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Leading Innovation

Thermostat

Application Block Diagram - ABD -

Toshiba Electronic Devices & Storage Corporation
Discrete Application Engineering Center

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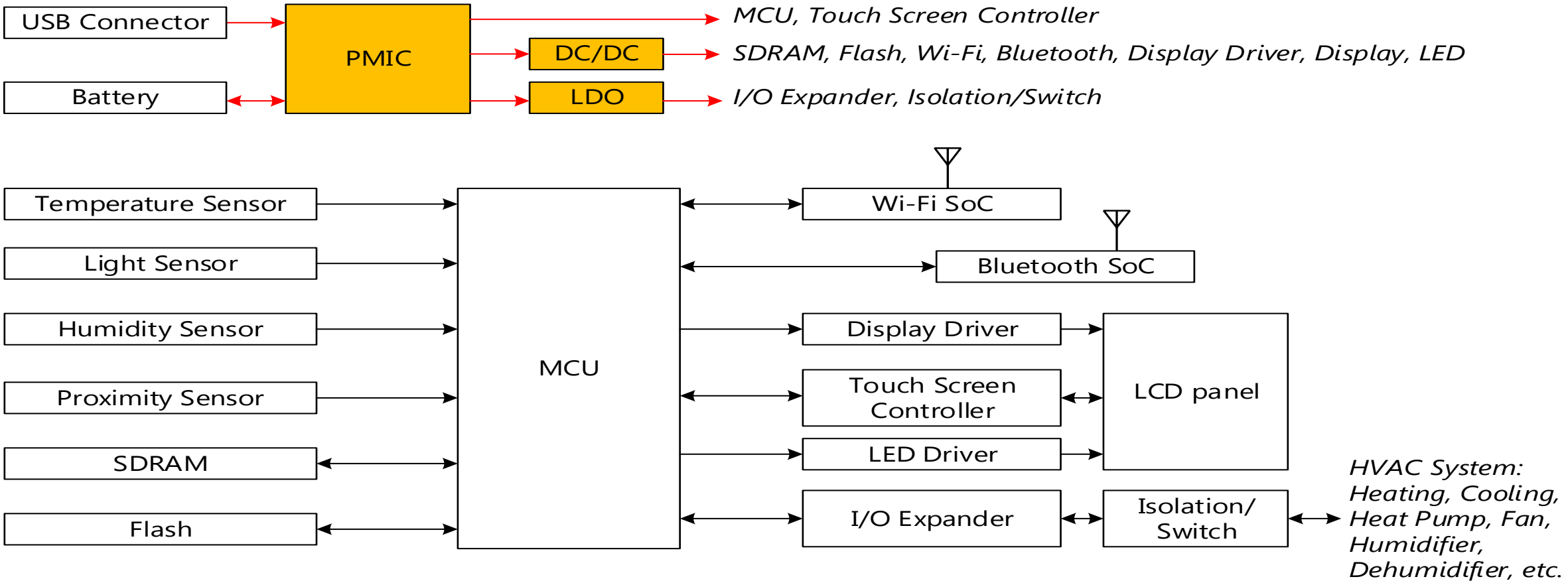
Block diagram for Thermostat



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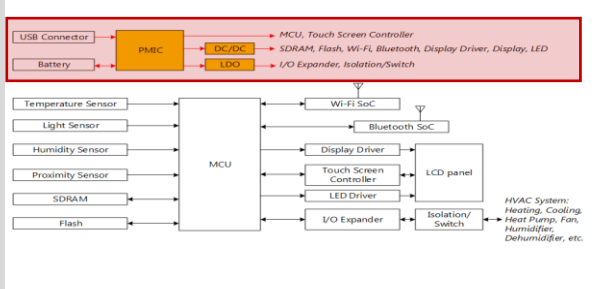
Power supply line Recommended Devices

