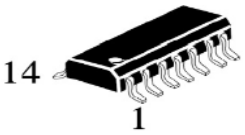
5V Low-Drop Fixed Voltage Regulator

ILE4278

FUNCTIONAL DESCRIPTION

The ILE4278 is designed to create 5V constant voltage and can provide the load current up to 200mA. The drop voltage of the IC is not more than 0.5V at 150mA load current.

The IC is designed to supply microprocessor systems under the severe conditions of automotive applications and therefore equipped with additional protection functions against over load and over temperature. Furthermore, the ILE4278 can also be used in other applications where a stabilized voltage is required.



ILE4278D

PDSOP-14

FEATURES

- The input voltage range from 5.7V to 45V;
- The accuracy of the output voltage ±2% in the range of output currents from 1mA to 150 mA and the input voltages from 6 to 28V;
- The accuracy of the output voltage ±4% in the range of output currents from 1mA to 50mA and the input voltages from 28V to 45V;
- Low current consumption;
- Low drop voltage;
- Reset function;
- Watchdog microcontroller function;
- Separated reset and watchdog outputs;
- Adjustable watchdog function activation threshold;
- Adjustable reset threshold;
- Built-in thermal protection;
- Reverse polarity protection;
- Compatible with automotive electronic circuits;
- AEC-Q100 Qualified;
- ESD protection: HBM ±8,000V/ MM ±400V/ CDM ±2,000V.

PIN CONFIGURATION

(top view)

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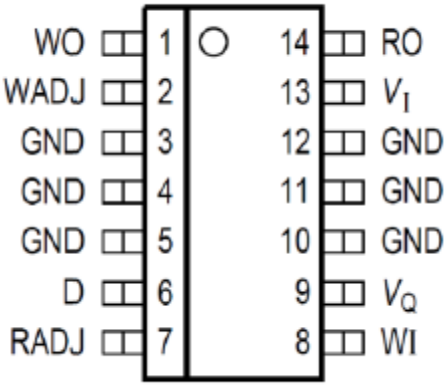

Figure 1

PIN DEFINITIONS AND FUNCTIONS

Table 1.

Pin	Symbol	Function
1	WO	**Watchdog Output**; the open collector output is connected to the 5V output via an integrated resistor of 30kΩ.
2	WADJ	**Watchdog Adjust**; an external resistor to GND determines the watchdog activating threshold.
3,4,5,10,11,12	GND	**Ground**
6	D	**Reset Delay**; connect a capacitor to ground for delay time adjustment.
7	RADJ	**Reset Switching Threshold Adjust**; for setting the switching threshold, connect a voltage divider from output to ground. If this input is connected to ground, the reset is triggered at the internal threshold.
8	WI	**Watchdog Input**; rising edge-triggered input for monitoring a microcontroller.
9	Q	**5V Output Voltage**; block to ground with min. 10uF capacitor, 1Ω ≤ ESR ≤ 5Ω
13	I	**Input Voltage**; block to ground directly on the IC with ceramic capacitor.
14	RO	**Reset Output**; the open collector output is connected to the 5V output via an integrated resistor of 30kΩ.

Table 2. **ABSOLUTE MAXIMUM RATINGS**

Parameter	Parameter name	Limit value		Unit
		Min.	Max.	
V_I	Input voltage	-42	45	V
I_{GND}	GND current	-100	50	mA
V_Q	Output voltage	-1	25	V
V_{RO}	Reset output voltage	-0.3	25	V
I_{RO}	Reset output current	-5	5	mA
V_{WO}	Watchdog output voltage	-0.3	25	V
I_{WO}	Watchdog output current	-5	5	mA
V_D	Reset delay voltage	-0.3	7	V
I_D	Reset delay current	-2	2	mA
V_{RADJ}	Reset switching Threshold Adjust voltage	-0.3	7	V
I_{RADJ}	Reset switching Threshold Adjust current	-	Internally limited	mA
V_{WI}	Watchdog input voltage	-0.3	7	V
I_{WI}	Watchdog input current	-	Internally limited	mA
V_{WADJ}	Watchdog adjust voltage	-0.3	7	V
I_{WADJ}	Watchdog adjust current	-	Internally limited	mA
T_J	Temperature	-60*	150	°C

_____
* ambient temperature

Note:

Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied.

Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

Table 3. **RECOMMENDED OPERATION RATE**

Symbol	Parameter	Limit Value		Unit
		Min	Max	
V_I	Input voltage	5.7	45	V
V_Q	Output voltage	4.8	5.2	V
T_J	Temperature	-40*	125	°C

_____
* ambient temperature

Table 4. **ELECTRICAL CHARACTERISTICS**

V_I = 13.5V; – 40℃ ≤ T_j ≤ 125℃ (unless otherwise specified)

Symbol	Parameter	Test Condition	Limit Values		Unit
			Min	Max	
Normal Operation					
I_q	Current consumption ($I_q = I_I - I_Q$)	I_Q = 0mA; T_j = 25°C	-	200	uA
		I_Q = 0mA; T_j = 85°C	-	230	uA
		I_Q = 150mA	-	12	mA
I_Q	Output current limiting	V_Q = 4.8V	200	-	mA
V_Q	Output voltage	6V ≤ V_I ≤ 28V 1mA ≤ I_Q ≤ 150mA	4.9	5.1	V
		28V ≤ V_I ≤ 45V 1mA ≤ I_Q ≤ 50mA	4.8	5.2	V
$\lvert\Delta V_{Q(v)}\rvert$	Line regulation	6V ≤ V_I ≤ 28V, I_Q = 5mA	-	20	mV
$\lvert\Delta V_{Q(I)}\rvert$	Load regulation	V_I = 13.5V, 5mA ≤ I_Q ≤ 150mA	-	30	mV
V_{DR}	Drop voltage	I_Q = 150mA[1)]	-	0.5	V
Reset Oscillator					
V_{RT}	Reset threshold	V_{RADJ} = 0V	4.5	4.8	V
$\Delta V_{Q,RT}$	Reset headroom	I_Q = 10mA	0.18	-	V
V_{RADJTH}	Reset adjust threshold	V_Q ≥ 3.5V	1.28	1.45	V
V_{ROL}	Reset low voltage	R_{ext} > 10kΩ to V_Q V_Q ≤ 1V	-	0.4	V
V_{ROH}	Reset high voltage	I_Q = 5mA	4.5	-	V
R_{RO}	Reset pull-up	V_Q = 0V, V_{RO} = 5V	20	45	kΩ
V_{DRL}	Lower reset threshold	I_Q = 5mA	0.2	0.4	V
I_d	Charging current	V_D = 1V	2	8	uA
t_d	Delay time	C_D = 47nF	12	28	ms
t_{rr}	Reset reaction time	C_D = 47nF	0.4	2.0	us

Table 4. **ELECTRICAL CHARACTERISTICS (continued)**
V_I = 13.5V; – 40℃ ≤ T_j ≤ 125℃ (unless otherwise specified)

Symbol	Parameter	Test Condition	Limit Values		Unit
			Min	Max	
Watchdog					
V_{WADJ}	Watchdog adjust voltage	I_Q = 10mA	1.28	1.45	V
V_{WOL}	Watchdog low voltage	I_Q = 10mA; R_{ext} > 10kΩ	-	0.4	V
V_{WOH}	Watchdog high voltage	I_Q = 10mA	4.5	-	V
V_{DU}	Upper timing threshold	I_Q = 10mA	1.5	2.3	V
V_{DWL}	Lower watchdog timing threshold	I_Q = 10mA	0.5	0.9	V
I_Q / I_{WADJ}	Current ratio	I_Q ≤ 10mA	650	800	-
I_{dis}	Discharge current	V_D = 1V; I_Q = 10mA	0.6	2.0	uA
R_{WO}	Watchdog pull-up	V_{WO} = 5V	20	45	kΩ
T_{WP}	Watchdog output period	C_D = 47nF	42	80	ms
t_{WR}	Watchdog output low time	C_D = 47 nF,V_Q > V_{WO}	7	19	ms
T_{WT}	Watchdog trigger time	C_D = 47nF	35	61	ms

1) Measured when the output voltage V_Q has dropped 100 mV from the nominal value.

