FUJITSU SEMICONDUCTOR
DATA SHEET

DS04-27800-2E

ASSP For Power Management Applications (Mobile Phones)

Power Management IC for Mobile Phone

MB3893A

■ DESCRIPTION

MB3893A is a multi-function power management IC chip with built-in 4-channel series regulator providing the output control functions and power supply drop detection circuits required for mobile phones. The MB3893A includes lithium-ion battery charge control functions and functions as a built-in power management system ideal for mobile phone devices.

■ FEATURES

[Power Supply Control Unit]

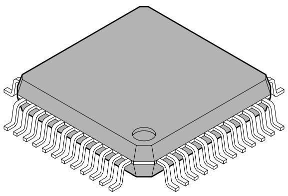
- Supply voltage range : V_{CC} = 3.1 V to 4.8 V
- Low power consumption current during standby : 110 µA (Max.)
- Built-in 4-channel low-saturation voltage type series regulator
  : 2.5 V/2 channels, 1.8 V/1 channels,
  2.0 V/1 channels (1.9 V and 2.2 V available as mask options)
- Built-in interruption detection and supply recovery functions eliminate need for supplementary power supply
- Built-in On/Off switch circuit with accidental operation prevention function
- Accurate supply voltage drop detection
- Built-in power-on reset (OUT1) function
- Detection voltage with hysteresis

[Charge Control Unit]

- Supply voltage range : VIN = 3.4 V to 5.9 V
- Built-in lithium-ion battery charge control functions
- Charging voltage : 4.1 V/4.2 V (switchable)
- Built-in preliminary charging function
- Built-in re-charging function
- Built-in timer functions
- Built-in battery temperature detection function

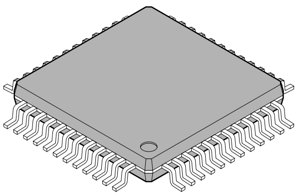
■ PACKAGES

48-pin plastic LQFP



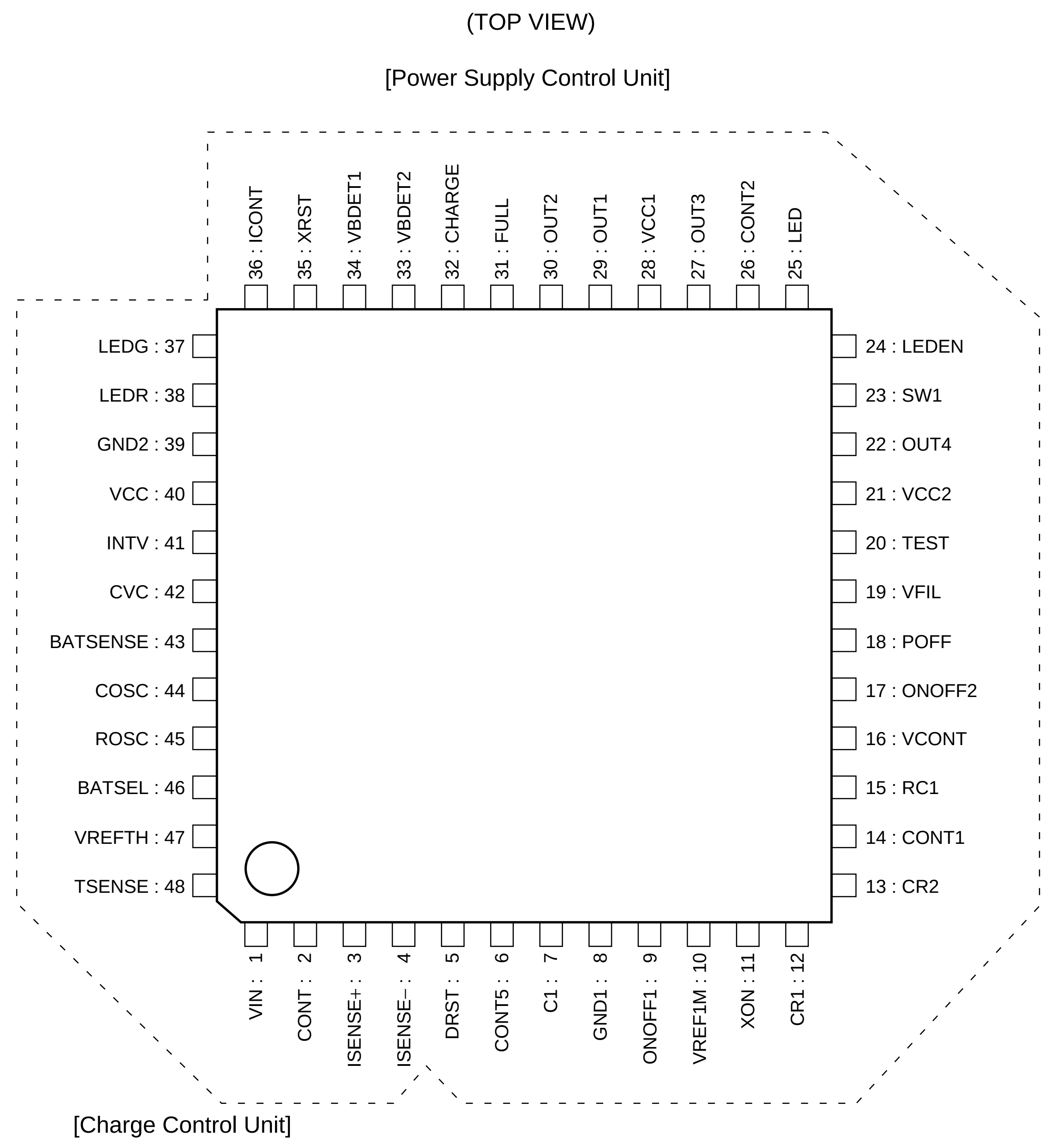
(FPT-48P-M05)

48-pin plastic TQFP



(FPT-48P-M24)

■ PIN ASSIGNMENT



(FPT-48P-M05)
(FPT-48P-M24)

■ PIN DESCRIPTION

Pin No.	Symbol	I/O	Description
1	VIN	—	Power supply pin for the charge control unit.
2	CONT	O	External P-ch MOS FET output control pin.
3	ISENSE+	I	Charge current detection input pin.
4	ISENSE–	I	Charge current/voltage detection input pin.
5	DRST	I	Power supply drop detection reset input pin. 100 kΩ pull-down.
6	CONT5	I	Battery voltage measurement setting pin. 100 kΩ pull-down.
7	C1	I	POR delay time setting capacitor connection pin.
8	GND1	—	Ground pin.
9	ONOFF1	I	REG ON control pin. 100 kΩ pull-up: VCC (edge input)
10	VREF1M	O	Reference voltage output pin. (Power supply control unit)
11	XON	I	REG On control pin. 100 kΩ pull-up: VCC (with delay)
12	CR1	I	Power supply drop detection judgement capacitor-resistor connection pin.
13	CR2	I	Cutoff detection judgement capacitor-resistor connection pin.
14	CONT1	I	REG ON control pin. 100 kΩ pull-up: VCC
15	RC1	I	XON delay time setting capacitor-resistor connection pin. 470 kΩ pull-up: VCC (XON = Lo)
16	VCONT	O	REG rise signal output pin.
17	ONOFF2	I	REG ON control pin. 100 kΩ pull-up: VCC (edge input)
18	POFF	I	REG OFF control pin. 100 kΩ pull-down (OFF)
19	VFIL	O	REG reference pin.
20	TEST	—	Testing auxiliary pin. (normally GND connection)
21	VCC2	—	REG4 power supply pin.
22	OUT4	O	REG4 output pin. (2.5 V Typ.)
23	SW1	O	Battery voltage measurement output pin.
24	LEDEN	I	LED input pin. 100 kΩ pull-down (LEDR : “L” = ON, “H” = OFF)
25	LED	I	LED input pin. 100 kΩ pull-down (LEDG : “H” = ON, “L” = OFF)
26	CONT2	I	REG3 On/Off control pin. 470 kΩ pull-up : OUT1
27	OUT3	O	REG3 output pin. (2.0 V Typ.)
28	VCC1	—	REG1, 2, 3 supply pin.
29	OUT1	O	REG1 output pin. (2.5 V Typ.)
30	OUT2	O	REG2 output pin. (1.8 V Typ.)
31	FULL	O	Charge state detection signal output pin. (full charge)
32	CHARGE	O	Charge state detection signal output pin. (charging)
33	VBDET2	O	Power supply drop detection output signal pin.

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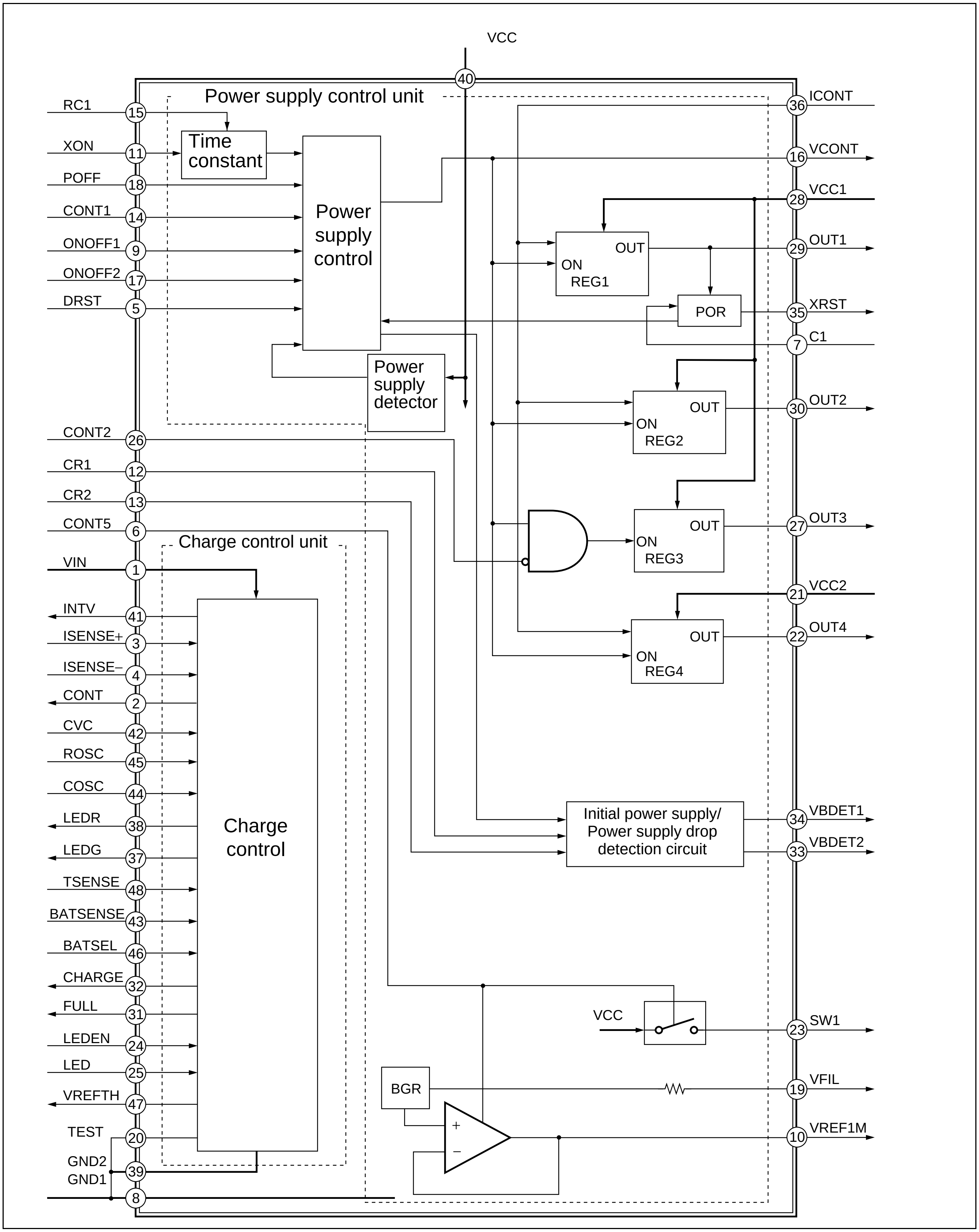
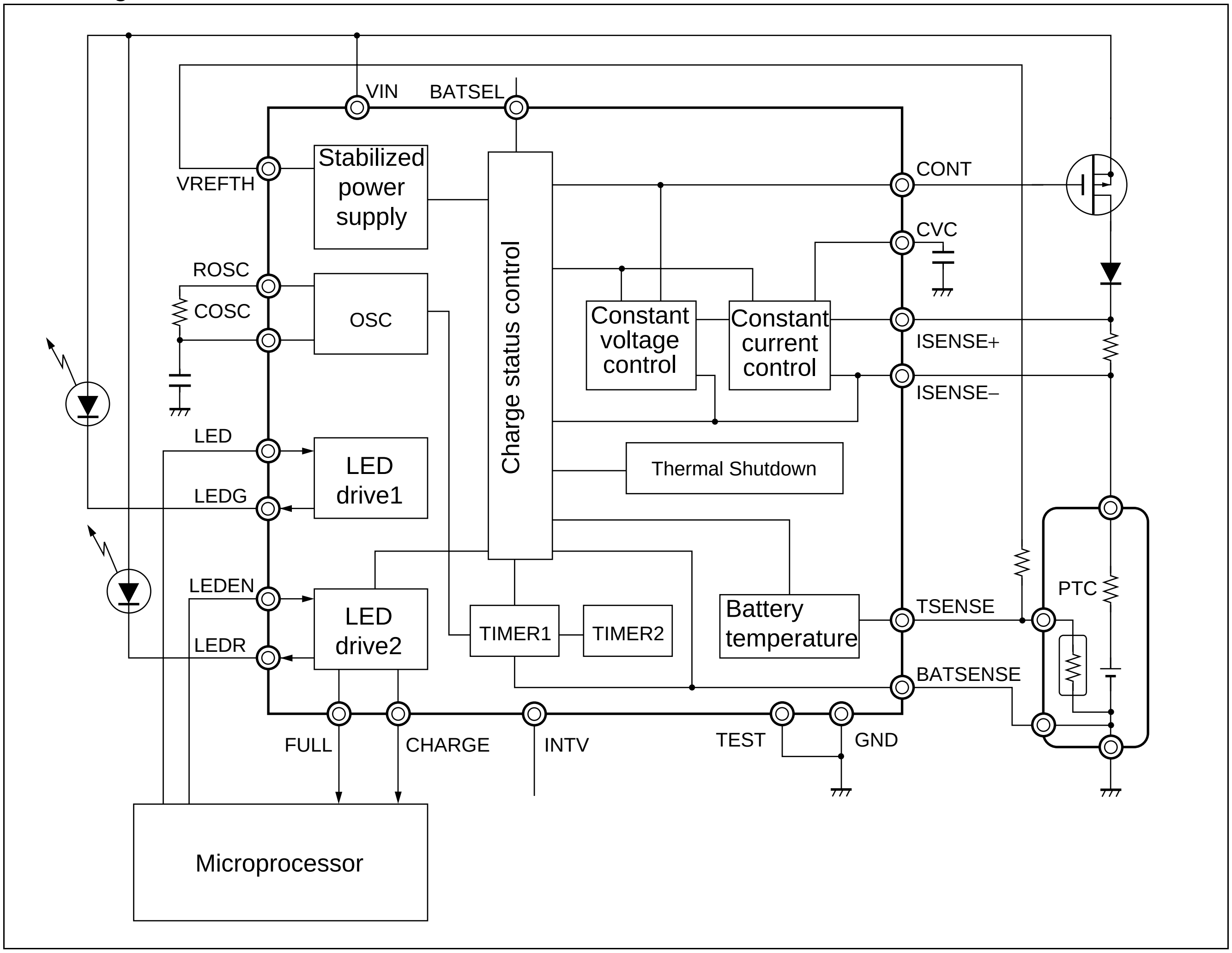
Pin No.	Symbol	I/O	Description
34	VBDET1	O	Power supply drop detection output signal pin. (10 s Typ.)
35	XRST	O	POR reset output pin.
36	ICONT	I	REG output mode switching pin. 100 kΩ pull-down
37	LEDG	O	LED output pin. (open drain)
38	LEDR	O	LED output pin. (open drain)
39	GND2	—	Ground pin.
40	VCC	—	Power supply pin for the power supply control unit
41	INTV	—	Internal power supply pin.
42	CVC	I	Phase compensation capacitor connection pin.
43	BATSENSE	I	Battery connection verification input pin. 100 kΩ pull-up : VIN
44	COSC	I	Oscillator frequency setting capacitor connection pin. 100 pF + 19 pF (reference capacitance)
45	ROSC	I	Oscillator frequency setting resistance connection pin.
46	BATSEL	I	Charge setting voltage switching pin. 100 kΩ pull-up : VIN (OPEN = 4.1 V, “L” = 4.2 V)
47	VREFTH	O	Temperature detection reference voltage pin
48	TSENSE	I	Temperature detection input pin.

