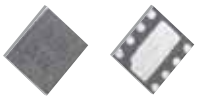
We recommend this extra manufacturers relay economizer. It is only available in Europe.	ACCESSORIES Solenoid / Valve driver with current limitation	IC3



Enlarged view: ≅ 3:1
Original size: 2.00 x 2.00 x 0.55mm

FEATURES

- Supply range: +5V to +50V
- Internal VDDA: 3.3V
- Supply current: 1 mA
- Internal osc frequency: 30kHz
- Fix delay: 136ms
- Adjustable duty cycle: 20% – 90% (IC3PWM only)
- Adjustable energising current: 10mA – 100mA
- Adjustable hold current: 30% - 70% of energising current
- Current limitation
- Thermal shutdown: 150ºC
- 8-pin MLPD (2x2mm) Package
- On request SOIC 8 Package (reduced temperature range -40°C to +85°C)

TYPICAL APPLICATIONS

1. Fluid and gas flow systems
2. Industrial control
3. Electrical heaters
4. Motor speed control

ORDERING INFORMATION

Ordering Code	Marking	Description	Delivery Form	Package
IC3DC	A0	Solenoid / Valve Driver with Current Limitation and with DC Current Source Operation	Tape and Reel	8-pin MLPD (2x2mm)
IC3PWM	AW	Solenoid / Valve Driver with Current Limitation and with PWM Switching Operation	Tape and Reel	8-pin MLPD (2x2mm)

Note:
All products are RoHS compliant and Pb-free.

