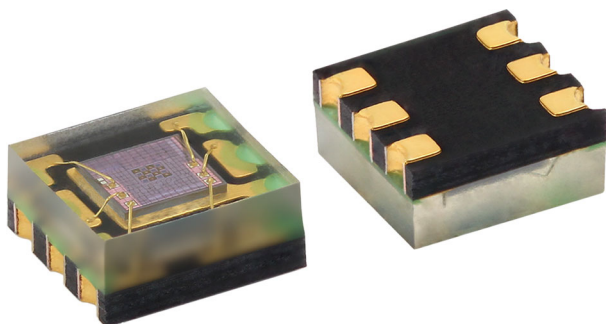# High Accuracy Ambient Light Sensor With I^{2}C Interface

FEATURES

- Package type: surface-mount
- Dimensions (L x W x H in mm): 2 x 2 x 0.87
- Integrated modules: ambient light sensor (ALS)
- Supply voltage range V$_{DD}$: 2.5 V to 3.6 V
- Communication via I^{2}C interface
- I^{2}C bus H-level range: 1.7 V to 3.6 V
- Floor life: 72 h, MSL 4, according to J-STD-020
- Low stand by current consumption: typ. 0.5 µA
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

Pb-free

e4

RoHS COMPLIANT

HALOGEN FREE

GREEN (5-2008)

DESCRIPTION

VEML6030 is a high accuracy ambient light digital 16-bit resolution sensor in a miniature transparent 2 mm x 2 mm package. It includes a high sensitive photodiode, a low noise amplifier, a 16-bit A/D converter and supports an easy to use I^{2}C bus communication interface and additional interrupt feature.

The ambient light result is as digital value available.

APPLICATIONS

- Ambient light sensor for mobile devices (e.g. smart phones, touch phones, PDA, GPS) for backlight dimming
- Ambient light sensor for industrial on- / off-lighting operation
- Optical switch for consumer, computing, and industrial devices and displays

AMBIENT LIGHT FUNCTION

- 16-bit dynamic range for ambient light detection from 0 lx to about 140 klx with resolution down to 0.0042 lx/ct, supports low transmittance (dark) lens design
- 100 Hz and 120 Hz flicker noise rejection
- Excellent temperature compensation
- High dynamic detection resolution
- Software shutdown mode control

PRODUCT SUMMARY

PART NUMBER	OPERATING RANGE (mm)	OPERATING VOLTAGE RANGE (V)	I^{2}C BUS VOLTAGE RANGE (V)	AMBIENT LIGHT RANGE (lx)	AMBIENT LIGHT RESOLUTION (lx)	OUTPUT CODE	ADC RESOLUTION PROXIMITY / AMBIENT LIGHT
VEML6030	n/a	2.5 to 3.6	1.7 to 3.6	0 to 140 000	0.0042	16 bit, I^{2}C	- / 0.0042

ORDERING INFORMATION

ORDERING CODE	PACKAGING	VOLUME [1]	REMARKS
VEML6030	Tape and reel	MOQ: 3000	2.0 mm x 2.0 mm x 0.87 mm
VEML6030-GS15		MOQ: 10 000	

Note

[1] MOQ: minimum order quantity

ABSOLUTE MAXIMUM RATINGS (T_{amb} = 25 °C, unless otherwise specified)

PARAMETER	TEST CONDITION	SYMBOL	MIN.	MAX.	UNIT
Supply voltage		V_{DD}	0	4	V
Ambient temperature range		T_{amb}	-25	+85	°C
Storage temperature range		T_{stg}	-25	+85	°C
Total power dissipation	$T_{amb} \leq 25$ °C	P_{tot}	-	50	mW
Junction temperature		T_j	-	110	°C

BASIC CHARACTERISTICS (T_{amb} = 25 °C, unless otherwise specified)

PARAMETER	TEST CONDITION	SYMBOL	MIN.	TYP.	MAX.	UNIT
Supply voltage		V_{DD}	2.5	3.3	3.6	V
Shut down current [2]	V_{DD} is 3.3 V	I_{sd}	-	0.5	-	µA
Operation mode current [1]	V_{DD} is 3.3 V, PSM = mode 4	I_{DD}	-	2	-	µA
	V_{DD} is 3.3 V, PSM = mode 1	I_{DD}	-	8	-	µA
	V_{DD} is 3.3 V, PSM_EN = disable	I_{DD}	-	45	-	µA
I²C clock rate range		f_{SCL}	10	-	400	kHz
I²C bus input H-level range	V_{DD} is 3.3 V	V_{ih}	1.3	-	3.6	V
I²C bus input L-level range	V_{DD} is 3.3 V	V_{il}	-0.3	-	0.4	V
Digital current out (low, current sink)		I_{ol}	3	-	-	mA
Digital resolution (LSB count) [3]	with ALS_GAIN = x 2, ALS_IT = 800 ms		-	0.0042	-	lx/step
Detectable maximum illuminance [3]	with ALS_GAIN = x 1/8, ALS_IT = 25 ms	$E_{V max.}$	-	140 000	-	lx
Dark offset [2]	with ALS_GAIN = x 2, ALS_IT = 800 ms		-	3	-	step

Notes

[1] Light source: white LED

[2] Light conditions: dark

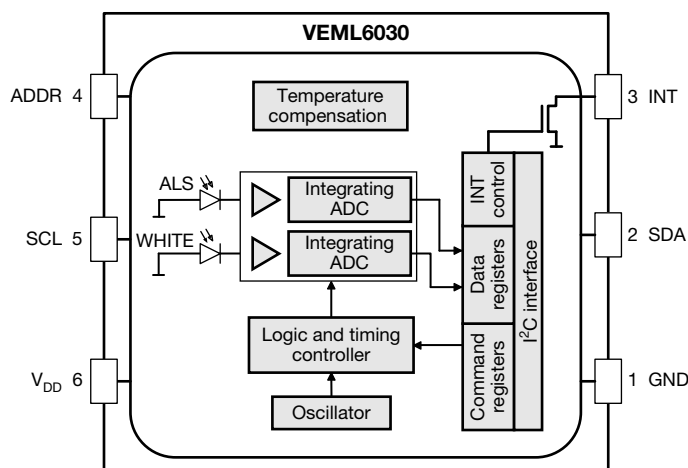[3] Please refer to the application note for resolution table at different settings

