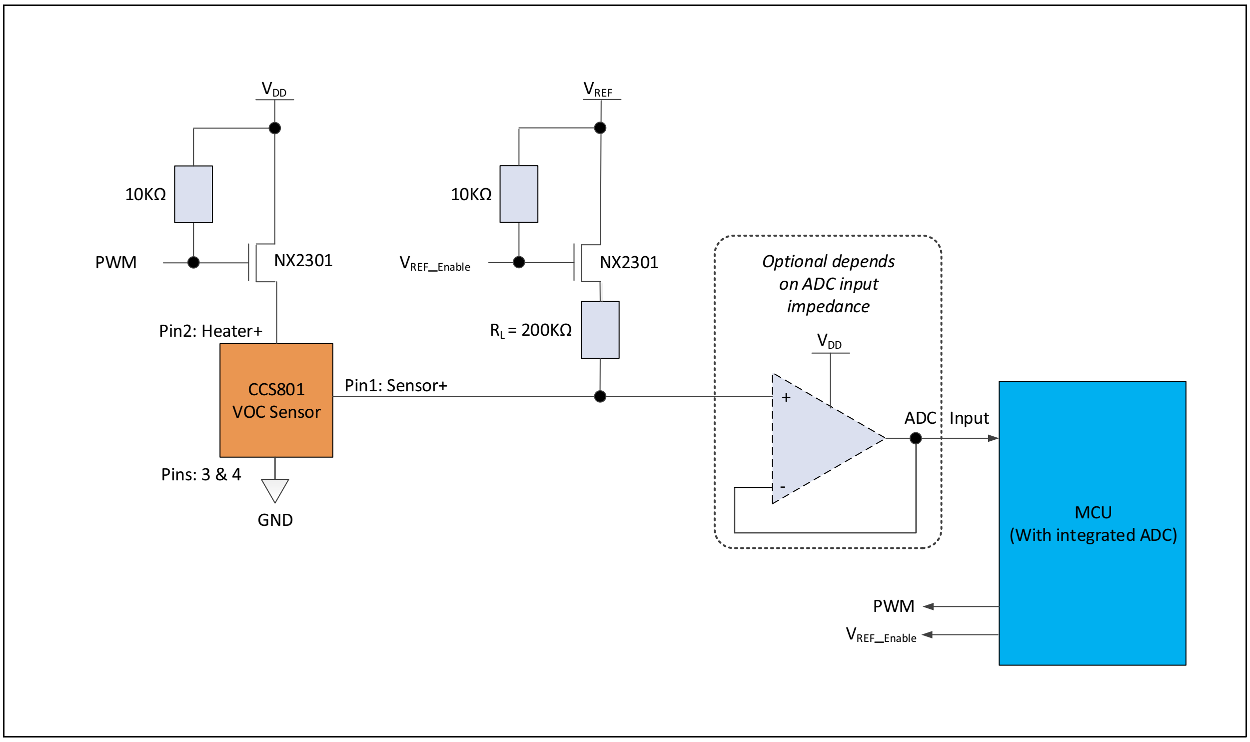
Figure 7:
Typical Sensitivity of CCS801 to CO, Ethanol and Toluene in Constant Power Mode (V_H = 1.4V)



Note(s): CCS801 performance in terms of resistance levels and sensitivities will change during early life use. This change in resistance is greatest over the first 48 hours of operation. **ams** advises customers to run CCS801 at V_H for 48 hours prior to normal operation to ensure sensor performance is stable.

Application Information

Figure 8:
Recommended Application Circuit



Note(s):

1. The sensor can be operated in pulsed mode to reduce overall power consumption. In this case the Heater V_H is only driven for a fraction of the time at regular intervals under the control of the MCU.
2. An equivalent V_H can be produced more efficiently with a PWM than with a linear regulator if a PWM output from the MCU is available to drive an external MOSFET switch (p-channel). If not driven the MOSFET input should be pulled high.
3. The PWM must operate with a minimum frequency of 10 kHz. The following table illustrates PWM duty cycle requirements to enable V_H in the range 1.4 – 1.6V for CCS801, other duty cycles can be calculated using the equation V_H^2 / V_{DD}^2:

