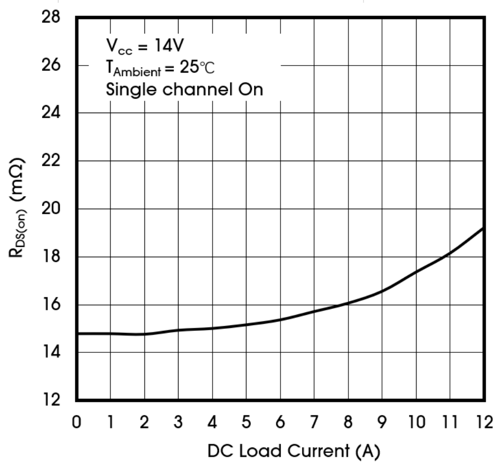
1. 特性

- 符合 AEC-Q100 标准
- 集成电流检测反馈的双通道智能高边驱动
- 正常工作电压范围：4V 到 36V，AMR 40V
- 导通电阻：15 mΩ （Typ, T_J = 25°C）
- 最大限流值：40A (Typ)
- 极低待机功耗：0.01μA (Max)
- 支持深度冷启动最低供电电压 2.85V
- 兼容 3V 和 5V CMOS 输入
- CS 管脚诊断功能
  - 带高精度比例电流镜的负载电流模拟反馈
  - 输出过载和输出短路到地警报
  - OFF 状态开路负载检测
  - 输出短路到 V_{CC} 检测
  - CS 支持启用/禁用
- 保护
  - Vcc 欠压关断保护
  - Vcc 过压钳位保护
  - V_{DS} 负压钳位保护
  - 热关断警报
  - 过流保护
  - 相对过温保护
  - 通过FaultRST引脚可配置过热或过功率闭锁
  - 接地丢失和 V_{CC} 丢失时自动关断保护
  - 电池反接保护
  - 静电放电保护

2. 应用

- 汽车应用中后接阻性、感性和容性负载
- ADAS 系统中带保护电源：雷达和传感器
- 车灯



3. 说明

HD70152Q 是一款车规级双通道智能高边开关，其输入控制引脚兼容 3V 和 5V CMOS 接口，配有两路独立输出通道。HD70152Q 广泛应用于汽车 12V 接地负载应用中，可以进一步提供智能保护和诊断功能。

HD70152Q 集成了先进的保护功能，包括负载过流限制保护、相对过温保护以及具有可配置闭锁功能的过热关断保护等。HD70152Q 的FaultRST引脚在出现故障时可以控制输出自动恢复或者输出闭锁。

此外，HD70152Q 内部集成专用多功能多路复用模拟输出引脚 CS，可以提供复杂的诊断功能，包括高精度比例负载电流检测，输出过载和对地短路警报，以及对 V_{CC} 短路诊断和 OFF 状态开路诊断。

输入 SEn 引脚为 HD70152Q 的检测使能引脚，其可以进一步禁用 OFF 状态下的诊断功能，获得更低的功耗。此外，在同一系统使用多个 HD70152Q 的场景中，除了节省功耗外，SEn 还可以实现多片 HD70152Q 仅需一个 ADC 采样通道和一个 CS 对地电阻，极大地优化系统实现成本。

HD70152Q 支持 SSOP16P 封装，工作环境温度范围为-40°C 到 125°C，有关订购信息，请参见 Table 1。

Table 1 lists the order information.

Table 1. Order Information

ORDER NUMBER	PACKAGE	MARK	CH (#)	Vcc (V)	Rdson (mΩ)	$I_{Standby}$ (max) (µA)	I_{Limit} (A)	SLEW RATE (TYP) (V/µs)	OP. TEMP (°C)	RATING	PKG. OPTION
HD70152QASSOP16P	SSOP16P	HD70152Q	2	4-36	15	0.01	40	0.38	–40-125	Auto	TBD

4. PIN CONFIGURATION AND FUNCTIONS

Figure 1 illustrates the pin configuration.

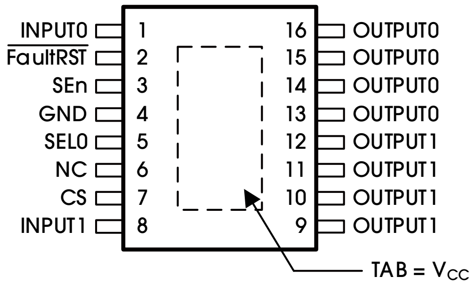


Figure 1. Pin Configuration

Table 2 lists the pin functions.

Table 2. Pin Functions

POSITION	NAME	TYPE	DESCRIPTION
1	INPUT0	Input	Voltage controlled input pin with hysteresis, compatible with 3V and 5V CMOS outputs. It controls output switch state.
2	$\overline{\text{FaultRST}}$	Input	Active low compatible with 3V and 5V CMOS outputs pin; it unlatches the output in case of fault; If kept low, sets the outputs in auto-restart mode.
3	SEn	Input	Active high compatible with 3V and 5V CMOS outputs pin; it enables the CS diagnostic pin.
4	GND	Ground	Ground connection. Must be reverse battery protected by an external diode / resistor network.
5	SEL0	Input	Active high compatible with 3V and 5V CMOS outputs pin; they address the CS multiplexer.
6	NC	—	Not connect for this pin.
7	CS	Output	Analog current sense output pin. It delivers a current proportional to the load current.
8	INPUT1	Input	Voltage controlled input pin with hysteresis, compatible with 3V and 5V CMOS outputs. It controls output switch state.
9-12	OUTPUT1	Output	Power outputs. All the pins must be connected together.
13-16	OUTPUT0	Output	Power outputs. All the pins must be connected together.
—	V_{CC}	Power	Battery connection

5. SPECIFICATIONS

5.1 ABSOLUTE MAXIMUM RATINGS

Table 3 lists the absolute maximum ratings of the HD70152Q.

Table 3. Absolute Maximum Ratings

PARAMETER	DESCRIPTION	MIN	MAX	UNITS
Voltage	DC supply voltage, V_{CC}		38	V
	Reverse DC supply voltage, $-V_{CC}$		0.3	V
	Maximum transient supply voltage (ISO 16750-2:2010 Test B clamped to 40V; $R_L = 4\Omega$), V_{CCPK}		40	V
	Maximum jump start voltage for single pulse short circuit protection, V_{CCJS}		28	V
Current	DC reverse ground pin current, $-I_{GND}$		200	mA
	OUTPUT DC output current, I_{OUT}		Internally limited	A
	Reverse DC output current, $-I_{OUT}$		28	A
	INPUT DC input current, I_{IN}	-1	10	mA
	SEn DC input current, I_{SEn}	-1	10	mA
	SEL0 DC input current, I_{SEL}	-1	10	mA
	$\overline{\text{FaultRST}}$ DC input current, I_{FR}	-1	1.5	mA
	CS pin DC output current ($V_{GND} = V_{CC}$ and $V_{SENSE} < 0V$), I_{SENSE}		10	mA
	CS pin DC output current in reverse ($V_{CC} < 0V$), I_{SENSE}		-20	mA
	Maximum switching energy (single pulse) ($T_{DEMAG} = 0.4ms$; $T_{JSTART} = 150°C$), E_{MAX}		TBD	mJ
Temperature	Junction, T_J	-40	150	°C
	Storage, T_{stg}	-55	150	°C

Note: Stresses beyond those listed under Table 3 may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Table 5. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

5.2 ESD RATINGS

Table 4 lists the ESD ratings of the HD70152Q.

