ML8540

Preliminary

Infrared sensor Packaging version

General Description

The ML8540 is an IR sensor consisting of 2000 pixels (precisely 47 rows x 48 columns = 2256 pixels) formed by thermopiles. A far-infrared image as a result of radiation from an object is formed on the sensor through an infrared lens, which, however, is not included in the ML8540. This causes temperature rise in the IR sensing pixels, and voltage across the thermopiles varies. The ML8540 includes two counter circuits and two decoder circuits. A set of the circuits is assigned in x and y directions. The pixels are scanned by the decoder circuits in combination with the counter circuits. The pixels are shifted by clock signal, and thermopiles in a selected pixel outputs voltage.

Features

• Pixels
IR sensing area: 48 rows x 48 columns
Pixels in the first row called black pixel are not thermally isolated.
Pixels other than the first row are effective pixels outputting voltage.

• Shifting Pixels
Clock signal and reset signal shift the pixels.
Reset the counter with signal high at RST pin. Afterwards, a pixel shifts every time clock signal goes high.
Horizontal scanning, x direction, starts from column 1 to column 48. Vertical scanning, y direction, starts from row 1 to row 48. Scanning the next row starts after scanning column 48 in the current row is completed.

• High-thermal isolation structure
Thermal isolation is achieved with etching a silicon substrate under the IR sensing diaphragm. The diaphragm-supporting beams prevent heat from conducting away from the IR sensing diaphragm to the substrate, resulting in the warmer IR sensing diaphragm than the substrate.
The sensor outputs voltage in line with the change in temperature of the IR sensing area caused by infrared absorption.

• Thermopiles
Thermopiles are fabricated with hot junctions and cold junctions on the IR sensing diaphragm of each pixel and the substrate respectively, and formed in series by joining hot and cold junctions alternately. Voltage is induced proportional to temperature gradient between the IR sensing diaphragm and the substrate. When the IR sensor is pointed to an object to be measured, induced voltage of the IR sensor is equivalent to the change in temperature across the thermopiles. The temperature of the IR sensor itself varies as a result of the change in environmental temperature. Although under this circumstance, accurate temperature measurement of objects will be achieved using an external MPU which compensates for the temperature read from the IR sensor with an aid of an external thermistor.

- Reference supply power to thermopiles

Positive voltage is generated when higher IR energy on the IR sensing area than that on the substrate is exerted. Negative voltage is generated when the temperature of the IR sensing area is lower than that of the substrate as a result of radiative heat loss. Because an op amp with a single power supply does not work with negative voltage, supply the thermopiles with reference voltage at the pin N considering if an external circuitry requires.

- Black pixel

A black pixel generates always zero voltage as a result of the same temperature across the substrate and the IR sensing area. Measuring voltage of the black pixel allows to find effective voltage of the reference voltage in each column, track resistance of thermopiles and voltage drop due to resistance of transistors for selecting x direction. Compensation for every column will be made meticulously by subtracting voltage of the black pixel from voltage of thermopiles of each IR sensing pixel.

1. Product specifications

1.1. Main specification

	Parameter	Specification	Condition
1	Sensing element	Thermopile	
2	Spectral response	8 to 14um	
3	Effective number of pixels	48 x 47=2256 pixels 48 x 1 =48 Black pixels	Row one
4	NETD	T.B.D.	Environmental temperature: 25℃ Black body: 200℃
5	Responsivity	3000 V/W	
6	Power consumption	≤40mW	
7	Active pixels	more than 99.6%	Defect number: less than 10 pixels
8	Thermal time constant	≤100 msec	as designed
9	Minimum number of pins required	8 pin	
10	Output signal	Analog voltage	
11	Supply voltage	VDD = +5.0V, AVDD = +5.0V	
12	Maximum frequency	6Hz	Designed value
13	Package	24 LCC	Vacuum
14	Package size	8.5x8.5mm, t=1.85mm	

