



LV8099CS

Bi-CMOS IC
For VCMs
Constant-current Driver IC

Overview

The LV8099CS is a constant current driver IC for voice coil motors that supports I²C control integrating a digital/analog converter (DAC). It uses an ultraminiature WLP package and includes a current detection resistor for constant current control, which makes the IC ideal for miniaturization of camera modules intended for use in camera-equipped mobile phones. The output transistor has a low on-resistance of 1Ω and the resistance of the built-in current detection resistor is 1Ω, which minimizes the voltage loss and helps withstand voltage drop in V_{CC}. The function is incorporated, which, by changing the current in a stepped pattern while taking time at rise and fall of the output current, provides the current a slope, improving the converging stability of the voice coil motor (current slope function).

Functions

- Constant current driver for voice coil motors.
- I²C bus control supported.
- Built-in current detection resistor.
- Built-in voltage drop protection circuit (V_{CC} = 2V output off).
- Low output block total-resistance of 2Ω helps withstand voltage drop in V_{CC}. (Current detection resistance + output transistor on-resistance).
- Built-in VCM overshoot preventive function (current slope function).
- Constant current control enabled by DAC (10 bits).
- Wide operating voltage range (2.2 to 5.0V).
- 6-pin WLP package used (1.27 × 0.87 × 0.5mm).
- Built-in thermal protection circuit.

Specifications

Absolute Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Maximum supply voltage	V _{CC} max		5.5	V
Output voltage	V _{OUT} max		V _{CC} + 0.5	V
Input voltage	V _{IN} max	SCL, SDA, ENA	5.5	V
GND pin source current	I _{GND}		150	mA
Allowable power dissipation	P _d max	With specified substrate *	350	mW
Operating temperature	T _{opr}		-30 to +85	°C
Storage temperature	T _{stg}		-40 to +150	°C

* Specified substrate : 40mm × 40mm × 1.6mm, Single layer glass epoxy substrate

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Allowable Operating Conditions at $T_a = 25^\circ\text{C}$

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage	V_{CC}		2.2 to 5.0	V
Maximum preset output current	I_O		100	mA
High-level input voltage	V_{IH}	Applied to SCL, SDA, and ENA pins	1.3 to V_{CC}	V
Low-level input voltage	V_{IL}		-0.3 to 0.5	V

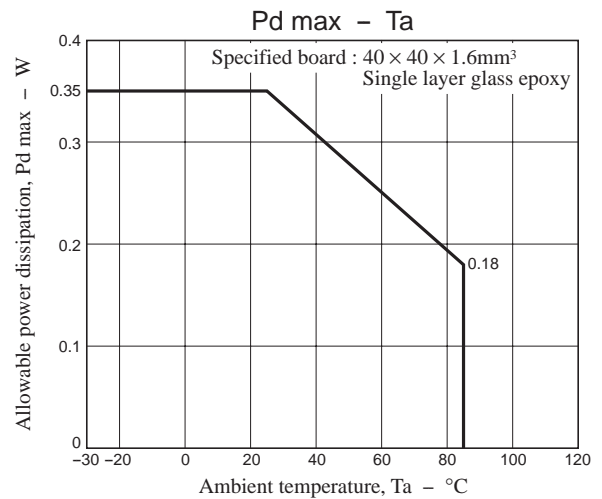
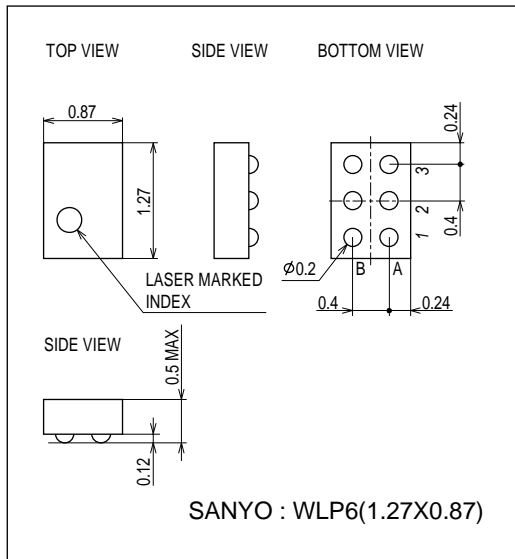
Electrical Characteristics at $T_a = 25^\circ\text{C}$, $V_{CC} = 2.8\text{V}$