Table 4. ESD Ratings

PARAMETER	SYMBOL	DESCRIPTION	VALUE	UNITS
Electrostatic Discharge	$V_{(ESD)}$	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001[(1)]	±2000	V
		Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001[(1)] Vcc, Output0 and Output1	±4000	
		Charged-device model (CDM), per JEDEC specification JESD22-C101[(2)]	±1000	

Note 1: The JEDEC document JEP155 indicates that 500V HBM allows safe manufacturing with a standard ESD control process.
Note 2: The JEDEC document JEP157 indicates that 250V CDM allows safe manufacturing with a standard ESD control process.

5.3 RECOMMENDED OPERATING CONDITIONS

Table 5 lists the recommended operating conditions for the HD70152Q.

Table 5. Recommended Operating Conditions

PARAMETER	DESCRIPTION	SYMBOL	MIN	NOM	MAX	UNITS
POWER SUPPLY						
Power Supply			4		28	V
DIGITAL INPUTS						
Digital Input Voltage		V_{DIG}	0		5.5	V
TEMPERATURE RANGE						
Operating Ambient Temperature		T_A	-40		125	°C

5.4 THERMAL INFORMATION

Table 6 lists the thermal information for the HD70152Q.

Table 6. Thermal Information

PARAMETER	SYMBOL	Value	UNITS
Junction-to-Ambient Thermal Resistance	$R_{\theta JA}$	32.9	°C/W
Junction-to-Case (Top) Thermal Resistance	$R_{\theta JC(top)}$	24.7	°C/W
Junction-to-Board Thermal Resistance	$R_{\theta JB}$	14.8	°C/W
Junction-to-Top Characterization Parameter	ψ_{JT}	5.2	°C/W
Junction-to-Board Characterization Parameter	ψ_{JB}	13.8	°C/W
Junction-to-Case (Bottom) Thermal Resistance	$R_{\theta JC(bot)}$	—	°C/W

5.5 ELECTRICAL CHARACTERISTICS

Table 7 lists the electrical characteristics of the HD70152Q. 7V < V_{CC} < 36V; −40°C < T_J < 150°C, unless otherwise specified. All typical values refer to V_{CC} = 13V; T_J = 25°C, unless otherwise specified.

Table 7. Electrical Characteristics

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
DURING CRANKING						
Minimum Cranking Supply Voltage (V_{CC} Decreasing)	$V_{USD\_Cranking}$				2.85	V
Shutdown Temperature (V_{CC} Decreasing)(2)	T_{TSD}	V_{CC} = 2.85V; V_{CC} decreasing	140			°C
POWER						
Operating Supply Voltage	V_{CC}		4	13	36	V
Undervoltage Shutdown	V_{USD}				2.85	V
Undervoltage Shutdown Reset	$V_{USDReset}$				3.8	V
On-State Resistance(1)	R_{ON}	I_{OUT} = 3A; T_J = 25°C		14.5		mΩ
		I_{OUT} = 3A; T_J = 150°C			TBD	mΩ
		I_{OUT} = 3A; V_{CC} = 4V; T_J = 25°C(3)			15.5	mΩ
Nominal Load Current Per Channel (2 channel active)	$I_{L(NOM)}$	T_J < 150°C(10)		5		A
VBB Clamp Voltage	V_{clamp}	I_S = 20mA; 25°C < T_J < 150°C		45		V
		I_S = 20mA; T_J = −40°C	TBD			V
Supply Current in Standby at V_{CC} = 13V(4)	I_{STBY}	V_{CC} = 13V; V_{IN} = V_{OUT} = V_{FR} = V_{SEn} = 0V; V_{SEL0} = 0V; T_J = 25°C		0.006	0.01	μA
		V_{CC} = 13V; V_{IN} = V_{OUT} = V_{FR} = V_{SEn} = 0V; V_{SEL0} = 0V; T_J = 85°C(5)			TBD	μA
		V_{CC} = 13V; V_{IN} = V_{OUT} = V_{FR} = V_{SEn} = 0V; V_{SEL0} = 0V; T_J = 125°C			TBD	μA
Standby Mode Blanking Time	t_{D_STBY}	V_{CC} = 13V; V_{IN} = V_{OUT} = V_{FR} = V_{SEL0} = 0V; V_{SEn} = 5V to 0V		650		μs
Supply Current	$I_{S(ON)}$	V_{CC} = 13V; V_{SEn} = V_{FR} = V_{SEL0} = 0V; V_{IN0} = 5V; V_{IN1} = 5V; I_{OUT0} = 0A; I_{OUT1} = 0A		3.9	4	mA
Control Stage Current Consumption in ON State. All Channels Active.	$I_{GND(ON)}$	V_{CC} = 13V; V_{SEn} = 5V; V_{FR} = V_{SEL0} = 0V; V_{IN0} = 5V; V_{IN1} = 5V; I_{OUT0} = 3A; I_{OUT1} = 3A			4.8	mA
Off-State Output Current at V_{CC} = 13V(4)	$I_{L(off)}$	V_{IN} = V_{OUT} = 0V; V_{CC} = 13V; T_J = 25°C		0.01	0.5	μA
		V_{IN} = V_{OUT} = 0V; V_{CC} = 13V; T_J = 125°C			TBD	μA
Output - V_{CC} Diode Voltage at T_J = 150°C	V_F	I_{OUT} = −3A; T_J = 150°C			0.7	V
SWITCHING (V_{CC} = 13V; −40°C < T_J < 150°C, UNLESS OTHERWISE SPECIFIED)						
Turn-On Delay Time at T_J = 25°C(6)	$t_{d(on)}$	R_L = 4.3Ω	39	41	42	μs
Turn-Off Delay Time at T_J = 25°C(6)	$t_{d(off)}$	R_L = 4.3Ω	92.5	96.5	100	μs
Turn-On Voltage Slope at T_J = 25°C(6)	$(dV_{OUT}/dt)_{on}$	R_L = 4.3Ω		0.3		V/μs
Turn-Off Voltage Slope at T_J = 25°C(6)	$(dV_{OUT}/dt)_{off}$	R_L = 4.3Ω		0.3		V/μs
Switching Energy Losses at Turn-On (t_{won})	W_{ON}	R_L = 4.3Ω	—	TBD	TBD(2)	mJ
Switching Energy Losses at Turn-Off (t_{woff})	W_{OFF}	R_L = 4.3Ω	—	TBD	TBD(2)	mJ
Differential Pulse Skew (t_{PHL} − t_{PLH})(6)	t_{SKEW}	R_L = 4.3Ω		60.5		μs

