

## Preliminary

## TECHNICAL DATA

### 5-V Low-Drop Fixed Voltage Regulator

ILE 4278

#### Features

- Output voltage tolerance  $\leq \pm 2\%$ , 4%
- Very low current consumption
- Separated reset and watchdog output
- Low-drop voltage
- Watchdog
- Adjustable watchdog activating threshold
- Adjustable reset threshold
- Overtemperature protection
- Reverse polarity protection
- Short-circuit proof
- Suitable for use in automotive electronics
- Wide temperature range



#### Functional Description

The ILE 4278 is a monolithic integrated low-drop fixed-voltage regulator which can supply loads up to 200 mA. The device is available in the 14-SOP-225 package. It is designed to supply microprocessor systems under the severe conditions of automotive applications and therefore equipped with additional protection functions against over load, short circuit and overtemperature. Of course the ILE 4278 can also be used in other applications where a stabilized voltage is required.

An input voltage  $V_i$  in the range of  $6V \leq V_i \leq 28V$  is regulated to  $V_{Q,nom} = 5V$  with an accuracy of  $\pm 2\%$ .

An input voltage  $V_i$  in the range of  $28V \leq V_i \leq 45V$  is regulated to  $V_{Q,nom} = 5V$  with an accuracy of  $\pm 4\%$ .

The device operates in the wide temperature range of  $T_j = -40$  to  $125^\circ C$ .

Two additional features are implemented in the ILE 4278 a load dependent watchdog function as well as a sophisticated reset function including power on reset, under voltage reset, adjustable reset delay time and adjustable reset switching threshold.

The watchdog function monitors the microcontroller, including time base failures. In case of a missing rising edge within a certain pulse repetition time the watchdog output is set to LOW. Programming of the max. repetition time can be done easily by an external reset



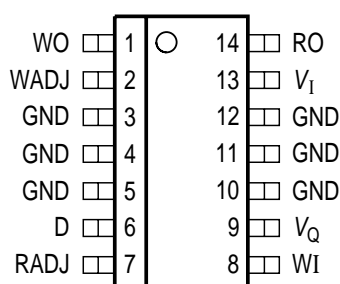
delay capacitor. To prevent a reset in case of missing pulses, the watchdog output WO is separate from the reset output RO for the ILE 4278. The watchdog output can be used as an interrupt signal for the microcontroller. In any case it is possible to connect pin WO and pin RO externally.

When the controller is set to sleep mode or low power mode its current consumption drops and no watchdog pulses are created. In order to avoid unnecessary wake up signals due to missing pulses at pin WI the watchdog feature can be disabled as a function of the load current. The switch off threshold is set by an external resistor to pin WADJ. The watchdog 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 Q.

The power on reset feature is necessary for a defined start of the microprocessor when switching on the application. The reset signal at pin RO goes high after a certain delay timed  $t_{rd}$  when the output voltage of the regulator has surpassed the reset threshold. The delay time is set by the external delay capacitor. An under voltage reset circuit supervises the output voltage. In case  $V_Q$  falls below the reset threshold the reset output is set to LOW after a short reset reaction time  $t_{rr}$ . The reset LOW signal is generated down to an output voltage  $V_Q$  of 1 V. In addition the reset switching threshold can be adjusted by an external voltage divider. This feature is useful with microprocessors which guarantee a safe operation down to voltages below the internally set reset threshold of 4.65 V typical.