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Supply current	I_{CC0a}	ENA = L			1	μA
	I_{CC0b}	ENA = H, PD = 1			1	μA
	I_{CC0c}	ENA = H, D0 to D9 = 0			1	μA
	I_{CC1}	ENA = H, D0 to D9 \neq 0		0.5	3	mA
Input current	I_{IN}	SCL, SDA, ENA	-1	0	1	μA
Total resistance value of the output block (built-in resistor + transistor on-resistance)	RTTL	$V_{CC} = 2.8\text{V}$, $I_{OUT} = 80\text{mA}$		2	3	Ω
DAC block						
Resolution				10		bits
Relative accuracy	INL				± 2	LSB
Differential linearity	DNL				± 1	LSB
Full code current	I_{full}	D0 to D9 = 1		100		mA
Error code current 0	I_{zero}	D0 to D9 = 0			1	μA
Spark killer diode						
Reverse current	I_S (leak)				1	μA
Forward voltage	VSF	$I_{OUT} = 100\text{mA}$			1.3	V

Package Dimensions

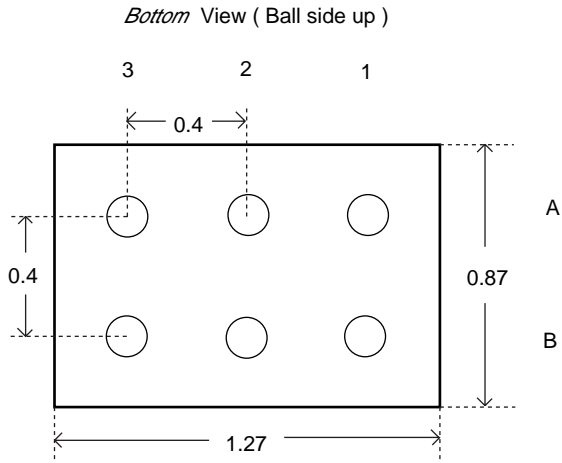
unit : mm (typ)

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Pin Assignment



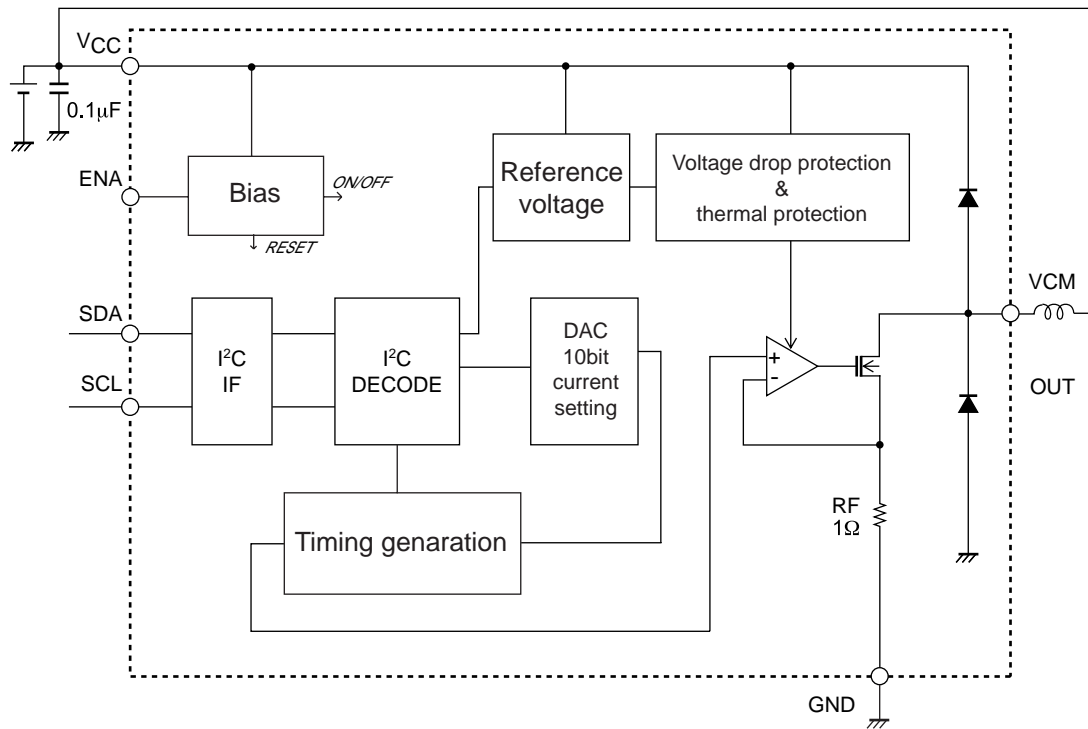
Pin No.	Pin Name	Pin Description
A1	SCL	I ² C SCL input pin
A2	ENA	Enable & reset *1, 2
A3	GND	Ground
B1	SDA	I ² C SDA input pin
B2	V _{CC}	Power supply pin
B3	OUT	Output pin