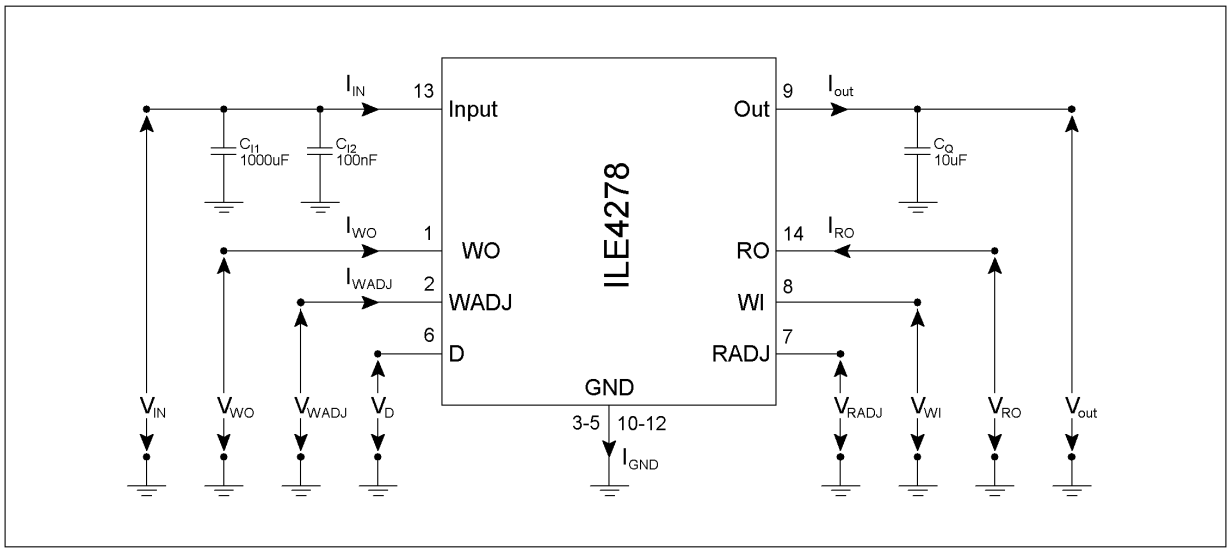

Figure 2. Test circuit

Application information

Input and Output capasitors

The input capacitors C_{I1}, C_{I2} (**see Figure 3**) should be used for compensation of line influence. Using a resistor about 1Ω in series with capacitor C_{I1} may weaken LC circuit consisting of the input inductance and the input capacitance. Stability of the regulation circuit requires the output capacitor C_Q. Stability is guaranteed when C_Q ≥ 10uF with 1Ω ≤ ESR ≤ 5Ω within the operating temperature range at frequency of 10kHz.

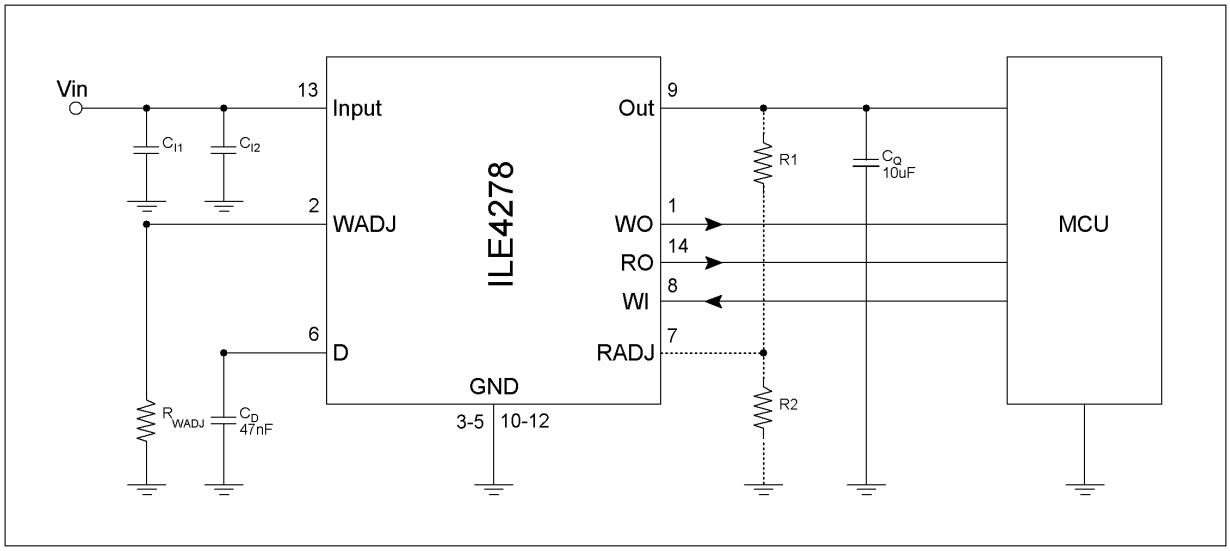

Figure 3. Typical application circuit

Additional functions

The ILE4278 has a load dependent watchdog function as well as a power on reset and under voltage reset function with an adjustable reset delay time and adjustable reset switching threshold.