Navigation Window

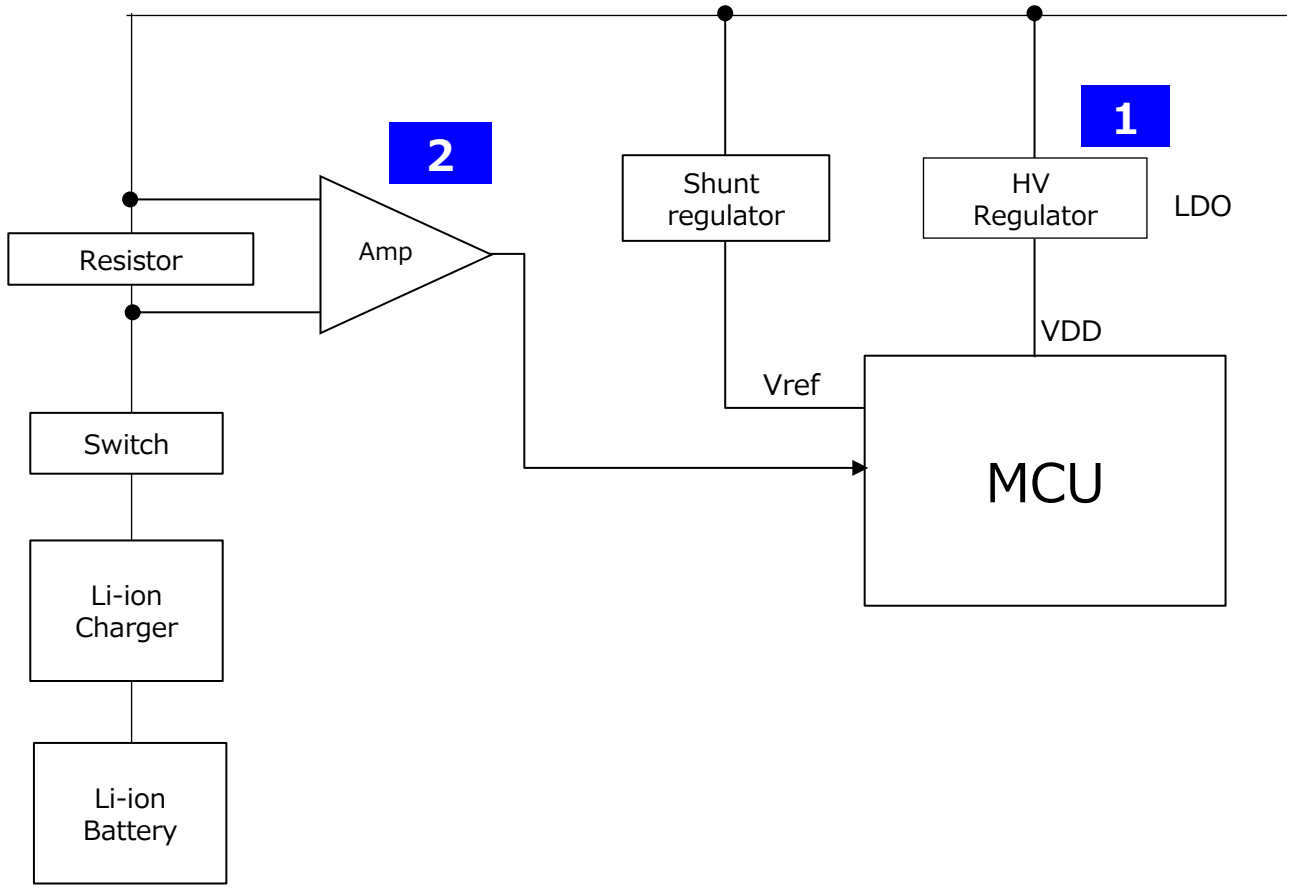
Map



Tips for Device Selection

- ☑ Surge protection is needed for power line from battery.
- ☑ NPN and PNP are part of FET driver block
- ☑ Smaller package saves board space

Power Supply



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Power supply line Recommended Devices

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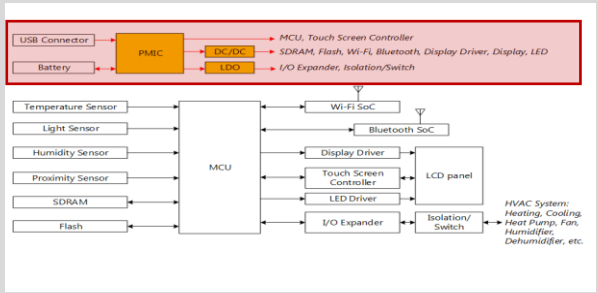