*1 : Setting the ENA pin to low powers down and resets the IC.

It is necessary to power on the IC by setting the ENA pin to low and hold it high during normal operation.

*2 : When the ENA pin is to be used with pull_up, it is necessary to send code 0 in advance after power-on.

Block Diagram



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Pin Description

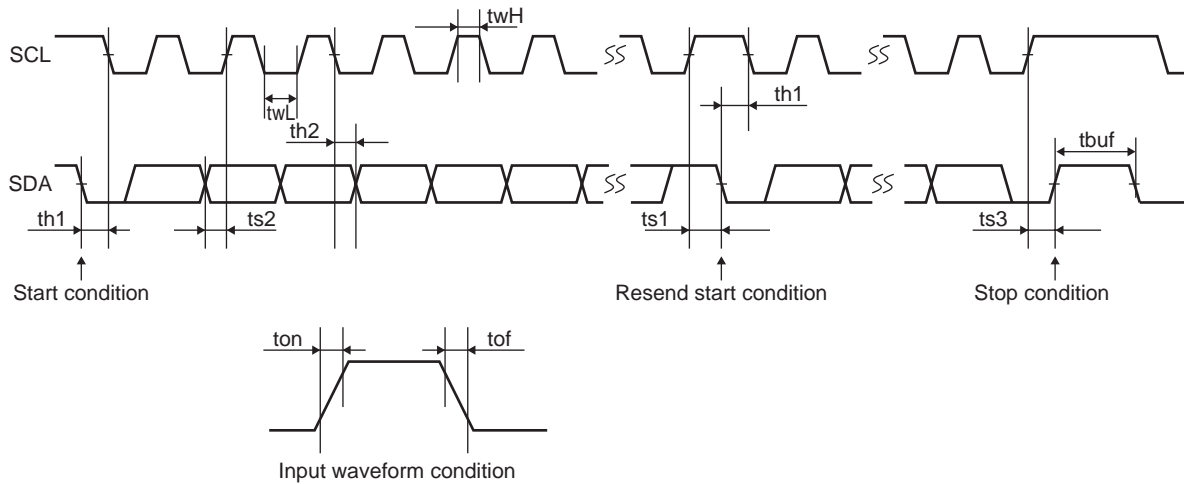
Pin No.	Pin name	Description	Equivalent circuit
A1	SCL	<p>SCL I²C serial clock input pin</p> <p>Input high level : 1.3V to 5.0V Input low level : -0.3V to 0.5V</p>	
A2	ENA	<p>ENABLE</p> <p>When low, standby mode and reset is performed at the same time. This pin is held high for normal use.</p> <p>Input high level : 1.3V to 5.0V Input low level : -0.3V to 0.5V</p>	
A3	GND	Ground pin.	
B3	OUT	<p>OUT Output pin</p> <p>This is an NMOS open drain output, and the voice coil motor is connected between this pin and the V_{CC} pin for use.</p>	
B2	V _{CC}	V _{CC} Power supply input pin	
B1	SDA	<p>SDA I²C serial data input pin</p> <p>Input high level : 1.3V to 5.0V Input low level : -0.3V to 0.5V</p>	