■ BLOCK DIAGRAM

• Overall



- **Charge control unit**



■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Condition	Rating		Unit
			Min.	Max.	
Power supply voltage	V_{CC}	21, 28, 40 pin	–0.3	7	V
	V_{IN}	1 pin	–0.3	15	V
Input voltage	V_{IN1}	2, 37, 38, 42 to 48 pin	–0.3	V_{IN} + 0.3	V
	V_{IN2}	3 to 7, 9 to 20, 22 to 27, 29 to 36, 41 pin	–0.3	V_{CC} + 0.3	V
Power dissipation	P_D	Ta ≤ +25 °C (LQFP-48P)	—	860*	mW
		Ta ≤ +25 °C (TQFP-48P)	—	1230*	mW
Storage temperature	Tstg	—	–55	+125	°C

* : The packages are mounted on the dual-sided epoxy board (10 cm × 10 cm).

WARNING: Semiconductor devices can be permanently damaged by application of stress (voltage, current, temperature, etc.) in excess of absolute maximum ratings. Do not exceed these ratings.

■ RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Condition	Value			Unit
			Min.	Typ.	Max.	
Power supply voltage	V_{CC}	—	3.1	—	4.8	V
	V_{IN}	—	3.4	5.3	5.9	V
REG capacitor guarantee value	C_O	OUT1 to OUT4 pin	0.8	1.0	—	µF
REG capacitor ESR guarantee value	R_{ESR}	—	0.02	—	0.6	Ω
VREF1M capacitor guarantee value	C_O	VREF1M pin	—	—	100	pF
Operating ambient temperature	Ta	—	–30	+25	+85	°C

WARNING: The recommended operating conditions are required in order to ensure the normal operation of the semiconductor device. All of the device’s electrical characteristics are warranted when the device is operated within these ranges.

Always use semiconductor devices within their recommended operating condition ranges. Operation outside these ranges may adversely affect reliability and could result in device failure.

No warranty is made with respect to uses, operating conditions, or combinations not represented on the data sheet. Users considering application outside the listed conditions are advised to contact their FUJITSU representatives beforehand.

■ ELECTRICAL CHARACTERISTICS

(Ta = –30 to +85 °C, VCC = 3.1 V to 4.8 V)

Parameter		Symbol	Pin No.	Conditions	Value			Unit
					Min.	Typ.	Max.	
Reference voltage block	Reference voltage	V_{FIL}	19	VFIL = 0 mA	1.19	1.23	1.27	V
Constant voltage control block [REG1]	Output voltage	V_{O1S}	29	OUT1 = 0 to –500 µA, ICONT = “L” level	2.41	2.50	2.59	V
		V_{O1F}	29	OUT1 = 0 to –70 mA, ICONT = “H” level	2.41	2.50	2.59	V
	Input stability	Line	29	OUT1 = 0 to –70 mA, ICONT = “H” level	—	—	20	mV
	Load stability	Load	29	OUT1 = 0 to –70 mA, ICONT = “H” level	–30	—	0	mV
	Ripple rejection	R.R	29	VIN = 0.2 Vrms, f = 1 kHz, OUT1 = 0 to –70 mA, ICONT = “H” level	50	—	—	dB
				VIN = 0.2 Vrms, f = 10 kHz, OUT1 = 0 to –70 mA, ICONT = “H” level	50	—	—	dB
	Noise	V_{NOVL1}	29	f = 10 Hz to 20 kHz, VCC = 3.6 V, OUT1 = –70 mA, ICONT = “H” level	—	—	95	µVrms
	Overcurrent protection value	I_{L1}	29	OUT1 = 90 %, ICONT = “H” level	100	200	400	mA
	Rise time	t_{R1}	29	Pin 9, 14, 17 control OUT1 = 1.0 µF, OUT1 = 36 Ω, OUT1 = 90 %	—	—	200	µs
		t_{R2}	29	VCC control OUT1 = 1.0 µF, OUT1 = 36 Ω, OUT1 = 90 %	—	—	150	ms

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(Ta = –30 to +85 °C, VCC = 3.1 V to 4.8 V)

Parameter		Symbol	Pin No.	Conditions	Value			Unit
					Min.	Typ.	Max.	
Constant voltage control block [REG2]	Output voltage	V_{O2S}	30	OUT2 = 0 to –500 µA, ICONT = "L" level	1.71	1.80	1.89	V
		V_{O2F}	30	OUT2 = 0 to –50 mA, ICONT = "H" level	1.71	1.80	1.89	V
	Input stability	Line	30	OUT2 = 0 to –50 mA, ICONT = "H" level	—	—	20	mV
	Load stability	Load	30	OUT2 = 0 to –50 mA, ICONT = "H" level	–30	—	0	mV
	Ripple rejection	R.R	30	VIN = 0.2 Vrms, f = 1 kHz, OUT2 = 0 to –50 mA, ICONT = "H" level	50	—	—	dB
				VIN = 0.2 Vrms, f = 10 kHz, OUT2 = 0 to –50 mA, ICONT = "H" level	50	—	—	dB
	Noise	V_{NOVL2}	30	f = 10 Hz to 20 kHz, VCC = 3.6 V, OUT2 = –50 mA, ICONT = "H" level	—	—	95	µVrms
	Overcurrent protection value	I_{L2}	30	OUT2 = 90 %, ICONT = "H" level	65	130	260	mA
	Rise time	t_{R1}	30	Pin 9, 14, 17 control OUT2 = 1.0 µF, OUT2 = 36 Ω, OUT2 = 90 %	—	—	200	µs
		t_{R2}	30	VCC control OUT2 = 1.0 µF, OUT2 = 36 Ω, OUT2 = 90 %	—	—	150	ms

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(Ta = –30 to +85 °C, VCC = 3.1 V to 4.8 V)

Parameter		Symbol	Pin No.	Conditions	Value			Unit
					Min.	Typ.	Max.	
Constant voltage control block [REG3]	Output voltage	V_{O3S}	27	OUT3 = 0 to –500 µA, ICONT = "L" level, CONT2 = "L" level	(1.81) 1.91 (2.11)	(1.90) 2.00 (2.20)	(1.99) 2.09 (2.29)	V
		V_{O3F}	27	OUT3 = 0 to –70 mA, ICONT = "H" level, CONT2 = "L" level	(1.81) 1.91 (2.11)	(1.90) 2.00 (2.20)	(1.99) 2.09 (2.29)	V
	Input stability	Line	27	OUT3 = 0 to –70 mA, ICONT = "H" level, CONT2 = "L" level	—	—	20	mV
	Load stability	Load	27	OUT3 = 0 to –70 mA, ICONT = "H" level, CONT2 = "L" level	–30	—	0	mV
	Ripple rejection	R.R	27	VIN = 0.2 Vrms, f = 1 kHz, OUT3 = 0 to –70 mA, ICONT = "H" level, CONT2 = "L" level	50	—	—	dB
				VIN = 0.2 Vrms, f = 10 kHz, OUT3 = 0 to –70 mA, ICONT = "H" level, CONT2 = "L" level	50	—	—	dB
	Noise	V_{NOVL3}	27	f = 10 Hz to 20 kHz, VCC = 3.6 V, OUT3 = –70 mA, ICONT = "H" level, CONT2 = "L" level,	—	—	95	µVrms
	Overcurrent protection value	I_{L2}	27	OUT3 = 90 %, ICONT = "H" level, CONT2 = "L" level	65	170	340	mA
	Rise time	t_{R1}	27	Pin 9, 14, 17 control OUT3 = 1.0 µF, OUT3 = 27 Ω, OUT3 = 90 %, CONT2 = "L" level	—	—	200	µs
		t_{R2}	27	VCC control OUT3 = 1.0 µF, OUT3 = 27 Ω, OUT3 = 90 %, CONT2 = "L" level	—	—	150	ms

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(Ta = –30 to +85 °C, VCC = 3.1 V to 4.8 V)

Parameter		Symbol	Pin No.	Conditions	Value			Unit
					Min.	Typ.	Max.	
Constant voltage control block [REG4]	Output voltage	V_{O4S}	22	OUT4 = 0 to –500 µA, ICONT = “L” level	2.41	2.50	2.59	V
		V_{O4F}	22	OUT4 = 0 to –60 mA, ICONT = “H” level	2.41	2.50	2.59	V
	Input stability	Line	22	OUT4 = 0 to –60 mA, ICONT = “H” level	—	—	20	mV
	Load stability	Load	22	OUT4 = 0 to –60 mA, ICONT = “H” level	–30	—	0	mV
	Ripple rejection	R.R	22	VIN = 0.2 Vrms, f = 1 kHz, OUT4 = 0 to –60 mA, ICONT = “H” level	50	—	—	dB
				VIN = 0.2 Vrms, f = 10 kHz, OUT4 = 0 to –60 mA, ICONT = “H” level	50	—	—	dB
	Noise	V_{NOVL4}	22	f = 10 Hz to 20 kHz, VCC = 3.6 V, OUT4 = –60 mA, ICONT = “H” level	—	—	95	µVrms
	Overvoltage protection value	I_{L4}	22	OUT4 = 90 %, ICONT = “H” level	80	160	320	mA
	Rise time	t_{R1}	22	Pin 9, 14, 17 control OUT4 = 1.0 µF, OUT4 = 42 Ω, OUT4 = 90 %	—	—	200	µs
		t_{R2}	22	VCC control OUT4 = 1.0 µF, OUT4 = 42 Ω, OUT4 = 90 %	—	—	150	ms
VREF1M	Output voltage	V_O	10	VREF1M = 0 mA, CONT5 = “H” level	1.19	1.23	1.27	V
	Output current	I_O	10	CONT5 = “H” level	–1	—	—	mA
	Invalid current	I_{CCVR}	40	VREF1M = –1 mA, VCC = 3.6 V, CONT5 = “H” level	—	0.3	1.4	mA
	Input stability	Line	10	VREF1M = 0 to –1 mA, CONT5 = “H” level	—	—	20	mV
	Load stability	Load	10	VREF1M = 0 to –1 mA, CONT5 = “H” level	–30	—	0	mV

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(Ta = –30 to +85 °C, VCC = 3.1 V to 4.8 V)

Parameter		Symbol	Pin No.	Conditions	Value			Unit
					Min.	Typ.	Max.	
VREF1M	Ripple rejection	R.R	10	VIN = 0.2 Vrms, f = 1 kHz, VREF1M = 0 to –1 mA, CONT5 = “H” level	50	—	—	dB
			10	VIN = 0.2 Vrms, f = 1 kHz, VREF1M = 0 to –1 mA, CONT5 = “H” level	44	49	—	dB
	Noise	V_{NOVL}	10	f = 10 Hz to 20 kHz, VCC = 3.6 V, VREF1M = 0 to –1 mA, CONT5 = “H” level	—	—	95	µVrms
	Rise time	t_R	10	VREF1M = 1.2 kΩ, VREF1M = 90 %, CONT5 = “H” level	—	10	30	µs
ON/OFF control Block	Input voltage	V_{IL}	5, 6, 18, 24, 25, 26	—	0.0	—	0.3	V
		V_{IH}	5, 6, 18, 24, 25, 26	—	0.7 × OUT1	—	OUT1	V
		V_{IL}	9, 11, 14, 17	—	0.0	—	0.3 × V_{CC}	V
		V_{IH}	9, 11, 14, 17	—	0.7 × V_{CC}	—	V_{CC}	V
		V_{IL}	36	Ta = –20 °C to +75 °C	0.0	—	0.3	V
		V_{IH}	36	Ta = –20 °C to +75 °C	1.62	—	OUT1	V
	VCONT pin output voltage	V_{OL}	16	VCONT = 1 mA	0.0	—	0.4	V
		V_{OH}	16	VCONT = –1 mA	2.0	—	V_{CC}	V
	XRST pin output voltage	V_{OL}	35	XRST = 20 µA	0.0	—	0.2	V
		V_{OH}	35	XRST = –100 µA	OUT1 – 0.2	—	OUT1	V
	VBDET1 pin output voltage	V_{OL}	34	VBDET1 = 20 µA	0.0	—	0.2	V
		V_{OH}	34	VBDET1 = –20 µA	OUT1 – 0.2	—	OUT1	V
	VBDET2 pin output voltage	V_{OL}	33	VBDET2 = 20 µA	0.0	—	0.2	V
		V_{OH}	33	VBDET2 = –20 µA	OUT1 – 0.2	—	OUT1	V
	CHARGE pin output voltage	V_{OL}	32	CHARGE = 20 µA	0.0	—	0.2	V
		V_{OH}	32	CHARGE = –20 µA	OUT1 – 0.2	—	OUT1	V
	FULL pin output voltage	V_{OL}	31	FULL = 20 µA	0.0	—	0.2	V
		V_{OH}	31	FULL = –20 µA	OUT1 – 0.2	—	OUT1	V
	SW1 ON resistance	R_{ON}	23	SW1 = –600 µA, CONT5 = “H” level	—	—	500	Ω
	XON delay	t_{XON}	11, 15, 16	RC1 = 1 µF	300	600	900	ms

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(Ta = –30 to +85 °C, VCC = 3.1 V to 4.8 V)

Parameter		Symbol	Pin No.	Conditions	Value			Unit
					Min.	Typ.	Max.	
POR	Detection voltage (rise)	V_{SH}	29	—	—	2.3*	—	V
	Detection voltage (fall)	V_{SL}	29	—	2.15	2.2	2.25	V
	Rise delay	t_{POR}	29, 35	C1 = 0.1 µF	34	85	136	ms
Power supply drop detection block	Detection voltage	V_{CCE}	40	Initial power detected	2.62	2.75	2.87	V
		V_{CCD}	40	Power supply dorop detected	2.38	2.50	2.61	V
		V_{CCR}	40	Power supply recovery detected	3.35	3.50	3.65	V
		V_{CCF}	40	Initial or power supply drop determined Ta = +25 °C	—	2.0*	—	V
	V_{CCF} temperature correlation	V_{CCt}	40	—	—	–2.2	—	mV/ °C
	Power supply drop detection time	t_{DET1}	34	CR1 = 10 µF, CR1 = 1.8 MΩ	5	10	15	s
		t_{DET2}	33	CR2 = 1.5 µF, CR2 = 1.8 MΩ	0.75	1.5	2.25	s
Power supply control unit overall	Standby supply current	I_{CC1}	40	REG1 to REG4 : OFF, CONT5 = “L” level, ICONT = “L” level, VCC = 4.8 V	—	22	50	µA
	Power-on invalid current (receiving standby)	I_{CC2}	40	REG3 : OFF, CONT5 = “L” level, ICONT = “L” level, VCC = 4.8 V, OUT1 = –200 µA, OUT2 = –100 µA, OUT4 = –100 µA, Excluding OUT1, 2, 4 load current	—	60	110	µA
	Power-on invalid current (call in progress)	I_{CC3}	40	REG1 to REG4 : ON, CONT5 = “L” level, ICONT = “H” level, CONT2 = “L” level, VCC = 4.8 V, OUT1 = –70 mA, OUT2 = –50 mA, OUT3 = –70 mA, OUT4 = –60 mA, Excluding OUT1, 2, 4 load current	—	260	600	µA

*: Standard setting value

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(Ta = +3 to +48 °C, VIN = 5.3 V, BATSENESE = GND)