**Pin Configuration**  
(top view)

**14-SOP**



**Figure 1**

**Pin Definitions and Functions**

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

# Block Diagram

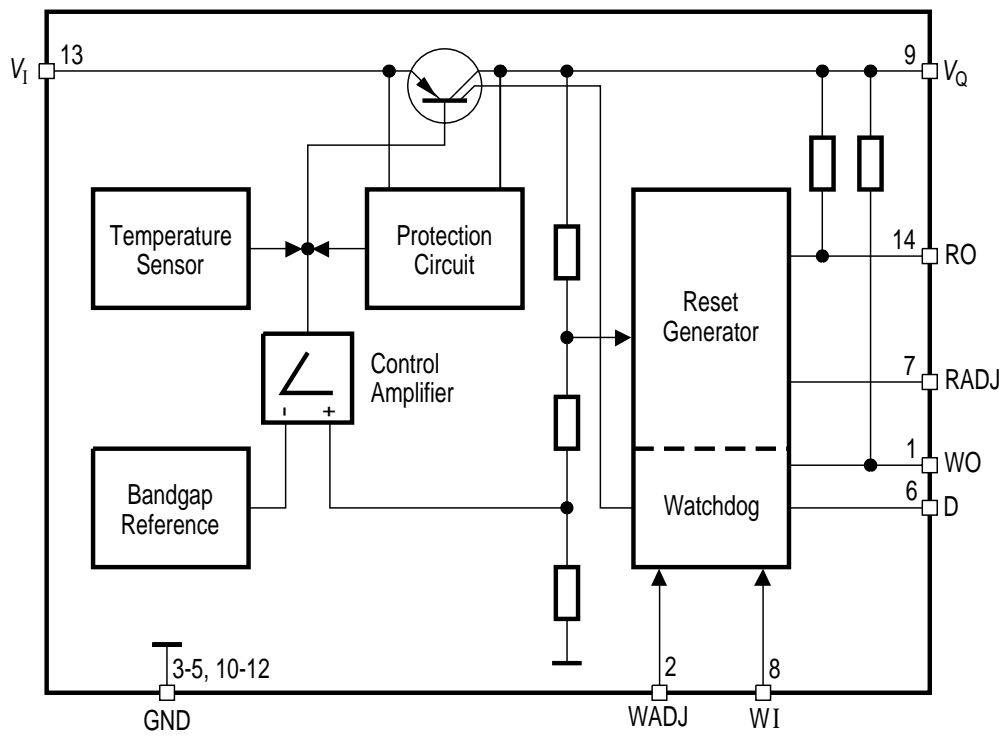


Figure 2

## Absolute Maximum Ratings

$T_j = -40$  to  $150\text{ }^{\circ}\text{C}$

Parameter	Symbol	Limit Values		Unit	Notes
		min.	max.		

## Input Voltage I

Voltage	$V_I$	$-42$	$45\text{ V}$	$-$	
Current	$I_I$	$-$	$-$	mA	Internally limited

## Output Voltage Q

Voltage	$V_Q$	$-1$	$25$	V	$-$
Current	$I_Q$	$-$	$-$	mA	Internally limited

## Reset Output RO

Voltage	$V_{RO}$	$-0.3$	$25$	V	$-$
Current	$I_{RO}$	$-5$	$5$	mA	$-$

## Reset Delay D

Voltage	$V_D$	$-0.3$	$7$	V	$-$
Current	$I_D$	$-2$	$2$	mA	$-$

## Reset Switching Threshold Adjust RADJ

Voltage	$V_{RADJ}$	$-0.3$	$7$	V	$-$
Current	$I_{RADJ}$	$-$	$-$	mA	Internally limited

## Watchdog Input WI

Voltage	$V_{WI}$	$-0.3$	$7$	V	$-$
Current	$I_{WI}$	$-$	$-$	mA	Internally limited

## Watchdog Output WO

Voltage	$V_{WO}$	$-0.3$	$25$	V	$-$
Current	$I_{WO}$	$-5$	$5$	mA	$-$

## Absolute Maximum Ratings (cont'd)

$T_j = -40$  to  $150\text{ }^{\circ}\text{C}$

Parameter	Symbol	Limit Values		Unit	Notes
		min.	max.		

## Watchdog Adjust WADJ

Voltage	$V_{\text{WADJ}}$	- 0.3	7	V	—
Current	$I_{\text{WADJ}}$	—	—	mA	Internally limited

## Ground GND

Current	$I_{\text{GND}}$	- 100	50	mA	—
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## Temperatures

Junction temperature	$T_j$	- 40	150	$^{\circ}\text{C}$	—
Storage temperature	$T_{\text{stg}}$	- 50	150	$^{\circ}\text{C}$	—

*Note: ESD protection according to MIL Std. 883:  $\pm 2\text{ kV}$ .*

*Maximum ratings are absolute ratings; exceeding any one of these values may cause irreversible damage to the integrated circuit.*

## Operating Range

Parameter	Symbol	Limit Values		Unit	Notes
		min.	max.		
Input voltage	$V_I$	6.0	45	V	—
Junction temperature	$T_j$	- 40	125	$^{\circ}\text{C}$	—

## Thermal Resistance

Junction ambient	$R_{\text{thj-a}}$	—	80	K/W	<sup>1)</sup>
Junction pin	$R_{\text{thj-pin}}$	—	30	K/W	Measured to pin 4

<sup>1)</sup> Package mounted on PCB  $80 \times 80 \times 1.5\text{ mm}^3$ ;  $35\mu\text{Cu}$  ;  $5\mu\text{Sn}$ ; Heat Sink Area  $6\text{ cm}^2$ ; zero airflow.

*Note: In the operating range the functions given in the circuit description are fulfilled.*

## Electrical Characteristics

$V_I = 13.5 \text{ V}$ ;  $-40 \text{ }^{\circ}\text{C} \leq T_j \leq 125 \text{ }^{\circ}\text{C}$  (unless otherwise specified)

Parameter	Symbol	Limit Values			Unit	Test Condition
		min.	typ.	max.		
Output voltage	$V_Q$	4.90	5.00	5.10	V	$1 \text{ mA} \leq I_Q \leq 150 \text{ mA}$ ; $6 \text{ V} \leq V_I \leq 28 \text{ V}$
Output voltage	$V_Q$	4.8	5.0	5.2	V	$1 \text{ mA} \leq I_Q \leq 50 \text{ mA}$ ; $28 \text{ V} \leq V_I \leq 45 \text{ V}$
Output current limiting	$I_Q$	200	400	—	mA	$V_Q = 4.8 \text{ V}$
Current consumption $I_q = I_I - I_Q$	$I_{q,o}$	—	180	200	$\mu\text{A}$	$T_j = 25 \text{ }^{\circ}\text{C}$ ; $I_Q = 0 \text{ mA}$
Current consumption $I_q = I_I - I_Q$	$I_{q,o}$	—	210	230	$\mu\text{A}$	$I_Q = 0 \text{ mA}$ ; $T_j = 85 \text{ }^{\circ}\text{C}$
Current consumption $I_q = I_I - I_Q$	$I_{q,150}$	—	5	12	mA	$I_Q = 150 \text{ mA}$
Drop voltage; $V_{DR} = V_I - V_Q$	$V_{dr}$	—	0.25	0.5	V	$I_Q = 150 \text{ mA}^{1)}$
Load regulation	$\Delta V_{Q,lo}$	— 30	— 5	—	mV	$I_Q = 5 \text{ to } 150 \text{ mA}$ ; $V_I = 6 \text{ V}$
Line regulation	$\Delta V_{Q,li}$	—	5	20	mV	$V_I = 6 \text{ to } 28 \text{ V}$ ; $I_Q = 5 \text{ mA}$