Reset Function

The Reset Output (RO) is used to reset the microprocessor in case of an emergency situation as well as for realisation Power-On-Reset function (POR).

In normal operation, the RO voltage V_{ROH}> 4.5V (HIGH level). In case of overheating of the chip, or lowering the input voltage below the limit, and therefore lowering the output voltage below the reset threshold V_{RT}, or output overload the RO goes to V_{ROL} < 0.4V (LOW level).

After power-on the reset signal at pin RO goes HIGH after the delay time t_d when the output voltage of the regulator has exceeded the reset threshold V_{rt}. In case V_Q falls below the reset threshold the reset output is set to LOW after a short reset reaction time t_{rr}. A delay time depends on value of external capacitor C_D, which is connected to pin D.

The timing diagram of the IC operation (the watchdog function is not active) shown on the Figure 4.

The delay time t_d can be calculated as follows:

$$C_D = (t_d \times I_d)/\Delta V \qquad (1)$$

Definitions:
- C_D - delay capacitor;
- t_d - delay time;
- I_d - charge current,typical 5uA;
- ΔV - V_{DU}, upper delay switching threshold, typical 1.9V.

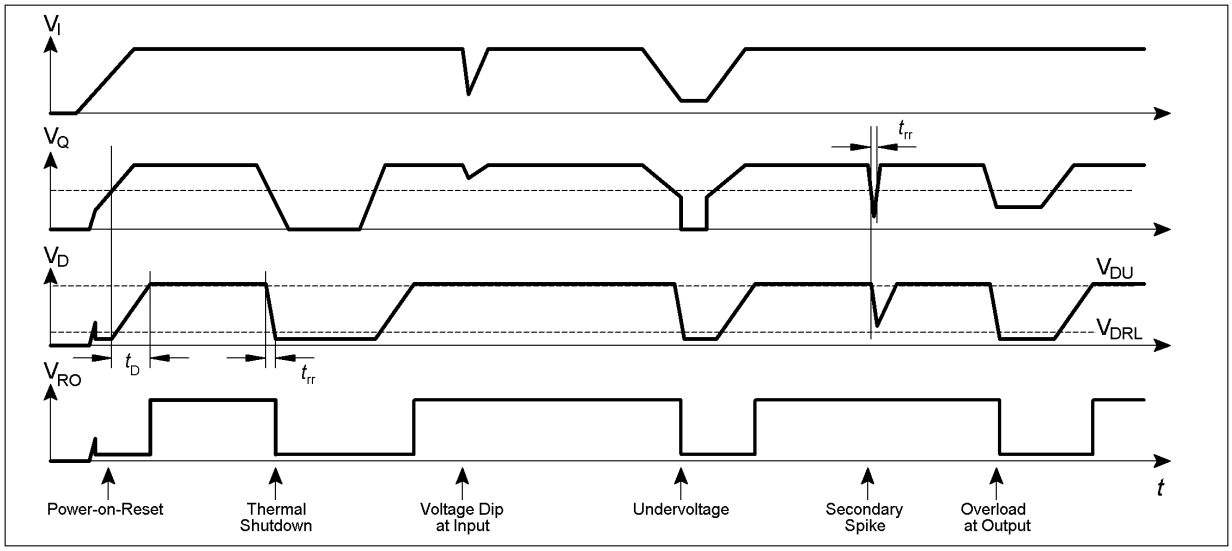

Figure 4. Reset Timing (Watchdog Disabled)

The reset reaction time t_{rr} is the time it takes the voltage regulator to set the reset out LOW after the output voltage has dropped below the reset threshold. It is typically 1us for delay capacitor of 47nF. For other values for C_D the reaction time can be estimated using the following equation:

$$t_{rr} \approx 20\ s/F \times C_D \qquad (2)$$

The IC has Reset Switching Threshold Adjust RADJ, depending on the voltage, which changes the value of the reset threshold V_{RT}.

The voltage at which V_{RT} changes is called “Reset adjust threshold”, V_{RADJTH} (the typical value is 1.35). When the voltage at the RADJ is less than V_{RADJTH}, V_{RT} value is in the range 4.5V ÷ 4.8V. If the voltage at the RADJ is more than V_{RADJTH}, V_{RT} value becomes less than 4.5V.