Parameter		Symbol	Pin No.	Conditions	Value Min.	Value Typ.	Value Max.	Unit
Charge control unit	Range of charging operation	VIN	1	Ta = –10 °C to +60 °C, BATSENSE = OPEN	—	—	5.5	V
			1	During charging	3.4	5.3	5.9	V
	Low voltage stop	V_{ADL}	1	Ta = –10 °C to +60 °C, BATSENSE = OPEN/GND	2.70	3.05	3.40	V
	Over voltage stop	V_{ADH}	1	Ta = –10 °C to +60 °C, BATSENSE = OPEN/GND	5.9	6.2	6.5	V
	Reference voltage	V_{REFTH}	47	Ta = 0 °C to +50 °C, VREFTH = 0 to –1 mA	1.64	1.70	1.76	V
	Output current	I_{REFTH}	47	Ta = 0 °C to +50 °C	–1	—	—	mA
	Output voltage	V_{BAT1}	4	Ta = –10 °C to +60 °C, BATSEL = OPEN	4.070	4.112	4.154	V
		V_{BAT2}	4	Ta = –10 °C to +60 °C, BATSEL = “L” level	4.170	4.212	4.254	V
		V_{BPT}	4	Overvoltage stop	4.257	4.327	4.397	V
		V_{BFT}	4	Rapid charging start voltage	3.015	3.115	3.215	V
		V_{BRC}	4	Recharging start voltage	3.877	3.942	4.007	V
		V_{BPC}	4	Preliminary charging start voltage	2.015	2.115	2.215	V
		ΔV_B	4	$V_{BAT2} – V_{BRC}$	0.215	0.271	0.327	V
	Output current	I_{FT}	3, 4	Rapid charging current V_{BFT} < VBAT < V_{BPT}, RSENSE = 0.333 Ω	565	590	615	mA
		I_{CMP}	3, 4	Charge control current V_{BFT} < VBAT < V_{BPT}, RSENSE = 0.333 Ω	46	53	60	mA
		I_{PC}	3, 4	Preliminary charging current V_{BPC} < VBAT < V_{BFT}, RSENSE = 0.333 Ω	72	80	95	mA
		I_{RECO}	3, 4	Over discharge recovery charging current VBAT < V_{BPC}, VIN = 5.6 ± 0.2 V	0.8	2.1	10.0	mA

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(Ta = +3 to +48 °C, VIN = 5.3 V, BATSENESE = GND)

Parameter		Symbol	Pin No.	Conditions	Value			Unit
					Min.	Typ.	Max.	
Charge control unit	Timer	t_{FT}	4	ROSC = 56 kΩ, COSC = 100 pF + 19 pF, Rapid charging V_{BFT}< VBAT < V_{BPT}	216	240	264	min
		t_{PC}	4	ROSC = 56 kΩ, COSC = 100 pF + 19 pF, Preliminary charging V_{BPC} < VBAT < V_{BFT}	14.4	16.0	17.6	min
		t_{RECO}	4	ROSC = 56 kΩ, COSC = 100 pF + 19 pF, Over discharge recovery charging VBAT < V_{BPC}	13.5	15.0	16.5	s
	Initial determination delay	t_{DD}	1	ROSC = 56 kΩ, COSC = 100 pF + 19 pF, Ta = –10 °C to +60 °C	30	45	60	ms
	Full charge determination delay	t_{DIC}	—	ROSC = 56 kΩ, COSC = 100 pF + 19 pF	78	117	156	ms
	Overvoltage stop determination delay	t_{BOV}	—	ROSC = 56 kΩ, COSC = 100 pF + 19 pF	0.30	0.46	0.62	s
	Charging restart determination delay	t_{RC}	—	ROSC = 56 kΩ, COSC = 100 pF + 19 pF	153	230	312	ms
	Battery tempera-ture detection	T_{HLT}	48	VREFTH = 1.7 V, Ta = –10 °C to +60 °C, 3 °C detected	1.154 0	1.189 3	1.223 6	V °C
		T_{HSU}	48	VREFTH = 1.7 V, Ta = –10 °C to +60 °C, 41 °C detected (initial)	0.539 38	0.571 41	0.601 45	V °C
		T_{HOM1}	48	VREFTH = 1.7 V, Ta = –10 °C to +60 °C, 48 °C detected	0.463 45	0.488 48	0.511 51	V °C
		T_{HOM1}	48	VREFTH = 1.7 V, Ta = –10 °C to +60 °C, 41 °C detecxted (restart)	0.539 38	0.571 41	0.601 45	V °C
	BATSENSE pin input voltage	V_{IL}	43	Battery present	0.0	—	0.3 × VIN	V
		V_{IH}	43	Battery not present	0.7 × VIN	—	VIN	V

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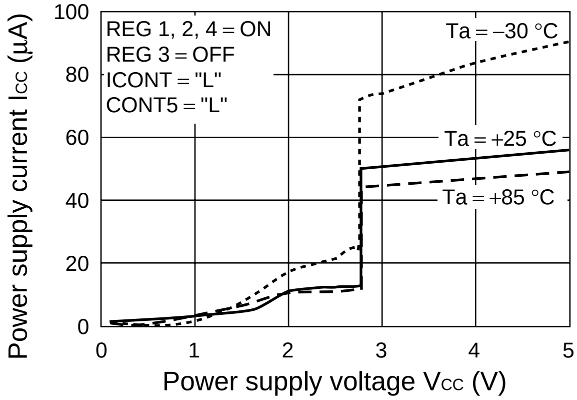
(Ta = +3 to +48 °C, VIN = 5.3 V, BATSENESE = GND)

Parameter		Symbol	Pin No.	Conditions	Value			Unit
					Min.	Typ.	Max.	
Charge control unit	BATSEL pin input voltage	V_{IL}	46	4.2 V battery selected	0.0	—	0.3 × VIN	V
		V_{IH}	46	4.1 V battery selected	0.7 × VIN	—	VIN	V
	LEDR pin ON resistance	Ron	38	LEDR = 5 mA	—	—	80	Ω
	LEDG pin ON resistance	Ron	37	LEDG = 5 mA	—	—	80	Ω
	LEDR, LEDG pin output current	I_O	37, 38	—	—	—	10	mA
	Supply current	I_{VIN}	1	VIN = 5.8 V, Fast charging	—	1.5	3.0	mA
	Leak current	I_{SEN}	3, 4	ISENSE+ = ISENSE– = 4.8 V, VCC = 4.8 V, VIN = CONT = GND	—	—	1	µA
	Test mode ISENSE- pin clamp voltage	V_{PR}	4	BATSENSE = OPEN, V_{ADL} < VIN < V_{ADH}, Ta = –10 °C to +60 °C	4.75	4.88	5.01	V
	Test mode CONT pin voltage	V_{THR}	2	BATSENSE = OPEN, V_{ADL} < VIN < V_{ADH}, VISENSE– = 2.5 V, CONT = 10 µA	—	—	0.1	V
	Test mode response time	R_{TOP}	—	BATSENSE = OPEN, external FET, gate capacitor < 1000 pF, Ta = –10 °C to +60 °C	—	—	100	µs
	BATSENSE response time	R_{TTOVR}	—	BATSENSE = GND→OPEN or OPEN→GND, external FET, gate capacitor< 1000 pF, Ta = –10 °C to +60 °C	—	—	30	ms
	Thermal protection	T_{H+}	—	V_{ADL} < VIN < V_{ADH}	125	—	158	°C

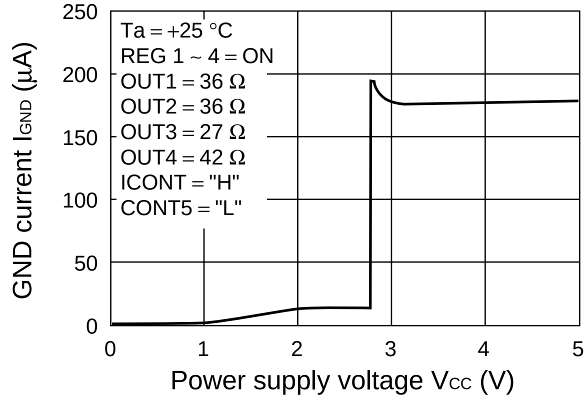
■ TYPICAL CHARACTERISTICS

- Power Supply Control Unit Overall

Power supply current vs. Power supply voltage

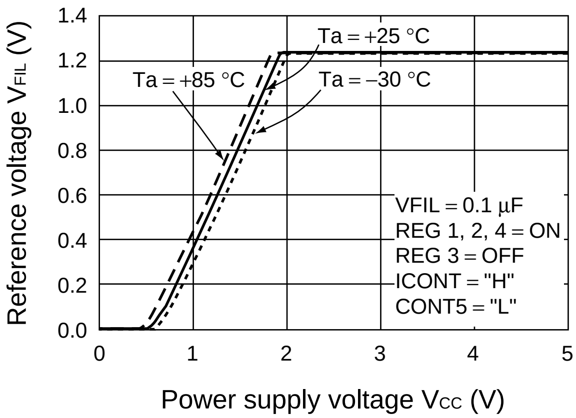


GND current vs. Power supply voltage

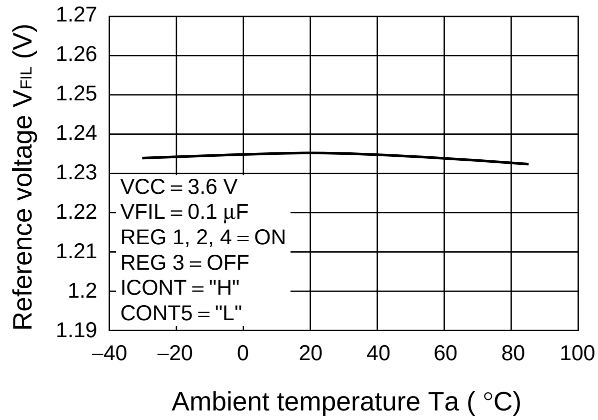


- Reference Voltage Block

Reference voltage vs. Power supply voltage

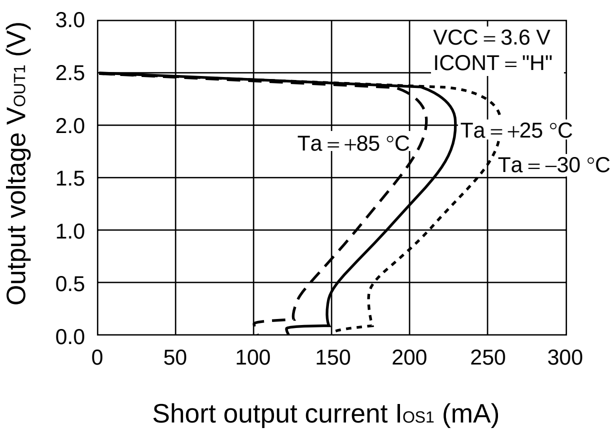


Reference voltage vs. Ambient temperature

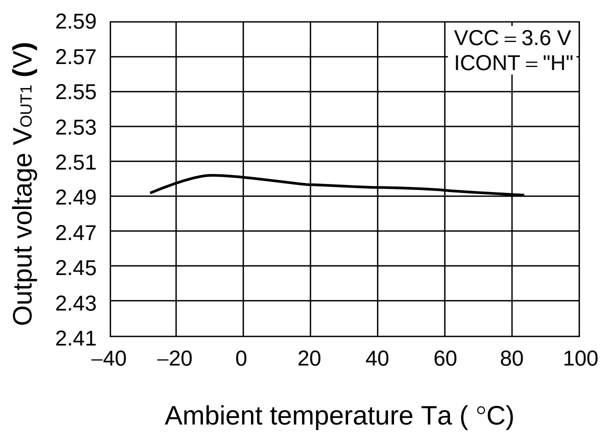


- Constant Voltage Control Block

Output voltage vs. Short output current (REG1)



Output voltage vs. Ambient temperature (REG1)



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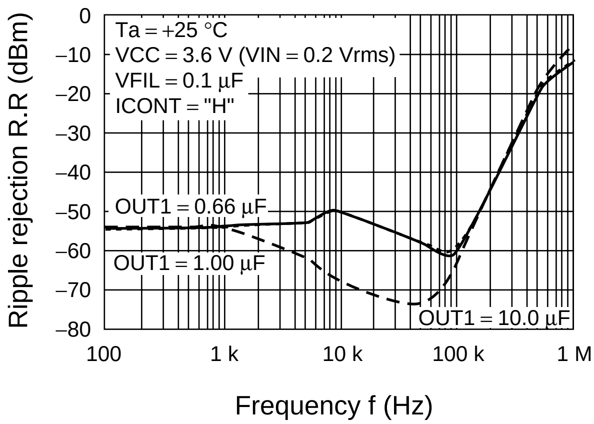
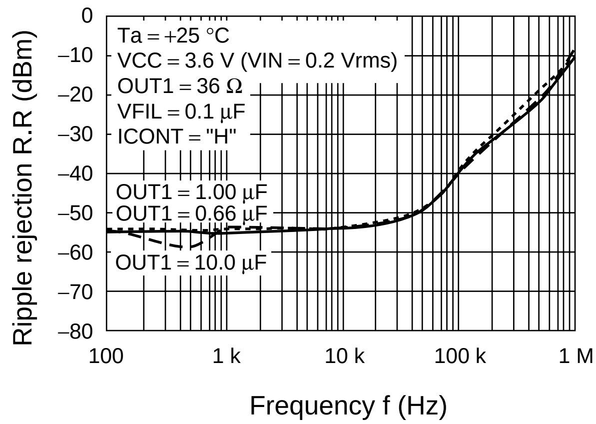
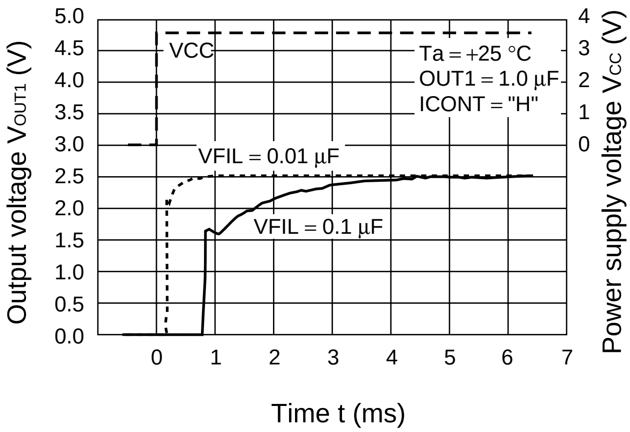
Ripple rejection vs. Frequency (1) (REG1 No-Load)



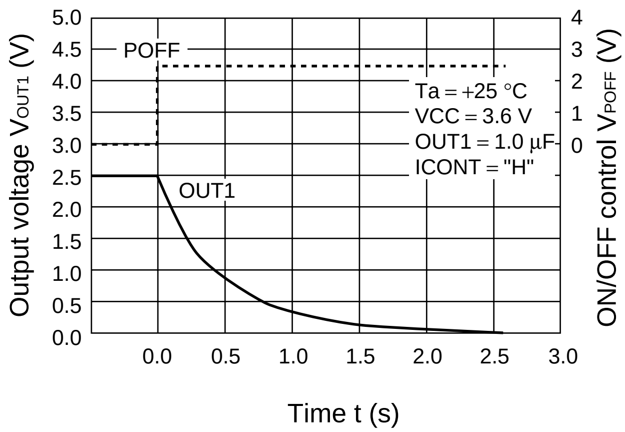
Ripple rejection vs. Frequency (2) (REG1 Load)



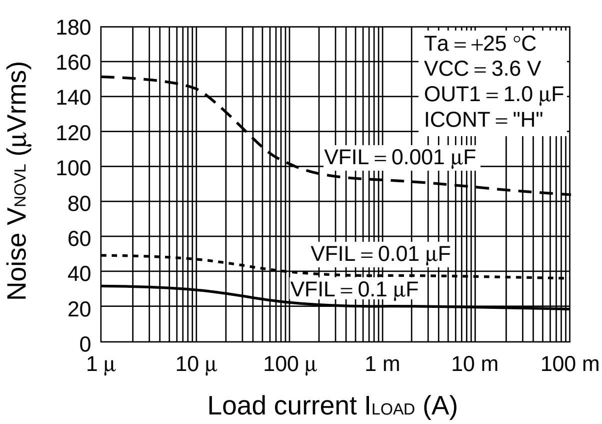
Output voltage rising waveforms
(REG1 Battery Load)



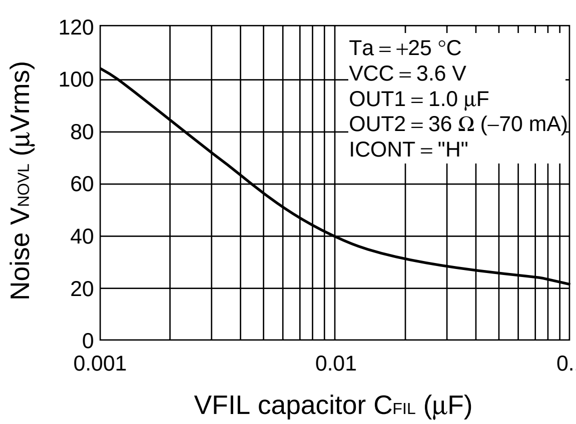
Output voltage falling waveforms
(REG1 ON/OFF Control)