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
LOGIC INPUTS (7V < V_{CC} < 28V; −40°C < T_J < 150°C)						
INPUT0/1 Characteristics						
Input Low Level Voltage	V_{IL}				0.9	V
Low Level Input Current	I_{IL}	V_{IN} = 0.9V	1			µA
Input High Level Voltage	V_{IH}		2.1			V
High Level Input Current	I_{IH}	V_{IN} = 2.1V			10	µA
Input Hysteresis Voltage	$V_{I(hyst)}$		0.15			V
$\overline{\text{FaultRST}}$ Characteristics						
Input Low Level Voltage	V_{FRL}				0.9	V
Low Level Input Current	I_{FRL}	V_{IN} = 0.9V	1			µA
Input High Level Voltage	V_{FRH}		2.1			V
High Level Input Current	I_{FRH}	V_{IN} = 2.1V			10	µA
Input Hysteresis Voltage	$V_{FR(hyst)}$		0.15			V
SEL0 Characteristics (7V < V_{CC} < 18V)						
Input Low Level Voltage	V_{SELL}				0.9	V
Low Level Input Current	I_{SELL}	V_{IN} = 0.9V	1			µA
Input High Level Voltage	V_{SELH}		2.1			V
High Level Input Current	I_{SELH}	V_{IN} = 2.1V			10	µA
Input Hysteresis Voltage	$V_{SEL(hyst)}$		0.15			V
SEn Characteristics (7V < V_{CC} < 18V)						
Input Low Level Voltage	V_{SEnL}				0.9	V
Low Level Input Current	I_{SEnL}	V_{IN} = 0.9V	1			µA
Input High Level Voltage	V_{SEnH}		2.1			V
High Level Input Current	I_{SEnH}	V_{IN} = 2.1V			10	µA
Input Hysteresis Voltage	$V_{SEn(hyst)}$		0.15			V
PROTECTIONS (7V < V_{CC} < 18V; −40°C < T_J < 150°C)						
DC Short-Circuit Current	I_{LIMH}	V_{CC} = 13V		40	TBD	A
		4V < V_{CC} < 18V(2)				
Short-Circuit Current During Thermal Cycling	I_{LIML}	V_{CC} = 13V; T_R < T_J < T_{TSD}		25		
Shutdown Temperature	T_{TSD}		150	175	200	°C
Reset Temperature(2)	T_R		T_{RS} + 1	T_{RS} + 7		
Thermal Reset of Fault Diagnostic Indication	T_{RS}	V_{FR} = 0V; V_{SEn} = 5V	135			
Thermal Hysteresis (T_{TSD} − T_R)(2)	T_{HYST}			7		
Dynamic Temperature	ΔT_{J_SD}	T_J = −40°C; V_{CC} = 13V		60		K
Fault Reset Time for Output Unlatch(2)	t_{LATCH_RST}	V_{FR} = 5V to 0V; V_{SEn} = 5V; V_{IN} = 5V; V_{SEL0} = 0V		10		µs
Turn-Off Output Voltage Clamp	V_{DEMAG}	I_{OUT} = 2A; L = 6mH; T_J = −40°C				V
		I_{OUT} = 2A; L = 6mH; T_J = 25°C to 150°C		V_{CC} − 45		V

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
CURRENT SENSE (7V < V_{CC} < 18V; -40°C < T_J < 150°C)						
Current Sense Clamp Voltage	V_{SENSE_CL}	V_{SEn} = 0V; I_{SENSE} = 1mA	-9.4		-9.2	V
		V_{SEn} = 0V; I_{SENSE} = -1mA		5		V
Current Sense Characteristics						
I_{OUT}/I_{SENSE}	K_0	I_{OUT} = 0.1A; V_{SENSE} = 0.5V; V_{SEn} = 5V		2950		
Current Sense Ratio Drift(5)(7)	dK_0/K_0	I_{OUT} = 0.1A; V_{SENSE} = 0.5V; V_{SEn} = 5V				%
I_{OUT}/I_{SENSE}	K_1	I_{OUT} = 0.25A; V_{SENSE} = 0.5V; V_{SEn} = 5V		2950		
Current Sense Ratio Drift(5)(7)	dK_1/K_1	I_{OUT} = 0.25A; V_{SENSE} = 0.5V; V_{SEn} = 5V				%
I_{OUT}/I_{SENSE}	K_2	I_{OUT} = 3A; V_{SENSE} = 4V; V_{SEn} = 5V		2950		
Current Sense Ratio Drift(5)(7)	dK_2/K_2	I_{OUT} = 3A; V_{SENSE} = 4V; V_{SEn} = 5V				%
I_{OUT}/I_{SENSE}	K_3	I_{OUT} = 9A; V_{SENSE} = 4V; V_{SEn} = 5V		2950		
Current Sense Ratio Drift(5)(7)	dK_3/K_3	I_{OUT} = 9A; V_{SENSE} = 4V; V_{SEn} = 5V				%
CS Current for OL Detection	I_{SENSE_OL}	I_{OUT} = 0.01A; V_{SENSE} = 0.5V; V_{SEn} = 5V		3.6		μA
Current Sense Leakage Current	I_{SENSE0}	Current sense disabled: V_{SEn} = 0V			0.5	nA
		Current sense disabled: -1V < V_{SENSE} < 5V(5)	0.25		4	nA
		Current sense enabled: V_{SEn} = 5V; Channel ON; I_{OUT} = 0A; Diagnostic selected; V_{IN0} = 5V; V_{IN1} = 5V; V_{SEL0} = 0V; I_{OUT0} = 0A; I_{OUT1} = 3A		1.8		μA
		Current sense enabled: V_{SEn} = 5V; Channel OFF; Diagnostic selected: V_{IN0} = 0V; V_{IN1} = 5V; V_{SEL0} = 0V; I_{OUT1} = 3A		0.02		μA
CS Saturation Voltage	V_{SENSE_SAT}	V_{CC} = 7V; R_{SENSE} = 2.7kΩ; V_{SEn} = 5V; V_{IN} = 5V; V_{SEL0} = 0V; I_{OUT} = 9A; T_J = -40°C		5.15		V
CS Saturation Current(5)	I_{SENSE_SAT}	V_{CC} = 7V; V_{SENSE} = 4V; V_{IN} = 5V; V_{SEn} = 5V; V_{SEL0} = 0V; T_J = 150°C	4			mA
Output Saturation Current(5)	I_{OUT_SAT}	V_{CC} = 7V; V_{SENSE} = 4V; V_{IN} = 5V; V_{SEn} = 5V; V_{SEL0} = 0V; T_J = 150°C	11.5			A
OFF-State Diagnostic						
OFF-State Open-Load Voltage Detection Threshold	V_{OL}	V_{SEn} = 5V; Chx OFF; Chx diagnostic selected; V_{IN0} = 0V; V_{SEL0} = 0V		2.87		V
OFF-State Output Source Current(8)	$I_{L(off2)}$	V_{IN} = 0V; V_{OUT} = V_{OL}; T_J = -40°C to 125°C		10.7		μA
OFF-State Diagnostic Delay Time from Falling Edge of Input (See Figure 6)	t_{DSTKON}	V_{SEn} = 5V; Chx ON to OFF transition; Chx diagnostic selected; e.g. Ch0: V_{IN0} = 5V to 0V; V_{SEL0} = 0V; I_{OUT0} = 0A; V_{OUT} = 4V		368		μs
Settling Time for Valid OFF-State Open Load Diagnostic Indication from Rising Edge of SEn	$t_{D\_OL\_V}$	V_{IN0} = 0V; V_{IN1} = 0V; V_{FR} = 0V; V_{SEL0} = 0V; V_{OUT} = 4V; V_{SEn} = 0V to 5V		43	45	μs
OFF-State Diagnostic Delay Time from Rising Edge of V_{OUT}	t_{D_VOL}	V_{SEn} = 5V; Chx OFF; Chx diagnostic selected; e.g. Ch0; V_{IN0} = 0V; V_{SEL0} = 0V; V_{OUT} = 0V to 4V		1.6		μs
Fault Diagnostic Feedback (See Table 8)						
Current Sense Output Voltage in Fault Condition	V_{SENSEH}	V_{CC} = 13V; R_{SENSE} = 1kΩ e.g. Ch0 in open load: V_{IN0} = 0V; V_{SEn} = 5V; V_{SEL0} = 0V; I_{OUT0} = 0A; V_{OUT} = 4V	5		5.2	V
Current Sense Output Current in Fault Condition	I_{SENSEH}	V_{CC} = 13V; V_{SENSE} = 5V	6.2		6.5	mA