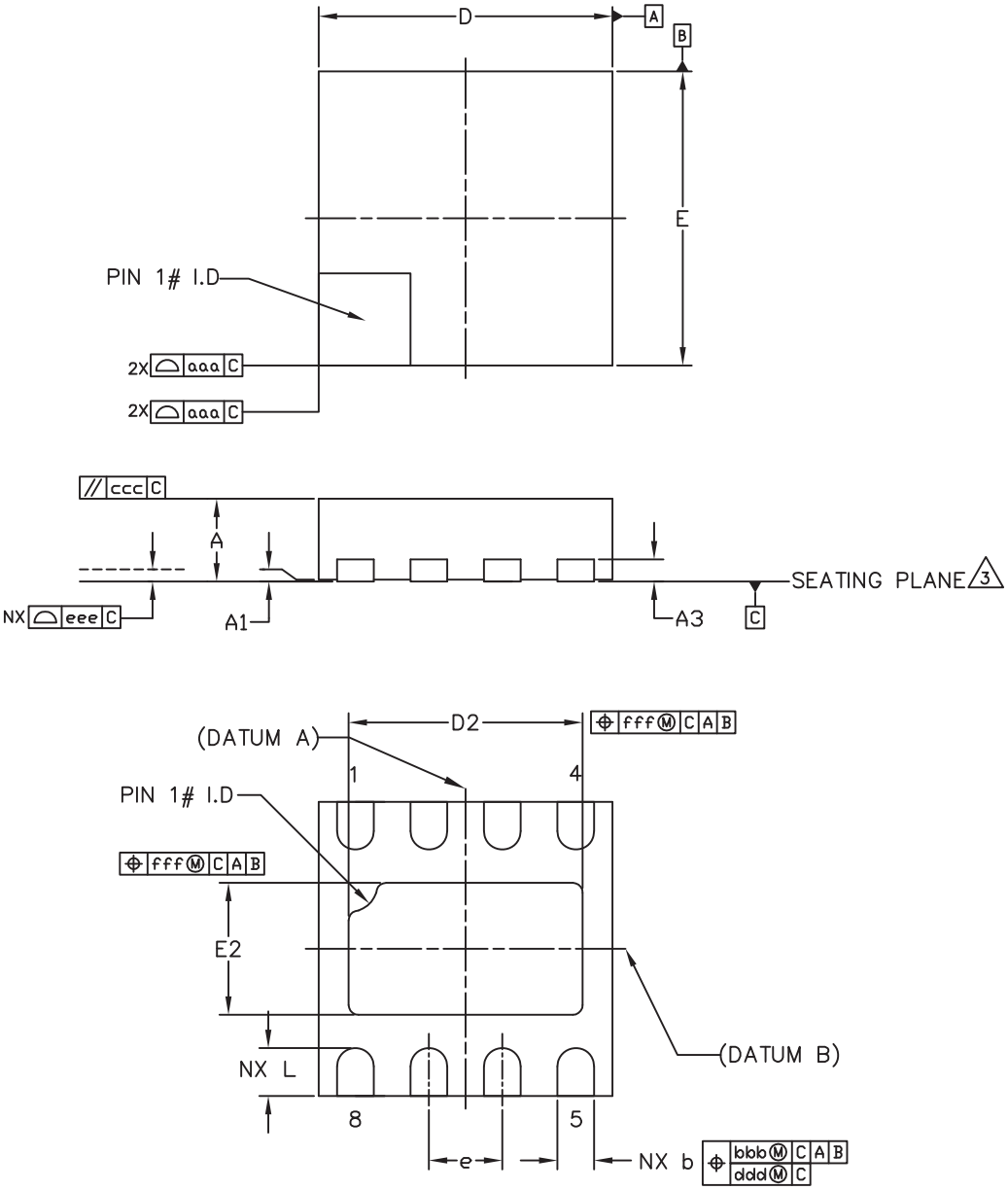
PACKAGING

The device is available in a 8-pin MLPD (2x2mm) package.

Symbol	Min	Type	Max
A	0.51	0.55	0.60
A1	0.00	0.02	0.05
A3		0.15 REF	
L	0.225	0.325	0.425
b	0.20	0.25	0.30
D		2.00 BSC	
E		2.00 BSC	
e		0.50	
D2	1.45	1.60	1.70
E2	0.75	0.90	1.00
aaa	—	0.15	—
bbb	—	0.10	—
ccc	—	0.10	—
ddd	—	0.05	—
eee	—	0.08	—
fff	—	0.10	—
N		8	

Notes:
*1. The package diagram is shown for illustration only.
*2. Dimensioning and tolerancing conform to *ASME Y14.5M-1994*.
*3. All dimensions are in millimeters, angle is in degrees (°).
*4. Coplanarity applies to the exposed heat slug as well as the terminal.
*5. Radius on terminal is optional.
*6. N is the total number of terminals.

8-pin MLPD (2x2mm) Package Diagram[1]



TYPES

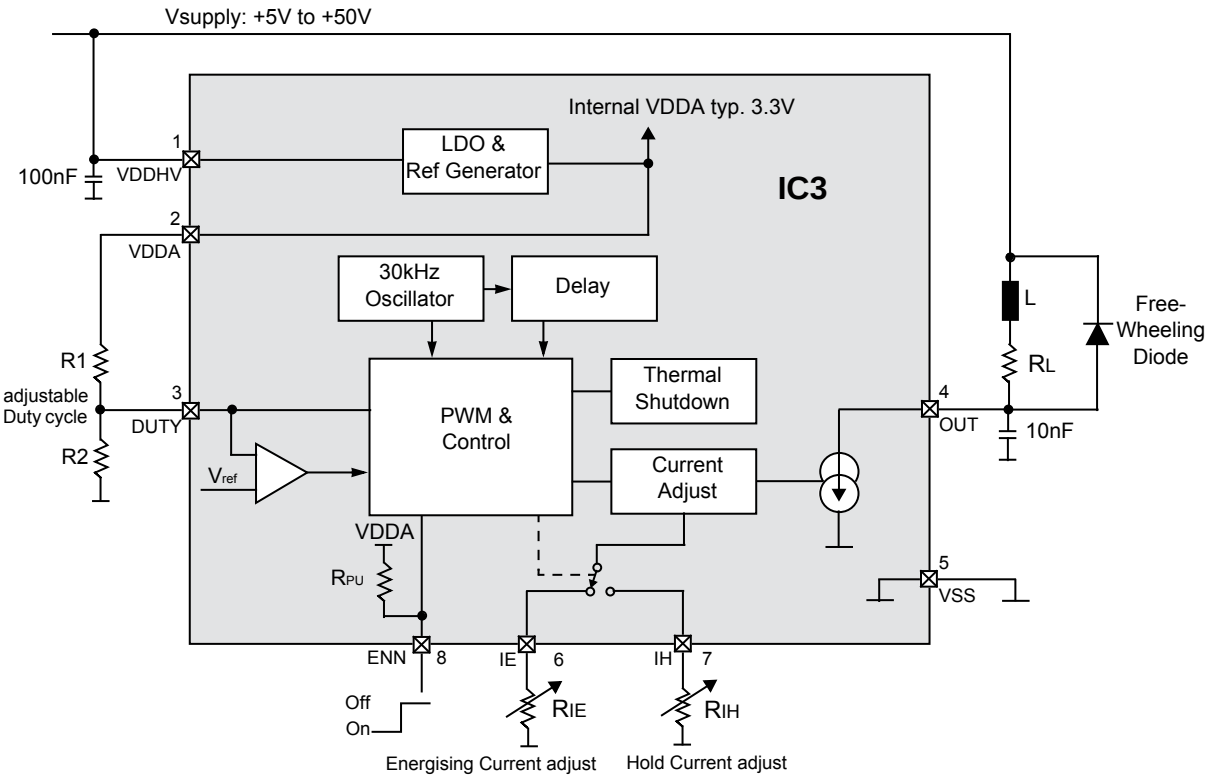
The IC3DC is a low side current source providing an optimized DC Operation for power saving and ultra low electro magnetic radiation.