Noise vs. Load current (REG1)



Noise vs. VFIL capacitor (REG1)



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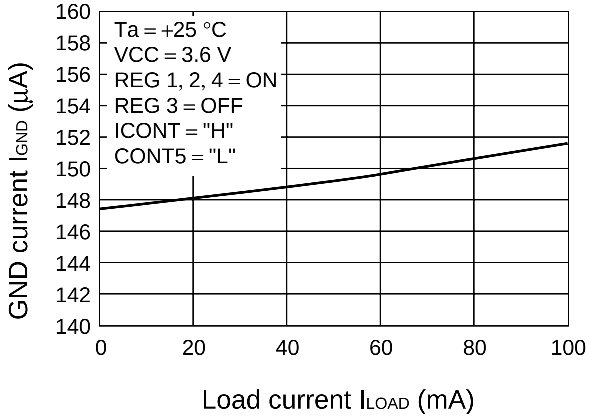
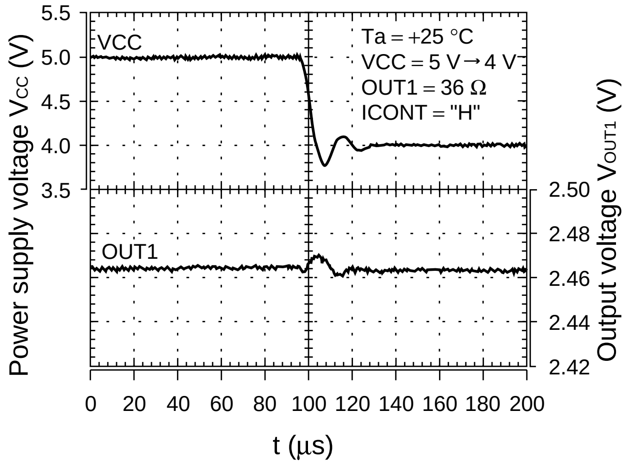
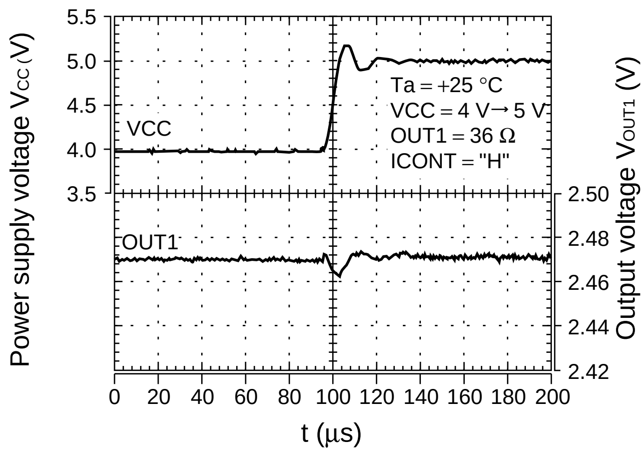
GND current vs. Load current (REG1)



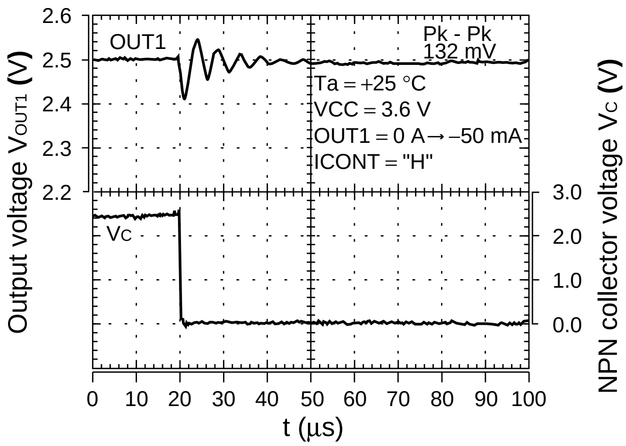
Output waveform at power supply change (1) (REG1)



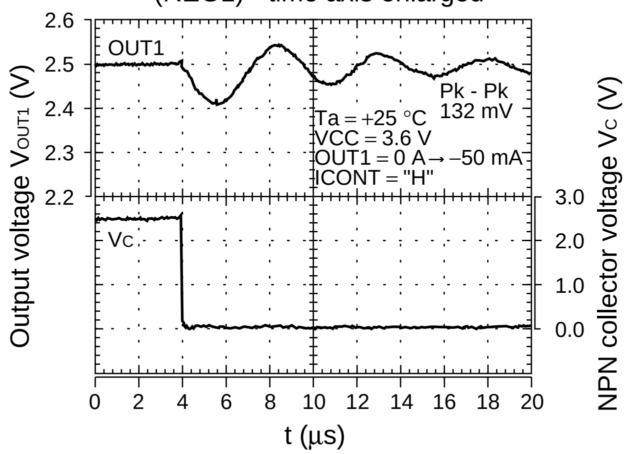
Output waveform at power supply change (2) (REG1)



Waveform at rapid change of output load (1) (REG1)



Waveform at rapid change of output load (1) (REG1) - time axis enlarged



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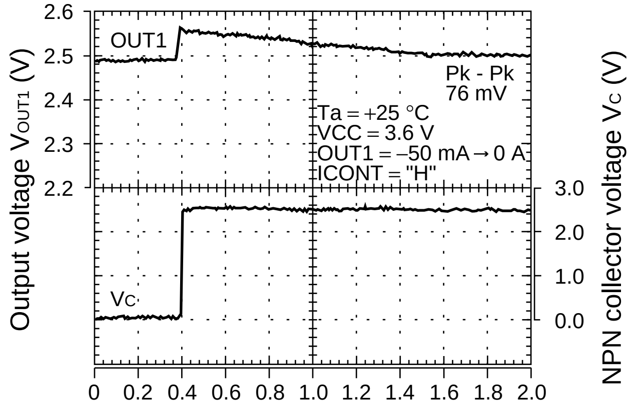
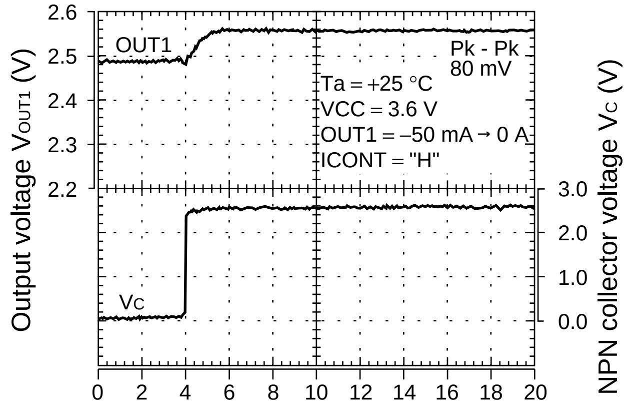
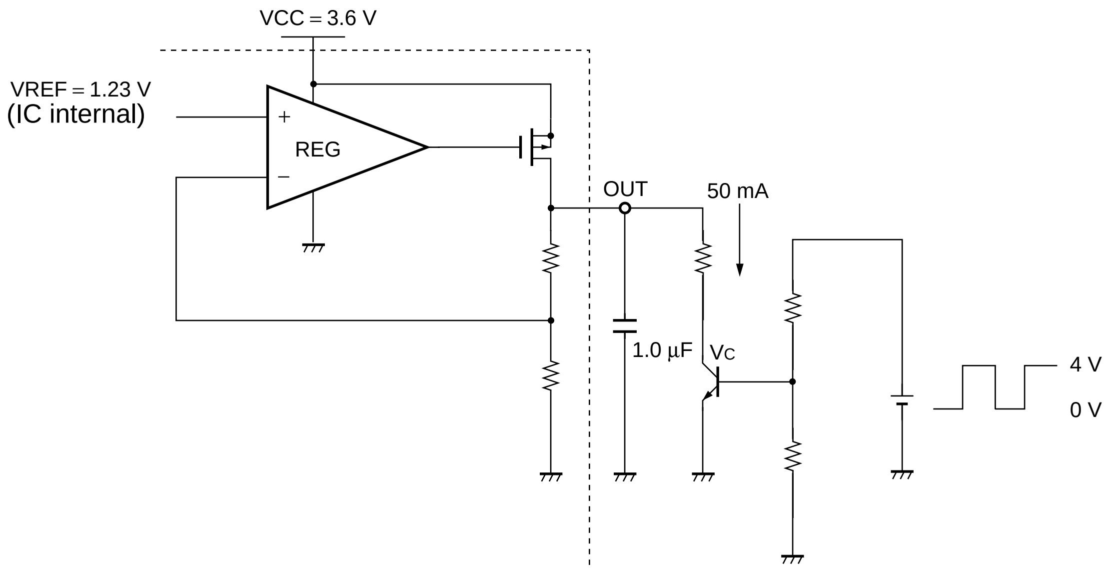
Waveform at rapid change of output load (2) (REG1)



Waveform at rapid change of output load (2) (REG1) - time axis enlarged



[Measurement Diagram for Rapid Change of Output Load]



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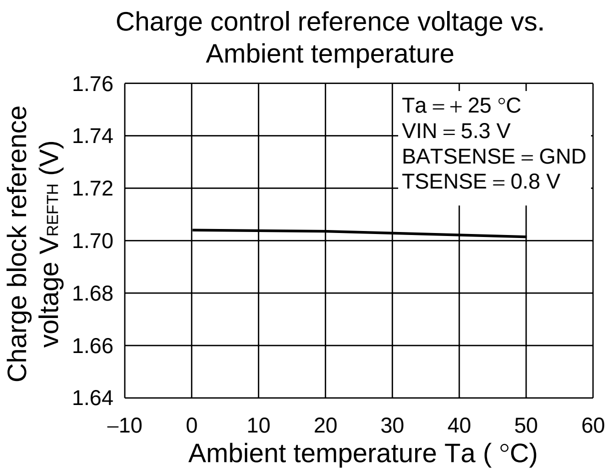
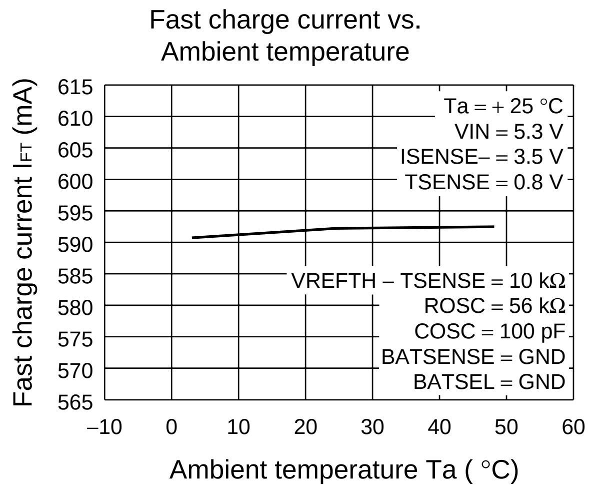
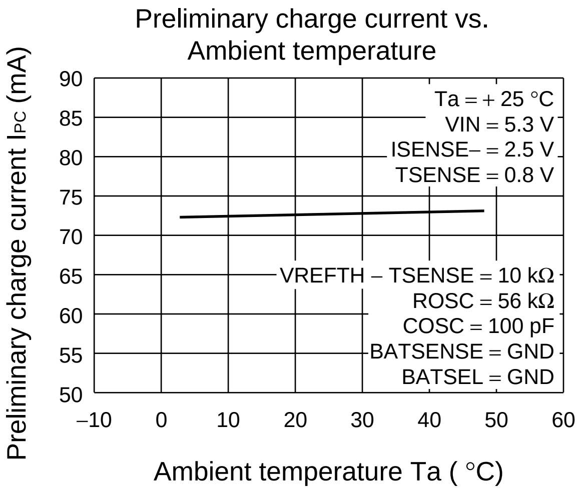
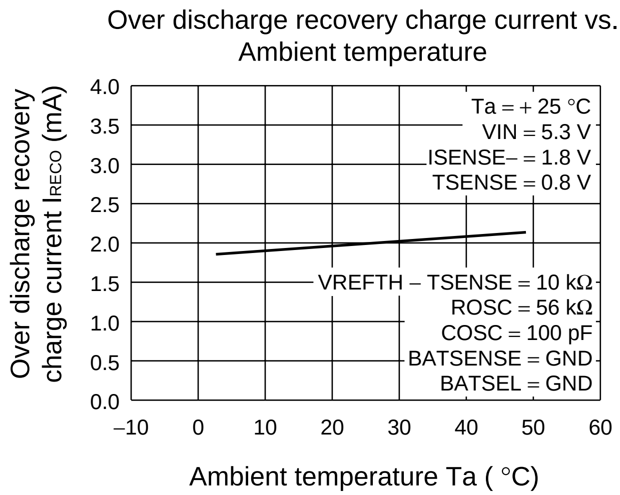
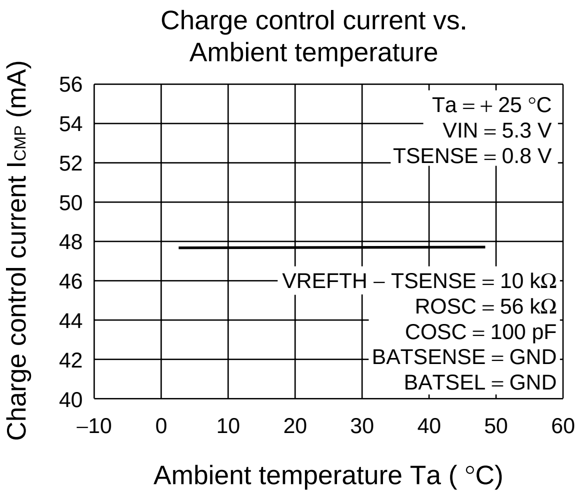
• Charge control unit

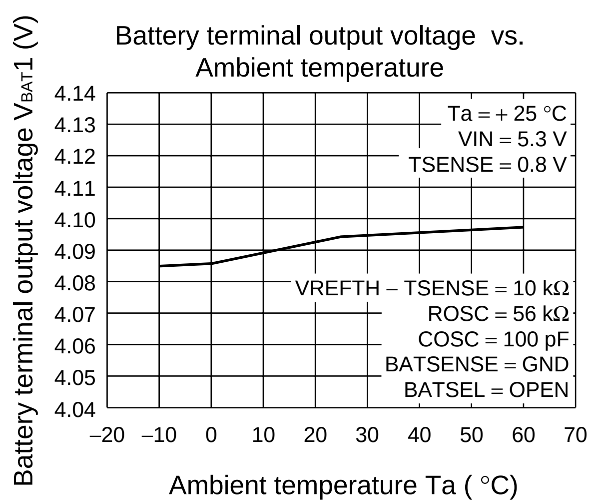












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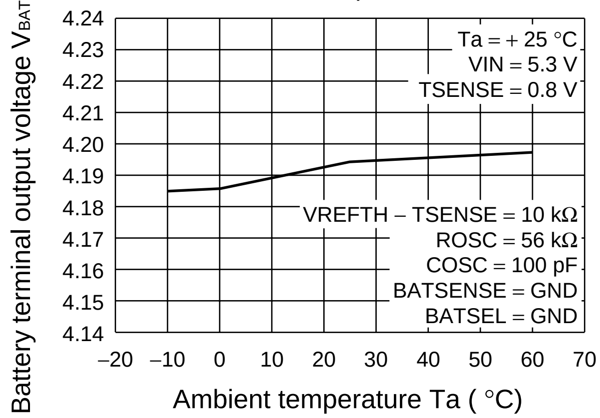
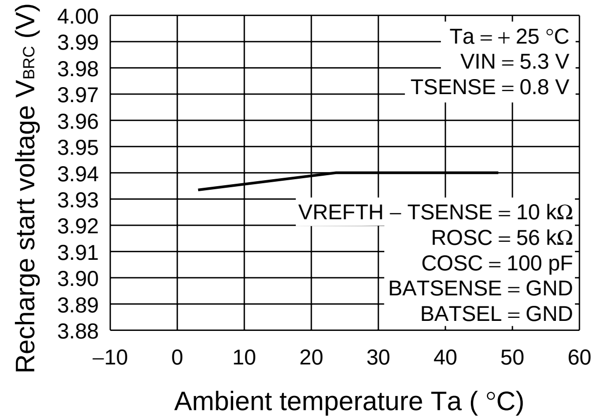
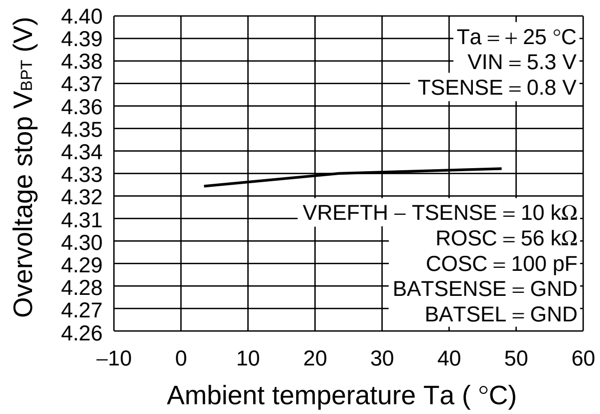
Battery terminal output voltage vs.
Ambient temperature