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Current Sense Timings (Current Sense Mode - See Figure 5)(9)						
Current Sense Settling Time from Rising Edge of SEn	$t_{DSENSE1H}$	V_{IN} = 5V; V_{SEn} = 0V to 5V; R_{SENSE} = 1kΩ; R_L = 4.3Ω		17	18.5	μs
Current Sense Disable Delay Time from Falling Edge of SEn	$t_{DSENSE1L}$	V_{IN} = 5V; V_{SEn} = 5V to 0V; R_{SENSE} = 1kΩ; R_L = 4.3Ω		7.5	8.5	μs
Current Sense Settling Time from Rising Edge of INPUT	$t_{DSENSE2H}$	V_{IN} = 0V to 5V; V_{SEn} = 5V; R_{SENSE} = 1kΩ; R_L = 4.3Ω		86	91	μs
Current Sense Settling Time from Rising Edge of I_{OUT} (Dynamic Response to a Step Change of I_{OUT})	$\Delta t_{DSENSE2H}$	V_{IN} = 5V; V_{SEn} = 5V; R_{SENSE} = 1kΩ; I_{SENSE} = 90% of $I_{SENSEMAX}$; R_L = 4.3Ω		0.56		μs
Current Sense Turn-Off Delay Time From Falling Edge of INPUT	$t_{DSENSE2L}$	V_{IN} = 5V to 0V; V_{SEn} = 5V; R_{SENSE} = 1kΩ; R_L = 4.3Ω		4		μs
Current Sense Timings (Multiplexer Transition Times)(9)						
Current Sense Transition Delay from ChX to ChY	t_{D_XtoY}	V_{IN0} = 5V; V_{IN1} = 5V; V_{SEn} = 5V; V_{SEL0} = 0V to 5V; I_{OUT0} = 0A; I_{OUT1} = 3A; R_{SENSE} = 1kΩ			TBD	μs
Current Sense Transition Delay from Stable Current Sense on ChX to V_{SENSEH} on ChY	$t_{D\_CStoVSENSEH}$	V_{IN0} = 5V; V_{IN1} = 5V; V_{SEn} = 5V; V_{SEL0} = 0V to 5V; I_{OUT0} = 0A; I_{OUT1} = 3A; R_{SENSE} = 1kΩ			7	μs

Note 1: For each channel
Note 2: Parameter guaranteed by design and characterization; not subject to production test.
Note 3: Parameter guaranteed only at V_{CC} = 4V and T_J = 25°C
Note 4: PowerMOS leakage included
Note 5: Parameter specified by design; not subject to production test.
Note 6: See Figure 4.
Note 7: All values refer to V_{CC} = 13V; T_J = 25°C, unless otherwise specified.
Note 8: Parameter granted at –40°C < T_J < 125°C
Note 9: Transition delays are measured up to ±10% of final conditions.
Note 10: Not subject to production test and specified by design.

TBD

Figure 2. I_{OUT}/I_{SENSE} vs. I_{OUT}

TBD

Figure 3. Current Sense Accuracy vs. I_{OUT}

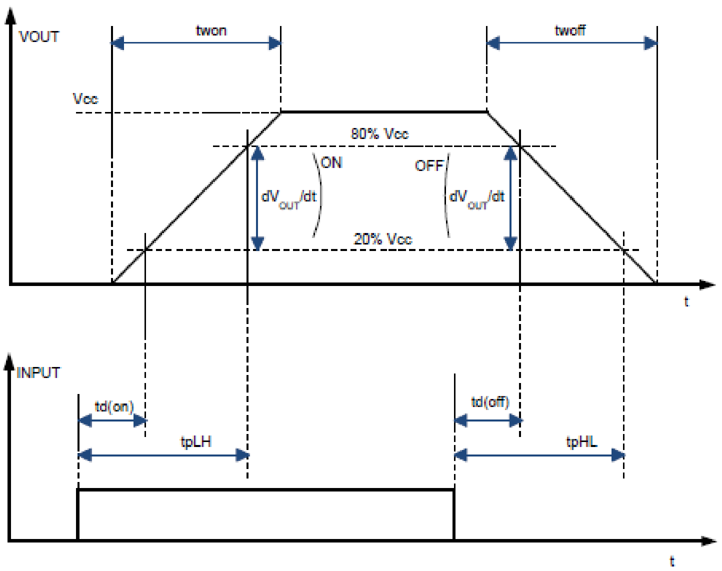


Figure 4. Switching Time and Pulse Skew

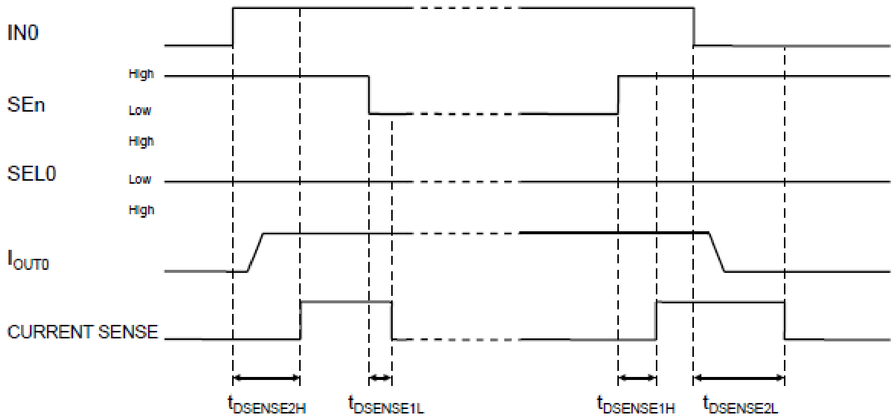


Figure 5. Current Sense Timings (Current Sense Mode)