The IC3PWM is a low side switch providing a PWM output, which frequency is defined by an internal RC oscillator. The adjustable PWM allows a fine control of the power delivered to the load.

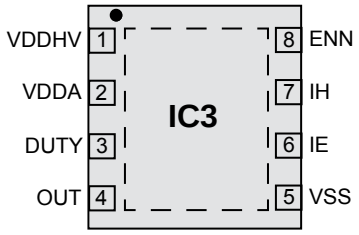
Model	Operation Mode
IC3DC	DC Current Source Operation
IC3PWM	PWM Switching Operation

The IC3DC and IC3PWM can be set to provide a strong initial closure current and is automatically switching to hold mode for power saving. The initial DC current, the hold current and the duty cycle of the PWM can be adjusted by external resistors. An internal thermal sensor prevents damage of the circuit due to excessive heating up.
Both devices are optimized for driving electromechanical devices such as valves, solenoids relays, actuators and positioners.

Block Diagram



Pin Assignments



Pin Description

Pin Name	Pin Number	Description
VDDHV	1	Positive supply voltage
VDDA	2	**Internal supply** of 3.3V (typ.)
DUTY	3	**Duty-Cycle.** By means of this pin the duty cycle can be adjusted between 20% and 90% during hold phase. The duty cycle can be adjusted by a voltage source or an external resistor divider. Setting this pin to VDDA the 50% duty cycle is selected automatically.
OUT	4	Current Source Output
VSS	5	Ground
IE	6	**Energize Current.** This pin defines the current during energize phase by means of a resistor.
IH	7	**Hold Current.** This pin defines the current during hold phase by means of a resistor.
ENN	8	**Enable Not.** This pin can be used to switch on/off the current source (e.g. via a µP), when the IC3 is always powerd on. **Low during start-up:** When VDDHV is applied, the device starts with the energise phase, followed by the hold phase. When the device is constantly powerd on, it can be controlled by this pin. **High:** The output current source is switched off. **Low:** The device starts with the energise phase, followed by the hold phase.

RATING

1. Absolute Maximum Ratings

Stresses beyond those listed in the table below 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 in the electrical characteristics is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Parameter	Min	Max	Units	Notes
VDDHV, OUT	-0.9	+55	V	
VDDA, DUTY, ENN, IE, IH	-0.3	+5	V	
Latch-Up	-100	100	mA	at 85°C, JEDEC 78
ESD	±1.5		kV	HBM MIL-Std. 883E method 3015
Thermal Resistance θ_{JA}	+36		ºC/W	
Junction Temperature TJ	+140		ºC	Internally limited
Operating Temperature Range	-40	+125	ºC	
Storage Temperature Range	-65	+150	ºC	
Package Body Temperature	+260		ºC	The reflow peak soldering temperature (body temperature) specified is in accordance with IPC/JEDEC J-STD-020 “Moisture/Reflow Sensitivity Classification for Non-Hermetic Solid State Surface Mount Devices”. The lead finish for Pb-free leaded packages is matte tin (100% Sn).
Humidity	5	85	%	Non-condensing
Moisture Sensitive Level	1			Unlimited storage time

2. Electrical characteristics

V_{DDHV}= 5V, V_{SS} = 0V, Typical values are at T_{AMB} = +25ºC (unless otherwise specified).