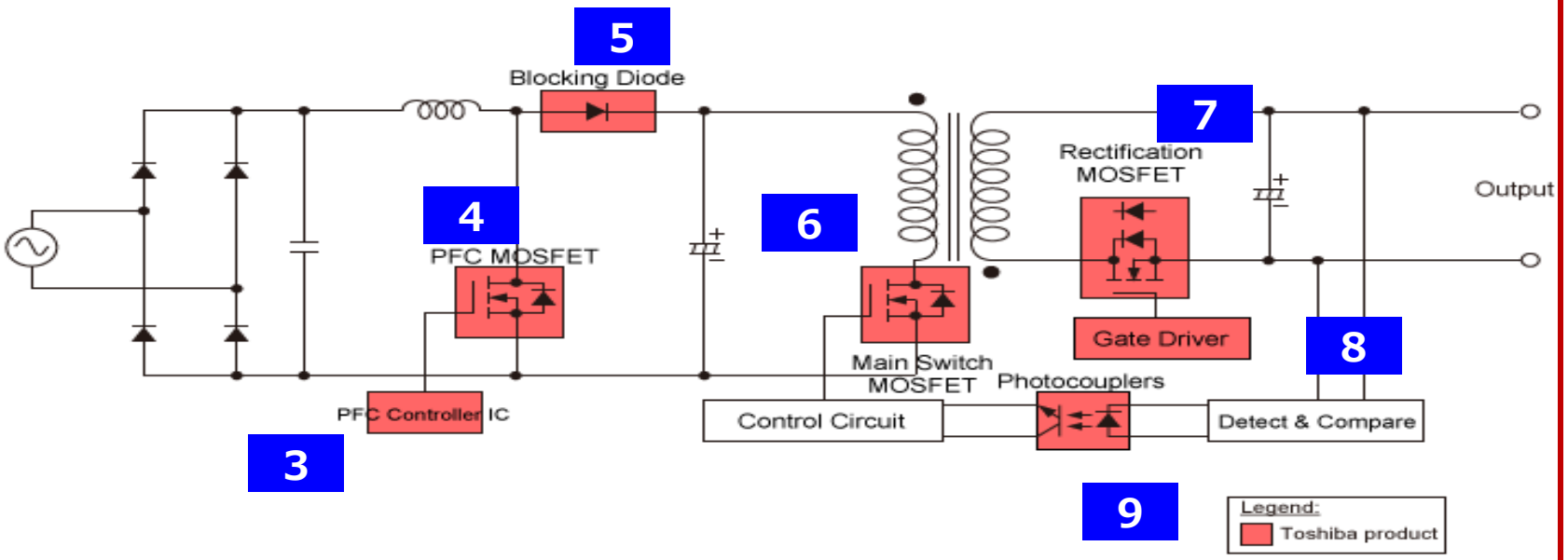
Tips for Device Selection

- ☑ Surge protection is needed for power line from battery.
- ☑ PSRR is key performance for Micro controller.
- ☑ ADC is needed for accuracy of measurement.

– In case of using AC commercial power supply –

Power Supply

AC-DC Flyback



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Power supply line Recommended Devices

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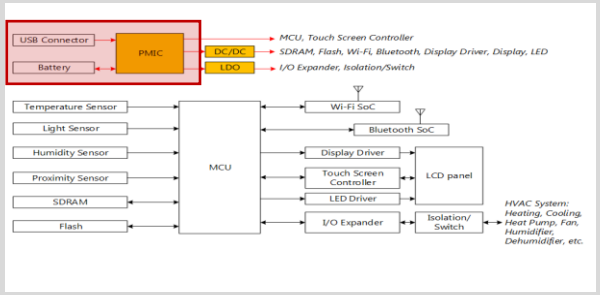
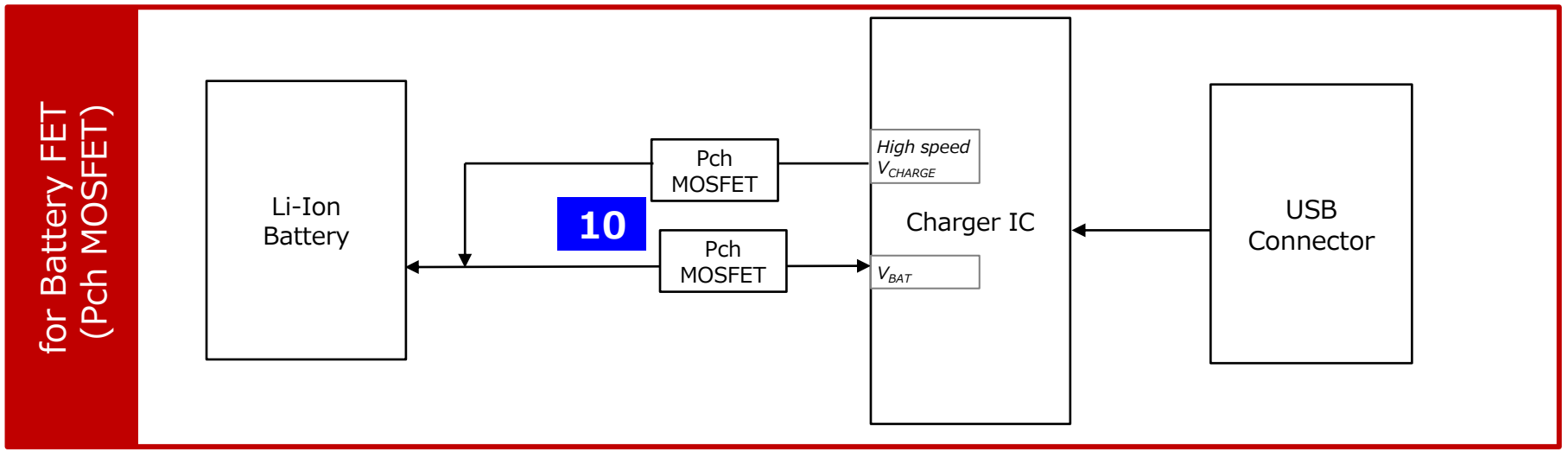
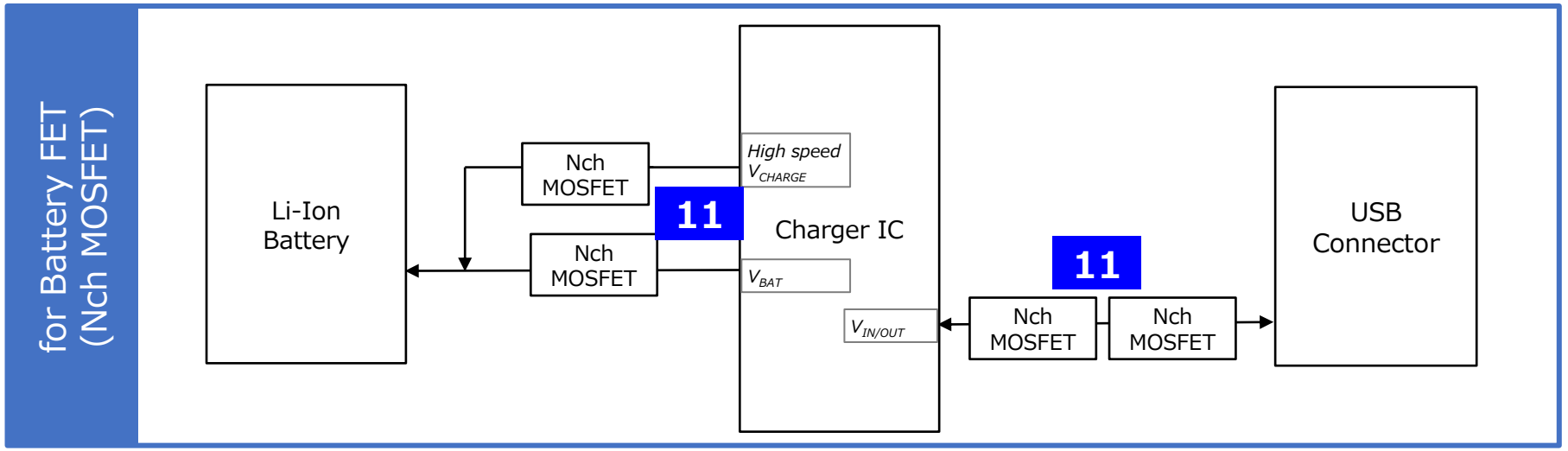