## Reset Generator

Reset threshold	$V_{Q,rt}$	4.5	4.65	4.8	V	RADJ connected to GND
Reset headroom	$\Delta V_{Q,rt} = (V_{Q,nom} - V_{Q,rt})$	180	350	—	mV	$I_Q = 10 \text{ mA}$
Reset adjust threshold	$V_{RADJ,th}$	1.28	1.35	1.45	V	$V_Q \geq 3.5 \text{ V}$
Reset low voltage	$V_{RO,l}$	—	0.20	0.40	V	$R_{ext} = 10 \text{ k}\Omega$ to $V_Q$ $V_Q \geq 1 \text{ V}$
Reset high voltage	$V_{RO,h}$	4.5	—	—	V	—
Reset pull-up	$R_{RO}$	20	30	46	k $\Omega$	Internal connected to $V_Q$
Charging current	$I_{D,c}$	2	5	8	$\mu\text{A}$	$V_D = 1.0 \text{ V}$

# Electrical Characteristics (cont'd)

$V_I = 13.5\text{ V}$ ;  $-40\text{ }^{\circ}\text{C} \leq T_j \leq 125\text{ }^{\circ}\text{C}$  (unless otherwise specified)

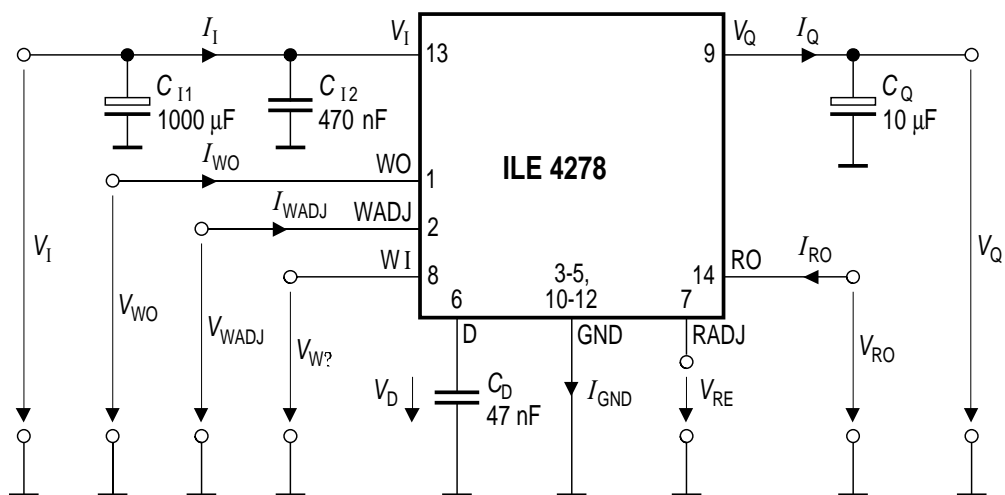
Parameter	Symbol	Limit Values			Unit	Test Condition
		min.	typ.	max.		
Upper timing threshold	$V_{DU}$	1.5	1.9	2.3	V	–
Lower reset timing threshold	$V_{DRL}$	0.2	0.3	0.4	V	–
Delay time	$t_{rd}$	12	20	28	ms	$C_D = 47\text{ nF}$
Reset reaction time	$t_{rr}$	0.4	1.0	2.0	$\mu\text{s}$	$C_D = 47\text{ nF}$

# Watchdog

Activating threshold	$V_{WADJ,th}$	1.28	1.35	1.45	V	Voltage at WADJ
Current ratio	$I_Q/I_{WADJ}$	650	720	800	–	$I_Q \leq 10\text{ mA}$
Slew rate	$dV_{WI}/dt$	5	–	–	V/ $\mu\text{s}$	From 20% up to 80% $V_Q$
Watchdog low voltage	$V_{WOL}$	–	0.2	0.4	V	$R_{ext} > 10\text{ k}\Omega$ to $V_Q$
Watchdog high voltage	$V_{WOH}$	4.5	–	–	V	–
Watchdog pull-up	$R_{WO}$	20	30	46	k $\Omega$	Internally connected to $V_Q$
Charge current	$I_{D,wc}$	2	5	8	$\mu\text{A}$	$V_D = 1.0\text{ V}$
Discharge current	$I_{D,wd}$	0.6	1.3	2.0	$\mu\text{A}$	$V_D = 1.0\text{ V}$
Upper timing threshold	$V_{DU}$	1.5	1.9	2.3	V	–
Lower watchdog timing threshold	$V_{DWL}$	0.5	0.7	0.9	V	–
Watchdog output pulse period	$T_{WD,p}$	42	60	80	ms	$C_d = 47\text{ nF}$
Watchdog output low time	$t_{WD,l}$	7	13	19	ms	$V_Q > V_{RT}$
Watchdog trigger time	$T_{WI,tr}$	35	47	61	ms	$C_d = 47\text{ nF}$

<sup>1)</sup> Measured when the output voltage  $V_Q$  has dropped 100 mV from the nominal value.