Symbol	Parameter	Conditions	Min	Type	Max	Units
T_{AMB}	Operating Ambient Temperature		-40		+85	°C
T_J	Operating Junction Temperature		-40		+125	°C
valid for IC3DC & IC3PWM						
V_{DDHV}	Supply Voltage Range		5		50	V
V_{DDA}	Internal Supply	no load	3.1	3.3	3.5	V
I_{DD}	Supply Current			1	2	mA
I_{OUT_E}	Output Energizing Current Range*1	defined by R_{IE} See “Current Adjust (IC3DC) and Current Limitation (IC3PWM)” on page 8.	10		100	mA
V_{IH}	Digital Input Threshold	at pin ENN	2		V_{DDA}	V
V_{IL}			V_{SS}		1.2	
V_{HYST}	Hysteresis	at pin ENN		200		mV
R_{PU}	Pull-Up Resistor	at pin ENN		100		kΩ
	Delay Time	See “Delay” on page 7.		136		ms
T_{SHDN}	Thermal Shutdown Temperature			160		ºC
ΔT_{SHDN}	Thermal Shutdown Hysteresis			15		ºC
only valid for IC3DC						
V_{OUT}	Saturation Voltage, Sink*1	I_{OUT} = 100mA		0.6	1	V
k	Transfer Value	R_{IE} = 12kΩ, V_{DDHV} = 5V to 50V, OUT = 1V to 40V See “Current Adjust (IC3DC) and Current Limitation (IC3PWM)” on page 8.	1080	1200	1320	AΩ
I_{OUT_H}	Output Hold Current Range*1	defined by R_{IH} See “REFERENCE DATA” on page 6.	0.3 x I_{OUT_E}		0.7 x I_{OUT_E}	mA
only valid for IC3PWM						
	Minimum Duty Cycle		15	20	25	%
	Maximum Duty Cycle		83	90	95	%
	Internal Duty Cycle			50		%
Vtrig	Trigger level to select internal voltage divider	at pin DUTY		V_{DDA}		V
f_{PWM}	PWM Frequency		25.5	30	34.5	kHz

Remarks

*1 The parameters are tested with proprietary test modes.

*2 All limits are guaranteed. The parameters with min and max values are guaranteed with production tests or SQC (Statistical Quality Control) methods.

REFERENCE DATA

Typical Operating Characteristics:
V_{SUPPLY} = 5V, R_{IE} = 30kW, R_{IH} = 120kW, T_{AMB} = +25ºC (unless otherwise specified);