• Number of defect pixels in a device passed the product test
The number of defect pixels is guaranteed. Defect pixel has no-sensitivity to IR.
Standard specification: less than 10 pixels

1.2. Environmental condition

	Parameter	Condition
1	Operating temperature	-30 to 85℃
2	Storage temperature	-40 to 120℃
3	Operating and storage humidity	Not required due to vacuum environment inside package
4	Storage condition	25±3℃, humidity 30%, dry air or N2 atmosphere

1.3. Electrical characteristics

• Maximum ratings

(Ta = 25℃, GND =0V)

	Parameter	Symbol	Condition	Rating	Unit
1	Supply voltage	VDD AVDD	Apply the same voltage to VDD and AVDD from the same power supply	-0.3 to +7.0	V
2	Input voltage	VIND	Applied to RST and CLK	-0.3 to VDD	V
3	Storage temperature	TSTG	-	-40 to +120	℃
4	Electrostatic	ESD	Human Body Model (HBM)	1000	V
			Machine Model (MM)	200	V

CAUTION

Stress above those listed as absolute ratings may cause permanent damage to the device. Exposure to maximum rating conditions for extended periods may affect device reliability.

This device is sensitive to mechanical shock; dropping, vibration, etc. Improper handling may cause permanent damage to the device or ill functioning.

1.4. Recommended operating conditions

	Parameter	Symbol	Condition	Recommended	Unit
1	Supply voltage	VDD AVDD	Apply the same voltage to VDD and AVDD from the same power supply	4.5 to +5.5	V
2	Sensor bias voltage	VN	Input voltage at pin N (Designed voltage = 1.2V)	0 to 5.0	V
3	Operating temperature	Ta	-	-30 to +85	℃

1.5. DC input/output characteristics

(VDD, AVDD=4.5 to 5.5V, Ta = -30 to +85℃)

	Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
1	High level input voltage [1]	VIH		0.8xVDD	-	VDD	V
2	Low level input voltage [1]	VIL		0	-	0.2xVDD	V
3	High level input current [1]	IIH	VIH = VDD	-	-	50	uA
4	Low level input current [1]	IIL	VIL = GND	-50	-	-	uA
5	Output current at pin P2 [2]	IP2	VN = 1.2V	2	4.35	12	uA

Notes:
1. Applicable for pins RST and CLK.
2. Applicable for current between pins P2 and N.

1.6. Current consumption

(VDD, AVDD=4.5 to 5.5V, Ta = -30 to +85℃)

	Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
1	Standby current consumption of VDD	IDDS	No output load	-	0.05	1	mA
2	Standby current consumption of AVDD	ICCS	No output load	-	3.3	6	mA

1.7. Infrared sensitivity characteristic (VIR)

(Tk=65℃) [1]

(VDD, AVDD=5V, Ta = +20℃) [2]

	Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
1	Infrared sensitivity [3]	VIR	VIR = VP(o)-VP(c)	0.3	0.4	-	mV

Conditions for determining VIR

1. Infrared sensitivity is measured without optical lens.
   Tk = Black body temperature
   VP(o) = Sensor output with shutter opened, allowing infrared radiation to pass through the shutter.
   VP(c) = Sensor output with shutter closed, blocking infrared radiation to reach the sensor.
   Shutter temperature = 20℃
2. VIR is proportional to the temperature difference between thermopile and package Ta. (Ta = 20℃)
3. Infrared sensitivity is determined by median in the infrared sensitivity distribution.