CIRCUIT BLOCK DIAGRAM

Fig. 1 - Block Diagram

I²C TIMING CHARACTERISTICS (T_{amb} = 25 °C, unless otherwise specified)

PARAMETER	SYMBOL	STANDARD MODE [1]		FAST MODE [1]		UNIT
		MIN.	MAX.	MIN.	MAX.	
Clock frequency	$f_{(SMBCLK)}$	10	100	10	400	kHz
Bus free time between start and stop condition	$t_{(BUF)}$	4.7	-	1.3	-	µs
Hold time after (repeated) start condition; after this period, the first clock is generated	$t_{(HDSTA)}$	4.0	-	0.6	-	µs
Repeated start condition setup time	$t_{(SUSTA)}$	4.7	-	0.6	-	µs
Stop condition setup time	$t_{(SUSTO)}$	4.0	-	0.6	-	µs
Data hold time	$t_{(HDDAT)}$	0	3450	0	900	ns
Data setup time	$t_{(SUDAT)}$	250	-	100	-	ns
I²C clock (SCK) low period	$t_{(LOW)}$	4.7	-	1.3	-	µs
I²C clock (SCK) high period	$t_{(HIGH)}$	4.0	-	0.6	-	µs
Detect clock / data low timeout	$t_{(TIMEOUT)}$	25	35	-	-	ms
Clock / data fall time	$t_{(F)}$	-	300	-	300	ns
Clock / data rise time	$t_{(R)}$	-	1000	-	300	ns

Note

[1] Data based on standard I²C protocol requirement, not tested in production
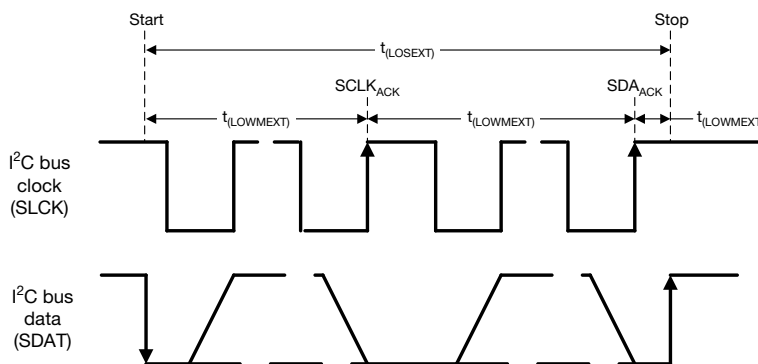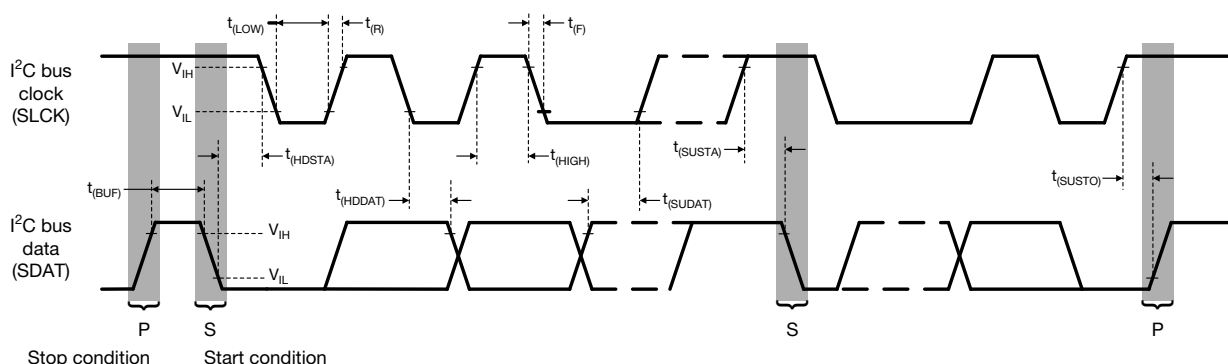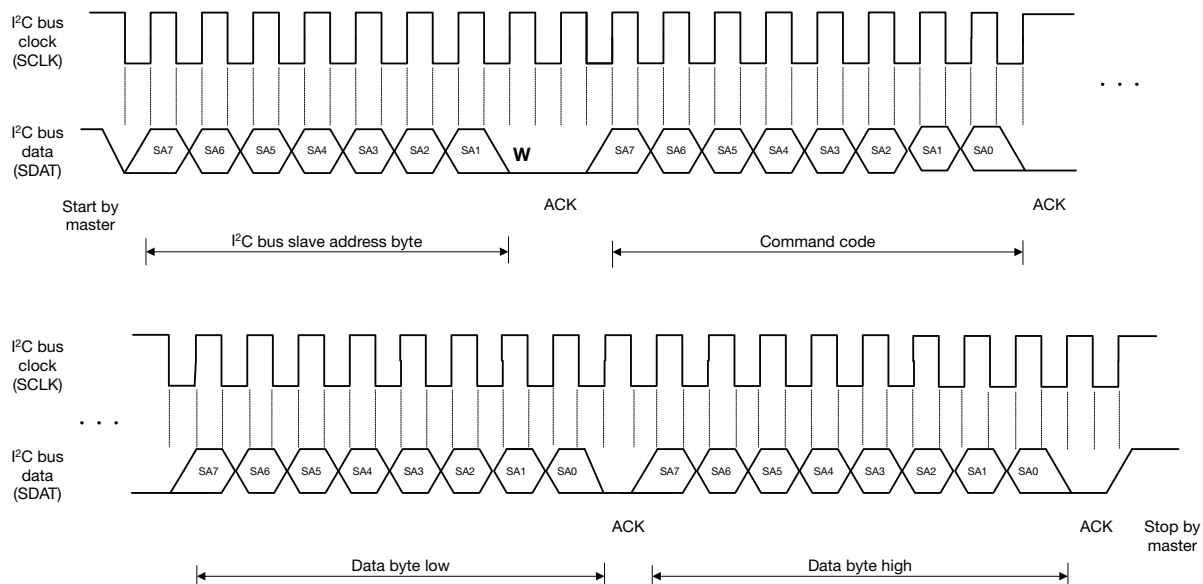

