11-MD115

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VCM Driver for Mobile Phone

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11-MD115

VCM Driver for Mobile Phone

General Specifications

The 11-MD115 is a voice coil motor driver which provides a controllable constant current via external PWM input signal control. With miniature package, it is suitable for reduced -space mounting in camera module application and other portable device.

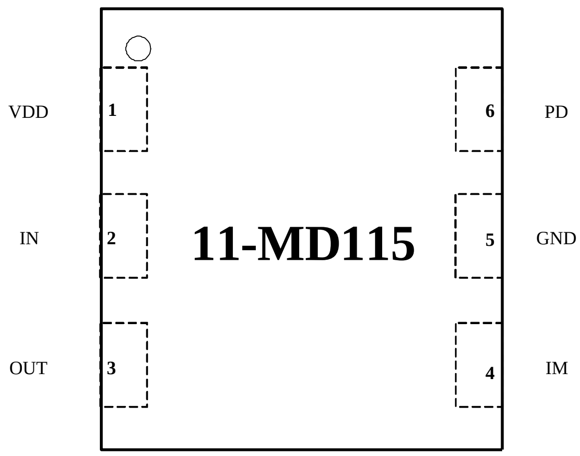
Features and Benefits

- Low voltage operation
- Low saturation voltage
- Low operating current
- Zero standby current
- Built-in pull down resistor for PD pin
- Built-in a freewheeling diode
- Constant current control
- PWM input control with low input current
- Ultra-small package (LFCSP6, 1.6mm*1.4mm*0.425mm) and (WLCSP, 1.5mm*1.0mm*0.5mm)

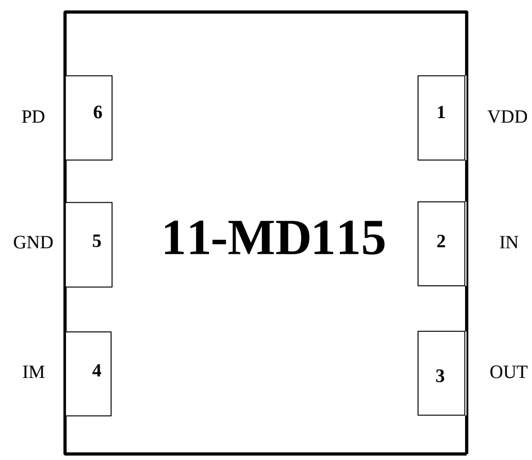
Pin Assignment

Pin Assignment of LFCSP6

TOP view



Bottom view

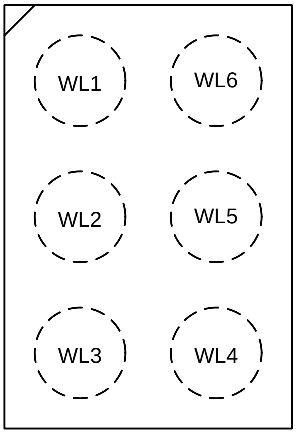


Pin Descriptions (LFCSP6)

Pin NO.	Pin Name	Description
1	VDD	Power supply pin for controller.
2	IN	Constant current setting pin
3	OUT	Motor output pin
4	IM	Current sense resistor
5	GND	Controller ground
6	PD	Power down. Asynchronous power down signal

Pin Assignment of WLCSP

Top View



Pin Descriptions (WLCSP)

Pin NO.	Pin Name	Description
WL1	OUT	Motor output pin
WL2	IN	Constant current setting pin
WL3	VDD	Power supply pin for controller.
WL4	PD	Power down. Asynchronous power down signal
WL5	VSS	Controller ground
WL6	IM	Current sense resistor

