SEMIKRON

Absolute Maximum Ratings (T_a = 25 °C)

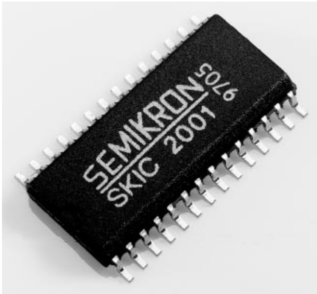
Symbol	Term	Values	Units
V_{DD15V}	15 V supply voltage (SKIC 2001 A)	18	V
V_{DD12V}	12 V supply voltage (SKIC 2001 B)	15	V
V_{DD5V}	5 V supply voltage (reference for input signals)	6	V
V_{IH}	input signal voltage (HIGH) max.	V_{DD5V} + 0,3	V
V_{IL}	input signal voltage (Low) min.	GND - 0,3	V
f_{sw}	switching frequency	50	kHz
T_{op} / T_{stg}	operating/storage temp.	– 25 ... + 85	°C

Electrical Characteristics (T_a = 25 °C) 1)

Symbol	Term	Values	Units
V_{DD15V}	15 V supply voltage (SKIC 2001 A)	15 $\pm$ 5 %	V
V_{DD12V}	12 V supply voltage (SKIC 2001 B)	12 $\pm$ 5 %	V
V_{DD5V}	5 V supply voltage	5 $\pm$ 5 %	V
$V_{BAND-GAP}$	reference voltage 10 V	9,99 ... 10,01	V
I_{S5V}	supply current (V_{DD5V}); typ 4)	3	mA
I_{S15V}	supply current (V_{DD15V}); typ 4)	15	mA
t_d	propagation time	960	ns
$t_{TDswitch}$ 2)	dead time of interlock; typ.	0, 1, 2, 3, 4	µs
$t_{supswitch}$	short pulse suppression TOP-BOT;typ		
	pulses are suppressed	< 480 3)	ns
	pulses are not suppressed	> 640	ns
$t_{supreset}$	short pulse suppression RESET; typ.	9	µs
V_{SU}	supply undervoltage monitoring		
	using V_{DD15V} SKIC 2001 A	13,0	V
	using V_{DD12V} SKIC 2001 B	10,0	V
$V_{SU\ 5\ V}$	supply undervoltage monitoring using V_{DD5V}	3	V
input signal TOP, BOTTOM, SELECT, TDT1, TDT2			
V_{it+}	input threshold voltage (High) min	3,5 - 3,9	V
V_{iT-}	input threshold voltage (Low) max	1,5 - 2,0	V
R_{down}	internal pull down resistor (TOP; BOTTOM)	66 $\pm$ 2	kΩ
R_{UP}	internal pull up resistor (SELECT, TDT1, TDT2)	64 $\pm$ 2	kΩ
ERROR input signals TOPERR, BOTERR			
V_{ET+}	input threshold voltage (High)	> 3,55	V
V_{ET-}	input threshold voltage (LOW)	< 1,3	V
R_{EUp}	internal pull up resistor	27 $\pm$ 0,2	kΩ
t_{swOSZ}	oszillator frequency DC/DC-conv.	500 3)	kHz
t_{Td}	time of interlock DC/DC-converter	250	ns
ERROR input signal SENSEERR			
V_{ET+}	input threshold voltage (High)	3,4 $\pm$ 0,2	V
V_{ET-}	input threshold voltage (LOW)	2,2 $\pm$ 0,2	V
R_{EUp}	internal pull up resistor	36 $\pm$ 2	kΩ
output signal ERROR; TPW, TW			
I_{outmax}	max. output current at V_{DD5V}	$\pm$ 5	mA
V_{outmax}	max. output voltage at + 5 mA	4,8	V
V_{outmin}	min. output voltage at - 5 mA	0,22	V
output signal TOPOUT; BOTOUT; TR1P; TR1N; TR2P; TR2N			
r_{Ti}	inhibit time for $V_{CE;\ ERR}$	2	µs
t_r typ.	rise time	25 5)	ns
t_f typ.	fall time	35 5)	ns