Fig. 2 - I²C Timing Diagram

PARAMETER TIMING INFORMATION

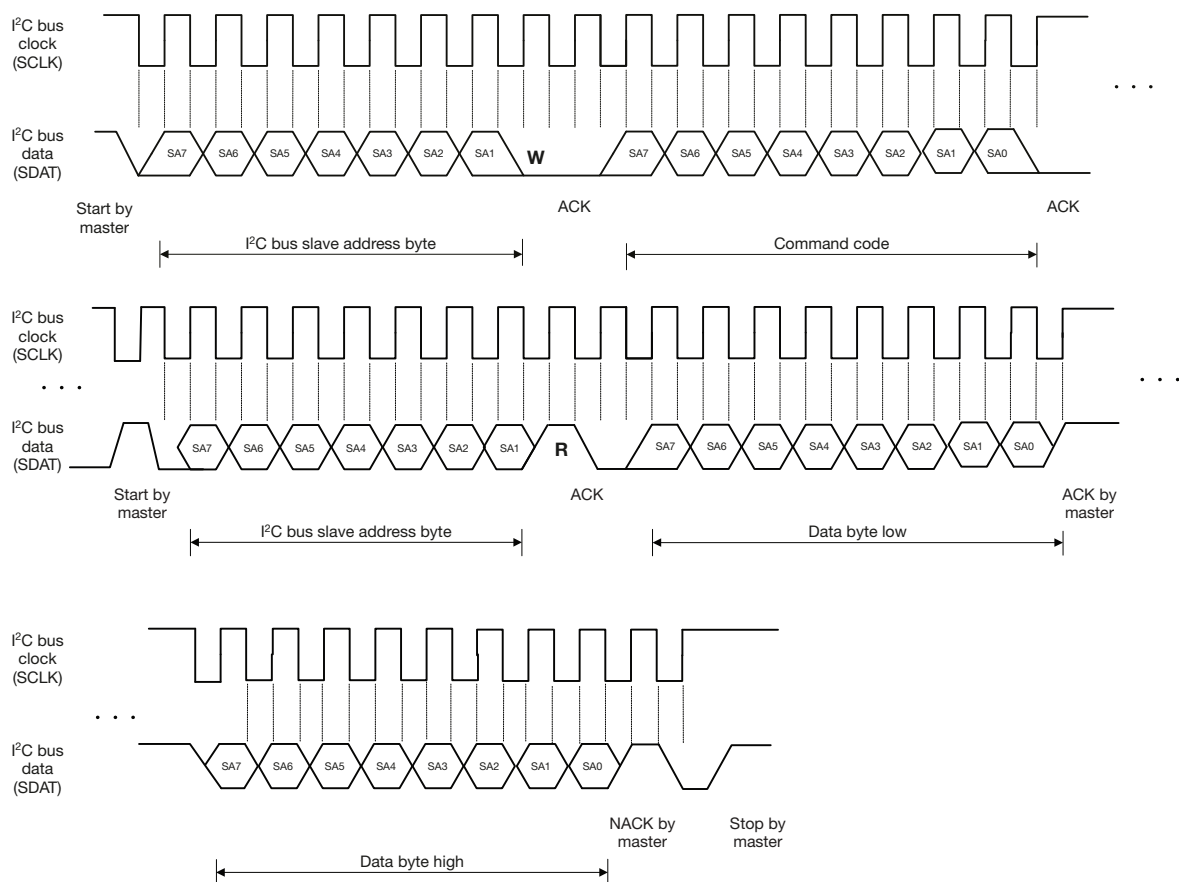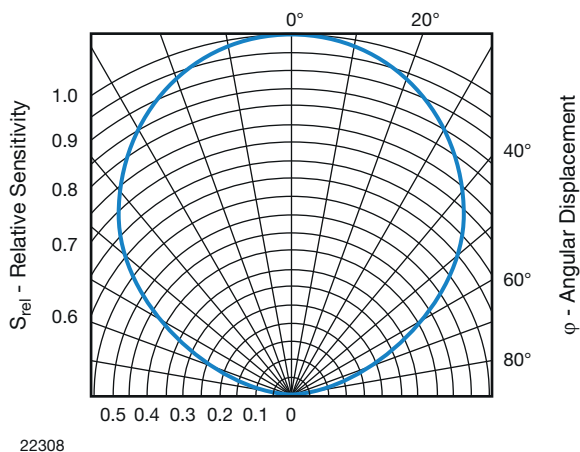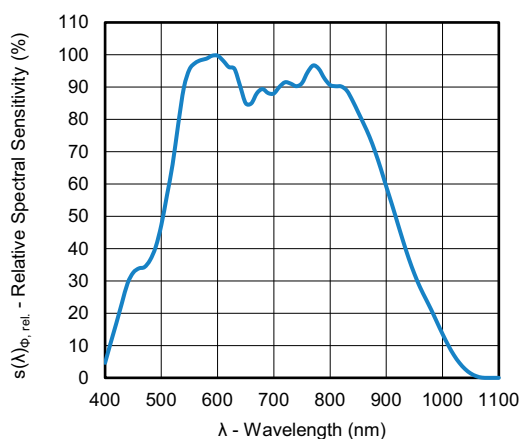Fig. 3 - I²C Bus Timing for Sending Word Command Format