The reset adjust threshold V_{RADJTH} can be adjusted by the external voltage divider connected to RADJ output. This feature is useful with microprocessors that ensure safe operation up to the voltage below the internally set typical values of the reset threshold making 4.65 V. In this case the reset threshold can be set in the range 3.5V <V_{RT} <4.5V with the help of connection of the external resistive divider R_1, R_2 to the RADJ.

One can carry out the calculation of nominal values of resistors R_1, R_2, because you can disregard the RADJ input current (the RADJ input current ≈ 50 nA). If this function is not used, RADJ left ragged or connected to GND.

Resistance of the resistor R_1, kΩ, is calculated by the formula

$$R_1=R_2 \times (V_{rt}-V_{ret})/V_{ref} \qquad (3)$$

Where: V_{ref} is the internal comparator voltage, the typical value is 1.35V.

The RO is internally connected to 5V output V_Q via the built-in 30kΩ resistor. The low reset signal is generated at RO output when the output voltage V_Q is reduced to 1V.

Watchdog Function

The embedded watchdog function monitors the connected microcontroller. The watchdog function monitors whether the microcontroller is functioning appropriately, including time base failures.

In the case that there is no positive-going edge within min 5V/µs within a certain pulse repetition-time (the typical pulse repetition time makes is 60 ms), the watchdog output is set to LOW.

Programming of the max. repetition time is done by the reset delay capacitor so that no additional external components are necessary. To prevent the microcontroller from an automatic reset in case of missing pulses, the watchdog output WO is separated from the reset output RO for the ILE4278. The watchdog output can be externally connected to RO.

Watchdog function is activated by the Watchdog Adjust **(**WADJ) voltage. This voltage is called the “activation threshold voltage”, V_{WADJ} (typical value is 1.35V). When the voltage at the WADJ is lower than V_{WADJ}, the watchdog function is not active. When the voltage at the WADJ is higher than V_{WADJ}, the watchdog function is active.

When the controller is set to sleep mode or low power mode its current consumption drops and no watchdog pulses are created coming to WI with the launch of the positive edge of a slope of at least 5V/s.

In order to prevent the microcontroller from unnecessary wake ups due to missing pulses at pin WI the watchdog feature can be disabled as a function of the load. The switch off threshold is set by an external resistor to pin WADJ. This function can also be used as a timer, which periodically wakes up the controller. Therefore the pin WADJ has to be connected to the output V_Q.

Timing diagram of IC operation with the active watchdog functions shown on the Figure 5