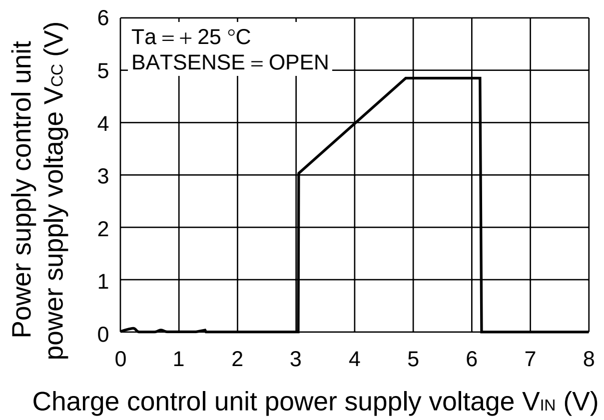
Recharge start voltage vs. Ambient temperature



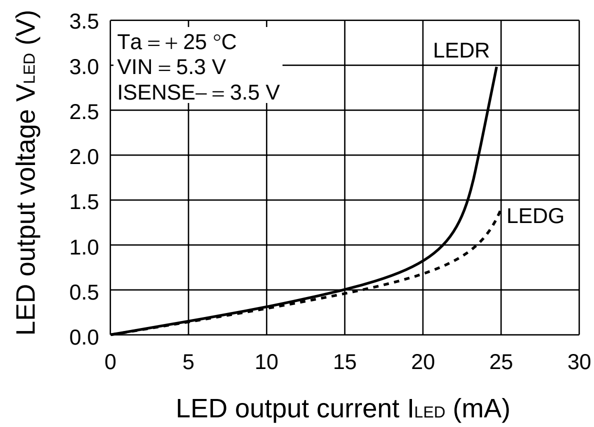
Overvoltage stop vs. Ambient temperature



Power supply control unit power supply voltage vs.
Charge control unit power supply voltage
(Transparent Mode)



LED output voltage vs. LED output current



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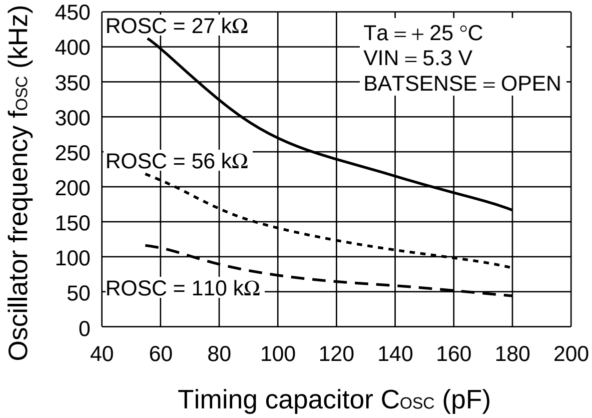
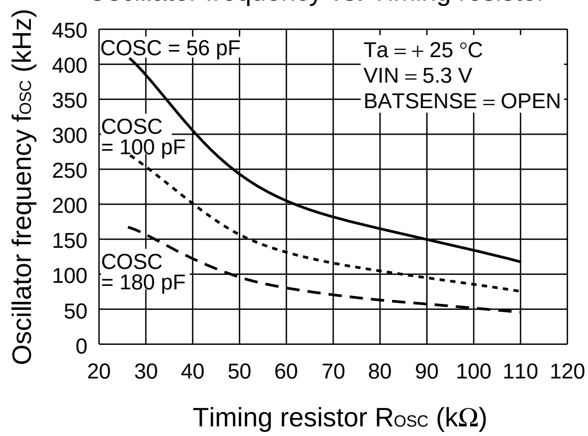
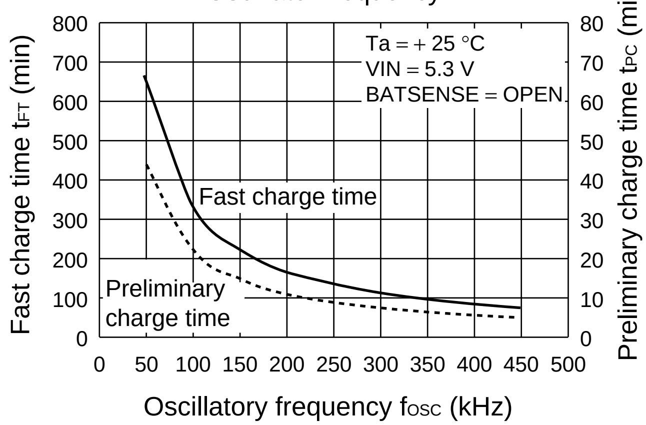
Oscillator frequency vs. Timing capacitor



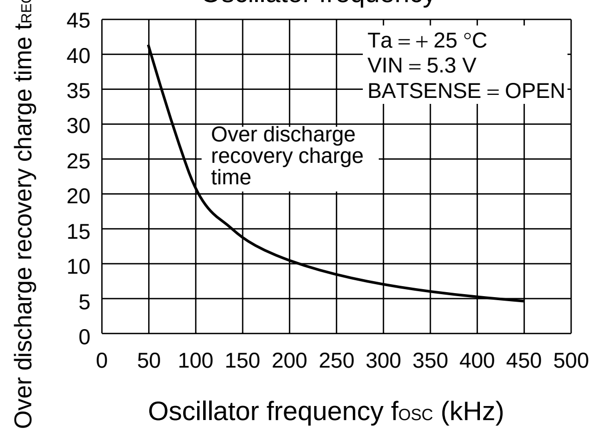
Oscillator frequency vs. Timing resistor



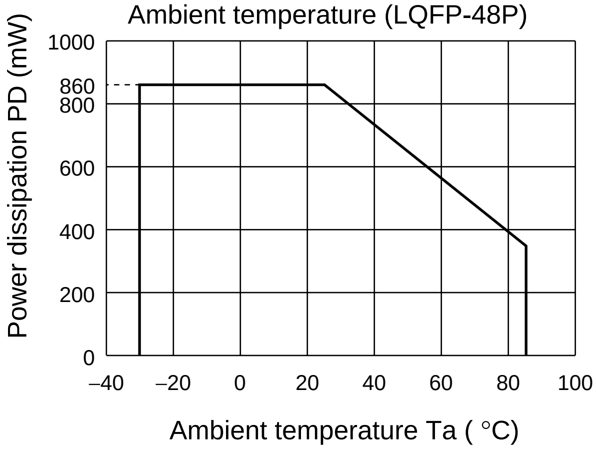
Preliminary charge - fast charge time vs. Oscillator frequency



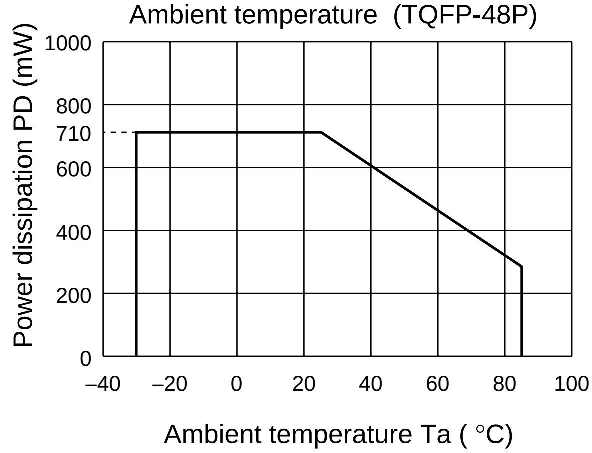
Over discharge recovery charge time vs. Oscillator frequency



Power dissipation vs. Ambient temperature (LQFP-48P)



Power dissipation vs. Ambient temperature (TQFP-48P)



■ FUNCTIONAL DESCRIPTION

1. Power Supply Control Unit

(1) Reference Voltage Block

The reference voltage circuit uses the voltage supplied from the VCC terminal (pin 40) and generates a temperature compensated reference voltage (1.23 V (Typ.)), for use as the reference voltage for the power supply control unit.

(2) Constant Voltage Control Block (REG1)

This constant voltage control block (REG1) uses the voltage supplied from the reference voltage and generates the output voltage (2.5 V) from the OUT1 terminal (pin 29).
An external load current can be obtained from the OUT1 terminal up to a maximum of 70 mA.
Also, by setting the ICONT terminal (pin 36) to “L” level the MB3893A can be placed in low current consumption (standby) mode. In standby mode, REG1 is On with a maximum output load of 500 µA, and REG3 is Off. In this state, ripple rejection and noise levels are not assured.

(3) Constant Voltage Control Block (REG2)

This constant voltage control block (REG2) uses the voltage supplied from the reference voltage and generates the output voltage (1.8 V) from the OUT2 terminal (pin 30).
An external load current can be obtained from the OUT2 terminal up to a maximum of 50 mA.
Also, by setting the ICONT terminal (pin 36) to “L” level the MB3893A can be placed in low current consumption (standby) mode. In standby mode, REG2 is On with a maximum output load of 500 µA, and REG3 is Off. In this state, ripple rejection and noise levels are not assured.

(4) Constant Voltage Control Block (REG3)

This constant voltage control block (REG3) uses the voltage supplied from the reference voltage and generates the output voltage from the OUT3 terminal (pin 27).
An external load current can be obtained from the OUT3 terminal up to a maximum of 70 mA.
Also, the output voltage can be changed to 1.9V or 2.2 V by mask option.

(5) Constant Voltage Control Block (REG4)

This constant voltage control block (REG4) uses the voltage supplied from the reference voltage and generates the output voltage (2.5 V) from the OUT4 terminal (pin 22).
An external load current can be obtained from the OUT4 terminal up to a maximum of 60 mA.
Also, by setting the ICONT terminal (pin 36) to “L” level the MB3893A can be placed in low current consumption (standby) mode. In standby mode, REG4 is On with a maximum output load of 500 µA, and REG3 is Off. In this state, ripple rejection and noise levels are not assured.

(6) VREF1M

This block takes the reference voltage (1.23 V (Typ.)) generated by the reference voltage block, and uses a voltage follower to produce a temperature compensated reference voltage (1.23 V (Typ.)) at the VREF1M terminal (pin 10).
Also, an external load current can be obtained from the VREF1M terminal up to a maximum of 1 mA.

(7) ON/OFF Control Block

This block controls regulator On/Off switching according to the voltage levels of the POFF terminal (pin 18), CONT2 terminal (pin 26), CONT5 terminal (pin 6), ICONT terminal (pin 36), DRST terminal (pin 5), XON terminal (pin 11), ONOFF1 terminal (pin 9), ONOFF2 terminal (pin 17), and CONT1 terminal (pin 14).

(8) POR Block

When the output voltage from the regulator (OUT1) exceeds 2.3 V (Typ.), the XRST terminal (pin 35) goes to "H" level following a delay time (85 ms (Typ.)) set by capacitors (0.1 µF (Typ.)) connected between the C1 terminal (pin 7) and the GND1 terminal (pin 8) and GND2 terminal (pin 39). Also, when the regulator (OUT1) output voltage falls below 2.2 V ((Typ.)), the XRST terminal goes back to "L" level.

(9) Initial Power Supply Drop Detection 1

This block controls MB3893A operation when VCC startup occurs at VCC voltage of 2.0V (Typ.) or greater. When VCC voltage exceeds 2.75V (Typ.) the VCONT terminal (pin 16) voltage goes to "H" level, and the regulated voltage is output from the OUT1 terminal (pin 29), OUT2 terminal (pin 30), and OUT4 terminal (pin 22). When VCC voltage falls below 3.1V (Typ.), the voltage at the OUT1, OUT2, and OUT4 terminals is outside of rated values. Then when VCC voltage falls below 2.5V (Typ.), the VCONT terminal (pin 16) voltage goes to "L" level, and the OUT1, OUT2, and OUT4 terminals go to "L" level (regulator "OFF" state). Hereafter this is referred to as "L" level. As long as the VCC voltage rises again before dropping below 2.0V (Typ.), the VCONT pin voltage will return to "H" level once VCC reaches 3.5 V (Typ.), and the regulated voltage is output from the OUT1, OUT2, and OUT4 terminals.

(10) Transient Power Supply Drop Detection 2

This block detects two types of power supply drop times according to the time constants CR1 and CR2, and produces the related output at the VBDET1 terminal (pin 34) and VBDET2 terminal (pin 33).

2. Charge Control Block

The charge control block checks VIN, battery voltage, and battery temperature before charging. If the results are within normal ranges, charging begins. During charging, the charging times and current levels are varied according to battery voltage. The VIN and battery temperature are monitored, and if either exceeds the normal range charging is stopped. Conditions are then monitored for a fixed time (16 min (Typ.)) and a resume charging/ abnormal termination determination is made.

The MB3893A also provides an overcharge protection function, as well as a function that stops charging when a rise in IC junction temperature is detected.

Once charging has stopped due to any of these abnormal conditions, it can be resumed by re-input of VIN, or by removing and replacing the battery.

(1) Constant Current/Constant Voltage Charging

The MB3893A applies a constant current charge according to the battery voltage level, selecting over discharge recovery charging (2.1 mA (Typ.)), preliminary charging (80 mA (Typ.)) or rapid charging (590 mA (Typ.)). Once battery voltage reaches 4.1 V (4.2 V), constant voltage charging is applied until the charge current falls to 53 mA (Typ.) at constant voltage.

(2) Timer Function

The timer switches the charging time according to the battery voltage level, between over discharge recovery charging (15 s (Typ.)), preliminary charging (16 min (Typ.)), and rapid charging (240 min (Typ.)).

(3) Temperature/AC Adapter Voltage Detection

This block detects the battery temperature and AC adapter voltage, and stops charging if either is outside of the normal charging range. If normal conditions are restored within a set time (16 min (Typ.)), charging is resumed, otherwise an abnormal termination is determined.

(4) Over-Charge Protection

If battery voltage exceeds 4.3 V (Typ.) this block determines an abnormal condition, and stops charging.

■ SETTING THE XON DELAY TIME

When the XON terminal (pin 11) voltage changes from "H" to "L" level, the VCONT signal (pin 16) rises. The time constant of the capacitor (C_{RC1}) and resistor (R_{RC1}) connected to the RC1 terminal (pin 15) determine the delay time before the rise of the VCONT signal (pin 16).

XON delay time : t_{XON} (ms) $\fallingdotseq 598.3 \times C_{RC1}$ (μF)

■ SETTING THE XRST DELAY TIME

The time constant of the capacitor (C_{C1}) connected to the C1 terminal (pin 7) determines the delay time between the rise of the OUT1 terminal (pin 29) voltage above 2.3 V (Typ.) and the rise of the XRST terminal (pin 35) voltage.

$$\text{XRST delay time : } t_{POR}\ (\text{s}) \fallingdotseq \frac{1.23\ (\text{V}) \times C_{C1}\ (\mu\text{F})}{1.45\ (\mu\text{A})}$$

■ SETTING THE POWER SUPPLY DROP DETECTION TIME

When the VCC terminal (pin 40) voltage falls below 2.0 V (Typ.) the CR1 terminal (pin 12) and CR2 terminal (pin 13) are opened, and the capacitors (C_{CR1}, C_{CR2}) connected to the CR1 and CR2 terminals are discharged through the respective resistors (R_{CR1}, R_{CR2}). The discharge time (cutoff detection time) of the CR1 and CR2 pins can be set according to the time constants of the capacitors and resistors connected to the CR1 and CR2 terminals respectively, between 0.89 V (Typ.) to 0.51 V (Typ.).