SEMIDRIVER®
IGBT Driver Circuit
SKIC 2001 A
SKIC 2001 B

Preliminary Data



Package SOP 28

Features

IGBT-halfbridge driver circuit with protection functions

- Interlock of TOP and BOTTOM switches of one halfbridge
- Short pulse suppression
- Temperature monitoring
- Supply undervoltage protection
- V_{CE} error protection
- Over-current error input
- Generation of the system clock
- Integrated DC/DC-converter driver circuit
- Error monitoring
- SKIC 2001 B with 12 V supply voltage for automotive applications

Typical Applications

- Driving of IGBTs
  - for halfbridge configuration, also for SIXPACK and single switch possible
  - due to isolation (magnetic transformer, optocoupler) can be used for voltages > 1200 V and high power applications
- Automotive applications (SKIC 2001 B)

Evaluation boards available on request

1) Values for V_{DD15V}; V_{DD5V}; f_{sw} = 25kHz
2) input "SELECT" = LOW = t_{TD} = 0 µs
3) with f_{sw} = 8 MHz at OSC1, OSC2
4) stand by
5) capacitive load (max) ≤ 1 nF at V_{DD15V} = 15 V

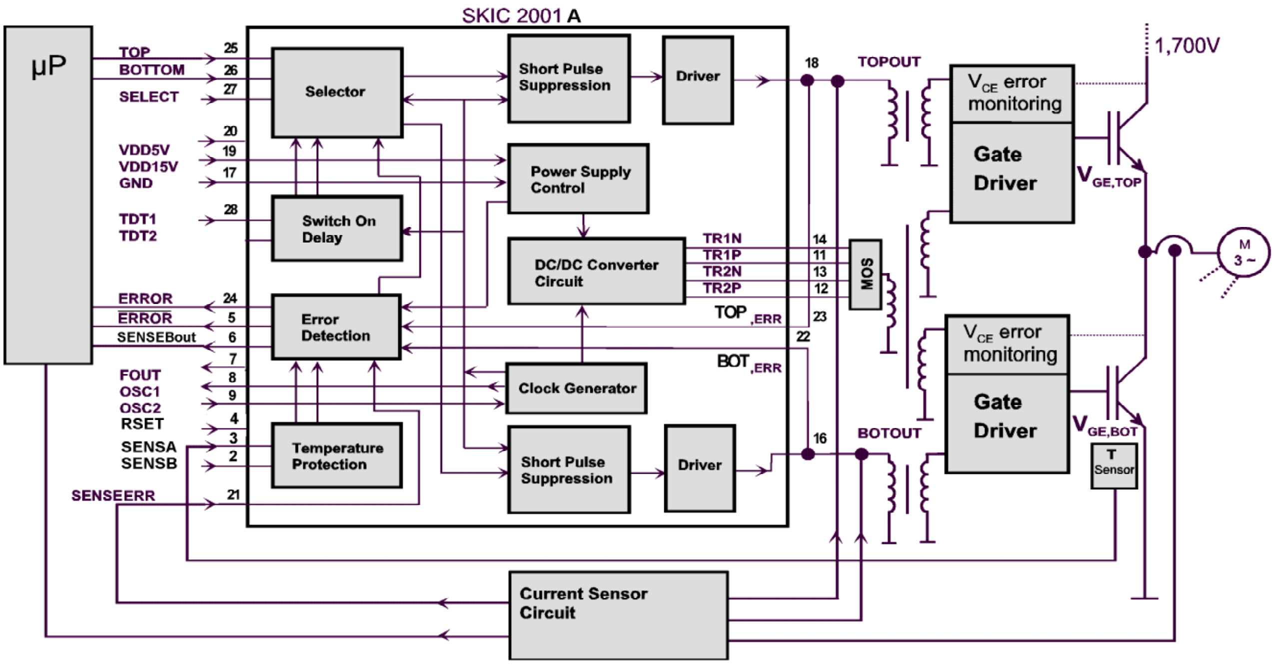


Fig. 1 Functional block diagram of the Control IC (SKIC2001A) inside a propulsion control

Pin Array:

PIN-No.	terminal	function
1	TDT2	code for interlock time
2	SENSB	input analogue sense B
3	SENSA	input analogue sense A (type KTY85, optional)
4	RSET	input, analogue temp. sense resistance for adjustment of comparator threshold
5	$\overline{\text{ERROR}}$	output error signal
6	SENSB_OUT	output for overtemperature signal
7	FOUT	system clock output
8	OSC1	input oscillator
9	OSC2	input oscillator, external switching
10	CPOR	time constante for POWER ON RESET
11	TR1P	output DC/DC-converter
12	TR2P	output DC/DC-converter
13	TR2N	output DC/DC-converter
14	TR1N	output DC/DC-converter
15	VDD15V	supply voltage 15 V (12 V for SKIC 2001 B)
16	BOTOUT	driver output BOTTOM
17	GND	GND
18	TOPOUT	driver output TOP
19	VDD15V	supply voltage 15 V (12 V for SKIC 2001 B)
20	VDD5V	supply voltage 5 V
21	SENSEERR	input error signal, secondary side
22	BOTERR	input error signal, secondary side
23	TOPERR	input error signal, secondary side
24	ERROR	output error signal
25	TOP	driver input TOP
26	BOTTOM	driver input BOTTOM
27	SELECT	interlock on/off
28	TDT1	code or interlock time

Overview

The integrated intelligent controller circuit (SKIC 2001) presented for the control of IGBTs, especially in a halfbridge, for high power applications (up to 1,700 V and several hundred amperes) and frequencies up to 50 kHz. It includes several driver, protection and monitor functions. Fig. 1. shows the functional block diagram of the control IC inside a propulsion control. It consists of a digital control unit, mostly a microprocessor (µP), the control IC (SKIC 2001), a potential separation (ferrite signal transformer or opto-couplers), the gate driver stages, an IGBT halfbridge and a consumer, in this case a motor.

With aid of the digital unit a pulse frequency modulation of the IGBT driver signals is possible and, therefore, a power control of the consumer can be realized. The developed control circuit contains the signal processing, power supply, the driving and monitoring functions for two IGBTs in a halfbridge (application also for SIXPACK and single switch possible). A power supply of 5 V and 15 V (12 V for SKIC 2001 B) is necessary.
The most important parts, functions, connections and in- and outputs are shown in Fig. 1:

- the forward branch with selector, switch on delay, short pulse suppression, driver and signal transformer to the secondary side (high voltage side)
- the backward branch with error detection and processing (undervoltage, temperature, V_{CE} and overcurrent)
- the additional part with clock generator, power supply control and dc/dc converter circuit

The control circuit has several inputs, some of them with a Schmitt-trigger characteristic for increased noise immunity. TOP and BOTTOM are the main control inputs. RESET sets back the error storage. With TDT1, TDT2 and SELECT a switch on delay between 0 and 4 µs can be chosen. SENSA, SENSB (temperature sensor) and RSET are optional inputs, if the customer applies a temperature monitoring. The KTY85 is used as temperature sensor which is placed insulated on the DCB-substrate. Thus the temperature of the heat sink is determined. With input RSET the variation of the comparator thresholds (A and B) or adaptations to an other sensor are possible with the help of an external resistance. The error signal of comparator A sets the internal error storage. The error signal of comparator B lies at output SENSB_OUT.

With the use of ferrite signal transformers the information between primary and secondary side may flow in both directions and high levels of dv/dt and insulation are guaranteed (opto-couplers are also possible). The high frequency dc/dc converter avoids the requirement of an externally insulated power supply to obtain the necessary voltage and power for the IGBT gates. For this operation the dc/dc converter circuit supplies a 15 V signal with a frequency of 500 kHz. There is the possibility to use one halfbridge of external power MOSFET (1 pMOS and 1 nMOS) for a lower power supply or a bridge (2 pMOS and 2 nMOS) for a higher power supply.

The IGBT driver stages are externally placed. So the stages can be matched to the respective power range and the optimum function (switching frequency and gate charge of the IGBTs, negative switch off voltage, soft turn off). A short circuit at the IGBT driver stages can be monitored by a permanent control of the collector-emitter-voltage (optionally). In general this method is used, but it has the disadvantage, that a time of a few µs has to be waited, until it can be decided between a normal switch on or a short circuit by the V_{CE}-value. A better and faster method is the evaluation of a differential quotient of the V_{CE}-drop. In the case of a detected short circuit, the IGBT is switched off immediately and an error signal V_{CE}-error is transformed to the control IC.