Tips for Device Selection

- ☑ Surge protection is needed for power line from battery.
- ☑ PSRR is key performance for Micro controller.
- ☑ ADC is needed for accuracy of measurement.





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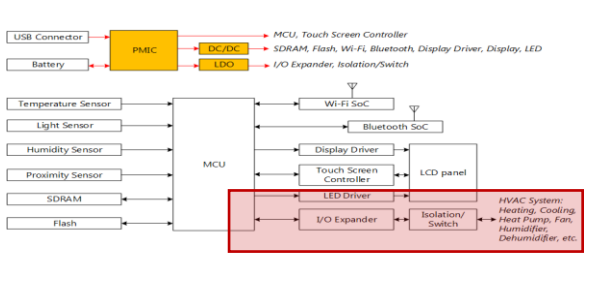
Analog Signal line Recommended Devices

Navigation Window

Map

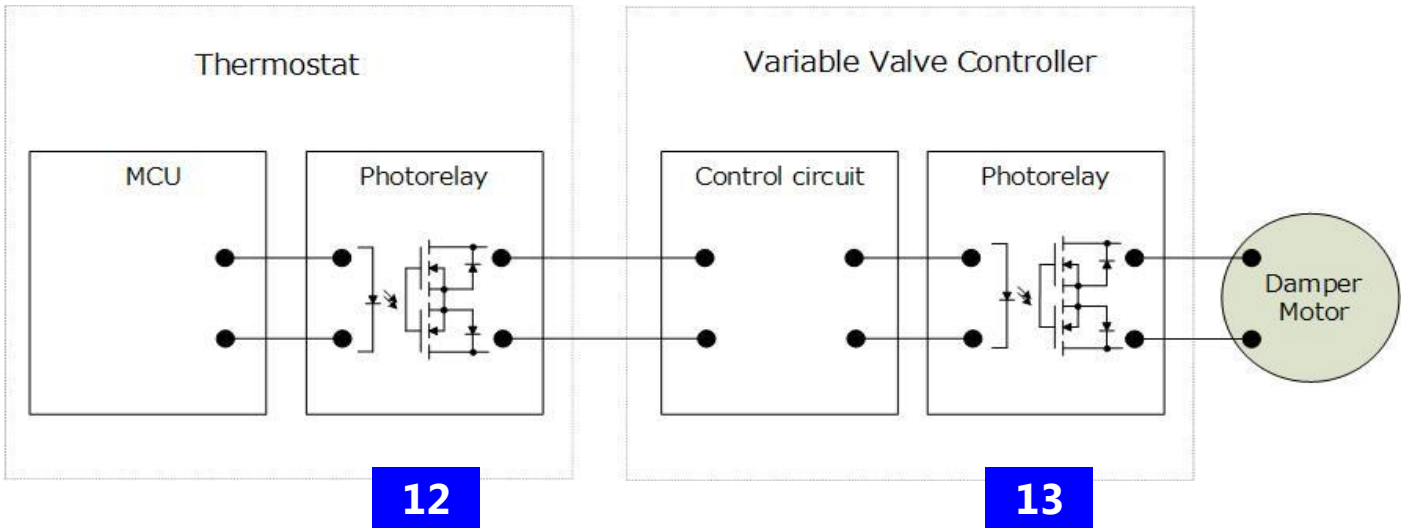


Tips for Device Selection

- LED current, output voltage of MCU and base-emitter voltage, DC current gain of the transistor are important in selecting transistor for LED drive.

- Small package saves board space.