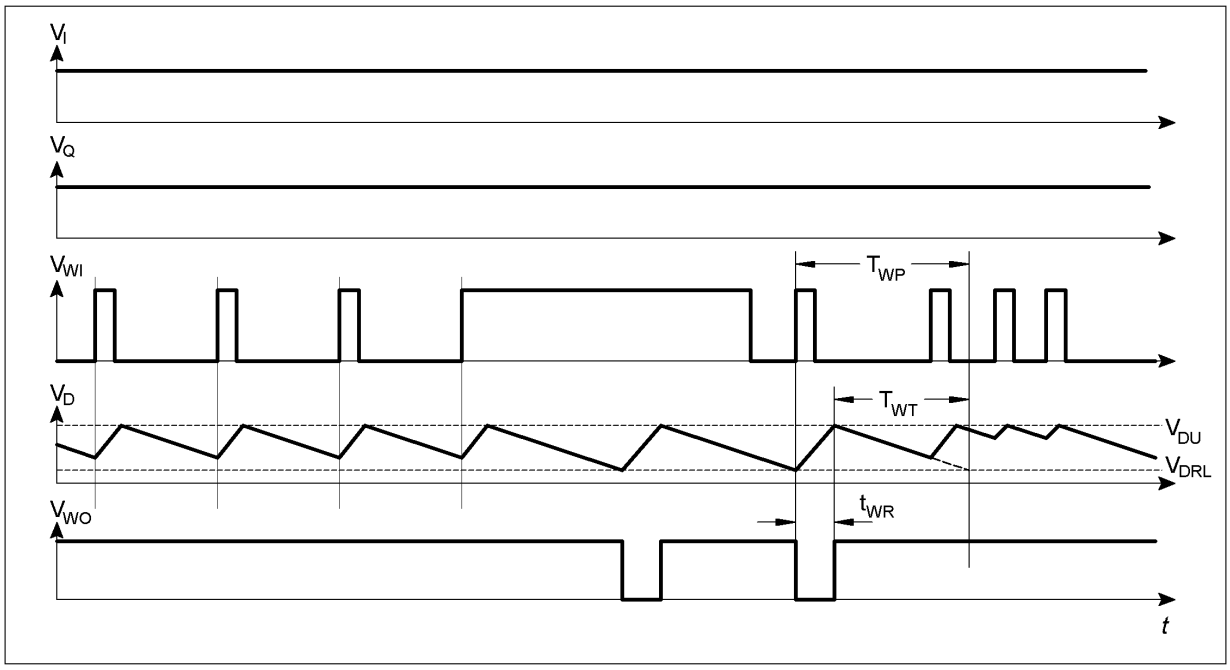

Figure 5. Timing of the Watchdog Function

Calculation of the external resistor R_{WADJ}, kΩ, adjusting the watchdog timer switch-off threshold is made by the formula

$$R_{WADJ} = V_{WADJ} \times (I_Q/I_{WADJ})/I_{QACT}, \qquad (3)$$

Where:

V_{WADJ} is the activation threshold voltage, the typical value is 1.35V;

I_Q/I_{WADJ} is the current ratio, the typical value is 720;

I_{QACT} is the load current required to disable the watchdog function, mA.

The watchdog timer pulse rate should be above the minimum pulse sequence that is set by the reset delay external capacitor C_D.

The pulse repetition period at the watchdog output T_{WP}, ms, is determined by the formula

$$T_{WP} = \frac{(V_{DU} - V_{DWL}) \times (I_d + I_{dis})}{I_d \times I_{dis}} \times C_D, \qquad (4)$$

Where:

V_{DU} is the maximum voltage at the pin D with the active watchdog function when there are no voltage fronts at the watchdog input, V;

V_{DWL} is the minimum voltage at the pin D with the active watchdog function when there are no voltage fronts at the watchdog input, V;

I_d – charge current, uA;

I_{dis} – discharge current, uA;

C_D - capacity, nF.

The duration of the low-level voltage pulse at the watchdog output t_{WT}, ms, is determined by the formula

$$t_{WR} = \frac{V_{DU} - V_{DWL}}{I_d} \times C_D \qquad (5)$$

The duration of the high-level voltage pulse at the watchdog output t_{WT}, ms, is determined by the formula

$$T_{WT} = \frac{V_{DU} - V_{DWL}}{I_{dis}} \times C_D \qquad (6)$$

The watchdog output WO is internally connected to the output V_Q via the built-in resistor 30kΩ. To generate a reset signal from the watchdog timer to the microcontroller, WO output should be connected to the microcontroller reset input.

PACKAGE DIMENSION

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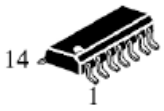
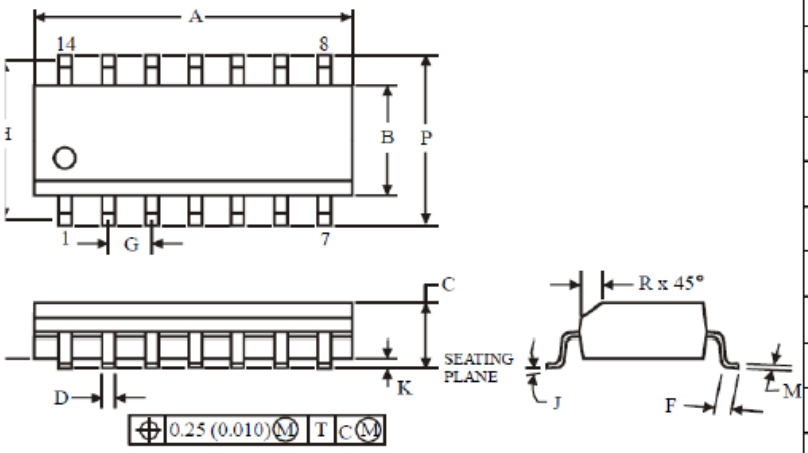
D SUFFIX SOIC
(MS - 012AB)





	Dimension, mm	
Symbol	MIN	MAX
A	8.55	8.75
B	3.80	4.00
C	1.35	1.75
D	0.33	0.51
F	0.40	1.27
G	1.27	
H	5.27	
J	0°	8°
K	0.10	0.25
M	0.19	0.25
P	5.80	6.20
R	0.25	0.50

NOTES:

1. Dimensions A and B do not include mold flash or protrusion.
2. Maximum mold flash or protrusion 0.15 mm (0.006) per side for A; for B - 0.25 mm (0.010) per side.