Another (optional) way to detect a short circuit is the use of a current sensor at the output of the halfbridge (Fig. 1). For high power application a current measuring signal is fundamentally indispensable for an optimum microprocessor control of the propulsion system. We use a newly developed compensating current sensor on the basis of a magnetic field sensor. It can be placed outside or inside the power module. The sensor current (in a ratio of 2000 : 1 to the output current) is converted into a proportional analog voltage signal in the separate sensor circuit and evaluated by the microprocessor. In addition the sensor circuit contains a comparator stage where the same signal is also used for the overcurrent monitoring of the IGBTs. In case of an overcurrent the IGBTs are switched off directly in about 1 µs and then an error signal I_{ERR} is sent to the control IC. The advantage of this solution is the saving of the expensive V_{CE}-monitoring and the very short reaction time to a short circuit.

An internal protection function of the SKIC 2001 is the power supply control. The circuit will be blocked, if the 15V-power supply (12 V for SKIC 2001 B) drops under a value of about 13,0 V (about 10 V for SKIC 2001 B). In this case a safe function, especially of the transformers, can't be guaranteed any longer.
All detected error signals are processed in the control IC. The forward driver signal is blocked or the IGBTs are switched off and error signals are given at the output to the microprocessor (ERROR and $\overline{\text{ERROR}}$ for undervoltage of power supply, V_{CE}-error and over temperature). The error storage can be reset by a RESET pulse, which is generated, if 9 µs the inputs (TOP, BOTTOM) are LOW.

Functional description

Interlock

Fig. 2 demonstrate the right function of interlock of TOP- and BOTTOM-IGBT.

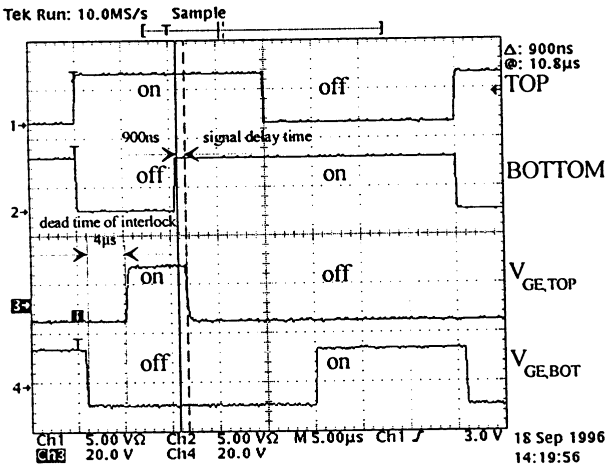


Fig. 2 Interlock function

At first BOTTOM is switched off immediately after the corresponding input signal (at 5 µs), while TOP is switched on with a delay of about 1 µs (setting of interlock 4 µs). After 10 µs both inputs become „on". This isn't a correct state (both IGBT „on" means short circuit) and that is why both are switched off. A switch on of BOTTOM is possible not before TOP is „off" (at 25 µs, interlock and delay time about 5 µs).
Fig. 3 shows the behavior, if the interlock function isn't active (SELECT „low"). Both outputs react immediately to the corresponding input (the difference is the signal delay time).

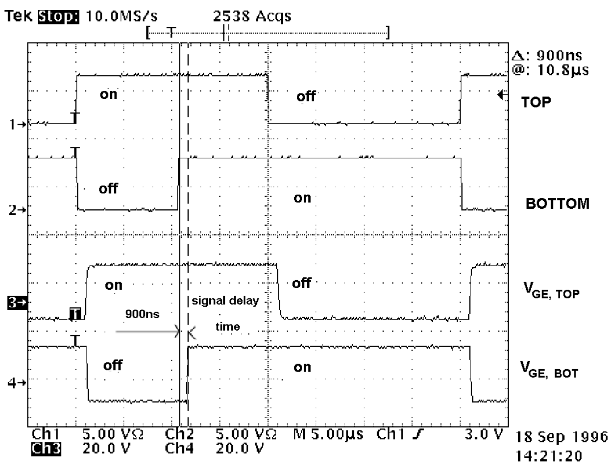


Fig. 3 Interlock function not active

Shortpulse suppression

Fig. 4 presents the short pulse suppression. Pulses shorter than 480 ns are suppressed (noise) and pulse longer than 640 ns are valid.