Wire Switch



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LDO Regulator

1

Device Type		LDO
Proposal Product		TAR5SB series
Package		SOT25
	Size [mm]	2.9×2.8
Characteristic	V_{IN}(Max)[V]	15
	I_{OUT}(Max)[mA]	200
	V_{IN}-V_{OUT}(Max)[V]	0.2@5V
	Output range[V]	1.5~5.0

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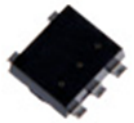
Operational Amplifier for current sensor

Device Type		Operational Amplifier
Proposal Product		TC75S67TU
Package		 UFV
	Size [mm]	2×2.1
Characteristic	$V_{DD, SS}$(Max)[V]	+/-2.75
	$V_{DD, SS}$(Min)[V]	+/-1.1
	I_{DD} (Max)[μA]	700
	V_{NI} (Typ) at f=1kHz[nV/√Hz]	6

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CRM PFC Control IC: TB6819AFG

Features

Maximum power supply voltage: 28 V

Operating voltage range: 10.0 V (typ.) to 25 V (max)

Startup voltage: 12.0 V (typ.)

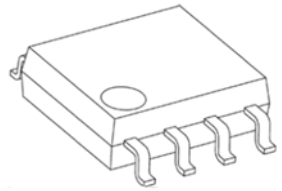
Operating current: 4 mA (typ.)

Maximum drive current: 1.0 A (typ.)

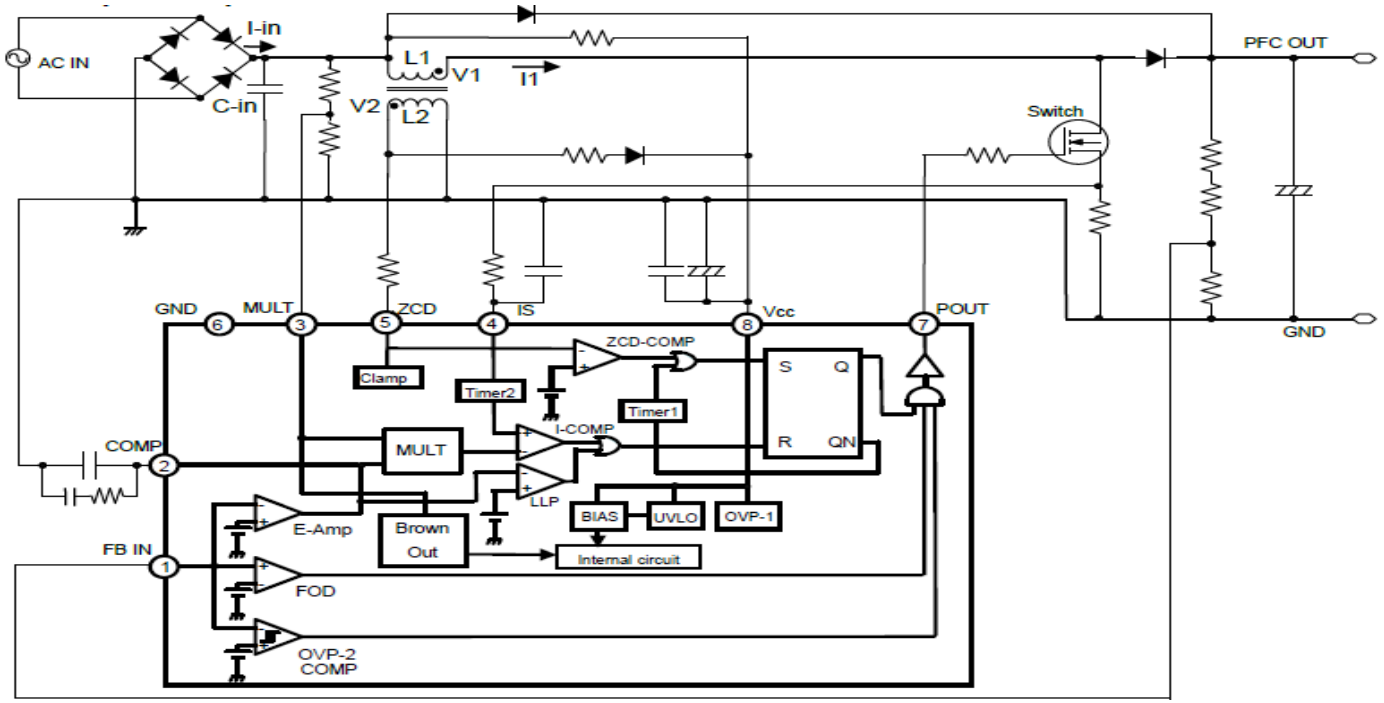
Pulse-out control at light load

Protection

- Input overvoltage protection (OVP-1)
- Output overvoltage protection (OVP-2)
- Overcurrent protection (OVP)
- Undervoltage lockout (UVLO)
- Open feedback-loop detection (OFD)
- Brownout protection (BOP)



Package: SOP8
(5.02 x 6.0 x 1.75 mm)



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MOSFET

4 6 7

Device Type		MOSFET	MOSFET
Proposal Product		TK18A50D	TK12P50W
Package		TO-220SIS	DPAK
	Size [mm]	10×28×4.5	6.6×10.0×2.3
Characteristic	Polarity	N-ch	N-ch
	V_{DSS} [V]	500	500
	I_D [A]	18	11.5
	P_D [W]	50	100
	C_{iss} [pF]	2600	890
	$R_{DS(ON)}$ (max) [Ω]	0.27	0.34