# Test Circiut



$V_{DR} = V_I - V_O$  Outside the control range

Figure 3

## Application Information

### Input, Output

The input capacitors  $C_{I1}$  and  $C_{I2}$  are necessary for compensating line influences. Using a resistor of approx.  $1\ \Omega$  in series with  $C_{I1}$ , the LC circuit of input inductance and input capacitance can be damped. To stabilize the regulation circuit the output capacitor  $C_Q$  is necessary. Stability is guaranteed at values  $C_Q \geq 10\ \mu\text{F}$  with an  $\text{ESR} \leq 5\ \Omega$  within the operating temperature range.

### Application Circuit

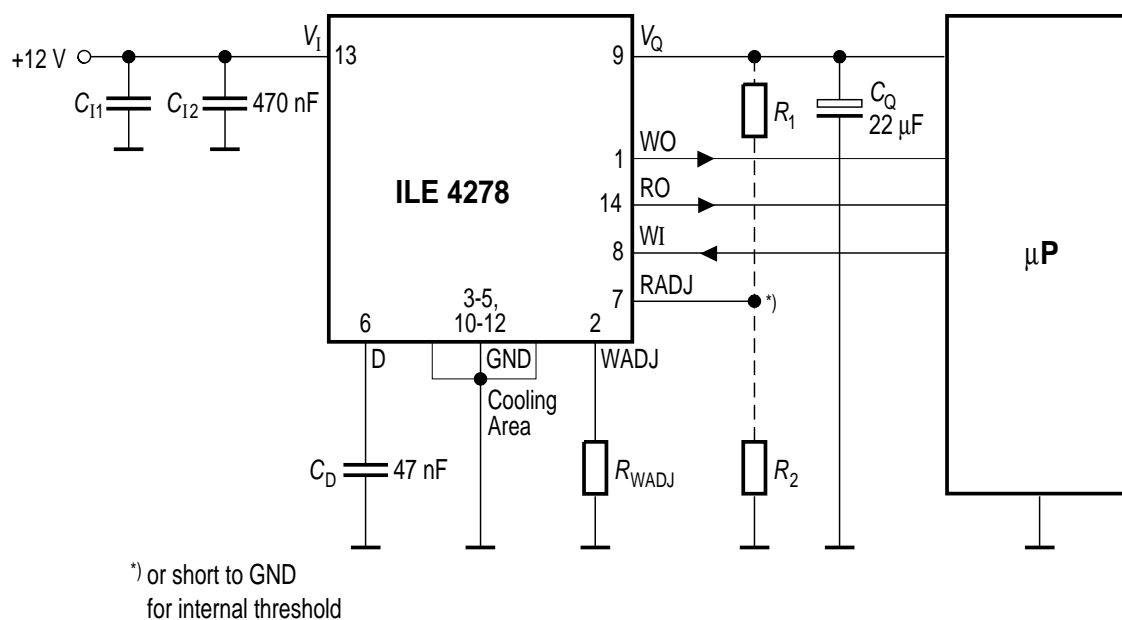


Figure 4

## Reset Timing

The power-on reset delay time is defined by the charging time of an external capacitor  $C_D$  which can be calculated as follows:

$$C_D = (\Delta t_{rd} \times I_{D,c}) / \Delta V$$

Definitions:  $C_D$  = delay capacitor

$\Delta t_{rd}$  = delay time

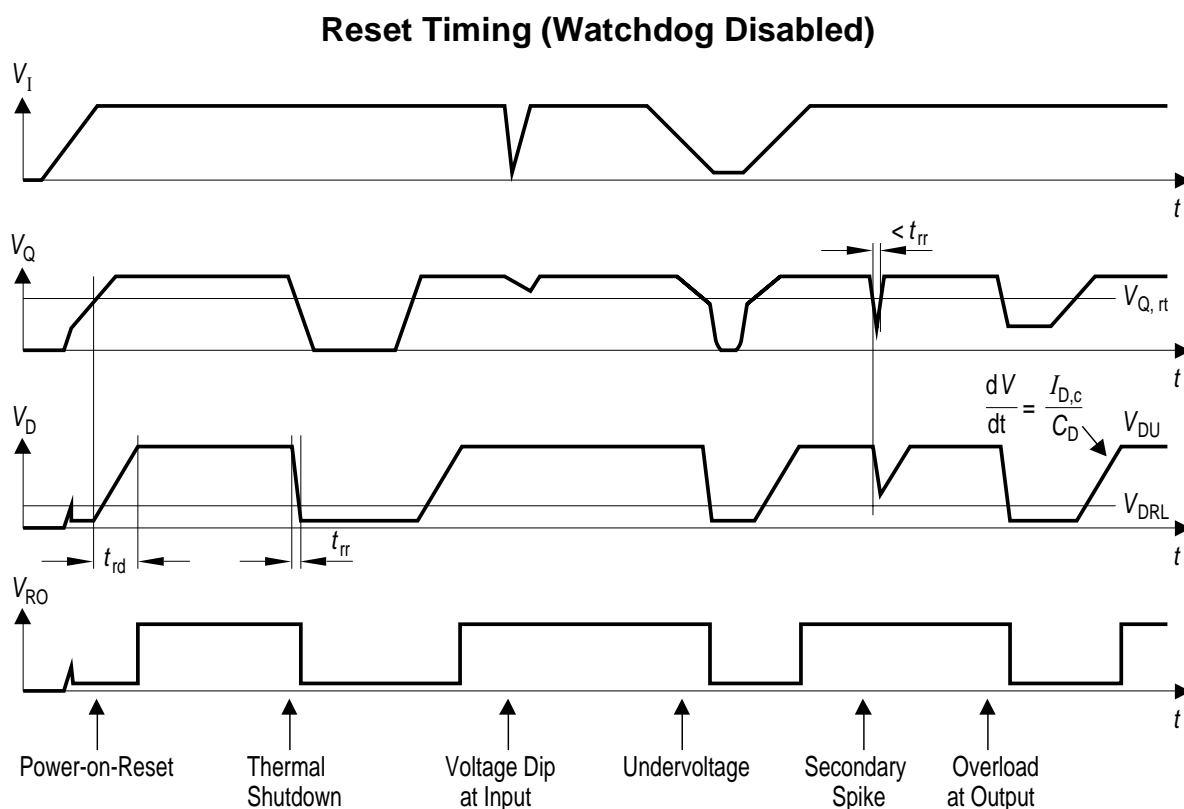
$I_{D,c}$  = charge current, typical 5  $\mu A$

$\Delta V = V_{DU}$ , typical 1.9 V

$V_{DU}$  = upper delay switching threshold at  $C_D$  for reset delay time

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 1  $\mu s$  for delay capacitor of 47 nF. For other values for  $C_D$  the reaction time can be estimated using the following equation:

$$t_{rr} \approx 20 \text{ s/F} \times C_D$$



**Figure 5**

# Reset Switching Threshold

The present default value is 4.65 V. When using the ILE 4278 the reset threshold can be set to  $3.5\text{ V} < V_{Q,rt} < 4.6\text{ V}$  by connecting an external voltage divider to pin RADJ. The calculation can be easily done since the reset adjust input current can be neglected. If this feature is not needed, the pin has to be connected to GND.

$$V_{Q,rt} = V_{ref}(1 + R_1/R_2)$$

Definitions:  $V_{Q,rt}$  = Reset threshold  
 $V_{ref}$  = comparator reference voltage, typical 1.35 V  
 (Reset adjust input current  $\approx 50\text{ nA}$ )

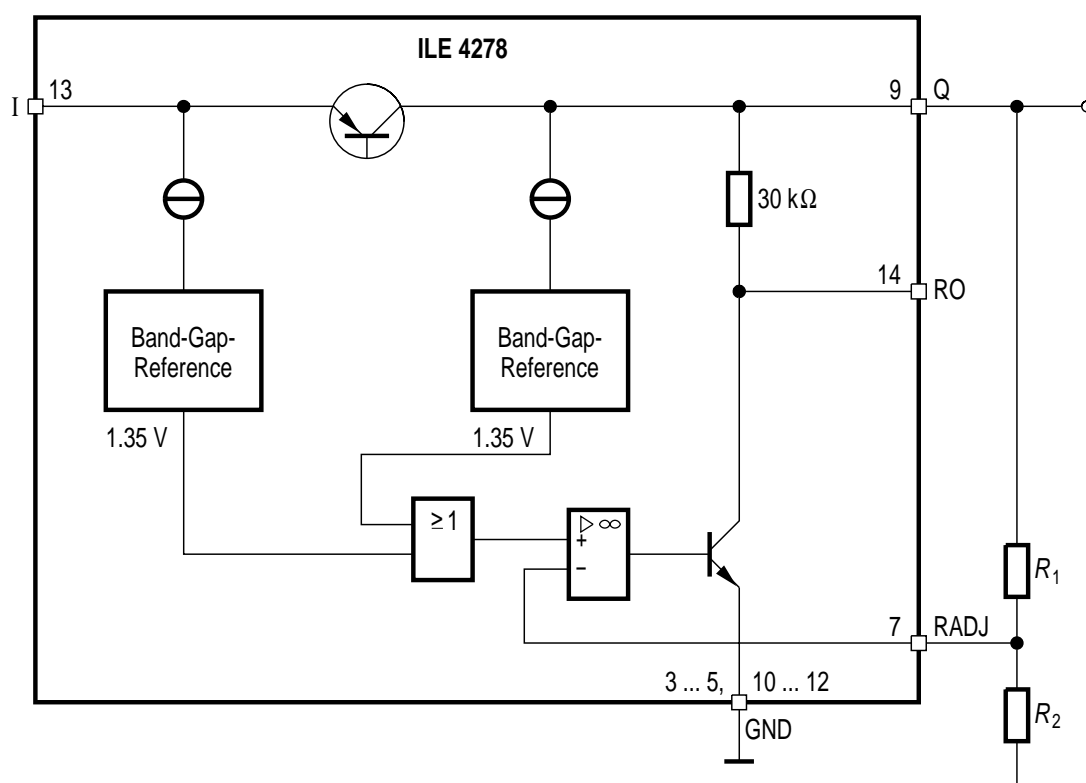


Figure 6

The reset output pin is internally connected to the 5 V output Q via a 30 k $\Omega$  pull-up resistor. Down to an output voltage  $V_Q$  of typical 1 V the reset LOW signal at pin RO is generated.