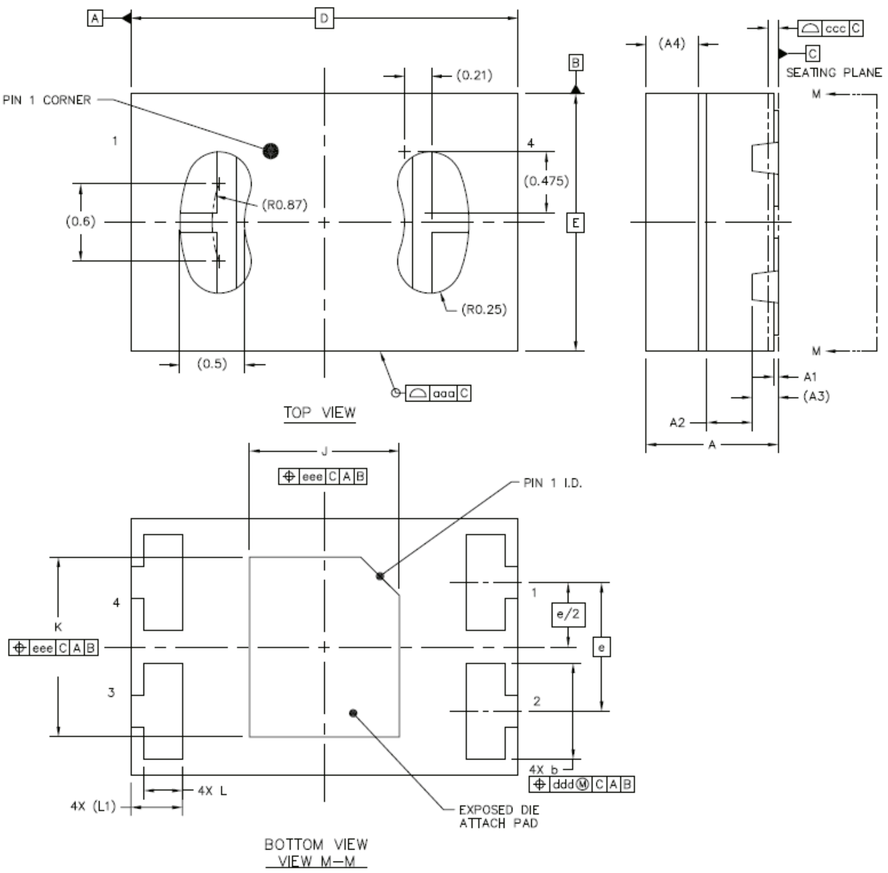
Target Heater Voltage (V_H)	Supply Voltage (V_{DD})				
	1.5V	1.8V	2.5V	3V	3.3V
1.40	87%	60%	31%	22%	18%
1.50	100%	69%	36%	25%	21%
1.60	-	79%	50%	28%	24%

4. An ADC input is required on the MCU to measure the sensor resistance, the recommended ADC reference voltage (V_{REF}) depends on what voltage range the ADC supports. Control of the sensor bias (V_{REF}) [e.g. by using an external MOSFET switch (p-channel)] is required to power the sensor bias only when needed for the ADC measurements, ensuring that all reference voltages are stable for the measurement.
5. A minimum load resistor (R_L) value of 200kΩ is recommended.

Package Information

DFN Package Outline

Figure 9:
DFN Package Drawings



DESCRIPTION	SYMBOL	MIN	NOM	MAX
TOTAL THICKNESS	A	0.95	1.0	1.05
STAND OFF	A1	0	0.035	0.05
LEAD WIDTH	b	0.7	0.75	0.8
BODY SIZE	D		3 BSC	
	E		2 BSC	
LEAD PITCH	e		1.0 BSC	
EP SIZE	J	1.06	1.16	1.26
	K	1.3	1.4	1.5
LEAD LENGTH	L	0.25	0.3	0.35
	L1	0.35	0.4	0.45