Fig. 4 - I²C Bus Timing for Receive Word Command Format

BASIC CHARACTERISTICS (T_{amb} = 25 °C, unless otherwise specified)

![Spectral Response graph showing Relative Spectral Sensitivity (%) vs Wavelength (nm) for V(λ) and VEML6030]

Fig. 5 - Spectral Response

![White Channel Responsivity graph showing Relative Spectral Sensitivity (%) vs Wavelength (nm)]

Fig. 6 - White Channel Responsivity

![Relative Sensitivity vs Angular Displacement polar plot]

22308

Fig. 7 - Relative Sensitivity vs. Angular Displacement
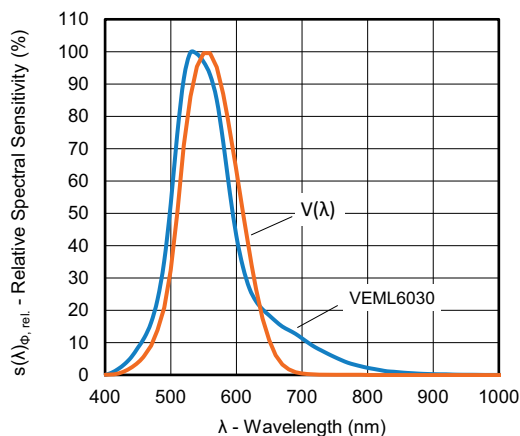
APPLICATION INFORMATION

VEML6030 is a cost effective solution of ambient light sensor with I^{2}C bus interface. The standard serial digital interface is easy to access "Ambient Light Signal" without complex calculation and programming by external controller. Beside the digital output also a flexible programmable interrupt pin is available.

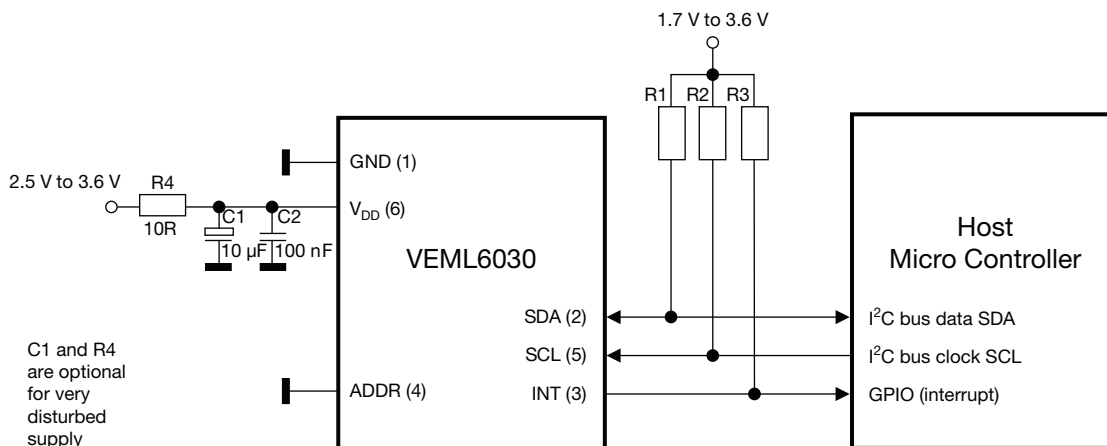### 1. Application Circuit

Fig. 8 - Application Circuit
(x) = Pin Number

Notes

- The interrupt pin is an open drain output. Proposed values for the pull-up resistors should be > 1 kΩ, e.g. 2.2 kΩ to 4.7 kΩ for the R1 and R2 (at SDA and SCL) and 10 kΩ to 100 kΩ for R3 (at interrupt).
  Normally just one decoupling capacitor is needed. This should be ≥ 100 nF and placed close to the V$_{DD}$ pin.
  Pin ADDR allows for the device addresses: pin 4 = high (V$_{DD}$) = 0x48, pin 4 = low (GND) = 0x10

  For detailed description about set-up and use of the interrupt as well as more application related information see AN: "Designing VEML6030 into an Application"

2. I^{2}C Interface

The VEML6030 contains actual six 16 bit command codes for operation control, parameter setup, and result buffering. All registers are accessible via I^{2}C communication. Figure 7 shows the basic I^{2}C communication with VEML6030.

The built in I^{2}C interface is compatible with I^{2}C modes "standard" and "fast": 10 kHz to 400 kHz.

I^{2}C H-level range = 1.3 V to 3.6 V.

Please refer to the I^{2}C specification from NXP for details.
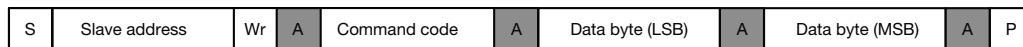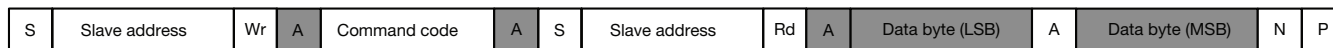
Fig. 9 - Send Byte / Receive Byte Protocol

Device Address

The VEML6030 has two fix slave addresses for the host programming and accessing selection.

With ADDR pin plugged to power supply = high = V$_{DD}$, the predefined 7 bit I2C bus address is set to 1001000 = 0x48. The least significant bit (LSB) defines read or write mode.

Accordingly the bus address is set to 1001 0000 = 90h for write and 1001 0001 = 91h for read.

With ADDR pin plugged to ground = low, the slave address (7 bit) is set to 0010000 = 0x10. According 8 bit the bus address is then 0010 0000 = 20h for write and 0010 0001 = 21h for read.

Register Addresses

VEML6030 has actual six user accessible 16 bit command codes.

The addresses are 00h to 06h (03h not defined / reserved).

Auto-Memorization

VEML6030 can memorize the last ambient data before shutdown and keep this data before waking up.

When VEML6030 is in shutdown mode, the host can freely read this data via read command directly.

When VEML6030 wakes up, the data will be refreshed by new detection.