Absolute Maximum Ratings *(Unless otherwise noted, T_A= 25℃)*

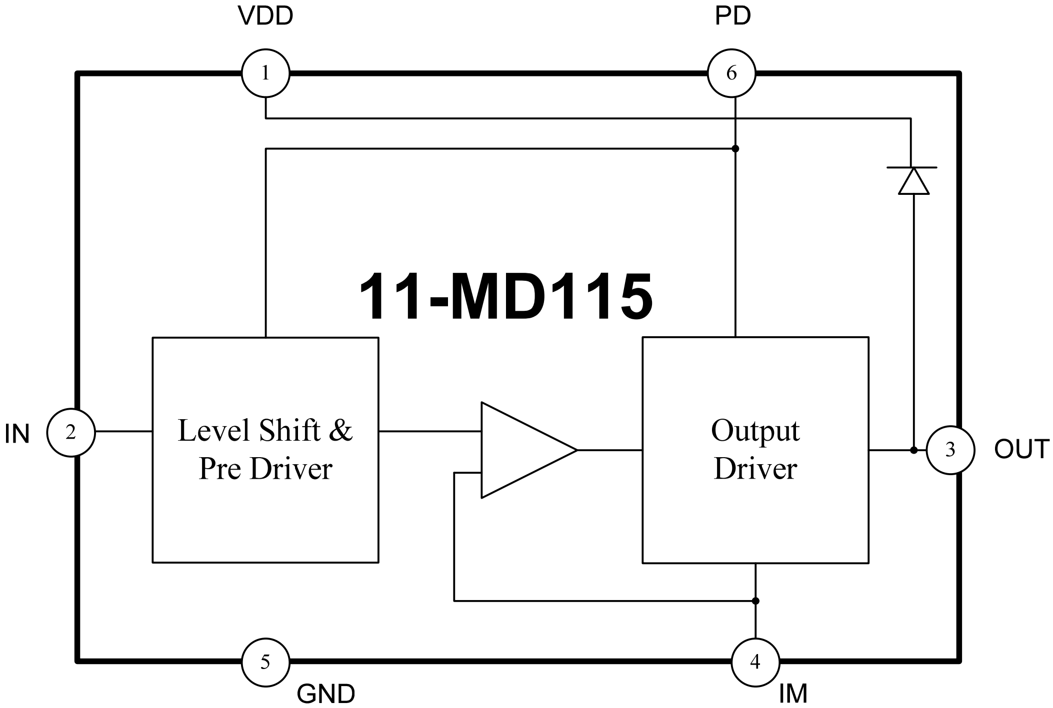
Characteristic	Symbol	Rating	Unit
Supply Voltage	V_{DD}	5.5	V
Input Voltage	V_{IN}	V_{DD}+0.4	V
Maximum output current	I_{OUT}	200	mA
Power Dissipation	P_D	400	mW
Operating Temperature Range	T_{OPR}	-40 ~ 125	°C
Storage Temperature Range	T_{STG}	-65 ~ 150	°C

Electrical Characteristic

(Unless otherwise noted, T_A= 25℃ & V_{DD} = 2.8V)

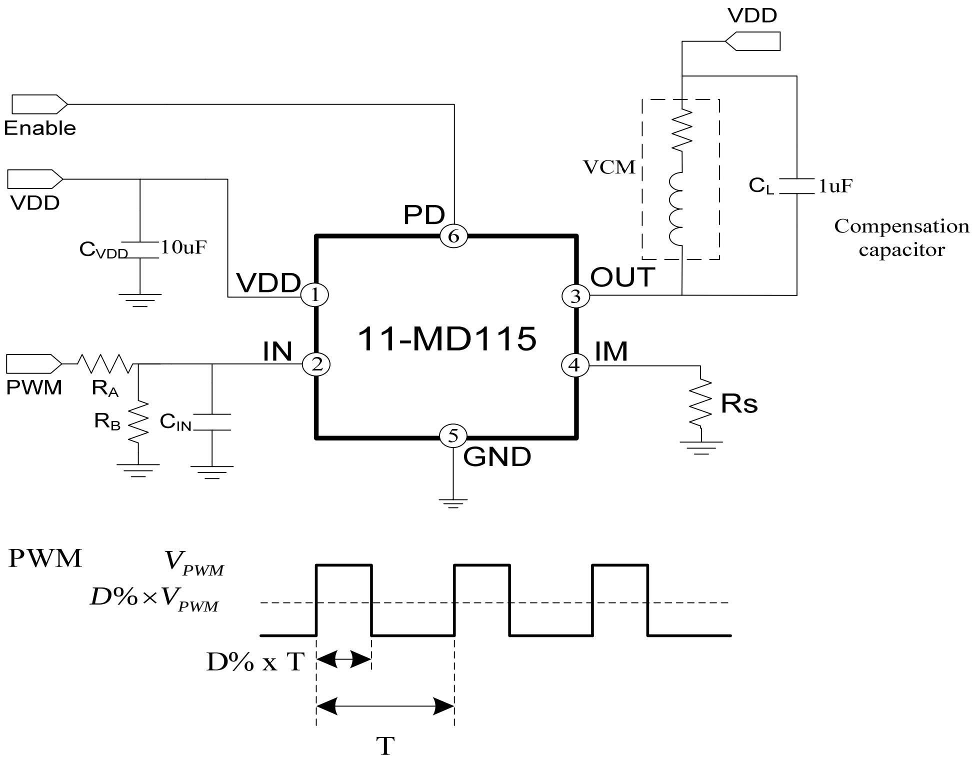
Item	Sym.	Condition	Limit			Unit
			Min.	Typ.	Max.	
Whole circuits						
Supply Voltage	V_{DD}		2.0	2.8	5.5	V
Supply Current (I_{DD})	I_{STB}	PD = L (Standby mode)		0.1	5	μA
	I_{DD1}	PD = H (Operation mode)		0.8	1.6	mA
Power down						
Input Voltage "H"	V_{PDH}	-	0.8*V_{DD}	-	V_{DD}+0.4	V
Input Voltage "L"	V_{PDL}	-	-0.4	-	0.15*V_{DD}	V
Input Current "H"	I_{PDH}	V_{PD} = V_{DD}=3V	-	10	20	μA
Input Current "L"	I_{PDL}	V_{PD} = 0 V	-	-	±5	μA
Constant Current Output Terminal						
Output constant current	I_{OUT}	R_S =1.5Ω ,PWM input control	10	-	120	mA
Output current during PD	$I_{OUT,PD}$	PD = L	-	-	5	μA
Saturation Voltage	V_{SAT}	I_{OUT} = 120 mA	-	0.1	0.15	V
Output Current Settling Time	t_s	VDD = 2.8V, C_L=1 μF , R_S =1.5Ω , VCM($28.5\ \Omega,\ 460\mu H$)		200	250	μs