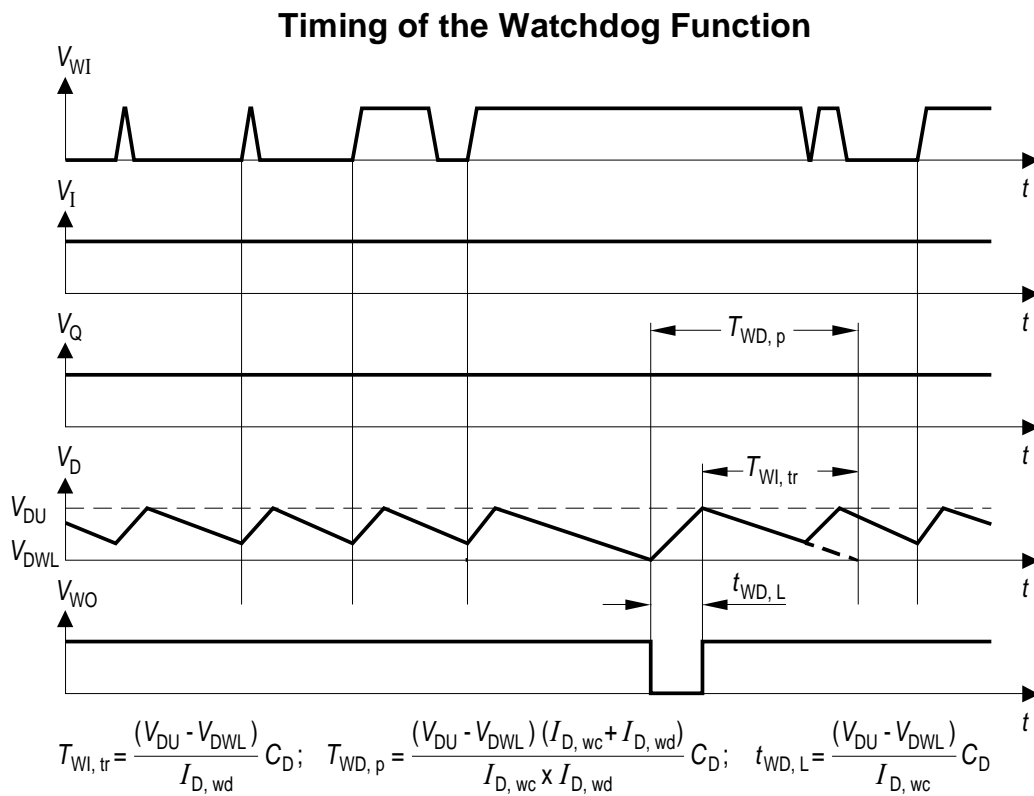
For the timing of the reset feature please refer to the data sheet, **Figure 5**.

The calculation of the external resistor which adjusts the watchdog switch off threshold can be done by the following equation.

## Watchdog Timing

The frequency of the watchdog pulses has to be higher than the minimum pulse sequence which is set by the external reset delay capacitor  $C_D$ . Calculation can be done according to the formulas given in **Figure 8**.

The watchdog output is internally connected to the output Q via a 30 kΩ pull-up resistor. To generate a watchdog created reset signal for the microcontroller the pin WO can be connected to the reset input of the microcontroller. It is also allowed to parallel the watchdog out to the reset out.