COMMAND REGISTER FORMAT					
COMMAND CODE	REGISTER NAME	BIT	FUNCTION / DESCRIPTION	R / W
00	ALS_CONF 0	15 : 0	ALS gain, integration time, interrupt, and shut down	R / W
01	ALS_WH	15 : 8	ALS high threshold window setting (MSB)	R / W
		7 : 0	ALS high threshold window setting (LSB)	R / W
02	ALS_WL	15 : 8	ALS low threshold window setting (MSB)	R / W
		7 : 0	ALS low threshold window setting (LSB)	R / W
03	Power saving	15 : 0	Set (15 : 3) 0000 0000 0000 0b	R / W
04	ALS	15 : 8	MSB 8 bits data of whole ALS 16 bits	R
		7 : 0	LSB 8 bits data of whole ALS 16 bits	R
05	WHITE	15 : 8	MSB 8 bits data of whole WHITE 16 bits	R
		7 : 0	LSB 8 bits data of whole WHITE 16 bits	R
06	ALS_INT	15 : 0	ALS INT trigger event	R
07	ID	15 : 0	Device ID	R

Note

• Command code 0 default value is 01 = devices is shut down

Command Code #0: Configuration Register

Register address = 00h
The command code #0 is for configuration of the ambient light measurements.

TABLE 1 - CONFIGURATION REGISTER #0			
REGISTER NAME	BIT	FUNCTION / DESCRIPTION	R / W
Reserved	15 : 13	Set 000b	R / W
ALS_GAIN	12 : 11	Gain selection 00 = ALS gain x 1 01 = ALS gain x 2 10 = ALS gain x (1/8) 11 = ALS gain x (1/4)	R / W
reserved	10	Set 0b	R / W
ALS_IT	9 : 6	ALS integration time setting 1100 = 25 ms 1000 = 50 ms 0000 = 100 ms 0001 = 200 ms 0010 = 400 ms 0011 = 800 ms	R / W
ALS_PERS	5 : 4	ALS persistence protect number setting 00 = 1 01 = 2 10 = 4 11 = 8	R / W
Reserved	3 : 2	Set 00b	R / W
ALS_INT_EN	1	ALS interrupt enable setting 0 = ALS INT disable 1 = ALS INT enable	R / W
ALS_SD	0	ALS shut down setting 0 = ALS power on 1 = ALS shut down	R / W

Note

• Light level [lx] is (ALS OUTPUT DATA [dec.] / ALS Gain x responsivity). Please study also the application note

Command Code #1: High Threshold Windows Setting

Command code address = 01h. Once enable INT function and use high / low windows threshold, bit 15:0 provides 16 bit register for high bound threshold windows setting.

TABLE 2 - HIGH THRESHOLD WINDOWS SETTING #1															
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Description															
ALS high threshold window setting (15:8 MSB 8 bits of whole 16 bits)															
ALS high threshold window setting (7:0 LSB 8 bits of whole 16 bits)															

Command Code #2: Low Threshold Windows Setting

Command code address = 02h. Once enable INT function and use high / low windows threshold, bit 15:0 provides 16 bit register for low bound threshold windows setting.

TABLE 3 - LOW THRESHOLD WINDOWS SETTING #2															
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Description															
ALS low threshold window setting (15:8 MSB 8 bits of whole 16 bits)															
ALS low threshold window setting (7:0 LSB 8 bits of whole 16 bits)															

Command Code #3: Power Saving Mode: PSM

Command code address = 03h. Bits 2 and 1 define the power saving modes. Bits 15 : 3 are reserved.

TABLE 4 - POWER SAVING MODES				
COMMAND CODE	**REGISTER NAME**	**BIT**	**FUNCTION / DESCRIPTION**	**R / W**
03	PSM	2 : 1	Power saving mode; see table "Refresh time" 00 = mode 1 01 = mode 2 10 = mode 3 11 = mode 4	R / W
	PSM_EN	0	Power saving mode enable setting 0 = disable 1 = enable	R / W

Command Code #4: ALS High Resolution Output Data

Command code address = 04h. To access 16 bit high resolution ALS output, it is suitable to follow read protocol to read from command code #04 16 bits register.

TABLE 5 - ALS HIGH RESOLUTION OUTPUT DATA #4															
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Description															
ALS high resolution output data (15 : 8 MSB 8 bits of whole 16 bits)															
ALS high resolution output data (7 : 0 LSB 8 bits of whole 16 bits)															

Command Code #5: White Channel Output Data

Command code address = 05h. To access 16 bit WHITE output, it is suitable to follow read protocol to read from command code #05 16 bits register.

TABLE 6 - WHITE CHANNEL OUTPUT DATA #5															
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Description															
WHITE output data (15 : 8 MSB 8 bits of whole 16 bits)															
WHITE output data (7 : 0 LSB 8 bits of whole 16 bits)															

Command Code #6: Interrupt Status

Command code address = 06h. Bit 15 defines interrupt flag while trigger occurred due to data crossing low threshold windows. Bit 14 defines interrupt flag while trigger occurred due to data crossing high threshold windows.

TABLE 7 - INTERRUPT STATUS #6		
Bit 15	Bit 14	Bit 13 to 0
int_th_low	int_th_high	reserved
Description		
int_th_low	Read bit. Indicated a low threshold exceed	
int_th_high	Read bit. Indicated a high threshold exceed	