Block Diagram

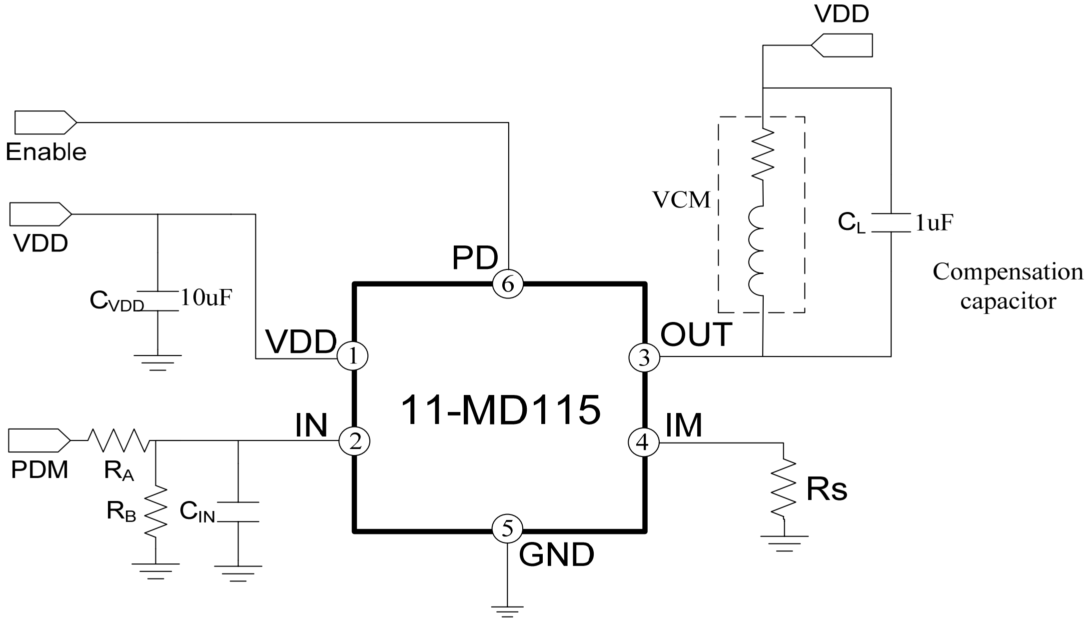


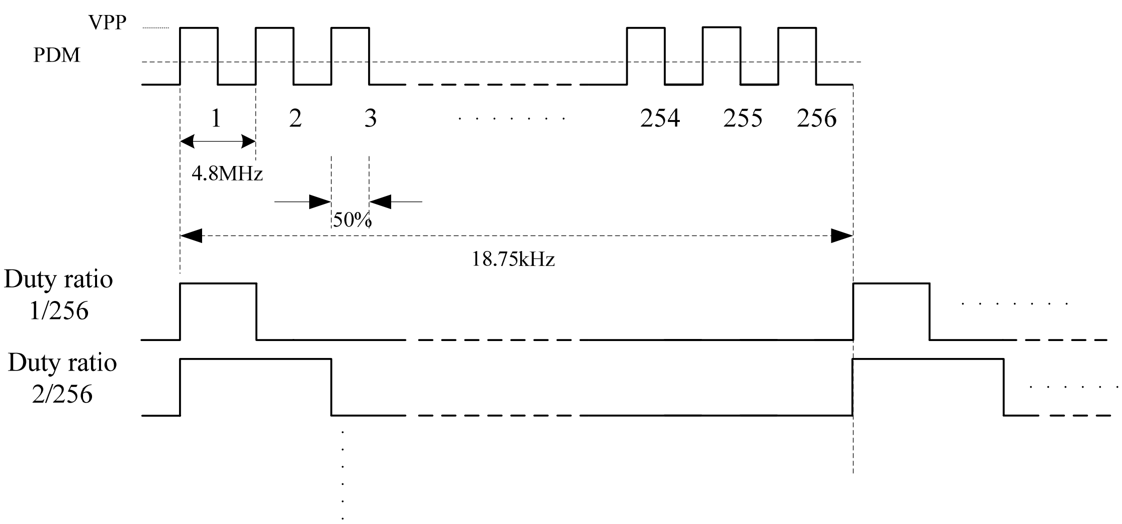
Application Circuit

1. <u>PWM control</u>



2. PDM control





Application Notes

- The 11-MD115 is constant current control for use in Auto-Focus. The range of supply voltage of 11-MD115, VDD is from 2.0V to 5.5V. The 11-MD115 digital control pin, PD, its input range is defined that logic "H" is from 0.8*VDD to VDD+0.4V and logic "L" is from –0.4V to 0.2*VDD. The input pin, IN, is VCM constant current setting pin.

- The power down pin (PD) is the enable pin of 11-MD115, which logic high level (PD = H) is for IC operation. On the other hand, its logic low level (PD = L) puts the chip into standby mode for power saving. Therefore, it is easy to switch the working status by controlling PD pin, and it is recommended that keeps PD at low level (PD = L) before operation to reach the maximum efficiency of power saving, especially in the application of portable device.

- Constant current operation of 11-MD115 provides the current, which can be evaluated by the formula $I = \frac{V_{IN}}{10 * R_S(\Omega)} \quad (\mathrm{A})$. It is obviously that constant current not only depends on the resistance load on the current sense terminal, IM, but the amount of input voltage level, V_{IN}. Therefore, by adjusting the resistance of R_A, R_B, and the capacitance C_{IN}, with appropriately PWM frequency will get the suitable and stable input voltage level, V_{IN}, for setting constant current in the output.

- In the application circuit diagram, the signal PWM, V_{PWM}, is filtered by a low pass filter which consists of R_A, R_B, and C_{IN}. The -3dB frequency ω_{3dB} and V_{IN} are given by

$$\omega_{3dB} = \frac{1}{(R_A // R_B) C_{IN}}$$