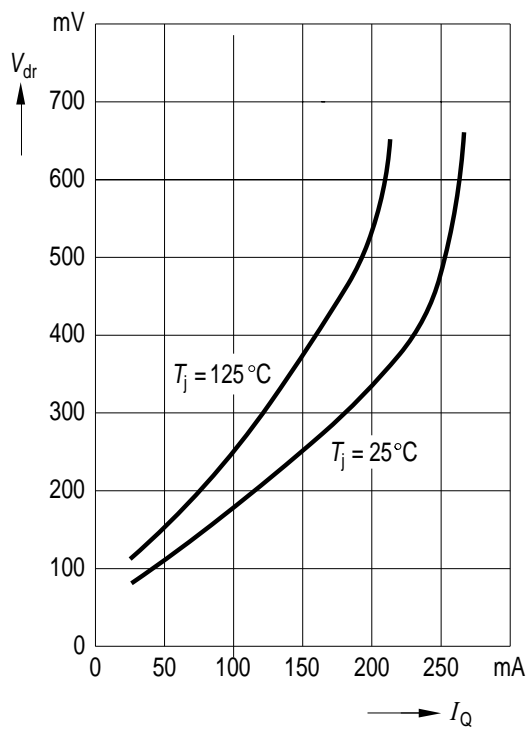


**Figure 8**

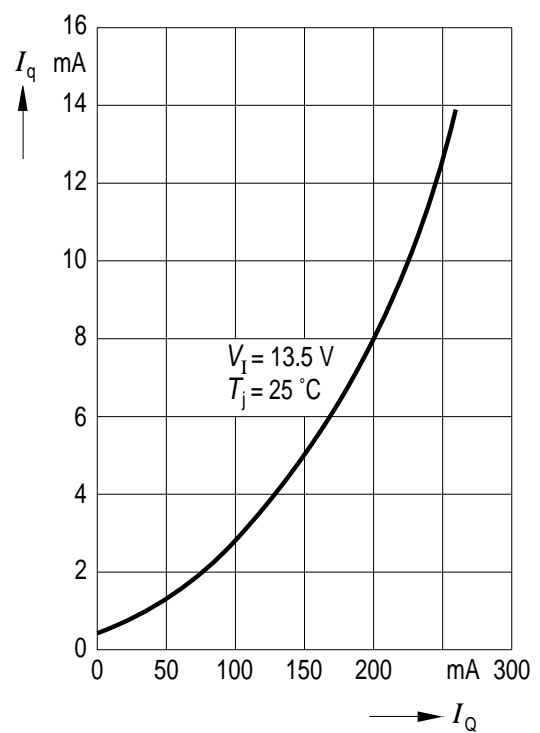
### Hints for Unused Pins

Symbol	Function	Connect to
RO	Reset output	open
D	Reset delay	open or to output Q
RADJ	Reset switching threshold adjust	GND
WI	Watchdog input	GND
WO	Watchdog output	open
WADJ	Watchdog adjust	<sup>1)</sup> to output Q via a 270 kΩ resistor: Watchdog always active <sup>2)</sup> to GND: Watchdog disabled

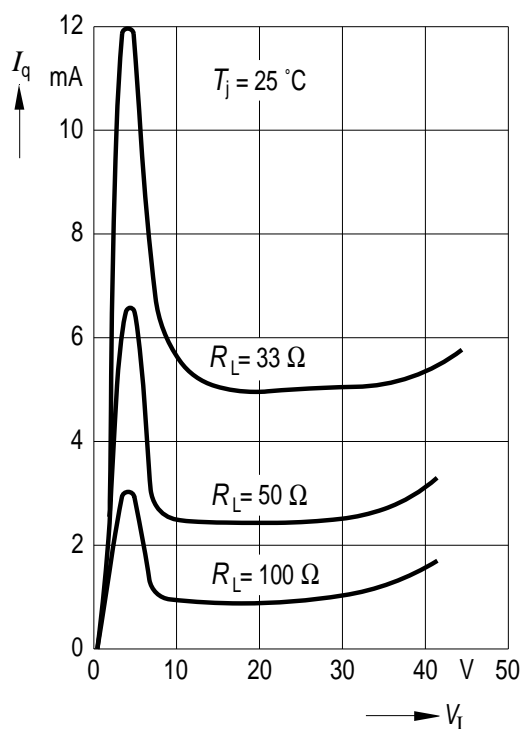
**Drop Voltage  $V_{dr}$  versus Output Current  $I_Q$**



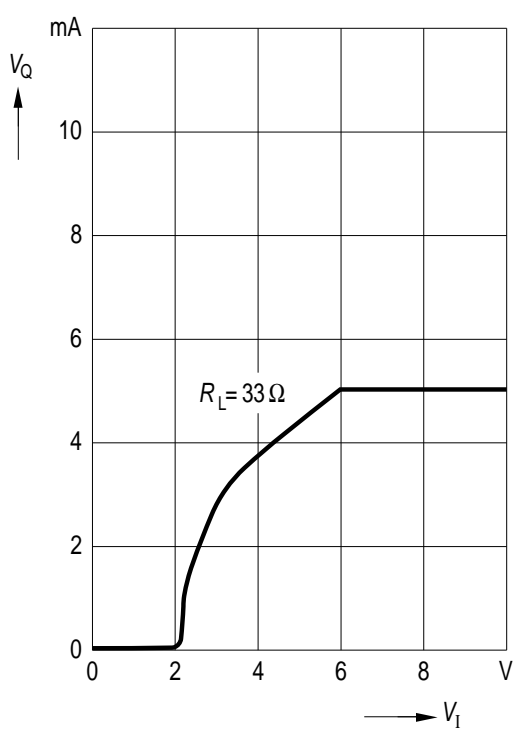
**Current Consumption  $I_q$  versus Output Current  $I_Q$**