Command Code #7: ID Register

Command code address = 07h. The low byte of the ID register contains the device specific ID code 81h. The high byte contains a code that depends on the chosen slave address option: either 0xC4 for a device with slave address 0x20, or 0xD4 for a device with slave address 0x90
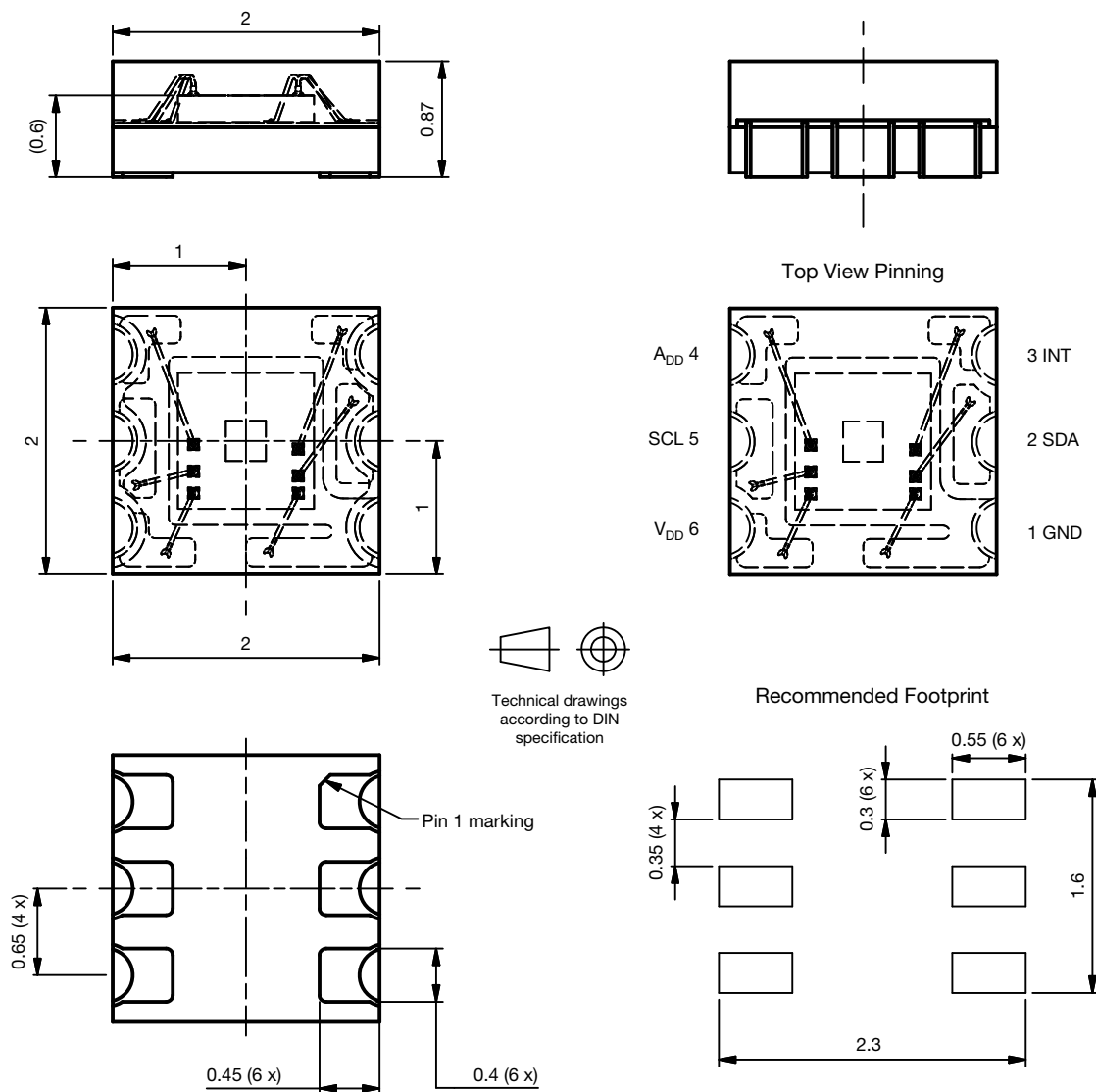
TABLE 8 - DEVICE ID #7	
Bit 15 to 8	Bit 7 to 0
Slave address option code	Device ID code
Description	
Slave address option code	Slave address specific ID For slave address option 0x20: 11000100 = 0xC4 For slave address option 0x90: 11010100 = 0xD4
Device ID code	Fixed device ID: 10000001 = 0x81

REFRESH TIME DETERMINATION OF PSM

VEML6030's refresh time can be determined by PSM and ALS_IT setting in power saving mode (PSM). Cooperating with the command register setting, the designer has a flexible method in defining the timing, power consumption, and sensitivity for light data collection.

REFRESH TIME, I_{DD}, AND RESOLUTION RELATION					
ALS_GAIN	PSM	ALS_IT (ms)	REFRESH TIME (ms)	I_{DD} (µA)	RESOLUTION (lx/bit)
x2	Mode 1	100	600	8	0.0336
x2	Mode 2	100	1100	5	0.0336
x2	Mode 3	100	2100	3	0.0336
x2	Mode 4	100	4100	2	0.0336
x2	Mode 1	200	700	13	0.0168
x2	Mode 2	200	1200	8	0.0168
x2	Mode 3	200	2200	5	0.0168
x2	Mode 4	200	4200	3	0.0168
x2	Mode 1	400	900	20	0.0084
x2	Mode 2	400	1400	13	0.0084
x2	Mode 3	400	2400	8	0.0084
x2	Mode 4	400	4400	5	0.0084
x2	Mode 1	800	1300	28	0.0042
x2	Mode 2	800	1800	20	0.0042
x2	Mode 3	800	2800	13	0.0042
x2	Mode 4	800	4800	8	0.0042

PACKAGE DIMENSIONS in millimeters

Top View Pinning

A_DD 4		3 INT
SCL 5		2 SDA
V_DD 6		1 GND

Technical drawings according to DIN specification

Pin 1 marking

0.65 (4 x)