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Serial Bus Communication Specifications

I²C serial transfer timing conditions

Standard mode



Standard mode

Parameter	symbol	Conditions	min	typ	max	unit
SCL clock frequency	fscL	SCL clock frequency	0		100	kHz
Data setup time	ts1	Setup time of SCL with respect to the falling edge of SDA	4.7			μs
	ts2	Setup time of SDA with respect to the rising edge of SCL	250			ns
	ts3	Setup time of SCL with respect to the rising edge of SDA	4.0			μs
Data hold time	th1	Hold time of SCL with respect to the rising edge of SDA	4.0			μs
	th2	Hold time of SDA with respect to the falling edge of SCL	0			μs
Pulse width	twL	SCL low period pulse width	4.7			μs
	twH	SCL high period pulse width	4.0			μs
Input waveform conditions	ton	SCL, SDA (input) rising time			1000	ns
	tof	SCL, SDA (input) falling time			300	ns
Bus free time	tbuf	Interval between stop condition and start condition	4.7			μs

High-speed mode

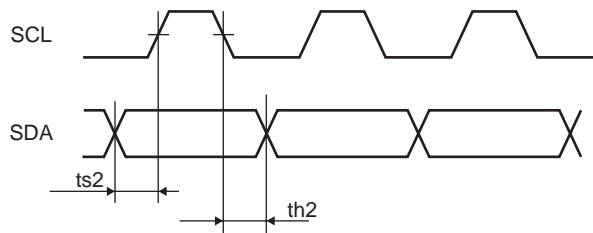
Parameter	Symbol	Conditions	min	typ	max	unit
SCL clock frequency	fscL	SCL clock frequency	0		400	kHz
Data setup time	ts1	Setup time of SCL with respect to the falling edge of SDA	0.6			μs
	ts2	Setup time of SDA with respect to the rising edge of SCL	100			ns
	ts3	Setup time of SCL with respect to the rising edge of SDA	0.6			μs
Data hold time	th1	Hold time of SCL with respect to the rising edge of SDA	0.6			μs
	th2	Hold time of SDA with respect to the falling edge of SCL	0			μs
Pulse width	twL	SCL low period pulse width	1.3			μs
	twH	SCL high period pulse width	0.6			μs
Input waveform conditions	ton	SCL, SDA (input) rising time			300	ns
	tof	SCL, SDA (input) falling time			300	ns
Bus free time	tbuf	Interval between stop condition and start condition	1.3			μs

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I²C bus transmission method

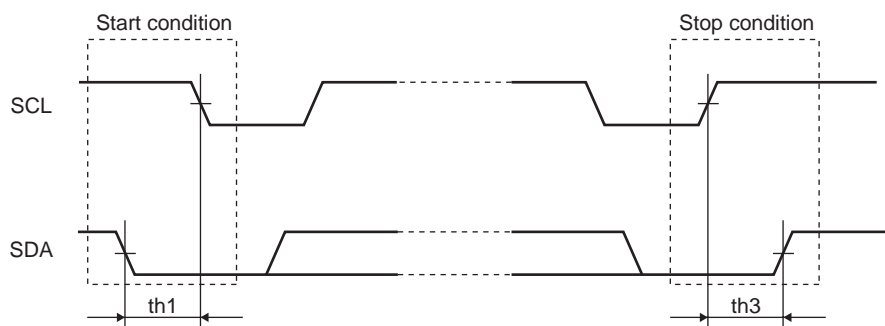
Start and stop conditions

The I²C bus requires that the state of SDA be preserved while SCL is high as shown in the timing diagram below during a data transfer operation.