2. Block diagram

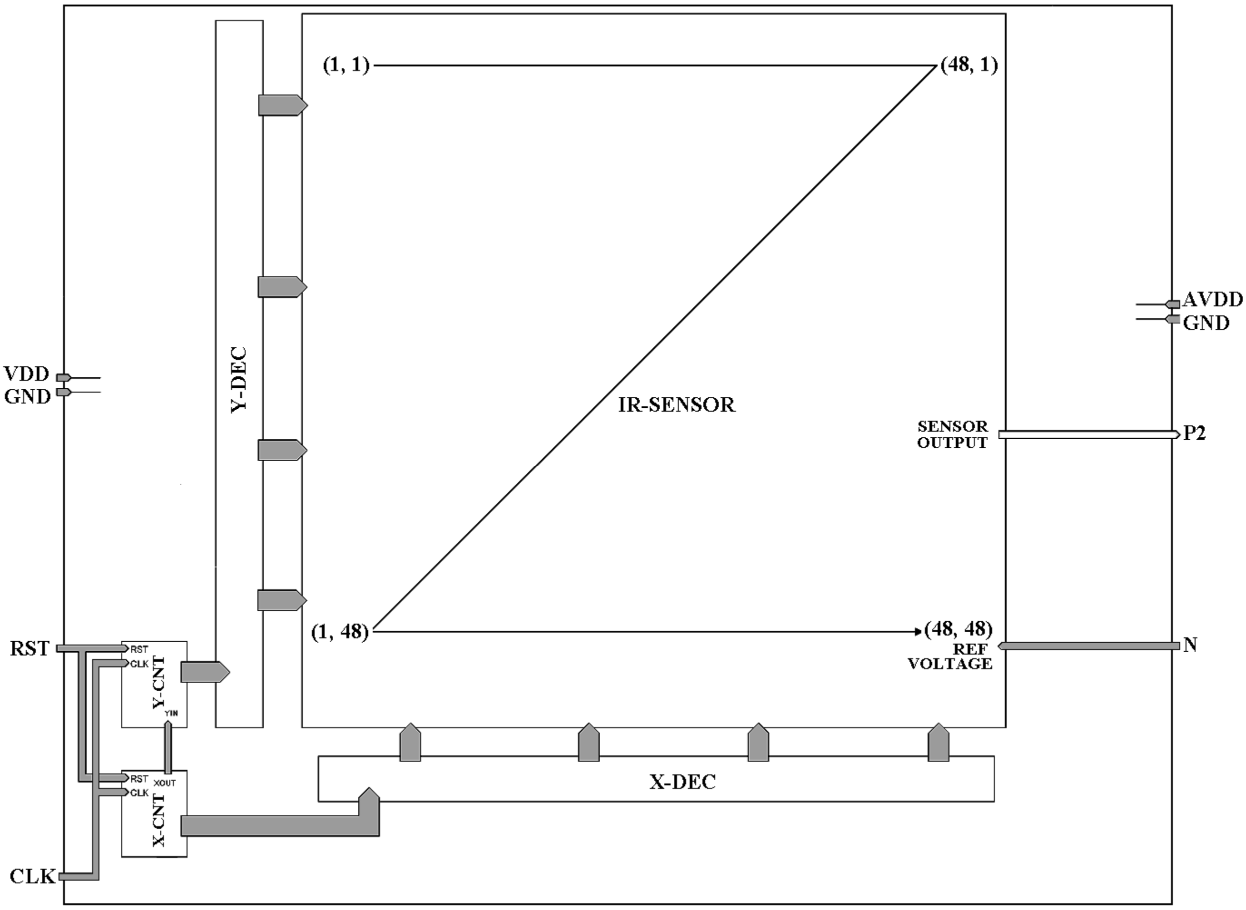
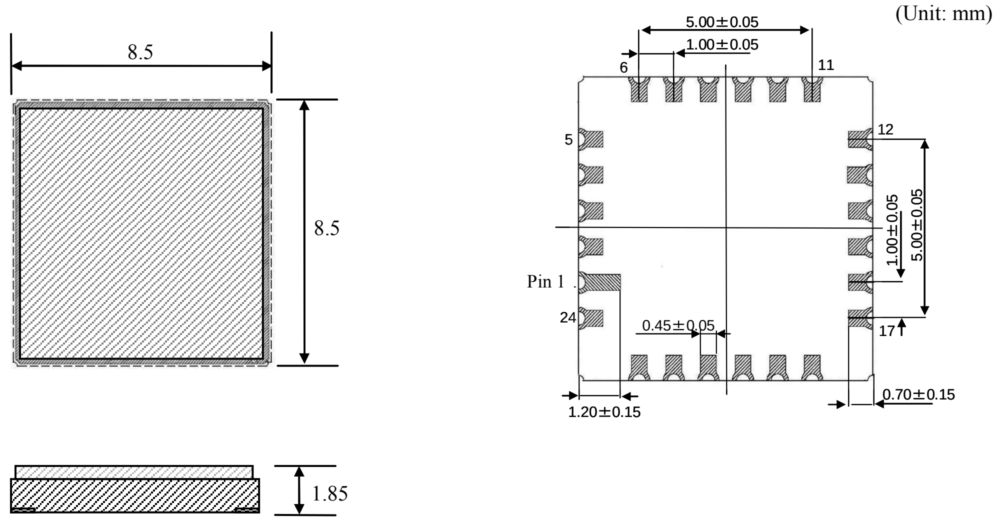