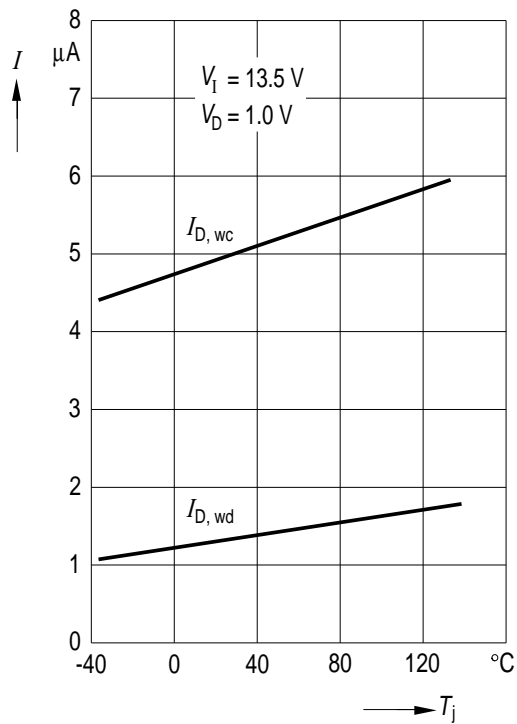
**Current Consumption  $I_q$  versus Input Voltage  $V_I$**



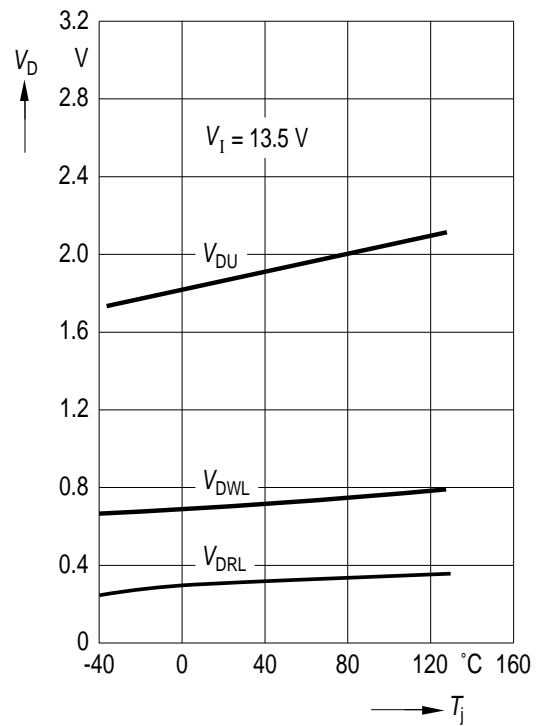
**Output Voltage  $V_Q$  versus Input Voltage  $V_I$**



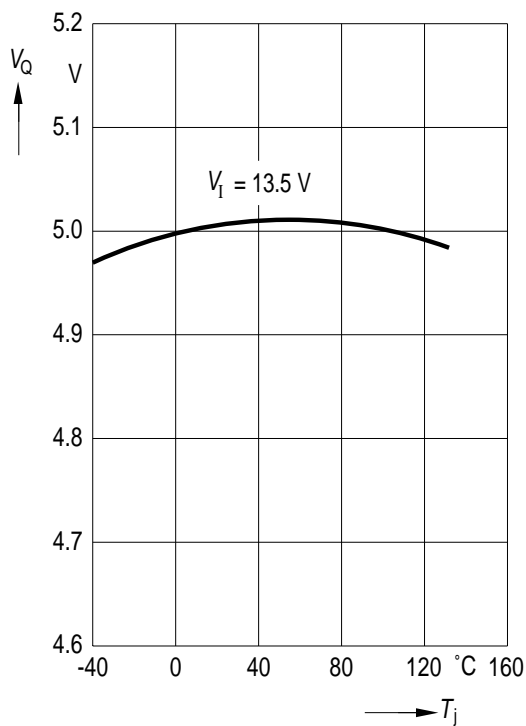
**Charge Current  $I_{D,wc}$  and Discharge Current  $I_{D,wd}$  versus Temperature  $T_j$**



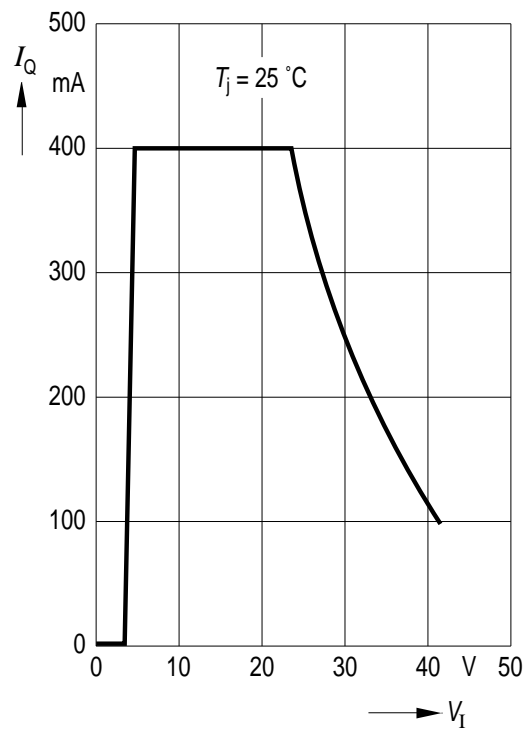
**Switching Voltage  $V_{DU}$ ,  $V_{DWL}$  and  $V_{DRL}$  versus Temperature  $T_j$**



**Output Voltage  $V_Q$  versus Temperature  $T_j$**



**Output Current Limit  $I_Q$  versus Input Voltage  $V_I$**



# Package Outlines

## 14-SOP-225