ams RoHS

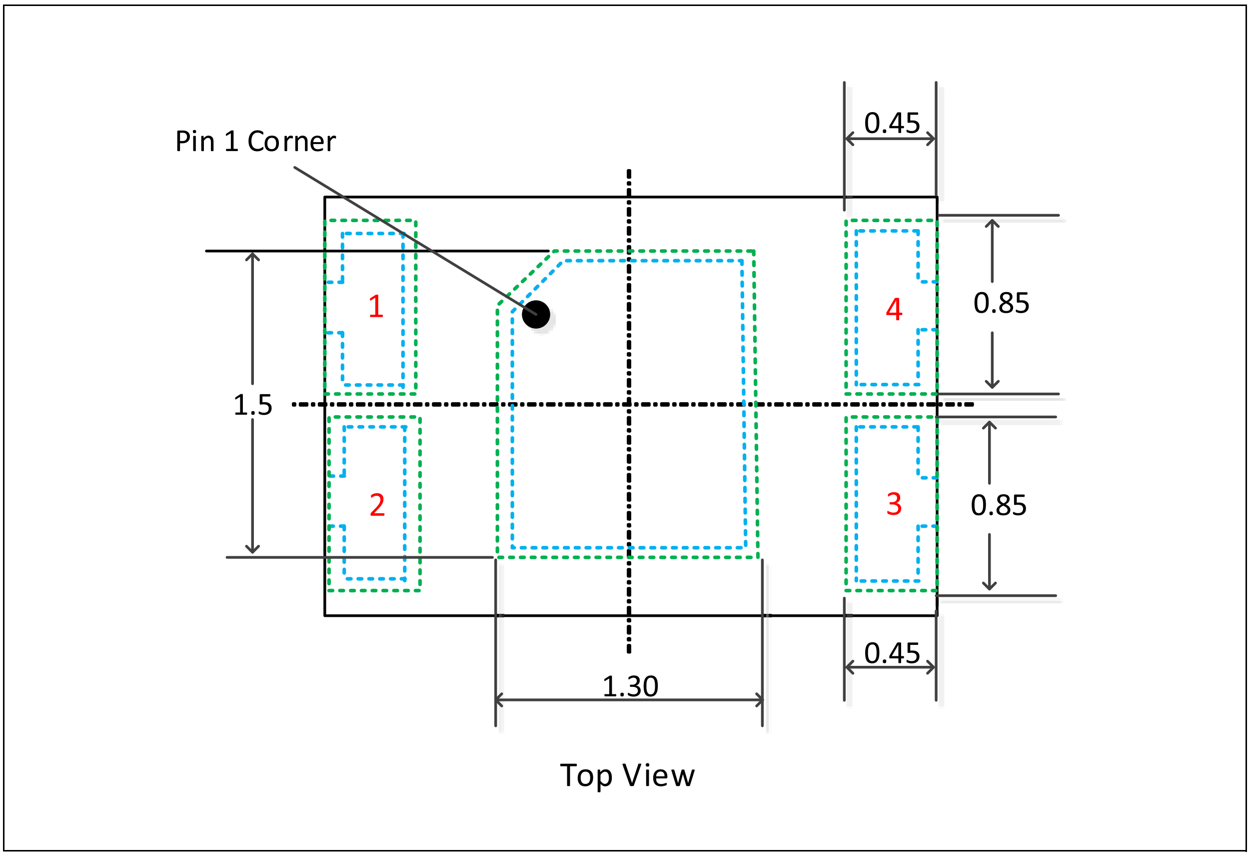
ams Green

Note(s):

1. All dimensions are in millimeters.

The recommended package footprint or landing pattern for CCS801 is shown below:

Figure 10:
Recommended Package Footprint for CCS801



Note(s):

1. All dimensions are in millimeters.
2. PCB land pattern in Green dash lines
3. Pin numbers are in Red
4. Add 0.05mm all around the nominal lead width and length for the PCB land pattern

Ordering & Contact Information

Figure 11:
Ordering Information

Ordering Code	Description	Package	MOQ
CCS801B-COPR	CCS801B Multi-gas sensor for indoor air quality monitoring	2mm x 3mm x 1mm DFN	5000
CCS801B-COPD	Samples of CCS801B Multi-gas sensor for indoor air quality monitoring	2mm x 3mm x 1mm DFN	500

Note(s):

1. Refer to JEDEC J-STD020 lead-free standard for typical soldering reflow profile
2. Refer to application note AN000364 on device assembly guidelines
3. Refer to application note AN000363 on CCS80x hardware design guidelines.

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Document Status

Document Status	Product Status	Definition
Product Preview	Pre-Development	Information in this datasheet is based on product ideas in the planning phase of development. All specifications are design goals without any warranty and are subject to change without notice
Preliminary Datasheet	Pre-Production	Information in this datasheet is based on products in the design, validation or qualification phase of development. The performance and parameters shown in this document are preliminary without any warranty and are subject to change without notice
Datasheet	Production	Information in this datasheet is based on products in ramp-up to full production or full production which conform to specifications in accordance with the terms of ams AG standard warranty as given in the General Terms of Trade
Datasheet (discontinued)	Discontinued	Information in this datasheet is based on products which conform to specifications in accordance with the terms of ams AG standard warranty as given in the General Terms of Trade, but these products have been superseded and should not be used for new designs

Revision Information

Changes from CCMOSS version 11 (2016-May-26) to current revision 1-02 (2016-Dec-19)	Page
CCMOSS version 11 (2016-May-26) to 1-00 (2016-Nov-23)	
Content of CCMOS Sensors datasheet was updated to the latest **ams** design	
1-00 (2016-Nov-23) to 1-01 (2016-Nov-28)	
Updated Product Overview	1
Updated Figure 1	2
Updated Figure 5 and added note below	4
Updated Figure 6 and note below	5
Updated Figure 7 and text above it	6
1-01 (2016-Nov-28) to 1-02 (2016-Dec-19)	
Updated Figure 6	5
Updated note under Figure 7	6
Updated Figure 11 and notes under it	10

Note(s):

1. Page and figure numbers for the previous version may differ from page and figure numbers in the current revision.
2. Correction of typographical errors is not explicitly mentioned.

Content Guide