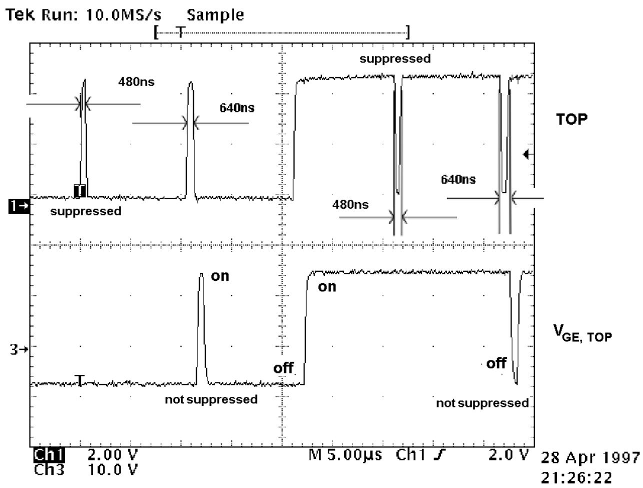


Fig. 4 Short pulse suppression

V_{CEsat} error processing

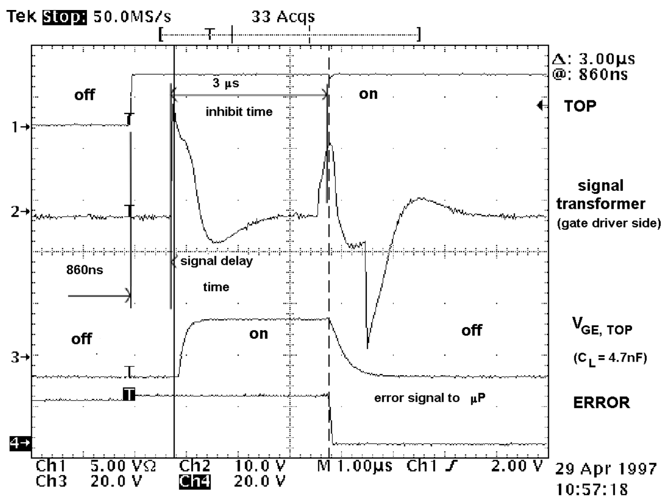


Fig. 5 V_{CE}-error processing

In Fig. 5 the signals at the signal transformer are described. About 860 ns after TOP is „on" (delay time), we see a positive needle on the transformer at the gate driver side and the IGBT will switch on. After about 3 µs a V_{CE}-error signal will appear, the IGBT will switch off and an error-signal (smaller positive needle) is transformed to the low voltage side. The control IC processes this signal and gives an off impulse (negative needle) to the IGBT. (The needles on the transformers are converted in rectangular pulses by a gate driver input with Schmitt trigger-characteristic).

DC-DC-Converter-Control signals

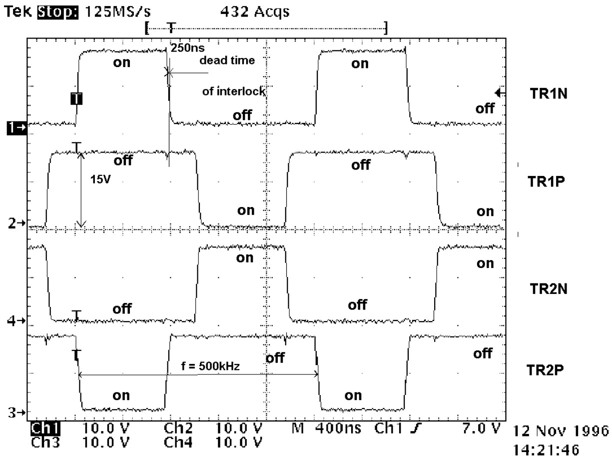


Fig. 6 DC/DC converter signals

Fig. 6 presents the output driver signals of dc/dc converter. The interlock time is 250 ns, the frequency is 500 kHz.