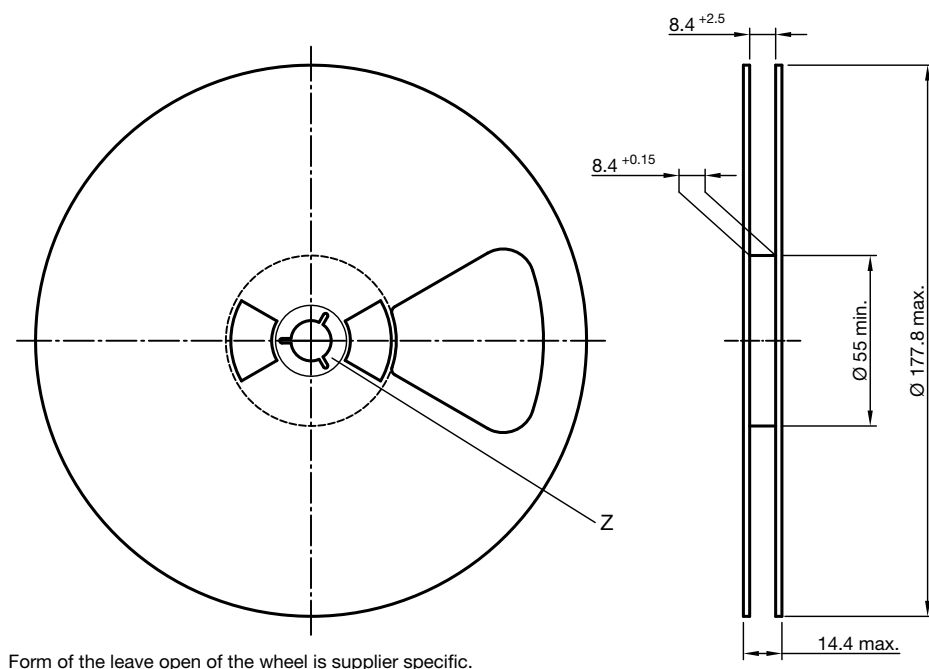0.45 (6 x)   0.4 (6 x)

Recommended Footprint

0.55 (6 x)

0.35 (4 x)

0.3 (6 x)

1.6

2.3

Drawing No.: 6.550-5348.01-4
Issue: 1; 19.02.16

Not indicated tolerances ± 0.1
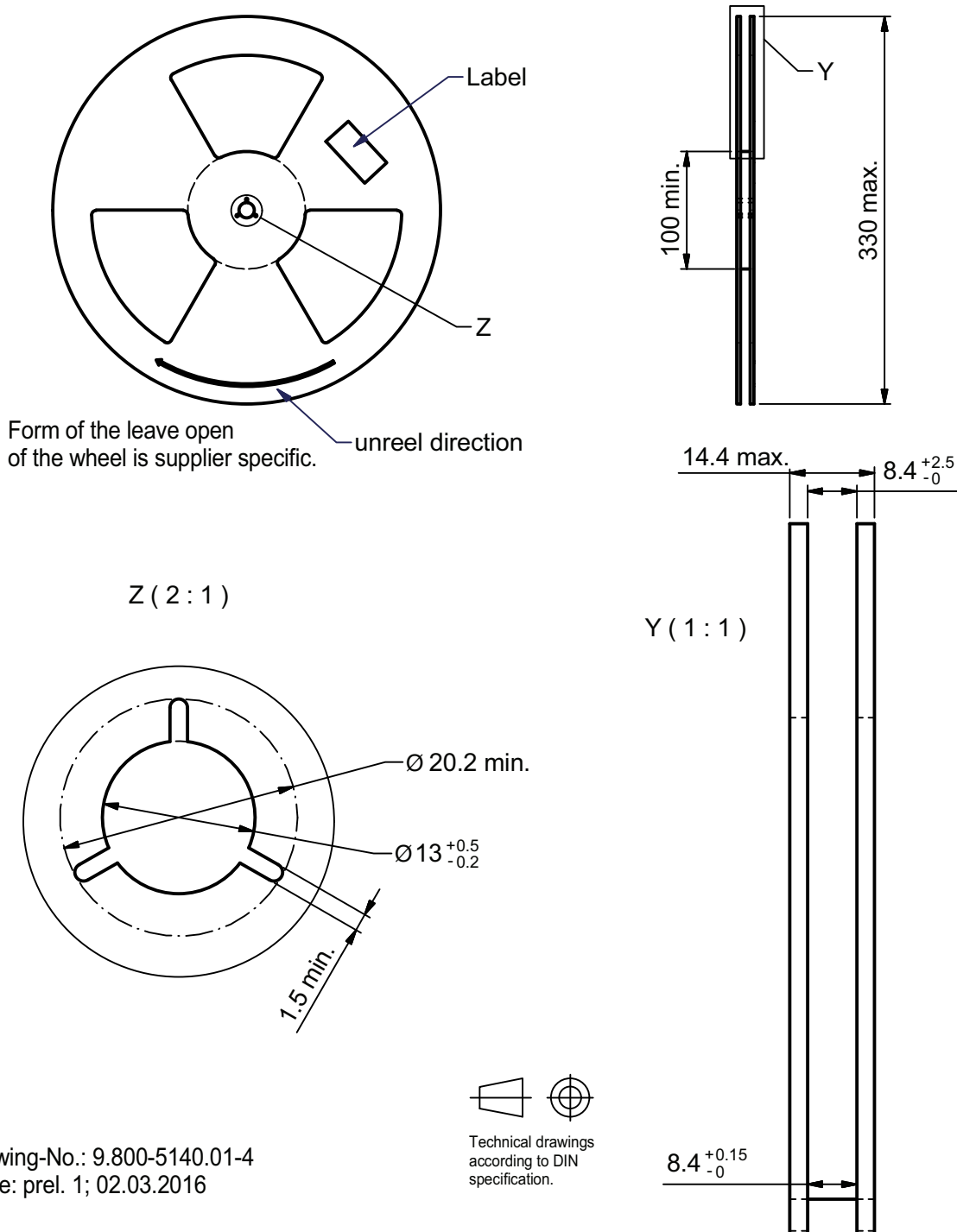
TAPE AND REEL DIMENSIONS in millimeters

8.4 +2.5

8.4 +0.15

Ø 55 min.

Ø 177.8 max.

14.4 max.

Z

Form of the leave open of the wheel is supplier specific.

Z 2:1

1.5 min.