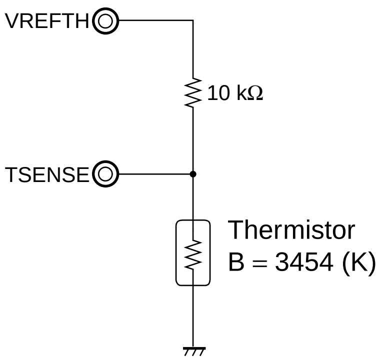
Cutoff detection time : t_{DET1} (s) $\fallingdotseq -C_{CR1}$ (μF) $\times R_{CR1}$ (MΩ) $\times$ ln (0.51 (V) /0.89 (V))
t_{DET2} (s) $\fallingdotseq -C_{CR2}$ (μF) $\times R_{CR2}$ (MΩ) $\times$ ln (0.51 (V) /0.89 (V))

■ BATTERY TEMPERATURE DETECTION

The battery temperature sensor uses the thermistor shown below. The thermistor temperature coefficient is set by the following formula.

$$\text{Thermistor temperature coefficient : } B = \frac{\ln R1 - \ln R2}{1/T1 - 1/T2} = 3454\ (\text{K})$$

T1 : 276 (K) = 3 (°C)
R1 : 23.27 (kΩ)
T2 : 321 (K) = 48 (°C)
R2 : 4.026 (kΩ)



■ SETTING THE OSCILLATOR PERIOD

The oscillator period is set by connecting a timing capacitor (C_{OSC}) to the COSC terminal (pin 44), and a timing resistor (R_{OSC}) to the ROSC terminal (pin 45).

Oscillator period : t_{OSC} (µs) ≒ $1.073 \times 10^{-3} \times \{C_{OSC}$ (pF) $+ C_P$ (pF) $\} \times R_{OSC}$ (kΩ)

C_P : Board capacitor ≒ 19 (pF)

■ SETTING THE OVER DISCHARGE RECOVERY CHARGE TIME

When battery voltage is less than the preliminary charge start voltage (2.115 V (Typ.)), the over discharge recovery charge time is set by the following formula.

Over discharge recovery charge time : t_{RECO} (s) ≒ T_{OSC} (s) $\times 2^{21}$

■ PRELIMINARY CHARGE TIME

When battery voltage is higher than the preliminary charge start voltage (2.115 V (Typ.)), and lower than the fast charge start voltage (3.115 V (Typ.)), the preliminary charge time is set by the following formula.

Preliminary charge time : t_{PC} (min) ≒ $\dfrac{t_{OSC}\ (s) \times 2^{27}}{60}$

■ RAPID CHARGE TIME

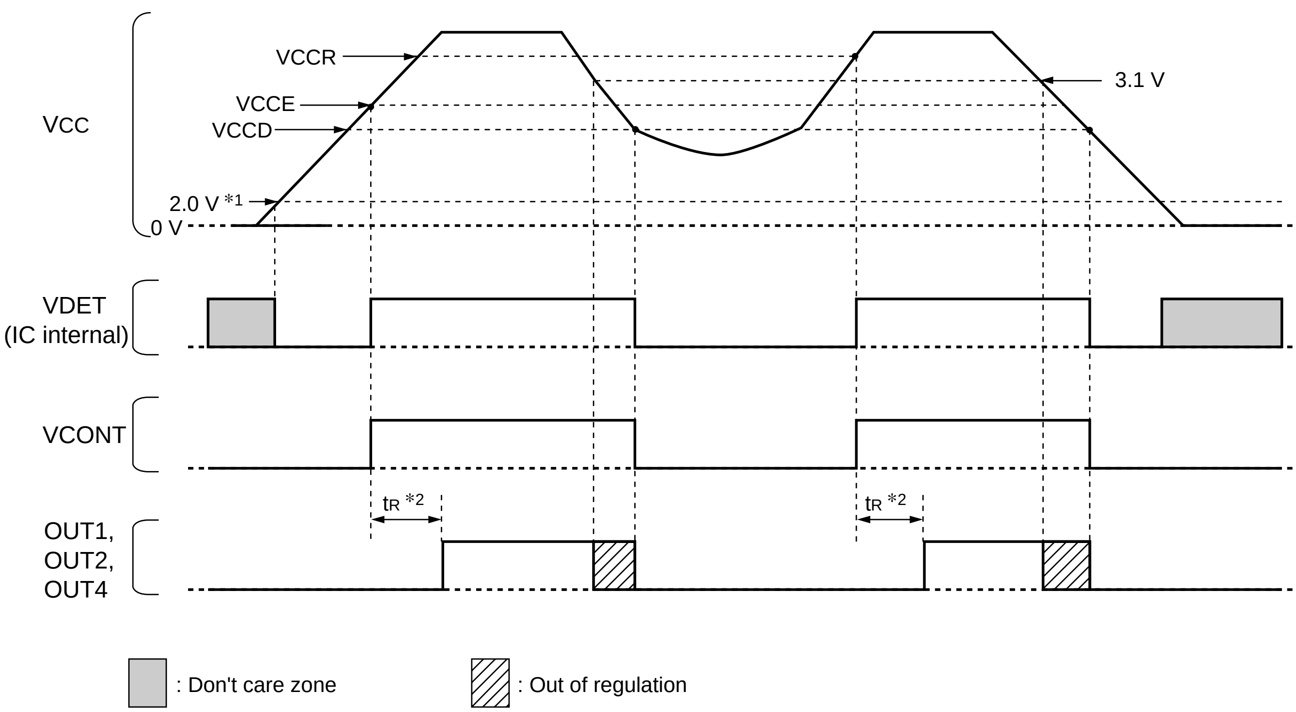
When battery voltage is higher then the fast charge start voltage (2.115 V (Typ.)), and lower than the overvoltage stop voltage (4.325 V (Typ.)), the rapid charging time is determined by the following formula.

Rapid charging time : t_{FT} (min) ≒ $\dfrac{t_{OSC}\ (s) \times (2^{27} + 2^{28} + 2^{29} + 2^{30})}{60}$

■ POWER SUPPLY CONTROL UNIT TIMING CHART

1. Power Supply Drop Detection 1

As Figure 1 shows, there is a “don’t care zone” where VCC voltage is below 2 V. When VCC voltage is above VCCE voltage (2.75 V (Typ.)), the VCONT terminal (pin 16) goes to “H” level, and after a delay time (t_R) the OUT1 terminal (pin 29), the OUT2 terminal (pin 30), and the OUT4 terminal (pin 22) output their regulated voltages. When VCC voltage falls below VCCD voltage (2.50 V (Typ.)), a power supply drop detection is determined and the VCONT terminal goes to “L” level, and therefore the OUT1, OUT2, and OUT4 terminals also go to “L” level. If the VCC voltage rises again before falling below 2 V, the OUT1, OUT2, and OUT4 terminals will once again output their regulated voltages once VCC exceeds the VCCR voltage (3.50 V (Typ.))



*1: Initial cutoff determination level

*2: $t_{R1} < t_R < t_{R2}$

Figure 1. Power Supply Cutoff Sensor 1

2. Delayed ON Input Operation (XON)

As Figure 2 shows, When the XON terminal (pin 11) changes from "H" to "L" level, the capacitor connected to the RC1 terminal (pin 15) starts to charge. After the delay interval (t_{XON} : 600ms (Typ.)), once the RC1 terminal exceeds the internal threshold voltage the VCONT terminal (pin 16) goes to "H" level, and the OUT1 (pin 29), OUT2 (pin 30), OUT3 (pin 27), and OUT4 (pin 22) terminals then output their respective regulated voltages after a delay interval (t_{R1}). Note however that for the OUT3 terminal to output its regulated voltage, it is necessary for the CONT2 terminal (pin 26) to be at "L" level. Also, for the XON pin to return from "L" level to "H" level, a delay interval (t_{XON} : 600 ms (Typ.)) is required.

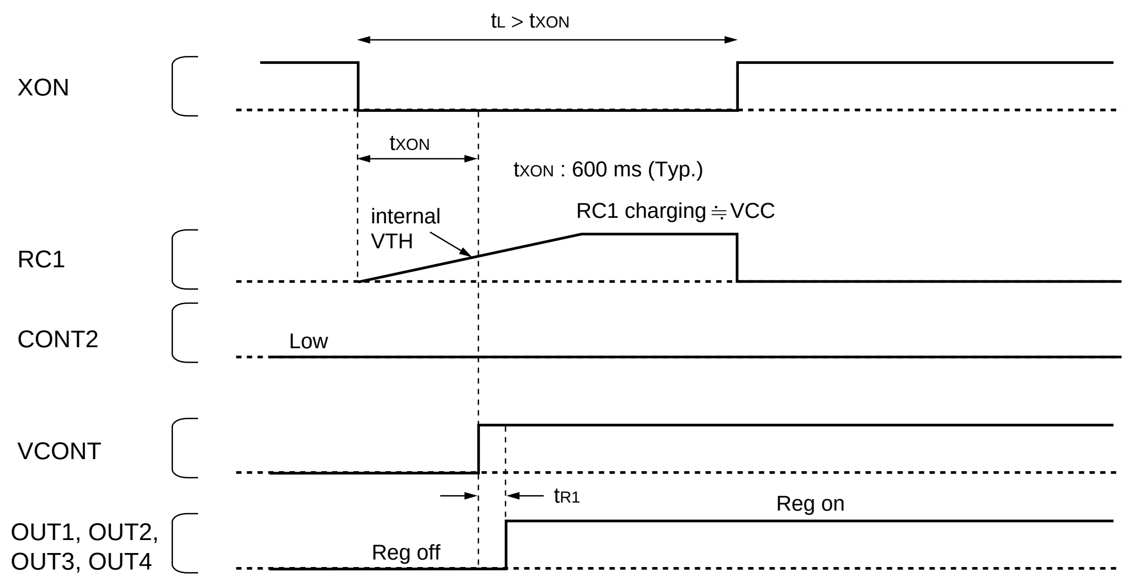


Figure 2. Delayed ON Input Operation (XON)

3. CONT1 Input Operation

As Figure 3 shows, when the CONT1 terminal (pin 14) goes from "H" to "L" level, the VCONT terminal (pin 16) goes to "H" level, and the OUT1 (pin 29), OUT2 (pin 30), OUT3 (pin 27), and OUT4 (pin 22) terminals then output their respective regulated voltages after a delay interval (t_{R1}). Note however that for the OUT3 terminal to output its regulated voltage, it is necessary for the CONT2 terminal (pin 26) to be at "L" level. Also once the OUT1, OUT2, OUT3, and OUT4 terminals have started to output their regulated voltages, the voltage at the OUT1, OUT2, OUT3, and OUT4 terminals will not change even if the CONT1 terminal goes from "L" to "H" level, or from "H" level to "L" level.

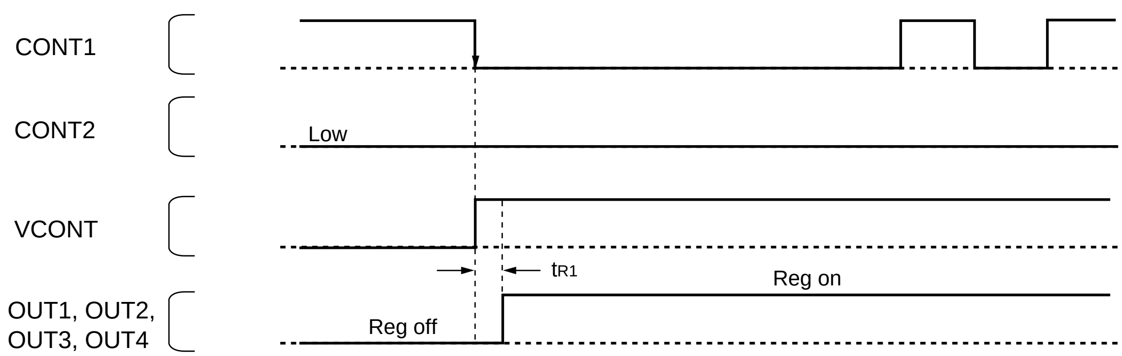
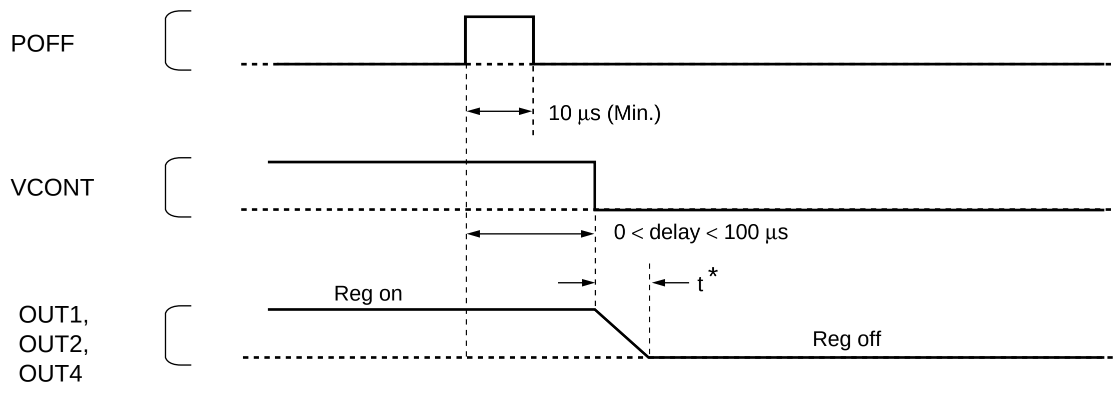


Figure 3. CONT1 Input Operation

4. POFF Input Operation

As Figure 4 shows, once when the POFF terminal (pin 18) goes to “H” level, then after a delay interval (0 < delay < 100 µs) the VCONT terminal (pin 16) goes to “L” level, and the OUT1 (pin 29), OUT2 (pin 30), and OUT4 (pin 22) terminals then after a delay interval (t) go to “L” level. Also, a minimum of 10 µs is required to set the POFF signal to “H” level.

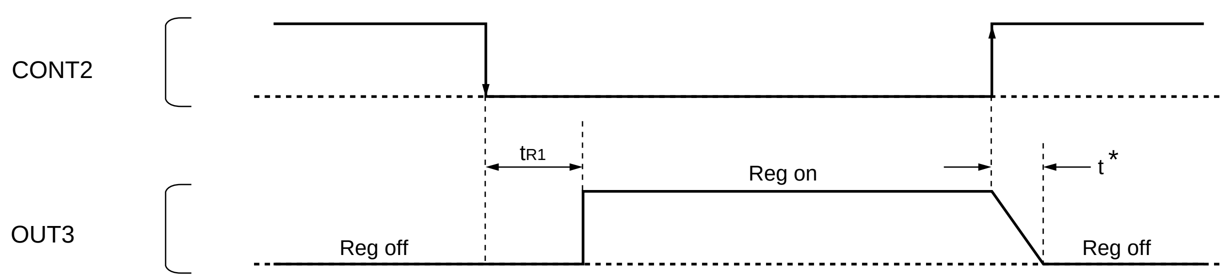


*: t : Varies according to the output status of each regulator.

Figure 4. POFF Input Operation

5. CONT2 Input Operation

As Figure 5 shows, when the CONT2 terminal (pin 26) goes from “H” to “L” level, the OUT3 terminal (pin 27) after a delay interval (t_{R1}) outputs its regulated voltage. When the CONT2 terminal goes from “L” to “H” level, then the OUT3 terminal returns to “L” level after the required fall time (t).



*: t : Varies according to the output status of the regulator.

Figure 5. CONT2 Input Operation

6. ONOFF1, 2 Input Operation

As Figure 6 shows, when the ONOFF1 terminal (pin 9) goes from “L” level to “H” level, the VCONT terminal (pin 16) goes to “H” level, and the OUT1 (pin 29), OUT2 (pin 30), OUT3 (pin 27), and OUT4 (pin 22) terminals output their respective regulated voltages.
The next time the POFF terminal (pin 18) goes from “L” level to “H” level, the VCONT terminal (pin 16) goes to “L” level, and the OUT1 (pin 29), OUT2 (pin 30), and OUT4 (pin 22) terminals go to “L” level. Then when the ONOFF2 terminal (pin 17) goes from “L” level to “H” level, the VCONT terminal returns to “H” level, and the OUT1, OUT2, OUT3 and OUT4 terminals output their respective regulated voltages.
The next time the POFF terminal goes from “L” level to “H” level, the VCONT terminal goes to “L” level, and the OUT1, OUT2, and OUT4 terminals go to “L” level. Then when the ONOFF1 terminal goes from “L” level to “H” level, the VCONT terminal returns to “H” level, and the OUT1, OUT2 and OUT4 terminals output their respective regulated voltages.
The next time the POFF terminal goes from “L” level to “H” level, the VCONT terminal goes to “L” level, and the OUT1, OUT2, and OUT4 terminals go to “L” level. Then when the ONOFF2 terminal goes from “H” level to “L” level, the VCONT terminal returns to “H” level, and the OUT1, OUT2 and OUT4 terminals output their respective regulated voltages.
The next time the POFF terminal goes from “L” level to “H” level, the VCONT terminal goes to “L” level, and the OUT1, OUT2, and OUT4 terminals go to “L” level.