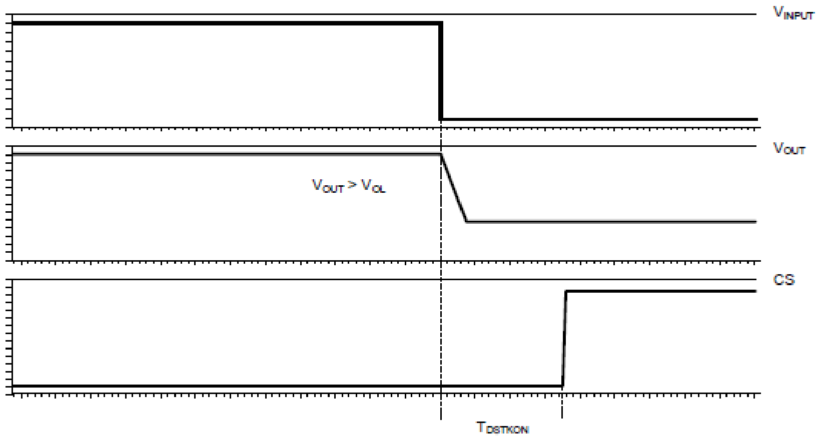


Figure 6. T_{DSTKON}

6. TYPICAL CHARACTERISTICS

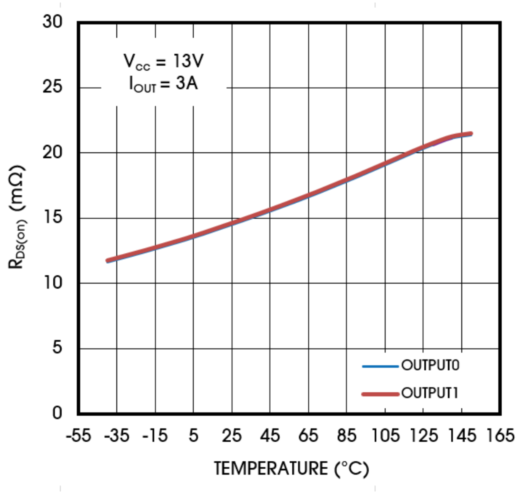


Figure 7. On-State Resistance vs. T_{case}

TBD

Figure 8. On-State Resistance vs. V_{CC}

7. 详细说明

7.1 概述

HD70152Q 是一款双通道智能高边驱动，可以用于驱动各类阻性负载，感性负载和容性负载，其集成有丰富的保护和诊断功能，十分适用于各类汽车应用。在诊断功能方面，HD70152Q 集成了高精度的比例电流镜电流检测模块，可以实时检测流经负载的电流，并通过模拟 CS 引脚输出。此外，HD70152Q 还可以对过载，短路到地，短路到电源，过温以及负载开路进行诊断。所有诊断功能都可以使能或者关闭。在保护方面，HD70152Q 可以进行供电欠压保护，过压钳位保护，过流保护，失地保护和 ESD 等保护。此外，还可以对快速相对过温进行保护，增加外围器件还可以实现电池反接保护。

7.2 功能模块框图

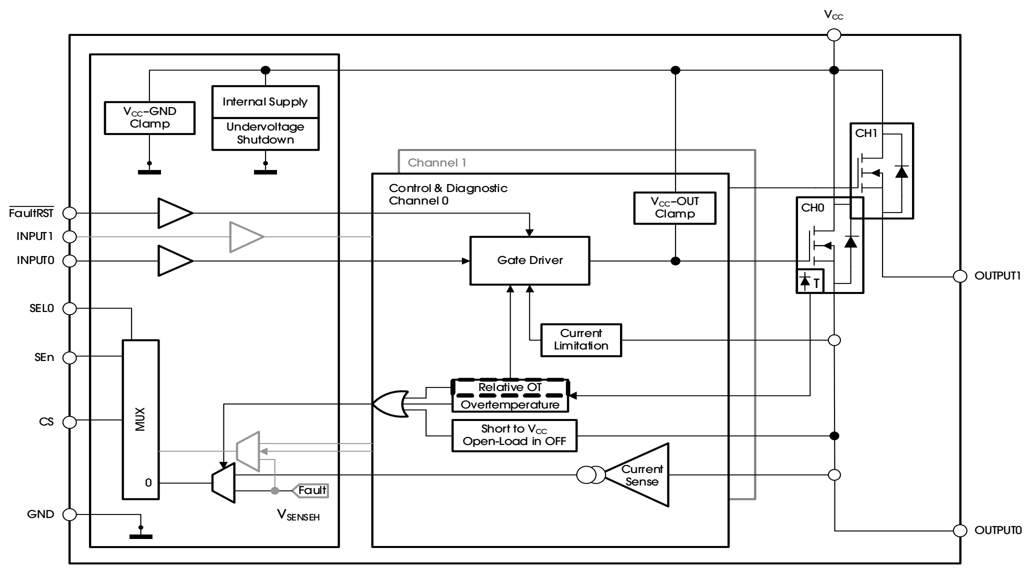


Figure 9. Functional Block Diagram

7.3 器件功能模式

7.3.1 进入和离开 STANDBY 工作模式

如下图所示，进入和退出 Stand-by 模式可以通过控制输入引脚高低实现。这里请注意，退出 stand-by 模式只能通过 INx 或者 SEn 拉高实现。

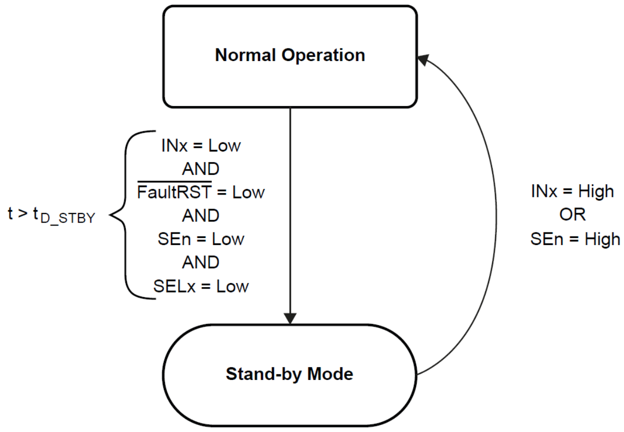


Figure 10. Standby State Diagram

7.3.2 工作模式配置真值表

除了正常工作模式和 stand-by 外，HD70152Q 还有可能出现例如过载、欠压、诊断和负压钳位的状态。下表列出各种状态模式下条件和各个管脚的状态：

Table 8. Truth Table

MODE	CONDITIONS	INx	FR	SEn	SELx	OUTx	CURRENT SENSE	COMMENTS
Standby	All logic inputs low	L	L	L	L	L	Hi-Z	Low quiescent current consumption
Normal	Nominal load connected; $T_J < 150°C$	L	L	See Table 9		L	See Table 9	
		L	H			L		
		H	L			H		Outputs configured for auto-restart
		H	H			H		Outputs configured for latch-off
Overload	Overload or short to GND causing: $T_J > T_{TSD}$ or $\Delta T_J > \Delta T_{J\_SD}$	L	X			L		
		H	L			H		Output cycles with temperature hysteresis
		H	H			L		Output latches-off
Undervoltage	$V_{CC} < V_{USD}$ (falling)	X	X	X	X	L	Hi-Z	Re-start when $V_{CC} > V_{USD} + V_{USDhyst}$ (rising)
OFF-State Diagnostics	Short to V_{CC}	L	X	See Table 9		H	See Table 9	
	Open-load	L	X			H		External pull-up
Negative Output Voltage	Inductive loads turn-off	L	X			< 0V		