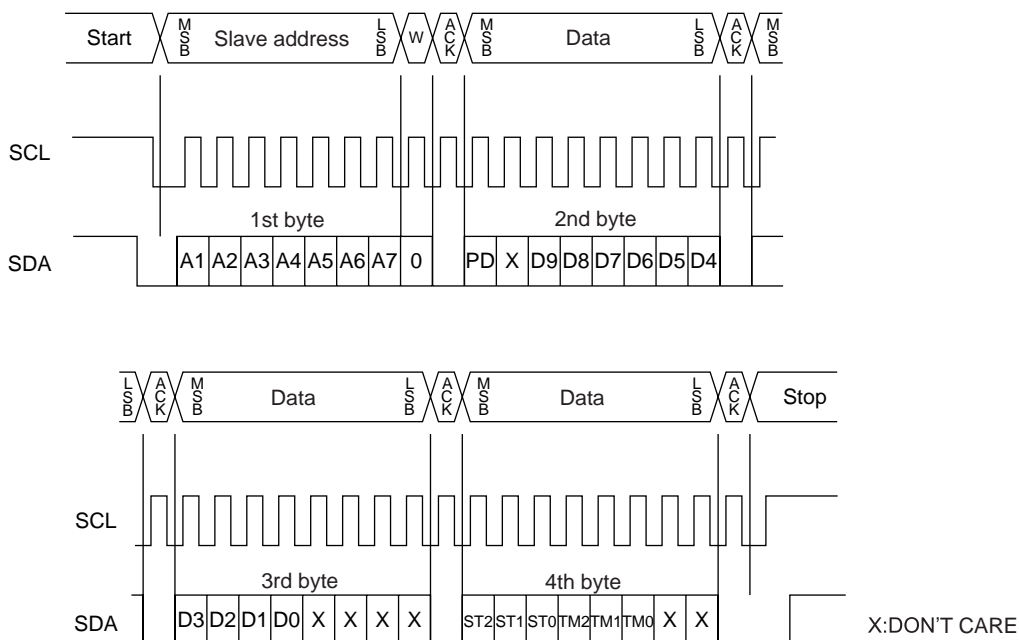
When data is not being transferred, both SCL and SDA are in the high state. The start condition is generated and access is started when SDA is changed from high to low while SCL and SDA are high.

Conversely, the stop condition is generated and access is ended when SDA is changed from low to high while SCL is high.



Data transfer and acknowledgement response

After the start condition has been generated, the data is transferred one byte (8 bits) at a time. Generally, in an I²C bus, a unique 7-bit slave address is assigned to each device, and the first byte of the transfer data is allocated to the 7-bit slave address and to the command (R/W) indicating the transfer direction of the subsequent data. However, this IC is provided with only a write mode for receiving the data. Every time 8 bits of data for each byte are transferred, the ACK signal is sent from the receiving end to the sending end. Immediately after the clock pulse of SCL bit 8 in the data transferred has fallen to low, SDA at the sending end is released, and SDA is set to low at the receiving end, causing the ACK signal to be sent. When, after the receiving end has sent the ACK signal, the transfer of the next byte remains in the receiving status, the receiving end releases SDA at the falling edge of the ninth SCL clock.



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The standard data transfer to this device consists of four bytes : the slave address of the first byte and the data of the second, third and four bytes.

Slave address : 0110011(0)

PD : Power-down

The table below shows the format of the second , third and four bytes.