$$V_{IN} = \frac{R_B}{R_A + R_B} D\% \times V_{PWM} \quad (\mathrm{V}),$$

, which D% is the duty ratio of PWM frequency. The corresponding of constant current at the output could be changed by setting different duty ratio of PWM, In order to confirm the accuracy and stable value of constant current, the amount of

-3dB frequency ω_{3dB} is suggested lower than the 1/100 of the PWM frequency. It is shown as follows,

$$\omega_{3dB} = \frac{1}{100}\omega_{PWM}$$

- The following example explains how to design the low pass filter. For PWM frequency $f_{PWM} = 20kHz$, the sense resistance $R_S = 1.5\ \Omega$, the desired maximum output constant current is 100mA and V_{PWM} = 3V, determine C_{IN}, R_A and R_B.

$$f_{3dB} = \frac{1}{2\pi\left(R_A // R_B\right)C_{IN}} = \frac{1}{100} f_{PWM} = 0.2kHz$$

By choosing $C_{IN} = 0.1uF$, we can get $\left(R_A // R_B\right) = 7.96k\Omega$.

Because to $I_{\max} = \frac{V_{IN,\max}}{10 * R_S\left(\Omega\right)}$ $\left(\mathrm{A}\right)$,

Then

$$R_A = \frac{\left(R_A // R_B\right)}{10 \times \mathrm{I}_{\max} \times R_S} V_{PWM} = 15.9k\Omega$$

$$R_B = 15.9k\Omega$$

- The accuracy of output constant current is closely dependent on the PWM frequency. The higher PWM frequency, there will be less voltage variation in IM pin within the desired constant current. The output sense resistor $R_{S1} = 1.5\ or\ 1.8\ \Omega$ is recommended to have a better accuracy of output constant current.

- In order to ensure the stabilization of output current, the compensation capacitance C_L is suggested to reserve between the both terminals of VCM. The suggestion value of C_L is about 1uF and maybe fine tune depending on the different VCM. It is the sense of frequency response compensation to confirm stability while VCM operating.