Fig.1 Block diagram

3. Package dimensions and pin configuration



Lid specification:
- Material : Silicon.
- Both sides are optically polished and anti-reflect coated
- Transmittance: 76% at IR (8 to 14um)

Fig.2 Package dimensions

Note. Pin positions and their names are subject to change without notice.

4. Pin descriptions

Pin #	Pin name	I/O	Description
1, 2	DNC	-	Do Not Connect.
3	CLK	I	Clock input pin for functioning counter which selects pixel coordinate. X counter increments at a high CLK, and a pixel coordinate shifts.
4	DNC	-	Do Not Connect.
5	VDD		Supply voltage input for digital circuitry.
6 to 8	DNC	-	Do Not Connect.
9	P2	O	Sensor output of a selected pixel.
10, 11	DNC	-	Do Not Connect.
12	AGND	-	Analog ground pin. Analog and digital grounds are internally connected.
13 to 18	DNC	-	Do Not Connect.
19	AVDD		Supply voltage input for analog circuitry. The same power source should be used for VDD and AVDD. It should be turned on and off simultaneously.
20	DNC	-	Do Not Connect.
21	N	I	Bias voltage input pin for IR sensor. Applying 1.2 V is recommended. However, the voltage to this pin should be adjusted between 0 and 5V in light of amplification of external amplifier, ADC resolution and its input voltage range, and temperature compensation method.
22	DNC	-	Do Not Connect.
23	DGND	-	Digital ground pin. Digital and analog grounds are internally connected.
24	RST	I	Reset input pin for counter which is used to select pixel coordinate. A signal high at the RST pin resets X and Y counters and set the pixel coordinate to (1, 1).

Symbols: I = Input, O = Output

5. Circuit functional description

- Sensor sensing pixel

The IR sensor array consists of 48 x 48 pixels including thermopiles. Infrared radiation absorbed by the sensor causes the temperature to rise at the sensor. The thermopiles output voltage proportional to the temperature difference between the sensing pixel and the substrate. This voltage is used to calculate sensor temperature, enabling infrared intensity and temperature of an object to be assumed. Temperature distribution of the entire sensing pixels will be revealed by selecting each pixel with the decoders. The black pixels are located on the top row.

- Black pixels

The black pixels located on the top row are not thermally isolated but identical in structure and characteristics to the effective pixels. Zero voltage is always output from the black pixels as a result of no temperature gradient between the substrate and sensing pixels. This allows the output to be a reference voltage to compensate for variation in resistance of transistors of horizontal shift register and sensitivity variation caused by on-chip temperature distribution.

- Horizontal shift register

The horizontal shift registers controls scanning from left to right.