Ø13 +0.5 -0.2

Ø20.2 min.
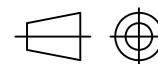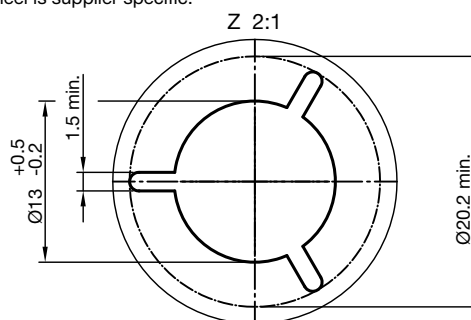
Technical drawings according to DIN specification.

Drawing-No.: 9.800-5096.01-4
Issue: 6; 20.03.2019

Fig. 10 - 7" Reel, 3000 Pieces

Label

Y

100 min.

330 max.

Z

Form of the leave open
of the wheel is supplier specific.

unreel direction

14.4 max.

8.4 $^{+2.5}_{-0}$

Z (2 : 1)

Y (1 : 1)

Ø 20.2 min.

Ø 13 $^{+0.5}_{-0.2}$

1.5 min.

Drawing-No.: 9.800-5140.01-4
Issue: prel. 1; 02.03.2016

Technical drawings
according to DIN
specification.

8.4 $^{+0.15}_{-0}$

Fig. 11 - 13" Reel, 10 000 Pieces
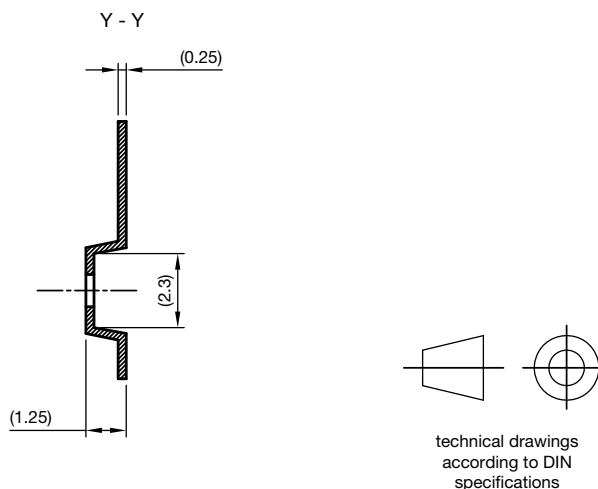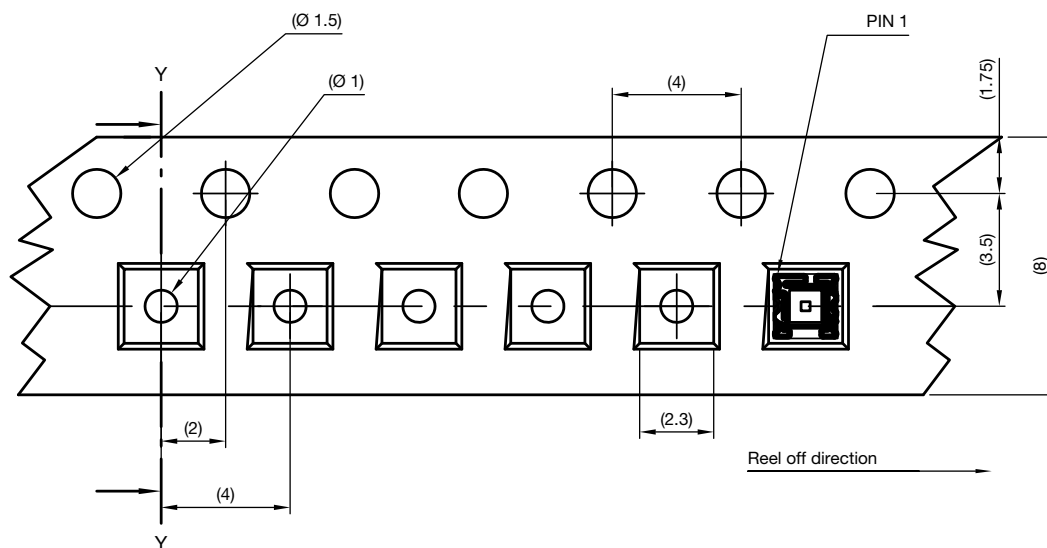
Fig. 12 - Taping

Drawing-No.: 9.700-5397.01-4
Issue: 1; 19.02.16

technical drawings
according to DIN
specifications
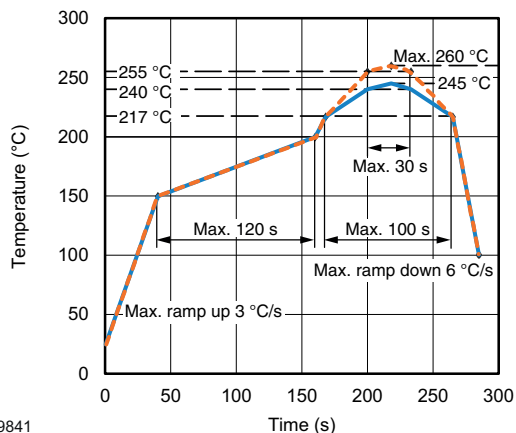
REFLOW SOLDER PROFILE

19841

Fig. 13 - Lead (Pb)-free Reflow Solder Profile
According to J-STD-020

DRYPACK

Devices are packed in moisture barrier bags (MBB) to prevent the products from moisture absorption during transportation and storage. Each bag contains a desiccant.

FLOOR LIFE

Floor life (time between soldering and removing from MBB) must not exceed the time indicated on MBB label:

Floor life: 72 h

Conditions: T_{amb} < 30 °C, RH < 60 %

Moisture sensitivity level 4, according to J-STD-020.

DRYING

In case of moisture absorption devices should be baked before soldering. Conditions see J-STD-020 or label. Devices taped on reel dry using recommended conditions 192 h at 40 °C (+ 5 °C), RH < 5 %.

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