- Suggestion Look Up Table (PWM control) :

Condition I: PWM freq. = 16 KHz, $R_{IM} = 1.5\Omega$

V_{PWM} = 2.8V

Max. output current *I (mA)*	C_{IN} (μF)	R_A ($k\Omega$)	R_B ($k\Omega$)
100	0.1	18.6	21.4
120	0.1	15.5	27.9

V_{PWM} = 3 V

Max. output current *I (mA)*	C_{IN} (μF)	R_A ($k\Omega$)	R_B ($k\Omega$)
100	0.1	20	20
120	0.1	16.6	24.9

Condition II: PWM freq. = 20 KHz, $R_{IM} = 1.5\Omega$

VPWM = 2.8V

Max. output current *I (mA)*	C_{IN} (μF)	R_A ($k\Omega$)	R_B ($k\Omega$)
100	0.1	14.9	17.1
120	0.1	12.4	22.3

V_{PWM} = 3 V

Max. output current *I (mA)*	C_{IN} (μF)	R_A ($k\Omega$)	R_B ($k\Omega$)
100	0.1	15.9	15.9
120	0.1	13.3	20

<u>*Condition III*</u>: PWM freq. = 24 KHz, $R_{IM}=1.5\Omega$

V_{PWM} = 2.8 V

Max. output current *I (mA)*	C_{IN} (μF)	R_A ($k\Omega$)	R_B ($k\Omega$)
100	0.1	12.4	14.3
120	0.1	10.3	18.6

V_{PWM} = 3 V

Max. output current *I (mA)*	C_{IN} (μF)	R_A ($k\Omega$)	R_B ($k\Omega$)
100	0.1	13.3	13.3
120	0.1	11	16.6

- With PDM signal as input, passed through a low pass filter made up by R_A, R_B, and C_{IN}, will essentially get the averaged dc value. For the overall 256 steps with duty ratio 50% and PDM base frequency $f_{PDM} = 4.8MHz$, the effectively PWM frequency is 18.75 KHz. Therefore, the parameters, R_A, R_B, and C_{IN}, of LPF corresponding to the effectively PWM frequency will suggest in the following look up table.

$$V_{pp} = 2.6\ (\mathrm{V}),\ f_{PDM} = 4.8MHz,\ and\ 256 steps\ with\ 50\%\ duty$$
$$18.75kHz\ PWM\ frequency\ effectively$$

$R_{IM} = 1.5\Omega$

Max. output current *I (mA)*	C_{IN} (μF)	R_A ($k\Omega$)	R_B ($k\Omega$)
100	0.1	14.7	20
100	0.01	147	200
120	0.1	12.3	27.6
120	0.01	123	276