- Vertical shift register

The vertical shift register controls scanning from the current row to the next row after the vertical register scans the right most columns.

- Counter

The register returns to coordinate (1, 1) when the counter is reset with a high signal at RST. The counter accumulates the counts at every CLK signal. It is recommended that the counter is reset each time the entire frame is scanned.

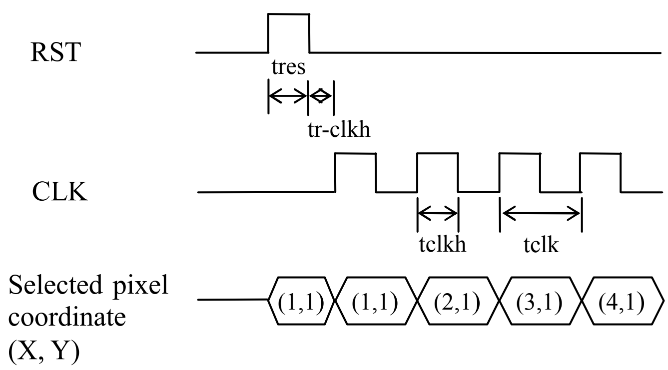
6. Readout sequence

The following Table 1 illustrates the sequence of reading data from pixels based on the timing chart shown in Fig.3. Pixel coordinates are represented as (X, Y) analogously in Fig.1 .

Table 1. Sequence of reading data from pixels

Sequence #	Input signal	Readout pixel coordinate
1	RST	(1, 1)
2	CLK	(1, 1) same as sequence 1
3	CLK	(2, 1)
4	CLK	(3, 1)
: :	: :	: :
49	CLK	(48, 1)
50	CLK	(48, 1) same as sequence 49
51	CLK	(1, 2)
: :	: :	: :

Please note that noise occurs in the transition from X=48 to X=1. The same pixel is read out twice at X=1 and X=48.



Symbol	Min	Typ	Max	Unit
tres	10	50	-	usec
tr-clkh	10	25	-	usec
tclkh	10	50	-	usec
tclk	70	100	-	usec

Fig.3 Timing chart

Fig.4 represents pixel coordinates placed in the same order that each pixel data is read out in accordance with the sequences given in Table 1. Valid data is shown in the blue shaded area. Invalid areas in output data may contain counter reset noise. To make one frame with only valid data, data in the invalid areas must be omitted.

Start of reading data

X direction

Y direction

(1,1)	(1,1)	(2,1)	(3,1)	(4,1)	->	(45,1)	(46,1)	(47,1)	(48,1)	(48,1)
(1,2)	(1,2)	(2,2)	(3,2)	(4,2)	->	(45,2)	(46,2)	(47,2)	(48,2)	(48,2)
(1,3)	(1,3)	(2,3)	(3,3)	(4,3)	->	(45,3)	(46,3)	(47,3)	(48,3)	(48,3)
:	:	:	:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:	:	:	:
(1,46)	(1,46)	(2,46)	(3,46)	(4,46)	->	(45,46)	(46,46)	(47,46)	(48,46)	(48,46)
(1,47)	(1,47)	(2,47)	(3,47)	(4,47)	->	(45,47)	(46,47)	(47,47)	(48,47)	(48,47)
(1,48)	(1,48)	(2,48)	(3,48)	(4,48)	->	(45,48)	(46,48)	(47,48)	(48,48)	(48,48)

End of reading data

Invalid data area | Valid data area | Invalid data area

Output data area

Fig.4 Pixel coordinate

REVISION HISTORY

Document No.	Date	Page		Description
		Previous Edition	Current Edition	
PDDC100542-01	29 Oct. 2012	-	-	Initial release
PEDL8540-00-01	14 Mar. 2013	2, 8	3, 5	NETD and VIR are revised.
		4, 6	6, 7	Figures are updated.
		7	8	Pin descriptions are revised.
		-	-	New document number is applied.

NOTES

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