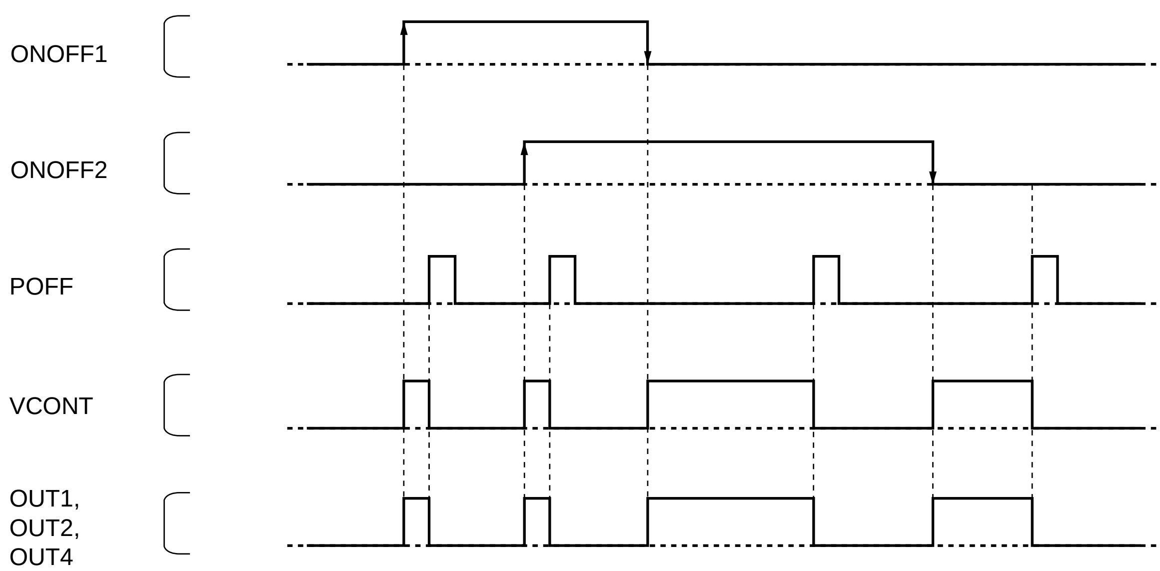


Figure 6. ONOFF1, 2 Input Operation

7. Power-On Reset (OUT1)

As Figure 7 shows, when the OUT1 terminal (pin 29) exceeds 2.3 V (Typ.), then after a delay interval (85 ms (Typ.)) the XRST terminal (pin 35) goes to “H” level.
When the OUT1 terminal falls back below 2.2 V (Typ.), the XRST terminal returns to “L” level.

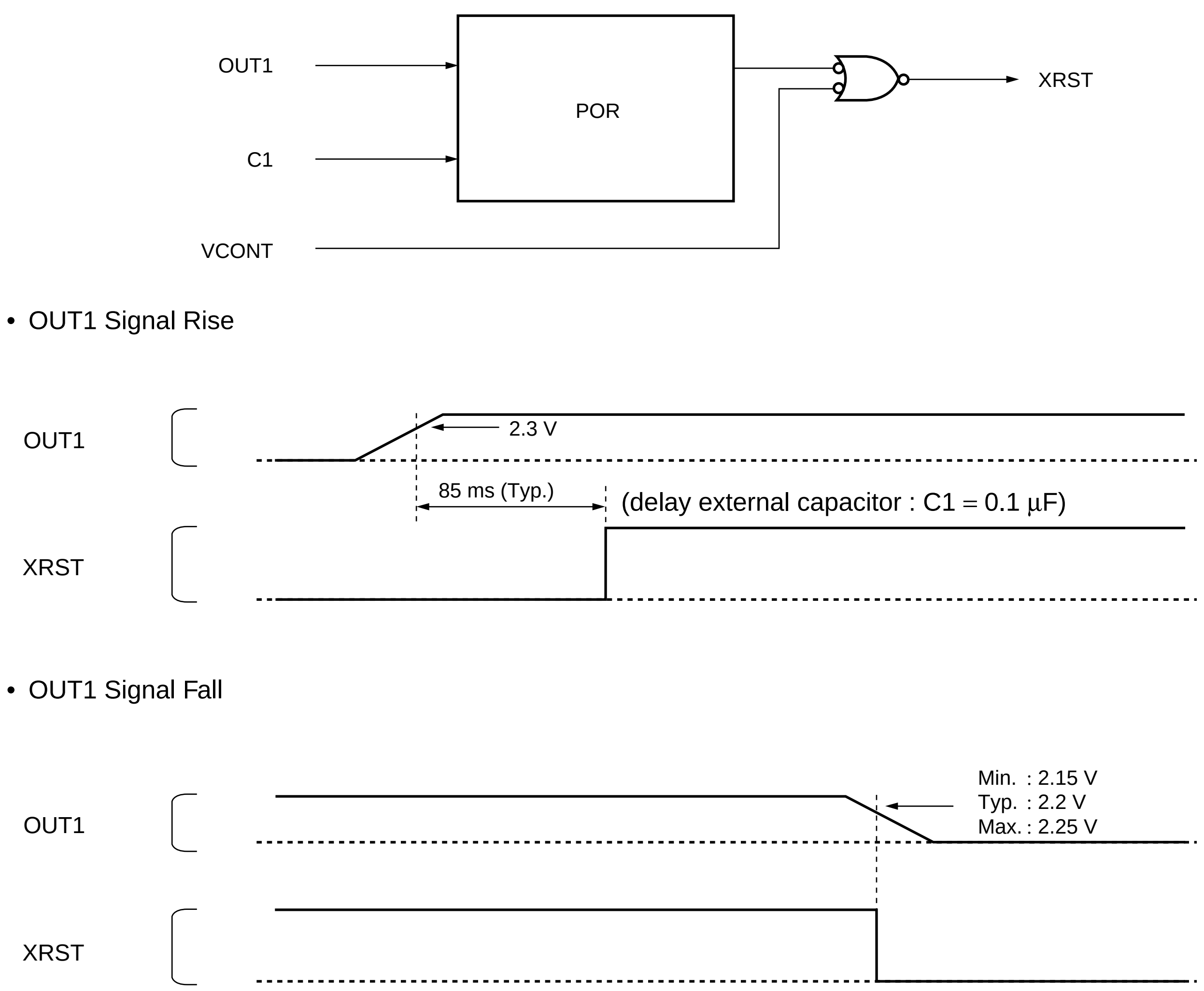


Figure 7. Power-On Reset (OUT1)

8. ICONT Input Operation

As Figure 8 shows, when the VCONT terminal (pin 16) goes from “L” level to “H” level, the OUT1 terminal (pin 29) outputs its regulated voltage. Then, after a delay interval (85 ms (Typ.)) the XRST terminal (pin 35) goes to “H” level.

If after the XRST terminal has gone to “H” level the ICONT terminal (pin 36) goes to “L” level, the MB3893A goes into standby mode, reducing the IC internal current consumption. When the ICONT terminal returns to “H” level normal operation is restored.

When the VCONT terminal goes from “H” level to “L” level, the OUT1 terminal goes to “L” level. At this time the XRST terminal also goes to “L” level.

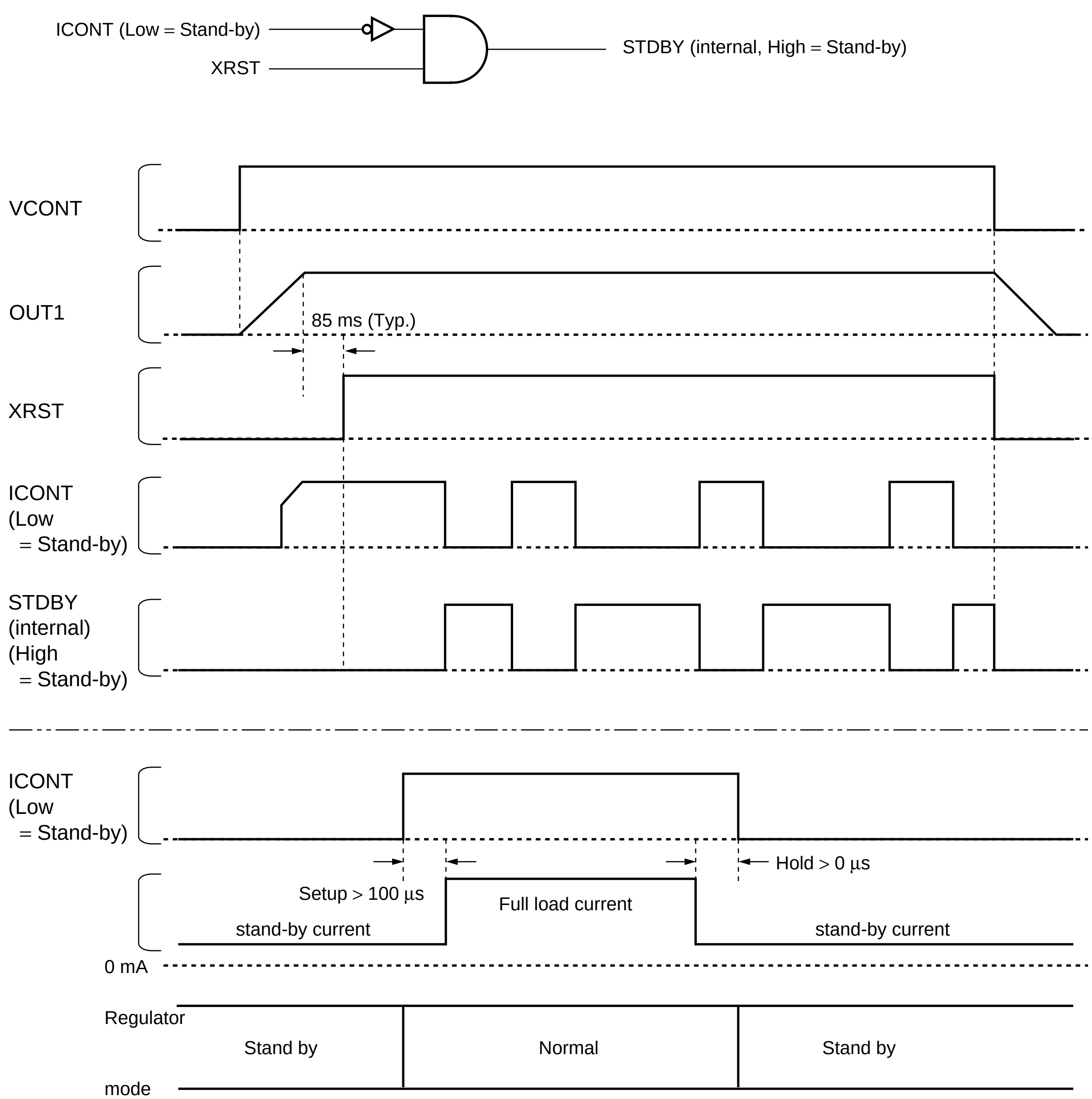


Figure 8. ICONT Input Operation

9. Power Supply Drop Detector 2 (Initial power supply detector/power supply drop detector)

a) t > 10 s

The MB3893A power supply drop detection intervals are set to t_{DET1} (10 s (Typ.)) and t_{DET2} (1.5 s (Typ.)) so that, as shown in Figure 9(a), when VCC goes from "H" level to "L" level, the OUT1 (pin 29), OUT2 (pin 30), and OUT4 (pin 22) terminals go to "L" level, and the XRST terminal (pin 35) also goes to "L" level. At this time, the VBDET1 terminal (pin 34) and VBDET2 terminal (pin 33) also go to "L" level. When VCC drops for a fixed interval (t > 10 s), and then returns to "H" level, the OUT1, OUT2, and OUT4 terminals after a delay interval (t_{R2}) output their regulated voltages, and the XRST terminal after a delay interval (t_{POR}) goes to "H" level. During the interval between the VCC drop and XRST terminal return to "H" level the VBDET1 terminal and VBDET2 terminal are in undefined state. Also once the XRST terminal returns to "H" level the VBDET1 terminal is at "L" level and the VBDET2 terminal is at "H" level. At this time, if the DRST terminal (pin 5) goes to "H" level, the VBDET1 terminal also goes to "H" level. Note that the DRST terminal must be at "H" level for at least an interval of 10 µs.

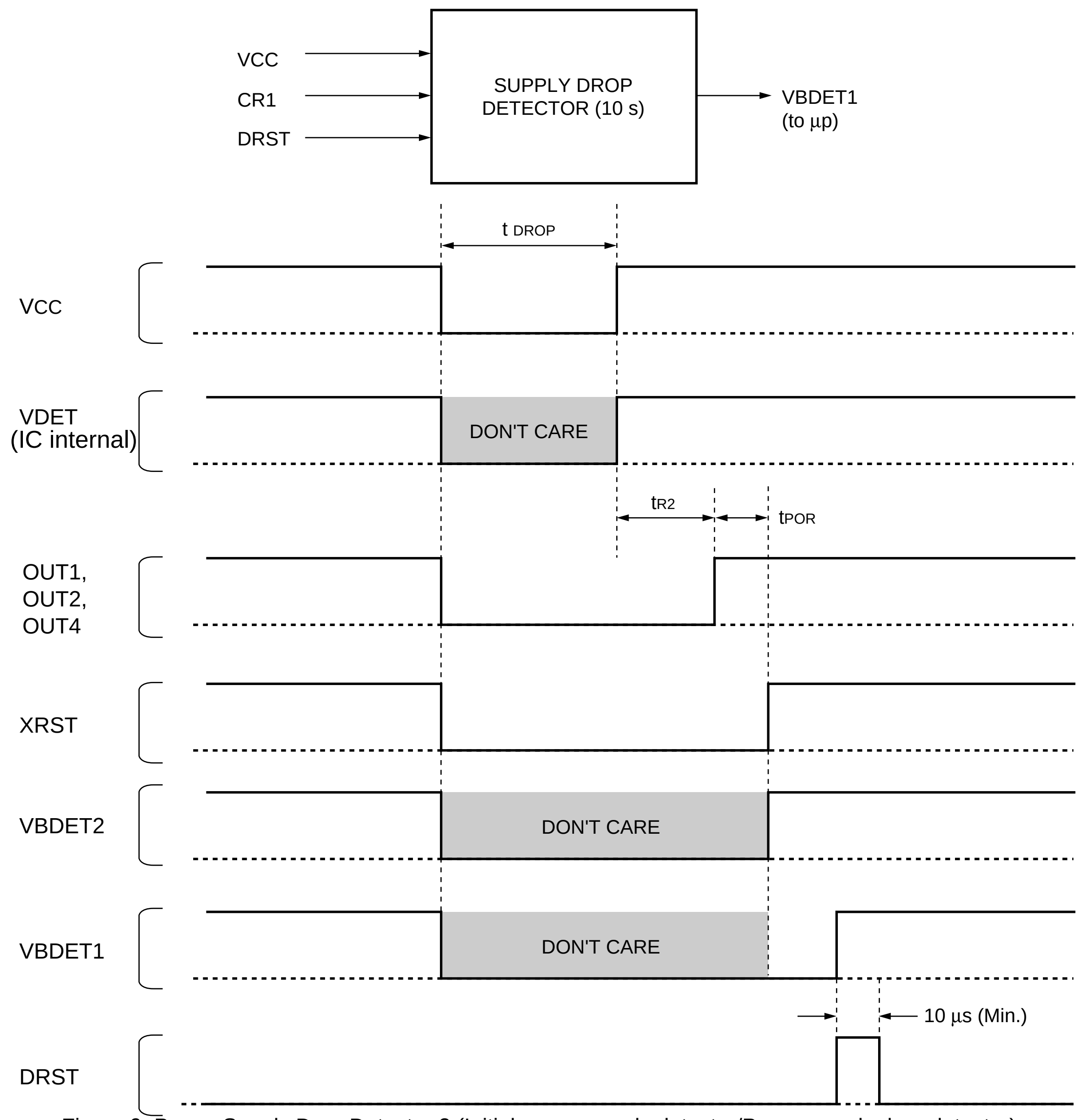


Figure 9. Power Supply Drop Detector 2 (Initial power supply detector/Power supply drop detector)
a) t > 10 s

b) 1.5 < t < 0 s

The MB3893A power supply drop detection intervals are set to t_{DET1} (10 s (Typ.)) and t_{DET2}(1.5 s (Typ.)) so that, as shown in Figure 9(b), when VCC goes from "H" level to "L" level, the OUT1 (pin 29), OUT2 (pin 30), and OUT4 (pin 22) terminals go to "L" level, and the XRST terminal (pin 35) also goes to "L" level. At this time, the VBDET1 terminal (pin 34) and VBDET2 terminal (pin 33) also go to "L" level. When VCC drops for a fixed interval (1.5 s < t < 10 s), and then returns to "H" level, the OUT1, OUT2, and OUT4 terminals after a delay interval (tR2) output their regulated voltages, and the XRST terminal after a delay interval (t_{POR}) goes to "H" level. During the interval between the VCC drop and XRST terminal return to "H" level the VBDET1 terminal and VBDET2 terminal are in undefined state. Also once the XRST terminal returns to "H" level the VBDET1 terminal is at "H" level and the VBDET2 terminal is also at "H" level. At this time, if the DRST terminal (pin 5) goes to "H" level, the VBDET1 and VBDET2 terminals remain at "H" level. Note that the DRST terminal must be at "H" level for at least an interval of 10 µs.