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SiC Schottky Barrier Diode

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Device Type		SiC SBD	SiC SBD
Proposal Product		TRS2P65F	TRS2E65F
Package		DPAK	TO-220-2L
	Size [mm]	6.6×10.0×2.3	10.05×28.64×4.45
Characteristic	V_{RRM} (max) [V]	650	650
	$I_{F(DC)}$ (max) [A]	2	2
	V_{FM} (max) [V]	1.6	1.6
	I_{RRM} (max) [μA]	20	20

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MOSFET for Gate Driver

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Device Type		MOSFET	MOSFET
Proposal Product		HN4B101J	HN4B102J
Package		SOT-25	SOT-25
	Size [mm]	2.9×2.8×1.1	2.9×2.8×1.1
Characteristic	Polarity	PNP + NPN	NPN + PNP
	V_{CEO} (max) @ Q1 [V]	-30	30
	I_C (max) @ Q1 [A]	-1.0	2
	V_{CEO} (max) @ Q2 [V]	30	-30
	I_C (max) @ Q2 [A]	1.2	-1.8

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Photocoupler

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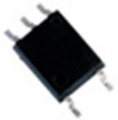
Device Type		Photocoupler	Photocoupler
Proposal Product		TLP2355	TLP2358
Package		5pin SO6	 5pin SO6
	Size [mm]	3.7×7.0×2.1	3.7×7.0×2.1
Characteristic	Output	Totem-pole (BUF)	Totem-pole (INV)
	V_{CC} [V]	3 to 20	3 to 20
	I_{CC} (max) [mA]	3	3
	T_{pd} (max) [ns]	250	250
	BVs (max) [Vrms]	3750	3750

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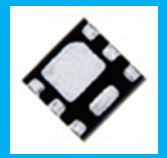
Pch MOSFET for Battery

SSM6J501NU

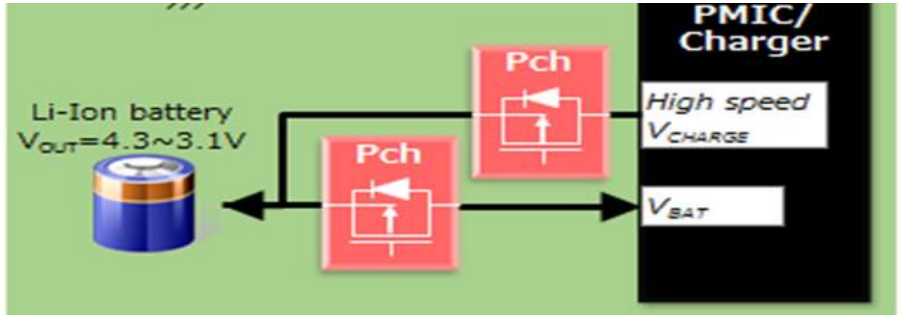
SOT-1220 (2.0x2.0mm)



Pch MOSFET

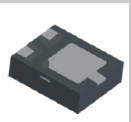
Feature

- Low $R_{DS(ON)}$: 15.3mΩ(MAX) @-4.5V,
- Small and high P_D SOT-1220 package



Toshiba research result in Dec. 2017

Low $R_{DS(ON)}$

		Toshiba SSM6J501NU	Company D DMG3415
Package dimension and Package Out-line		2.0x2.0mm	1.5x2.0mm 
V_{DSS}		-20V	-16V
V_{GSS}		±8	±8
I_D		-10	-2.5
P_D		1.0W	1.35W
$R_{DS(ON)}$ MAX	V_{GSS}=-1.8V	26.5mΩ	65mΩ
	V_{GSS}=-2.5V	19mΩ	52mΩ
	V_{GSS}=-4.5V	15.3mΩ	39mΩ

Products performance

Config-uration	Package	V_{DSS} (V)	V_{GSS} (V)	I_D (A)	PD (W)	RDS(ON) MAX (mΩ)		
						V_{GS}= -1.8V	V_{GS}= -2.5V	V_{GS}= -4.5V
Single Pch	SOT-1220 2.0x2.0mm	-20	±8	-10	1.0	26.5	19	15.3