	2nd byte								3rd byte							
Serial data bits	SD7	SD6	SD5	SD4	SD3	SD2	SD1	SD0	SD7	SD6	SD5	SD4	SD3	SD2	SD1	SD0
Function	PD	x	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0	x	x	x	x

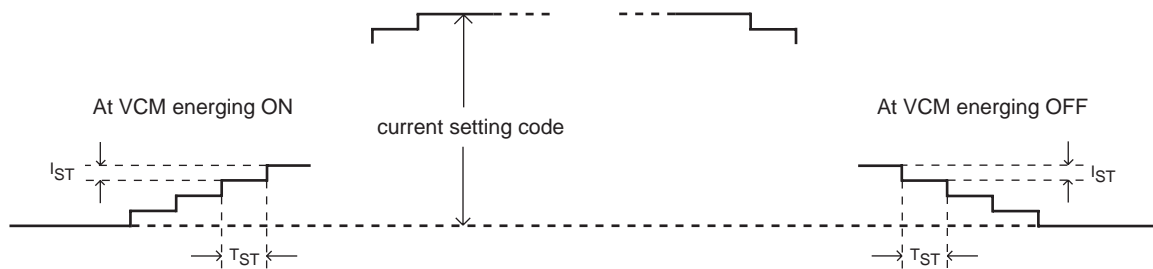
4th byte							
SD7	SD6	SD5	SD4	SD3	SD2	SD1	SD0
ST2	ST1	ST0	TM2	TM1	TM0	x	x

PD : Power_down (PD = 1 : standby mode and reset)

D0-D9 setting method

Current setting code	D9	D8	D7	D6	D5	D4	D3	D2	D1	Output current (mA) (design value)
0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	1	0.0978
2	0	0	0	0	0	0	0	1	0	0.1955
3	0	0	0	0	0	0	0	1	1	0.2933
1021	1	1	1	1	1	1	1	0	1	99.804
1022	1	1	1	1	1	1	1	1	0	99.902
1023	1	1	1	1	1	1	1	1	1	100

Current slope function operation image chart



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TIM		000	001	010	011	100	101	110	111
STP									
000		At current slope OFF							
001		0.032	0.064	0.128	0.256	0.512	1.024	2.048	4.096
		0.0978	0.0978	0.0978	0.0978	0.0978	0.0978	0.0978	0.0978
010		0.064	0.128	0.256	0.512	1.024	2.048	4.096	8.192
		0.1955	0.1955	0.1955	0.1955	0.1955	0.1955	0.1955	0.1955
011		0.128	0.256	0.512	1.024	2.048	4.096	8.192	16.38
		0.391	0.391	0.391	0.391	0.391	0.391	0.391	0.391
100		0.256	0.512	1.024	2.048	4.096	8.192	16.38	32.77
		0.782	0.782	0.782	0.782	0.782	0.782	0.782	0.782
101		0.512	1.024	2.048	4.096	8.192	16.38	32.77	65.54
		1.564	1.564	1.564	1.564	1.564	1.564	1.564	1.564
110		1.024	2.048	4.096	8.192	16.38	32.77	65.54	131.08
		3.128	3.128	3.128	3.128	3.128	3.128	3.128	3.128
111		2.048	4.096	8.192	16.38	32.77	65.54	131.08	262.16
		6.256	6.256	6.256	6.256	6.256	6.256	6.256	6.256
FULL_CODE Sweep time		32.7	65.5	130.9	261.9	523.8	1047.6	2095.1	4190.2

In the upper row in the above table each column, the lower is a current step value (I_{ST} :mA), at the step time (T_{ST} :msec).

Relationship between the ENA pin input, I²C input data PD, and current setting 0 (code 0)

This IC supports the following three modes of setting up the standby mode :

- 1) Setting the ENA pin low.
- 2) Setting the PD bit to 1 (high) with I²C input data.
- 3) Setting the output current to 0 with I²C input data.

Execution of one of the steps 1) to 3) causes the output current to 0 and stops operation of the circuit.

When the ENA pin is set low, the I²C data register is reset and the IC is reset to its default state (PD bit set to 0 and output current setting to code 0).

When the ENA pin is to be used with pull_up to VCC, it is necessary to send code 0 once after VCC ON.

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