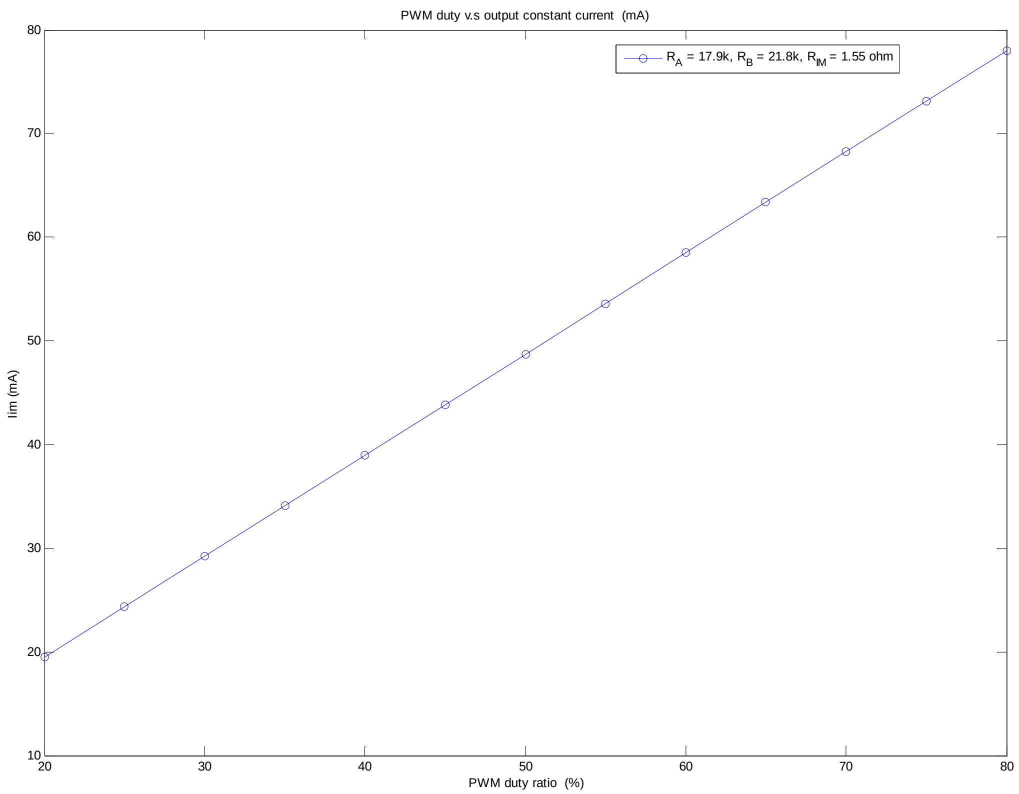
$R_{IM} = 1.8\Omega$

Max. output current *I (mA)*	C_{IN} (μF)	R_A ($k\Omega$)	R_B ($k\Omega$)
100	0.1	12.3	27.6
100	0.01	123	276
120	0.1	10.2	50.2
120	0.01	102	502

Measurement Result

In the following, we take some measured data as examples to explain the linear relationship between PWM duty and output current. From the measurement result, it appears that the output constant current is highly linear to the PWM duty ratio.

1. PWM freq. = 16 KHz, V_{PWM} = 2.8V, C_{IN} = 0.1 μF , I_{MAX} = 100mA. @25℃
   R_A = 17.9 $k\Omega$, R_B = 21.8 $k\Omega$, R_S = 1.55 Ω