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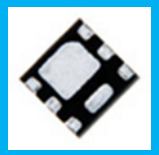
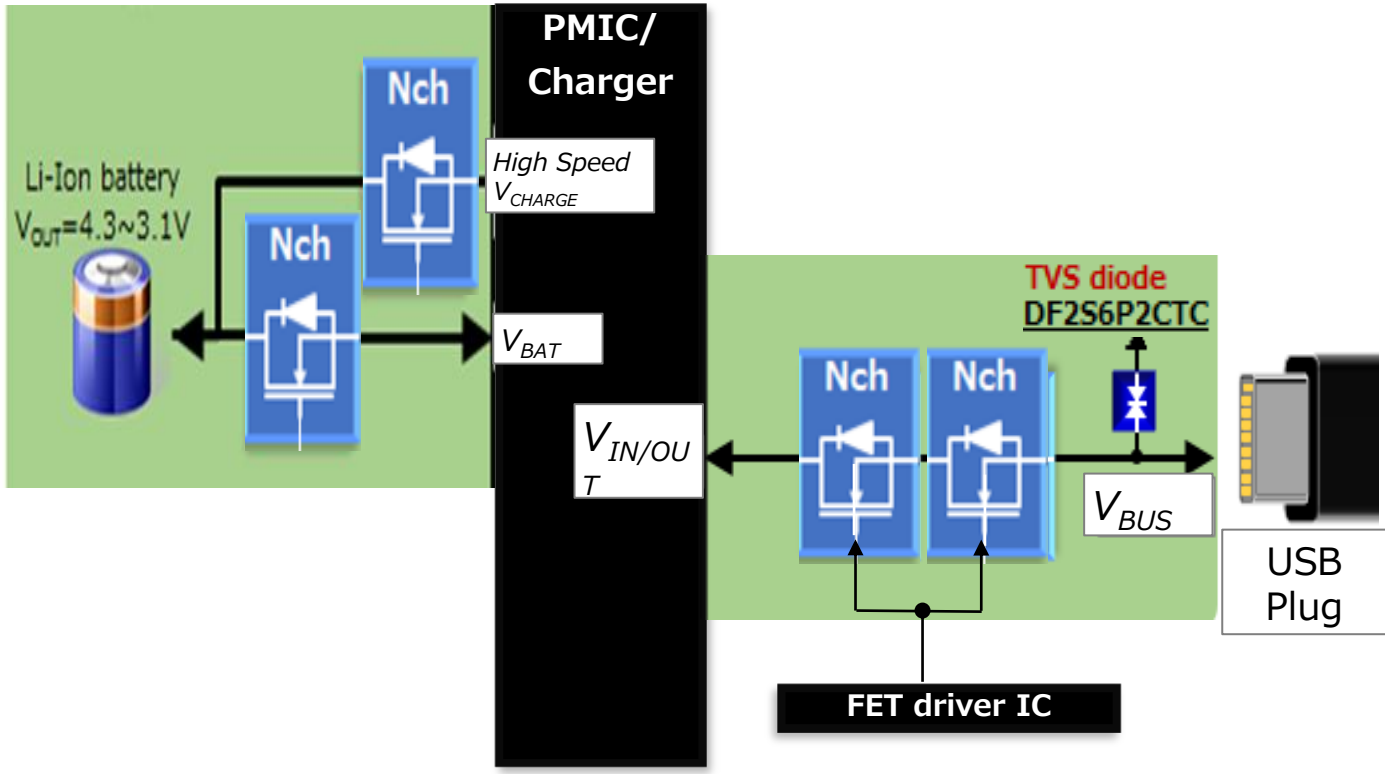
Nch MOSFET for Battery

SSM6K513NU
SSM6K514NU

SOT-1220
(2.0x2.0mm)



Nch MOSFET



Feature

SSM6K513NU

- V_{DSS}/V_{GSS}=**30V**/±20V
- $R_{DS(ON)}$ = **8mΩ(typ.)** @V_{GS}=4.5V

SSM6K514NU

- V_{DSS}/V_{GSS}=**40V**/±20V
- $R_{DS(ON)}$ = **11.2mΩ(typ.)** @V_{GS} =4.5V

Part Number	Config-uration	V_{DSS} (V)	V_{GSS} (V)	I_D (A)	$R_{DS(ON)}$ typ. (mΩ) V_{GS}=4.5V	Selling point
SSM6K513NU	Single Nch	**30**	±20	15	**8**	Low $R_{DS(ON)}$
SSM6K514NU		**40**	±20	12	**11.2**	High V_{DSS}

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Comparison with Mechanical relay

In recent years, replacement from mechanical relays and reed relays is accelerating.

	Mechanical relay (Signal relay)	Photorelay	Remarks (Feature of Photorelay)
Lifetime	△ (With contact limit)	◎ (No contact limit)	Long life
Contact Capacity	◎(2A) ※Ta 85℃/AC･DC applicable	○ (~5A) ※Ta 25℃/V_{OFF}=60V basis	
Contact Resistance (ON Resistance)	About 0.1Ω (Degraded by On/Off)	About 0.02~25Ω (Stable)	High reliability
Contact Voltage (OFF Voltage)	◎ (ex : AC 250V, DC 30V)	○ (ex : line up with 20V～600V)	
Isolation Voltage	○ (ex : 1KVrms)	◎ (max:5KVrms)	
Operation / Release Time	△ About 5ms	○ About 0.1ms	High speed
Operation Sound	△(exist)	◎(No sound)	No noise
Miniaturization	○ (ex : 60mm^2)	◎ (S-VSON: 2.9mm^2 - 1.45 × 2.0 mm)	Smaller size
Input Power Consumption	× (coil) 100mW～	◎ (LED) (ex: 0.5mW～)	Less power consumption
Contact Form	1c、2c	1a、1b、2a、1a1b	
Leakage Current	◎(not exist)	○(20pA～)	