7.3.3 电流检测多路复用寻址真值表

Table 9. Current Sense Multiplexer Addressing

SEn	SEL0	MUX CHANNEL	CURRENT SENSE OUTPUT			
			NORMAL MODE	OVERLOAD	OFF-STATE DIAG.[1]	NEGATIVE OUTPUT
L	X		Hi-Z			
H	L	Channel 0 diagnostic	I_{SENSE} = 1/K * I_{OUT0}	V_{SENSE} = V_{SENSEH}	V_{SENSE} = V_{SENSEH}	Hi-Z
H	H	Channel 1 diagnostic	I_{SENSE} = 1/K * I_{OUT1}			

Note: In case the output channel corresponding to the selected MUX channel is latched off while the relevant input is low, the CS pin delivers feedback according to OFF-State diagnostic.
Example 1: FR = 1; IN = 0; OUT = L (latched); MUX channel = channel 0 diagnostic; CS = 0.
Example 2: FR = 1; IN = 0; OUT = latched, V_{OUT} > V_{OL}; MUX channel = channel 0 diagnostic; CS = V_{SENSEH}.

7.3.4 LATCH 功能描述

TBD

Figure 11. Latch Functionality - Behavior in Hard Short-Circuit Condition (T_{AMB} << T_{TSD})

TBD

Figure 12. Latch Functionality - Behavior in Hard Short-Circuit Condition

TBD

Figure 13. Latch Functionality - Behavior in Hard Short-Circuit Condition (Autorestart Mode + Latch Off)

7.4 特性描述

7.4.1 保护

7.4.1.1 欠压过压保护

HD70152Q 具备欠压保护功能，当芯片供电电压 Vcc 降低至 $V_{USDReset}$ 以下时，会触发芯片复位功能，如果 Vcc 此时进一步降低 V_{USD} 以下时，HD70152Q 会处于掉电模式，此时无论输入状态如何，输出都将处于关闭状态。V_{USD} 最大值为 2.85V，该功能使得 HD70152Q 支持深度冷启动最低供电电压 2.85V 要求。

此外，HD70152Q 还支持输入供电电压过压钳位保护，可以有效应对输入电源侧在恶劣工况下的高压干扰，有效保护芯片自身和负载。

7.4.1.2 相对过温保护（POWER LIMITATION）

这种保护的基本工作原理包括通过直接测量器件表面的空间温度梯度来间接测量结温摆幅 ΔT_J，以便在 ΔT_J 超过 ΔT_{J_SD} 的安全水平时自动关断输出 MOSFET。根据$\overline{FaultRST}$引脚上的电压电平，输出 MOSFET 导通并根据可处理的最大瞬时功率($\overline{FaultRST}$ = 低)或保持关闭($\overline{FaultRST}$ = 高)。该保护可防止快速热瞬态效应，从而减少热机械疲劳。

在功率限制或者过热的情况下，CS 引脚会输出 V_{SENSEH} 进行故障报警。

7.4.1.3 过温关断保护（THERMAL SHUTDOWN）

如果 HD70152Q 的结温超过最大允许阈值(典型值为 175°C)，它会自动关闭并触发诊断指示。根据$\overline{FaultRST}$引脚上的电压电平，一旦结温降至 T_R ($\overline{FaultRST}$ = 低)或保持关闭状态($\overline{FaultRST}$ = 高)。

在功率限制或者过热的情况下，CS 引脚会输出 V_{SENSEH} 进行故障报警，此时 CS 切换为一个"限流"电压源，其电压为 V_{SENSEH},在任何情况下，CS 在这种情况下提供的电流都被限于 I_{SENSEH}。

7.4.1.4 过流保护（CURRENT LIMITATION）

HD70152Q 内部集成了一个输出电流过流保护模块，从而有效的保护芯片自身以及系统中的其他组件(例如键合线、线束、连接器、负载等)，使其免受大电流的影响而损害。在发生短路、过载或过载上电期间，过流保护门限为 I_{LIMH}。如果芯片处于自动恢复模式，那么过流保护被触发后，第二次过流保护门限会自动变成 I_{LIML}。

7.4.1.5 负压钳位保护（NEGATIVE VOLTAGE CLAMP）

如果器件驱动感性负载，则输出电压在关断期间达到负值。负电压钳位结构将最大负电压限制在特定值 V_{DEMAG}，从而允许在不损坏器件的情况下耗散电感器能量。

7.4.1.6 接地丢失（LOSS OF GROUND）AND 供电丢失（LOSS OF VCC）

如果芯片发生了接地丢失，芯片地会浮空并且电位大概为供电电压，芯片此时会自动关闭两个通道的输出，从而使得负载和地之间不会有电流流出。输入控制引脚由于有输入电阻的保护，也不会有安全问题。

如果芯片发生供电丢失问题，那么芯片会有欠压保护功能，保证芯片可以自动关闭输出，实现保护。

7.4.1.7 电池反接保护

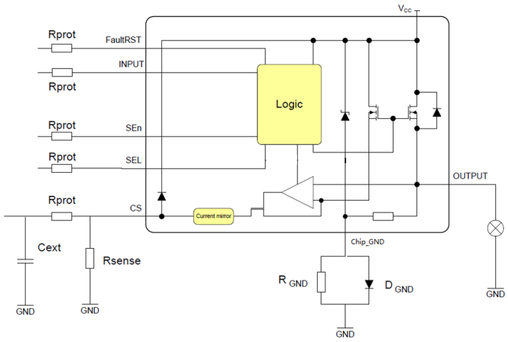


Figure 14. Simplified Internal Structure

对于需要支持电池反接的应用，建议在芯片地和 PCB 地之间增加如上图所示的电池反接保护网络，即上图 R_{GND}(typ. R_{GND} = 4.7kΩ)并联一个二极管。这样可以限制电池反接场景时通过芯片的电流，避免芯片损坏。有关电池反接保护的进一步详细方案和注意事项，请联系类比技术支持人员获取经过验证后的实际方案。

7.4.1.8 MCU IO 保护

在使用接地保护网络时，如果 Vcc 存在负压瞬变，则输入控制引脚将被拉至负压。针对这种场景，建议插入一个保护电阻(Rprot)，这样既可以防止微控制器的 I/O 引脚闩锁，也能有效保护 HD70152Q 的输入引脚。

这些保护电阻的阻值推荐为：R_{prot} = 15kΩ.