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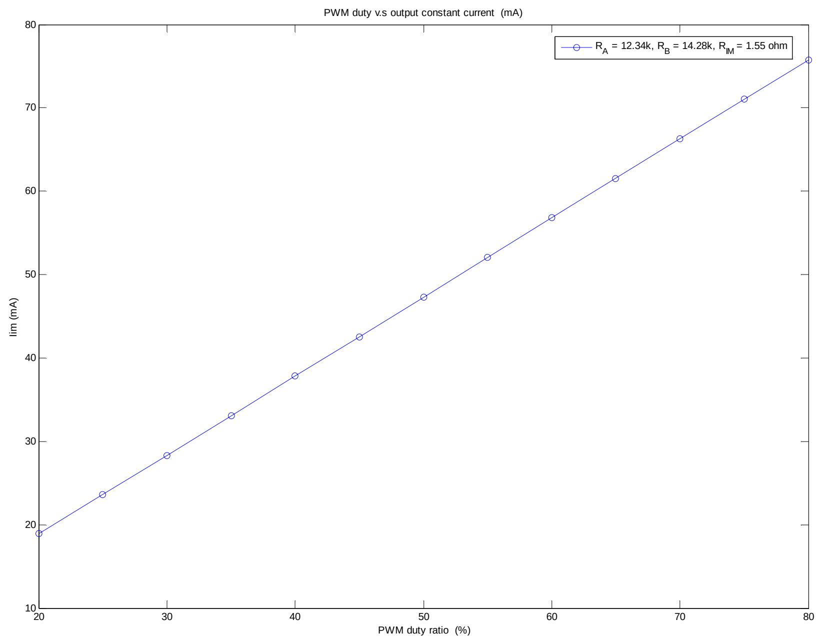
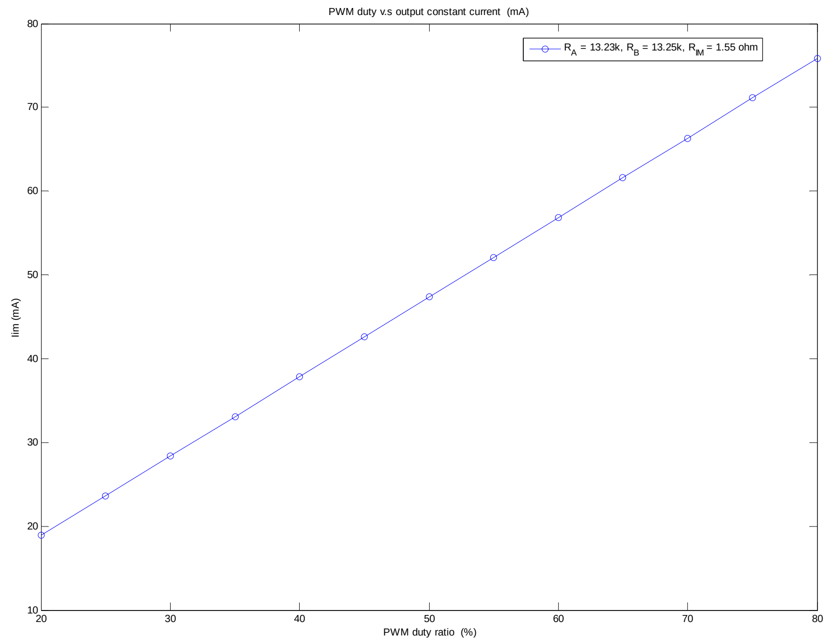
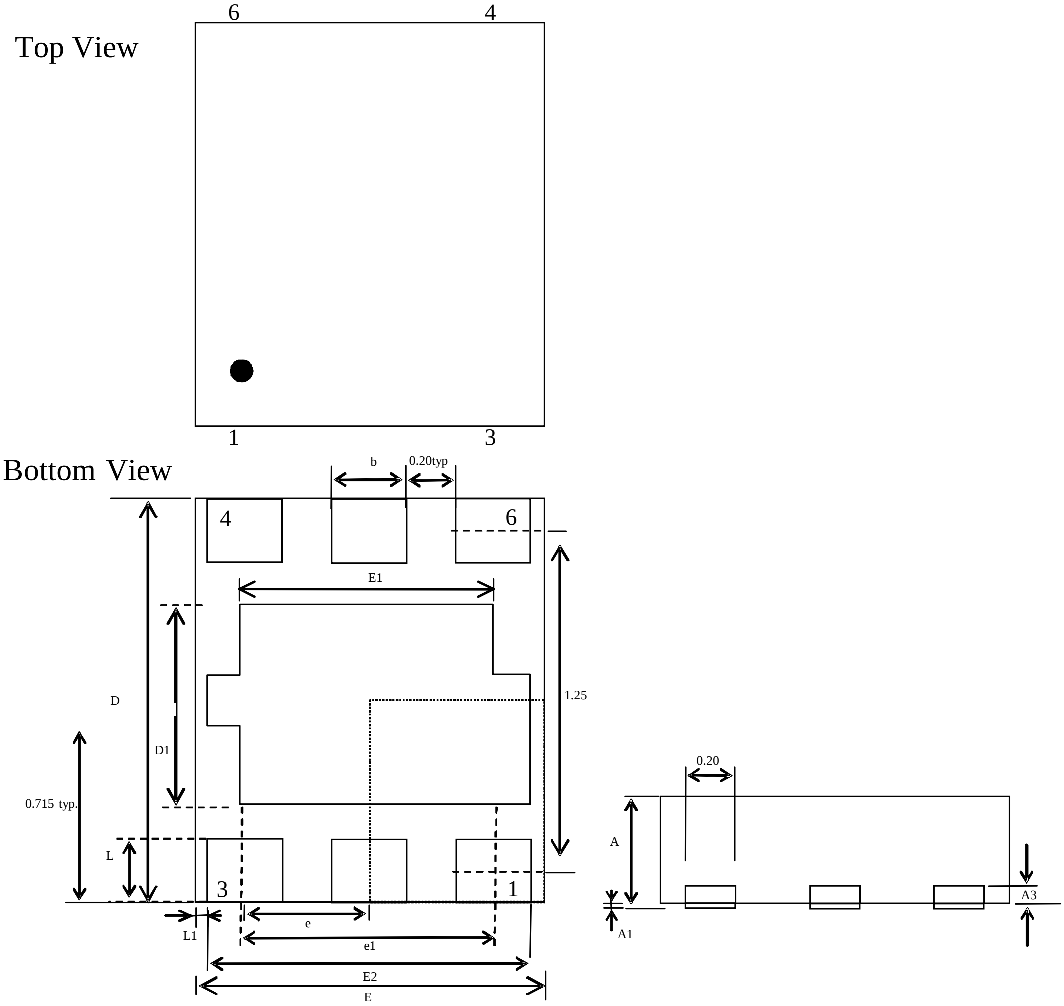
2. PWM freq. = 24 KHz, V_{PWM} = 2.8V, C_{IN} = 0.1 μF , I_{MAX} = 100mA. @25℃
   R_A = 12.34 $k\Omega$, R_B = 14.28 $k\Omega$, R_S = 1.55 Ω



3. PWM freq. = 24 KHz, V_{PWM} =3V, C_{IN} = 0.1 μF , I_{MAX} = 100mA. @25℃
   R_A = 12.23 $k\Omega$, R_B = 13.25 $k\Omega$, R_S = 1.55 Ω