Figure 1. Duty Cycle vs. V_{DUTY}

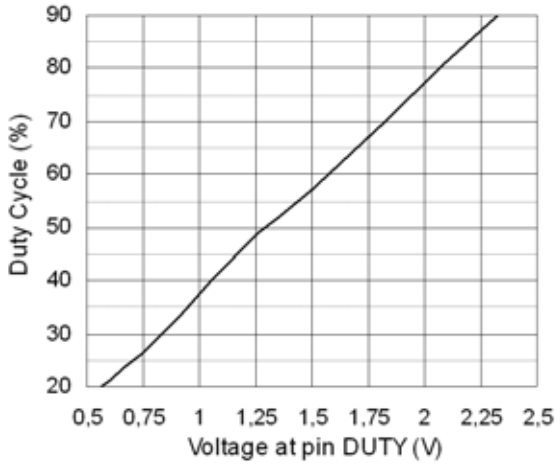


Figure 2. PWM Frequency vs. Temperature

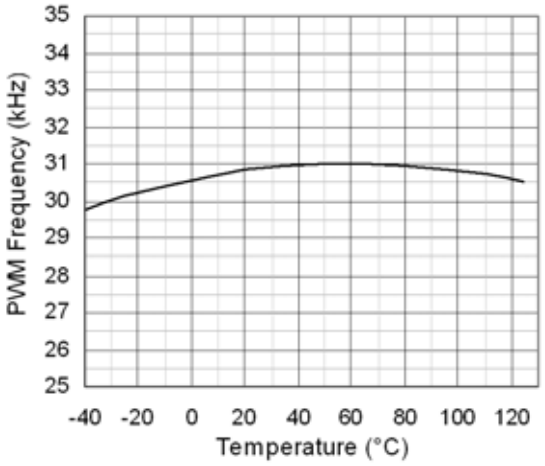


Figure 3. Supply Current vs. Supply Voltage

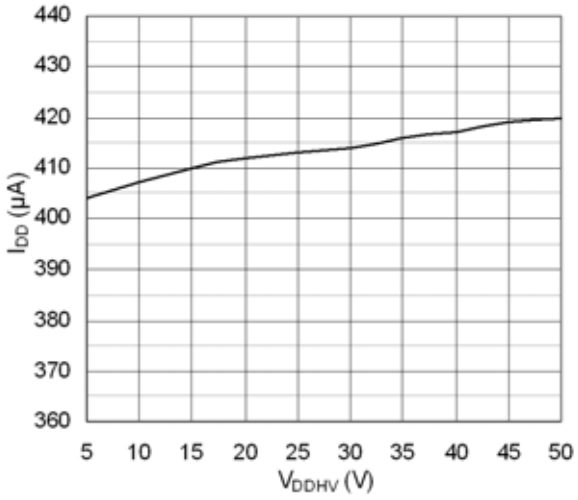


Figure 4. Supply Current vs. Temperature

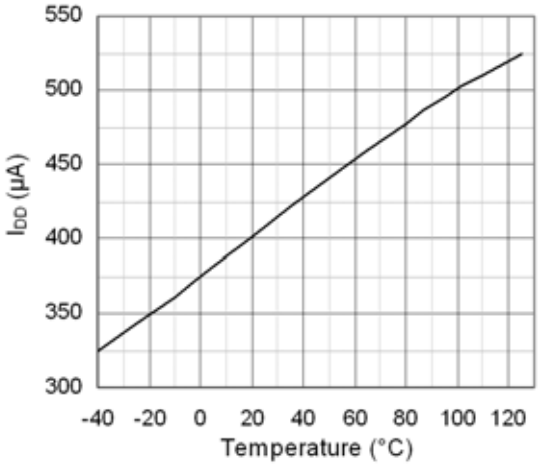


Figure 5. Transfer Function vs. Supply Voltage

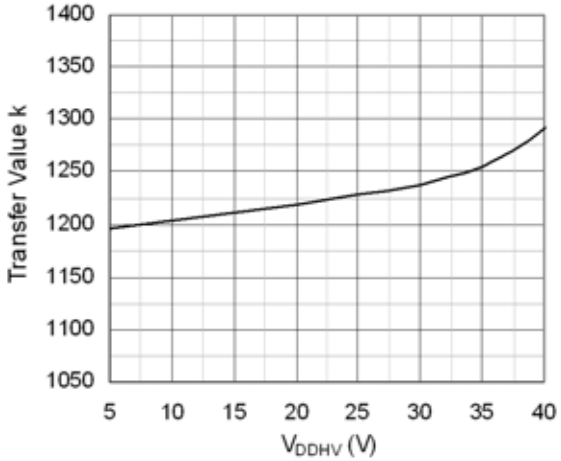
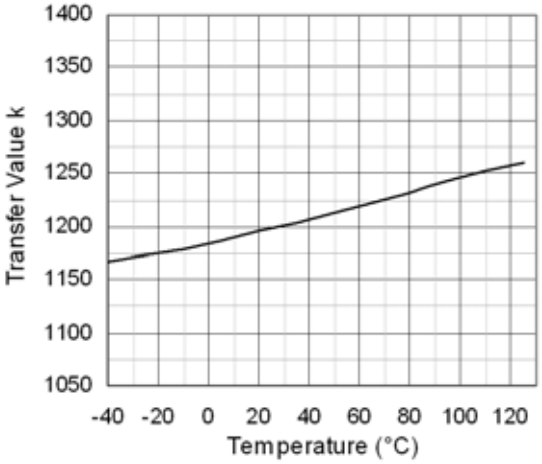


Figure 6. Transfer Function vs. Temperature



DETAILED DESCRIPTION

Delay
The delay time is generated internally by a digital divider.

LDO and Reference Generator
This block provides the internal supply voltage of typ. 3.3V and all bias currents for the analog cells. Further the external resistor divider for setting the duty cycle will be supplied.