7.4.2 诊断

7.4.2.1 高精度电流检测

芯片和负载状态的诊断信息由模拟输出引脚(CS)提供以下信号：电流监视：通道输出电流的电流镜。这些信号通过模拟多路复用器进行输出，该多路复用器通过 SELx 和 SEn 配置和控制。

TBD

Figure 15. **电流监测**

CS 引脚可以提供如下信息：

1. 与负载电流成正比的电流，该比例为已知比例 k。
2. 在故障条件下提供诊断标志，其电压为固定电压 V_{SENSEH}。

电流检测电路 I_{SENSE} 提供的电流可以通过使用外部检测电阻 R_{SENSE} 轻松转换为电压 V_{SENSE}，从而实现连续负载监控和异常情况检测。

在 Normal 工作模式下(没有故障)，V_{SENSE} 的计算公式如下：

CS 的电流 $I_{SENSE} = I_{OUT} / K$

CS 的电压：$V_{SENSE} = R_{SENSE} \times I_{SENSE} = R_{SENSE} \times I_{OUT} / K$

其中：

- V_{SENSE} 的电压可以通过对外部 R_{SENSE} 进行测量。
- I_{SENSE} 是 CS 输出的电流。
- Iout 是输出负载电流。
- K 是固定的输出电流和内部监测电流模块的比例。

7.4.2.2 过载和短路到地

过载主要指相对过温保护或者过温关断保护，而输出短路到地则会触发过流保护或者过温保护，以上两种情况都会通过 CS 输出报警。

7.4.2.3 离线负载开路诊断和短路到 VCC 诊断

在进行离线负载诊断时，其示意图如下图所示：

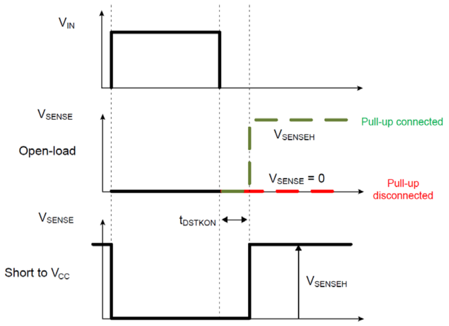


Figure 16. Open-Load / Short to V_{CC} Condition

下表表明了开路，短路到 V_{CC} 以及正常条件下的输出、CS 和 SEn 的情况：

Table 10. Current Sense Pin Levels in Off-State

CONDITION	OUTPUT	CS	SEn
Open-Load	$V_{OUT} > V_{OL}$	Hi-Z	L
		V_{SENSEH}	H
	$V_{OUT} < V_{OL}$	Hi-Z	L
		0	H
Short to V_{CC}	$V_{OUT} > V_{OL}$	Hi-Z	L
		V_{SENSEH}	H
Nominal	$V_{OUT} < V_{OL}$	Hi-Z	L
		0	H

7.4.2.3.1 离线负载诊断

在关闭模式下检测开路负载需要一个外部上拉电阻 RPU 将输出连接到正电源电压 V_{PU}。最好在模块待机模式期间关闭 VPU，以避免在正常情况下(即连接负载时)整体待机电流消耗增加。必须根据以下等式选择 RPU 以确保 $V_{OUT} > V_{OLmax}$：

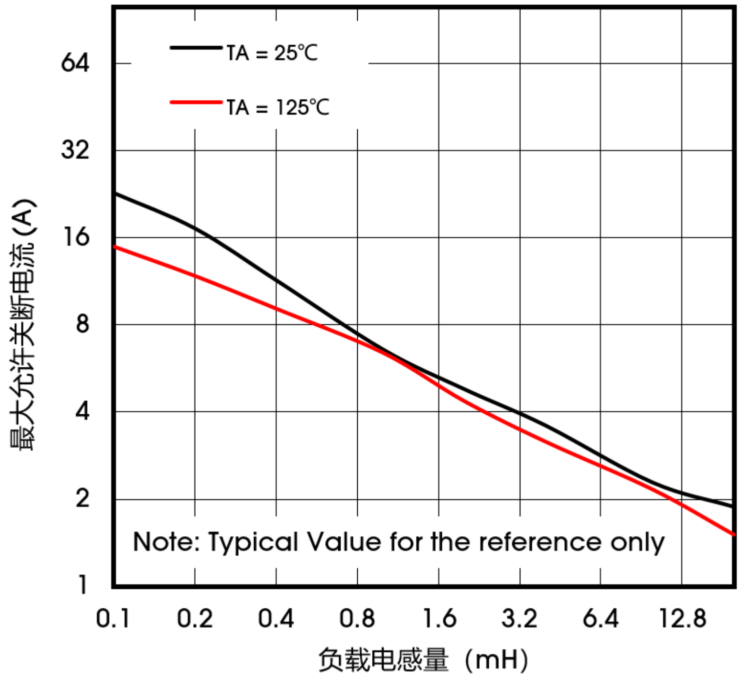
$$R_{PU} < \frac{V_{PU} - 4}{I_{L(off2)min@4V}}$$

7.4.2.3.2 短路到 V_{cc} 诊断

V_{CC} 和输出之间的短路由在器件关闭状态期间设置为 VSENSEH 的相关电流检测引脚指示。根据短路的性质，在导通状态期间电流感测器传送小电流或不传送电流。

7.5 VCC=16V 下最大退磁能量

HD70152Q 输出接感性负载时，其供电电压 Vcc 为 16V，负载等效电感 L 会限制其允许工作的最大连续电流。详细请参考下图：



请注意，上图通过负载等效电感获得最大的电流，然后根据电流和此时的 Vcc 值，会在 PWM 控制模式下限制输出最大占空比。所有控制建议在最大允许值范围内，以保证芯片正常工作不会损坏。此外，上图数据只是典型值，仅供参考，实际真正的边界值，请联系类比技术支持活得更加详细数据。

8. 应用与实现

注

以下应用部分中的信息不是公司组件规范的一部分，公司不保证其准确性或完整性。公司的客户有责任确定组件是否适合他们的用途。客户应验证和测试他们的设计实施以确认系统功能。