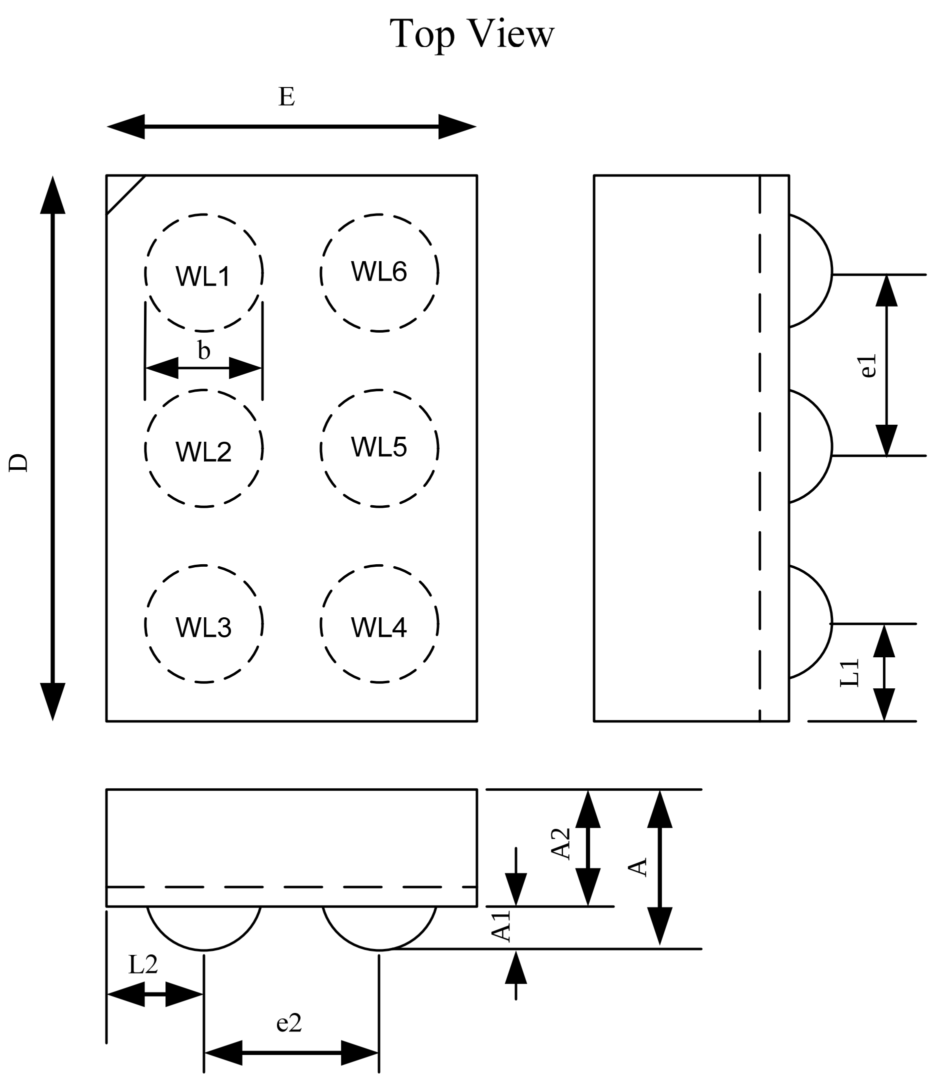


Package Specifications (LFCSP6)



SYMBOL	DIMENSION (mm)			DIMENSION (mil)		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	-	-	0.425	-	-	16.7
A1	0.00	0.02	0.05	0	0.8	2
A3	0.127 REF			5 REF		
b	0.22	0.30	0.38	8.7	11.8	15
D	1.50	1.60	1.70	59.1	63.0	66.9
D1	0.5	0.6	0.7	19.7	23.6	27.6
E	1.30	1.40	1.50	51.1	55.1	59.1
E1	1.00	1.10	1.20	39.4	43.3	47.2
E2	1.30 BASIC			51.2 BASIC		
L	0.25	0.30	0.35	9.8	11.8	13.8
L1	0.05 BASIC			2.00 BASIC		
e	0.50 BASIC			20.0 BASIC		
e1	1.00 BASIC			39.4 BASIC		
y	-	-	0.08	-	-	3

Package Specifications (WLCSP)



SYMBOL	DIMENSION (mm)		
	MIN.	NOM.	MAX.
A	0.45	0.50	0.55
A1	0.08	0.10	0.12
A2	0.37	0.40	0.43
b	0.26	0.28	0.30
D	1.45	1.50	1.55
E	0.95	1.00	1.05
e1	0.48	0.50	0.52
e2	0.48	0.50	0.52
L1	0.22	0.25	0.28
L2	0.22	0.25	0.28

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