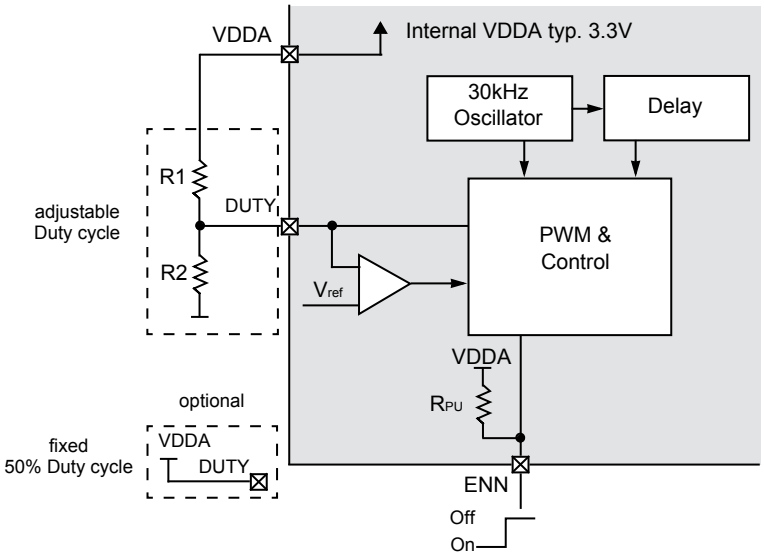
Thermal shutdown
The temperature is constantly monitored. If the temperature exceeds typ. 160ºC the output is disabled. In order to exit the over temperature condition, the device has to cool down and the reason of over temperature (e.g. short circuit) must be removed. After exiting the overtemperature condition the system restarts beginning with the energising phase followed by the hold phase.

DC Operation (IC3DC only)
After power up, the delay time starts running. After expiration of the delay the hold phase starts automatically. During the hold phase the DC output current is reduced according to the R_{IH} on pin IH.

PWM Operation (IC3PWM only)
After power up, the delay time starts running. After expiration of the delay the hold phase starts automatically. The internal RC oscillator sets the PWM period. The duty cycle is either defined by the external resistor divider (voltage) at pin DUTY or by the fixed internal divider. When using the external divider the duty cycle can be adjusted between 20% and 90% (e.g. from a DAC). Alternatively the pin can be driven by a voltage source. For using the internal divider the pin DUTY has to be connected to V_{DDA}. The comparator recognizes this condition and switches to the internal divider, which causes a fixed 50% duty cycle.

$$DUTYCYCLE(V_{DUTY}) = 0,381 \times V_{DUTY} - 0,014$$

Simplified Circuit of Block PWM and Control



Control by pin ENN

When VDDHV is constantly switched on the IC3 can be controlled by pin ENN. The functionality is the same as for controlling the device via pin VDDHV. This feature is useful when controlling by a microprocessor is desired.

Because of the internal pull-up resistor to V_{DDA} a microprocessor with open-drain or with push/pull (max 3.3V) output can be used.

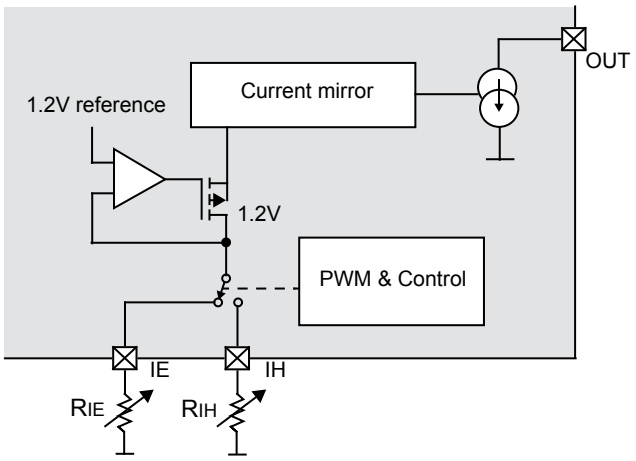
Current Adjust (IC3DC) and Current Limitation (IC3PWM)

This block provides the current reference for the output current source. The current is generated by regulating the internal Bandgap voltage to the pins IE and IH. The external resistors R_{IE} and R_{IH} define the output current and can be expressed as:

$$R_{IE/IH} = \frac{k}{I_{OUT}}$$

The temperature coefficient depends on the Bandgap voltage (100ppm/K, box method) and external resistor (in the range of several ppm/K). The saturation voltage of the output current source for a 100mA current is typical 600mV.

Simplified Circuit of Blocks Current Adjust and Current Source



TYPICAL APPLICATION: EXAMPLE

In order to drive relays, which need more than 100mA current, an external circuitry (see figure below) can be used. This application shows how to drive 5W at 12V relays.

This circuit is only applicable for IC3DC.

For this example with R1 = 100Ω and R_S = 2.5Ω the current Is is calculated as follows:

$$I_S = I_1 \times \frac{R_1}{R_S} = 0,01A \times \frac{100}{2,5} = 400mA$$

IC3DC - Typical Application