8.1 应用参考框图

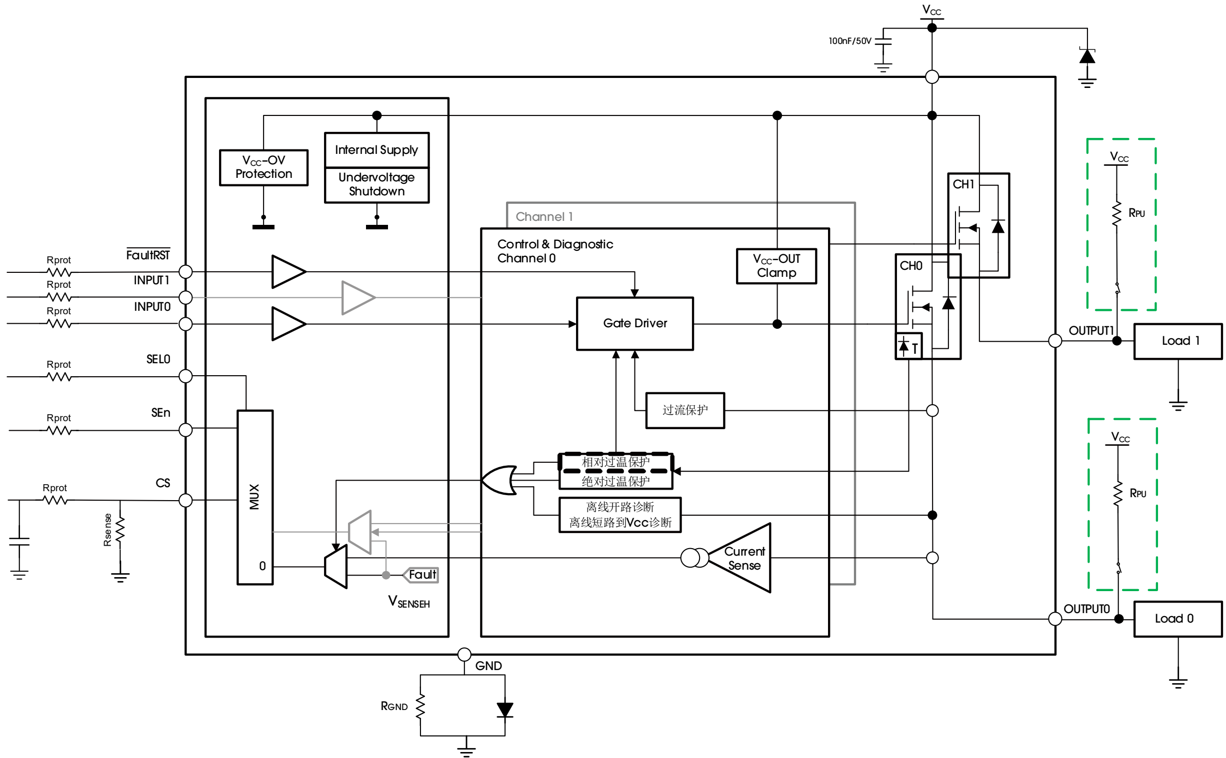


Figure 17. Application Diagram

8.2 未使用引脚或者 NC 引脚接法推荐

CONNECTION / PIN	CS	NC	OUTPUT	INPUT	SEn, SELx, FaultRST
Floating	Not allowed	X	X	X	X
To ground	Through 1kΩ resistor	X	Not allowed	Through 15kΩ resistor	Through15 kΩ resistor

Note: X: Do NOT care.

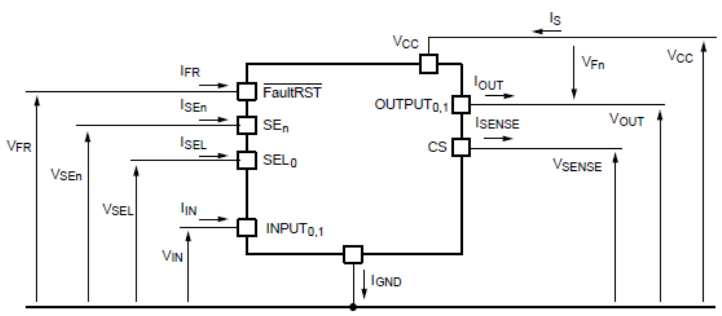


Figure 18. Current and Voltage Conventions

Note: $V_{Fn} = V_{OUT} - V_{CC}$ during reverse battery condition.

10. PACKAGE INFORMATION

The HD70152Q is available in the TSSOP-16 package. Figure 19 shows the package view.

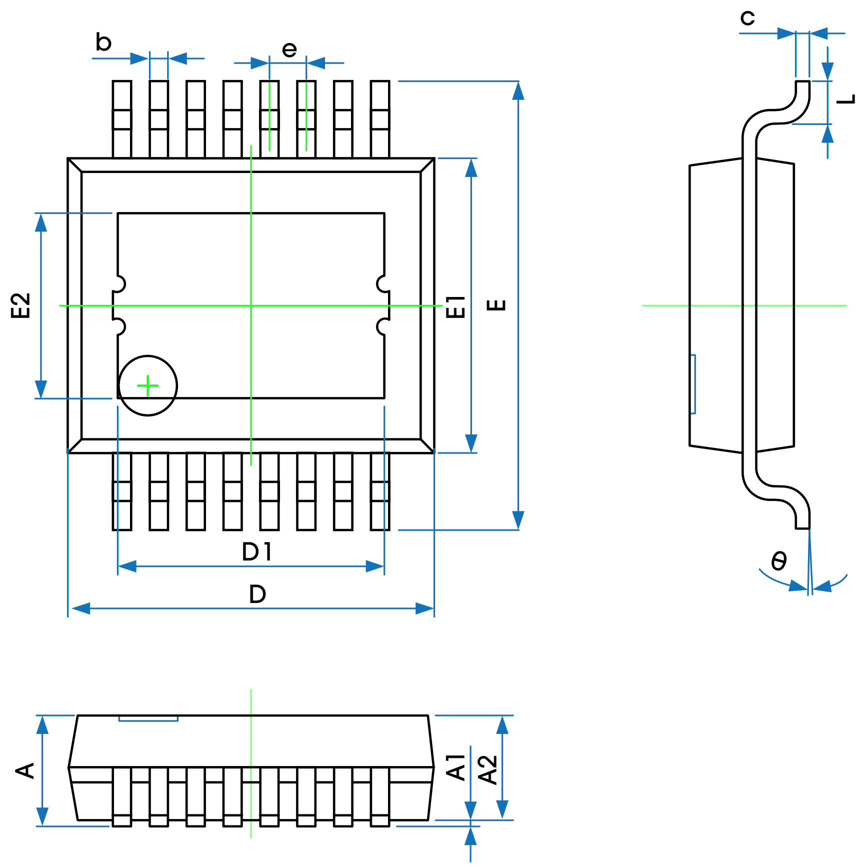


Figure 19. Package View

Table 11 provides detailed information about the dimensions.

Table 11. Dimensions

SYMBOL	DIMENSIONS IN MILLIMETERS		DIMENSIONS IN INCHES	
	MIN	MAX	MIN	MAX
A	1.350	1.650	0.053	0.065
A1	0.000	0.100	0.000	0.004
A2	1.350	1.550	0.053	0.061
b	0.200	0.300	0.008	0.012
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
D1	3.510	3.710	0.138	0.146
E	6.050	6.200	0.238	0.244
E1	3.800	4.000	0.150	0.157
E2	2.400	2.600	0.094	0.102
e	0.500 (BSC)		0.020 (BSC)	
L	0.400	0.900	0.016	0.035
θ	0°	8°	0°	8°