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Example of Mechanical Relay

Characteristics		A	B	C	D
Package Size		10x6x5.7 mm		16x10x8 mm	10x7.2x5.4 mm
Coil voltage range		1.5 to 24VDC	1.5 to 24VDC	5.0 to 48VDC	1.5 to 24VDC
Contact arrangement		DPDT（2 form C)	DPDT（2 form C)	SPDT (1 form C)	DPDT（2 form C)
Initial contact resistance		<50mΩ at 10mA/30mV	<50mΩ at 10mA/30mV	50mΩ以下	Max. 100 mΩ (By voltage drop 6 V DC 1A)
Normal operating current		2.4VDC, 41.7mA	3VDC, 46.7mA	5.0VDC, 40.0mA	1.5VDC, 66.7 mA
Max. switching power		60W, 62.5VA	60W, 62.5VA	約200mW	60 W (DC), 30 W (DC), 37.5 V A (AC) (resistive load)
Max. switching voltage		250VAC, 220VDC	250VAC, 220VDC	250VAC, 220VDC	125VAC, 110VDC
Max. switching current		2A	2A	3A	2A
Operate time [Set time]		typ. 1ms, max. 3ms	typ. 1ms, max. 3ms	5ms以下	Max. 4 ms
Release time [Reset time]		typ. 1ms, max. 3ms	typ. 1ms, max. 3ms	5ms以下	Max. 4 ms
Expected life	Mechanical life	10^8 operations	10^8 operations	10^8 operations	Min. 5×10^7 (at 180 cpm)
	Electrical life	min. $1x10^5$ operations	min. $1x10^5$ operations	min. $5x10^5$ operations	Min. 5×10^4 (2 A 30 V DC), Min. 10^5 (1 A 30 V DC)
Ambient temperature		-40°C to +85°C	-40°C to +85°C	-40°C to +70°C	-40°C to +85°C
Comment		■ These thermostats are almost used on 2 form C mechanical relays, it is able to replace to 1 form C photo relays. ■ Normal operating current : less than 5 VDC/66.7mA ■ Switching voltage : 250VAC/ 220VDC On application, 24 VAC relays are arranged in the control input part of Heatpump / Condenser which is externally attached to HVAC. These mechanical relays may not operate fully 250VAC switching voltage in some cases. ■ Switching current : 2～3 A			

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Recommendation for Mechanical Relay Replacement

Characteristics	TLP3103	TLP3107	TLP3109	TLP3555	TLP3555A	TLP3556A	TLP3823	TLP3825
Package	2.54SOP6 (6.3×7.0×2.1 mm)			DIP4 (4.58×7.62×3.65 mm)			DIP8 (9.66x7.62x3.65 mm)	
Forward voltage @I_F=10mA	1.18V(min), 1.33(typ), 1.48V(max)				1.5V(min), 1.64(typ), 1.8V(max)			
Contact arrangement	1a							
On-state resistance (R_{ON})	70mΩ	60mΩ	70mΩ	200mΩ	(100mΩ)	200mΩ	150mΩ	500mΩ
Diode power dissipation (P_D)	50mW							
Off-state output terminal voltage (V_{OFF})	60V		100V	60V	60V	100V	100V	200V
Turn-ON time (t_{ON})	Max. 5.0 ms				Max. 2.0 ms	Max. 2.0 ms	Max. 5.0 ms	
Turn-OFF time (t_{OFF})	Max 1.0 ms				Max 1.0 ms	Max 0.5 ms	Max 1.0 ms	
Operating temperature (T_{opr})	-40°C to +85°C				-40°C to +110°C			
Comment	■ In case of using 24VAC relay for Heat pump/Condenser, it is possible to recommend of Toshiba photo relays(VOFF=600VDC, 90VDC). ■ DIP4, 2.54SOP6 package is smaller than mechanical relay.							

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Photorelay

Device Type		Photorelay	Photorelay	Photorelay	Photorelay
Proposal Product		TLP3103	TLP3107	TLP3109	TLP3555
Package		2.54 SOP6	2.54 SOP6	2.54 SOP6	DIP4
	Size [mm]	6.3×7.0×2.1	6.3×7.0×2.1	6.3×7.0×2.1	4.58×7.62×3.65
Characteristic	Contact arrangement	1a	1a	1a	1a
	I_{ON} (max)[A]	2.3	3.3	2.0	2.0
	V_{OFF} (max) [V]	60	60	100	60
	R_{ON} (typ.) [mΩ]	70	60	70	200
	BVs (max) [Vrms]	1500	1500	1500	2500

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Photorelay

Device Type		Photorelay	Photorelay	Photorelay	Photorelay
Proposal Product		TLP3555A	TLP3556A	TLP3823	TLP3825
Package		DIP4	DIP4	DIP8	DIP8
	Size [mm]	4.58×7.62×3.65	4.58×7.62×3.65	9.66x7.62x3.65	9.66x7.62x3.65
Characteristic	Contact arrangement	1a	1a	1a	1a
	I_{ON} (max)[A]	3.0	2.0	3.0	1.5
	V_{OFF} (max) [V]	60	100	100	200
	R_{ON} (typ.) [mΩ]	100	200	150	500
	BVs (max) [Vrms]	2500	2500	1500	1500

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