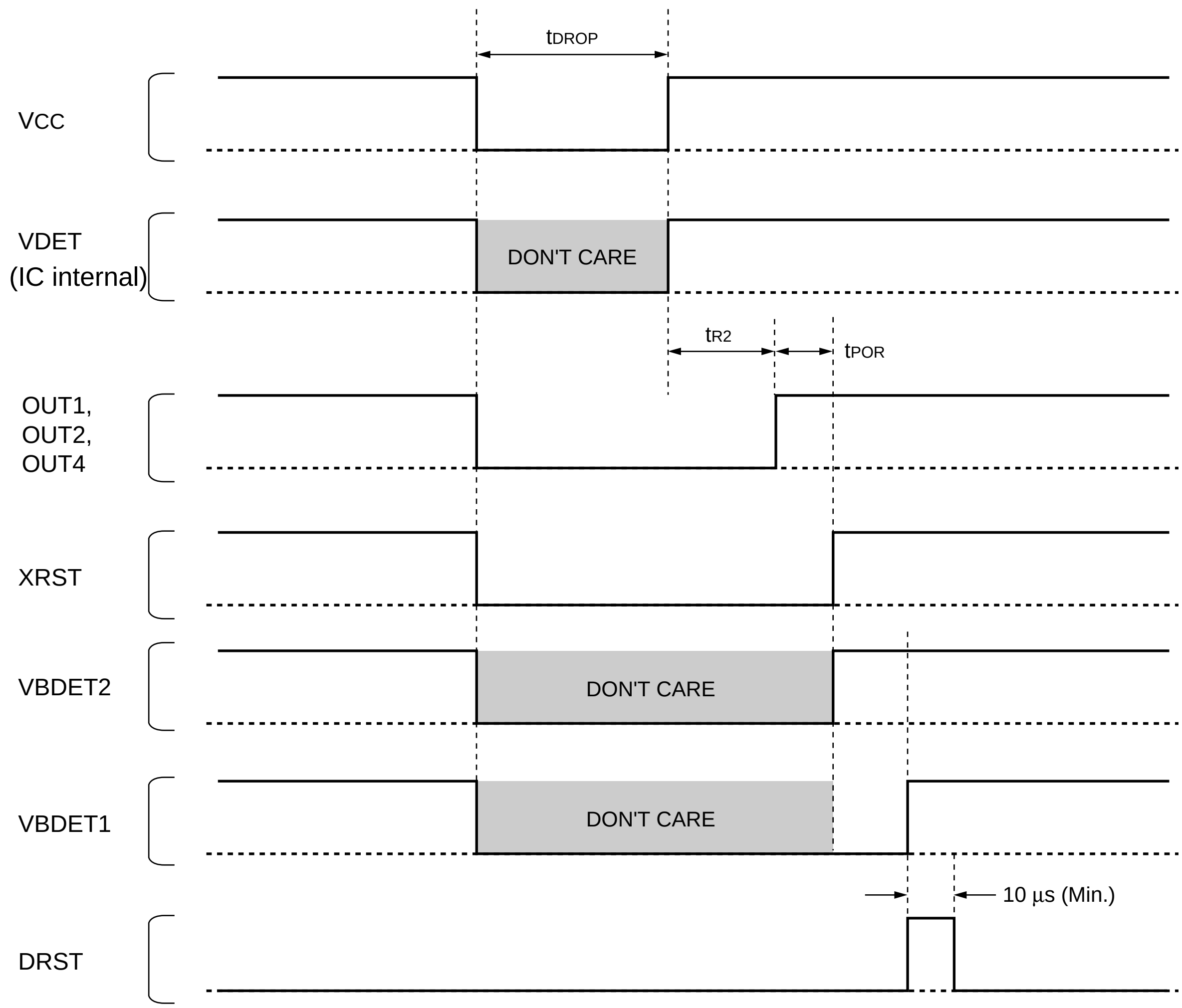


Figure 9. Power Supply Drop Detector 2 (Initial power supply detector/Power supply drop detector)
b) 1.5 < t < 10 s

c) t < 1.5 s

The MB3893A power supply drop detection intervals are set to t_{DET1} (10 s (Typ.)) and t_{DET2} (1.5 s (Typ.)) so that, as shown in Figure 9(c), when VCC goes from “H” level to “L” level, the OUT1 (pin 29), OUT2 (pin 30), and OUT4 (pin 22) terminals go to “L” level, and the XRST terminal (pin 35) also goes to “L” level. At this time, the VBDET1 terminal (pin 34) and VBDET2 terminal (pin 33) also go to “L” level. When VCC drops for a fixed interval (t < 1.5 s), and then returns to “H” level, the OUT1, OUT2, and OUT4 terminals after a delay interval (t_{R2}) output their regulated voltages, and the XRST terminal after a delay interval (t_{POR}) goes to “H” level. During the interval between the VCC drop and XRST terminal return to “H” level the VBDET1 terminal and VBDET2 terminal are in undefined state. Also once the XRST terminal returns to “H” level the VBDET1 terminal is at “H” level and the VBDET2 terminal is at “L” level. At this time, if the DRST terminal (pin 5) goes to “H” level, the VBDET2 terminal goes to “H” level. Note that the DRST terminal must be at “H” level for at least an interval of 10 µs.

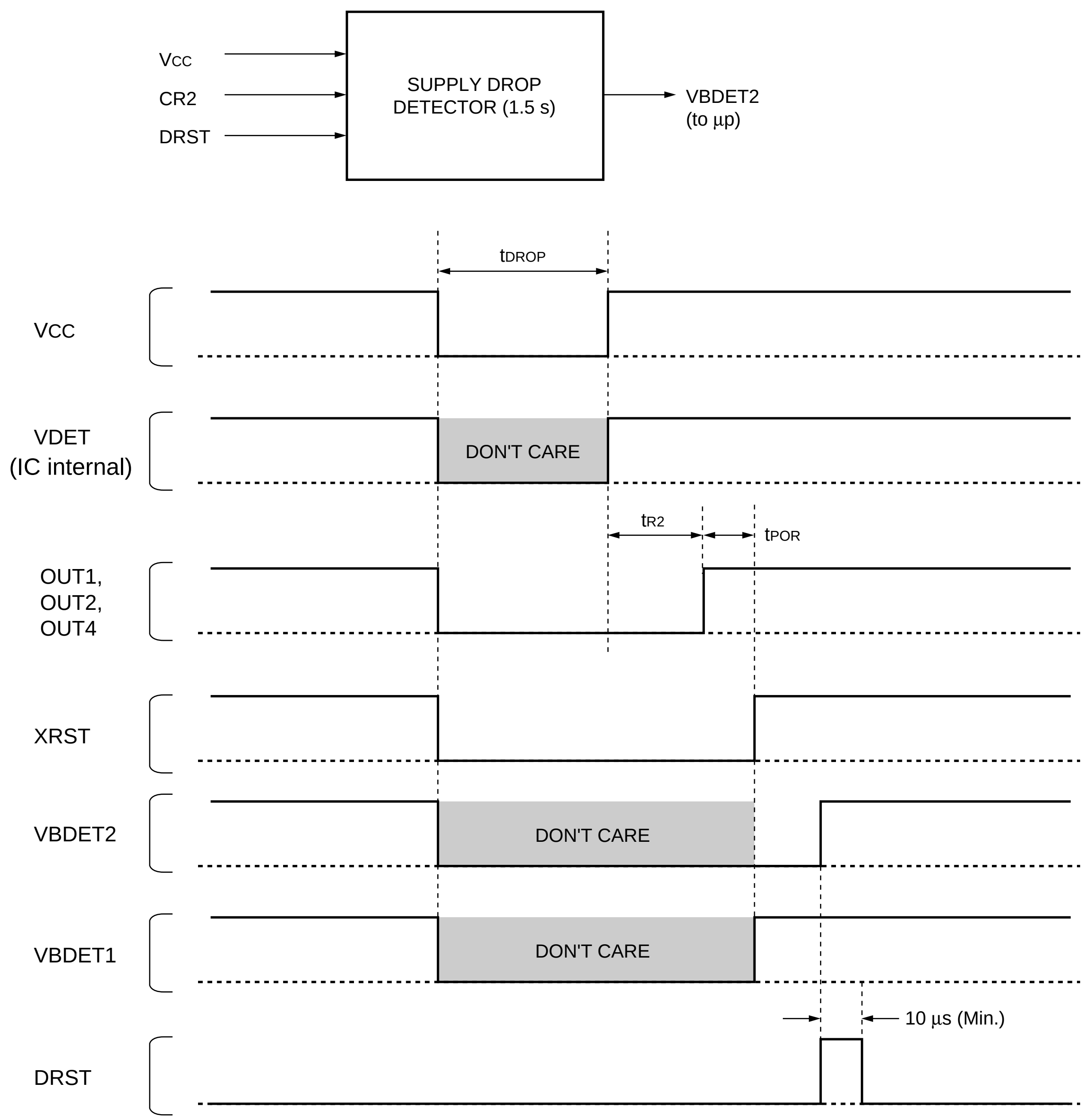
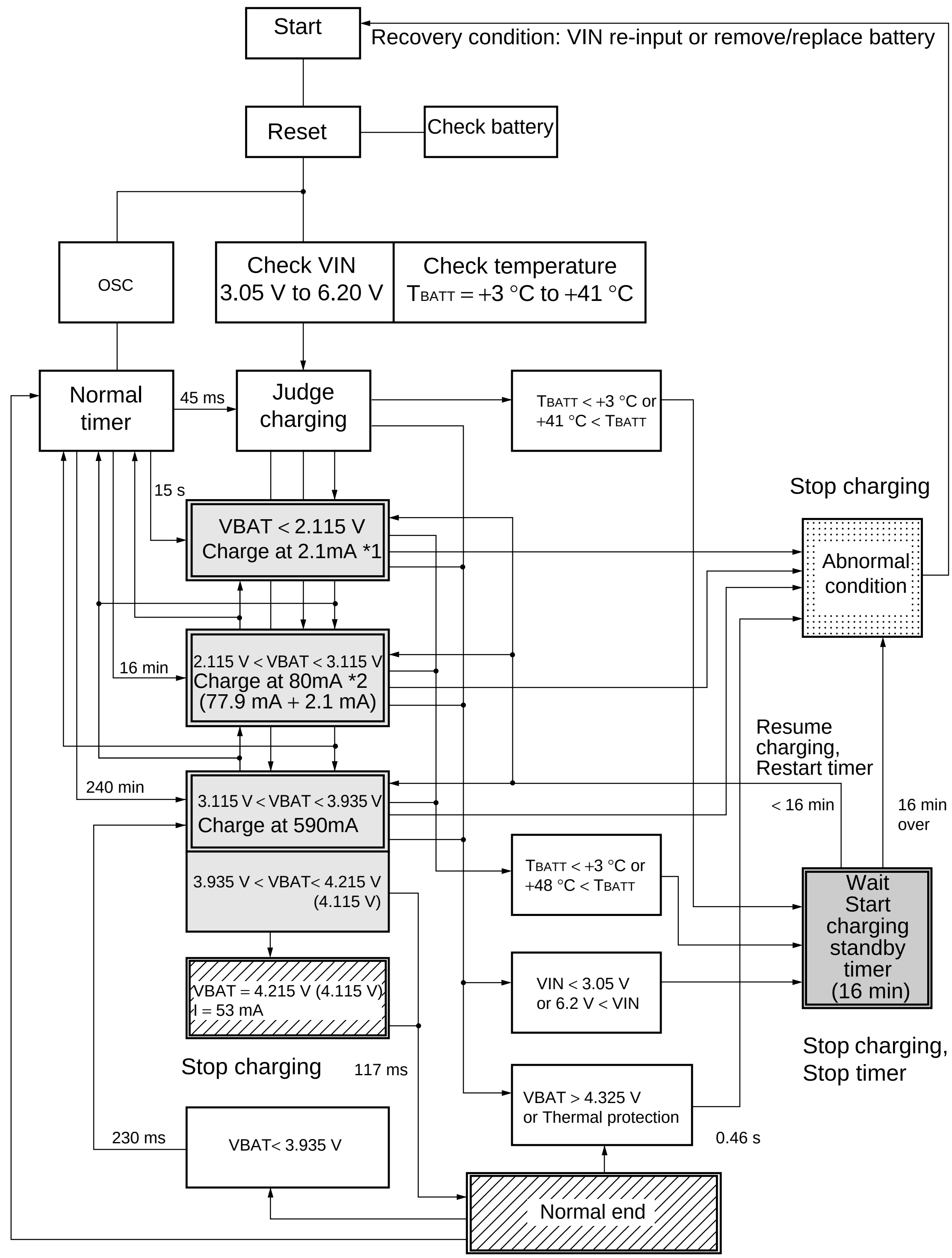


Figure 9. Power Supply Drop Detector 2 (Initial power supply detector/Power supply drop detector)
c) t < 1.5 s

■ CHARGE CONTROL UNIT OPERATION FLOWCHART



TBATT: Battery temperature

*1 : The 2.1 mA current is supplied from the IC internally

*2 : The 80 mA current is supplied from the external P-ch MOSFET (77.9 mA) plus the IC internal current of 2.1 mA.

■ CHARGE CONTROL UNIT LED OPERATION TABLE

- **FULL, CHARGE, LEDR Operation Table**

Operating condition		Switch	Signal pin			
			FULL	CHARGE	LEDR	
		OUT1	ON	ON	ON	ON/OFF
		LEDEN	—	—	H	L
No operation	VIN OFF		H	H	—	—
	VIN ON, BATSENSE open		H	H	H	H
Over discharge recovery charging 2.1 mA			—	—	—	L
Preliminary charging 80 mA			H	L	H	L
Rapid charging 590 mA			H	L	H	L
Charging completed			L	H	H	H
3.935 V recharging			H	L	H	L
Temperature detection 3 °C or lower	2.1 mA		—	—	—	H
	80 mA		H	H	H	H
	590 mA		H	H	H	H
Temperature detection 41 °C or 48 °C or greater	2.1 mA		—	—	—	H
	80 mA		H	H	H	H
	590 mA		H	H	H	H
VIN Low < 3.05 V VCC < VIN	2.1 mA		—	—	—	H
	80 mA		H	H	H	H
	590 mA		H	H	H	H
VIN High > 6.20 V	2.1 mA		—	—	—	H
	80 mA		H	H	H	H
	590 mA		H	H	H	H
Battery abnormal	15 s Time out		—	—	—	L↔H
	16 min Time out		H	L↔H	H	L↔H
	VCC < 3.935 V 240 min Time out		H	L↔H	H	L↔H
	VCC > 3.935 V 240 min Time out		L	H	H	H
	VCC > 4.325 V		H	L↔H	H	L↔H

LEDR, CHARGE = L↔H : Blinking, LEDR = L : ON, H : OFF
LEDEN, FULL, CHARGE : Power supply is OUT1, therefore undefined when OUT1 = OFF.
OUT1=OFF during over discharge recovery charging (2.1 mA) and 15 s time out

• **LEDG Operation Table**

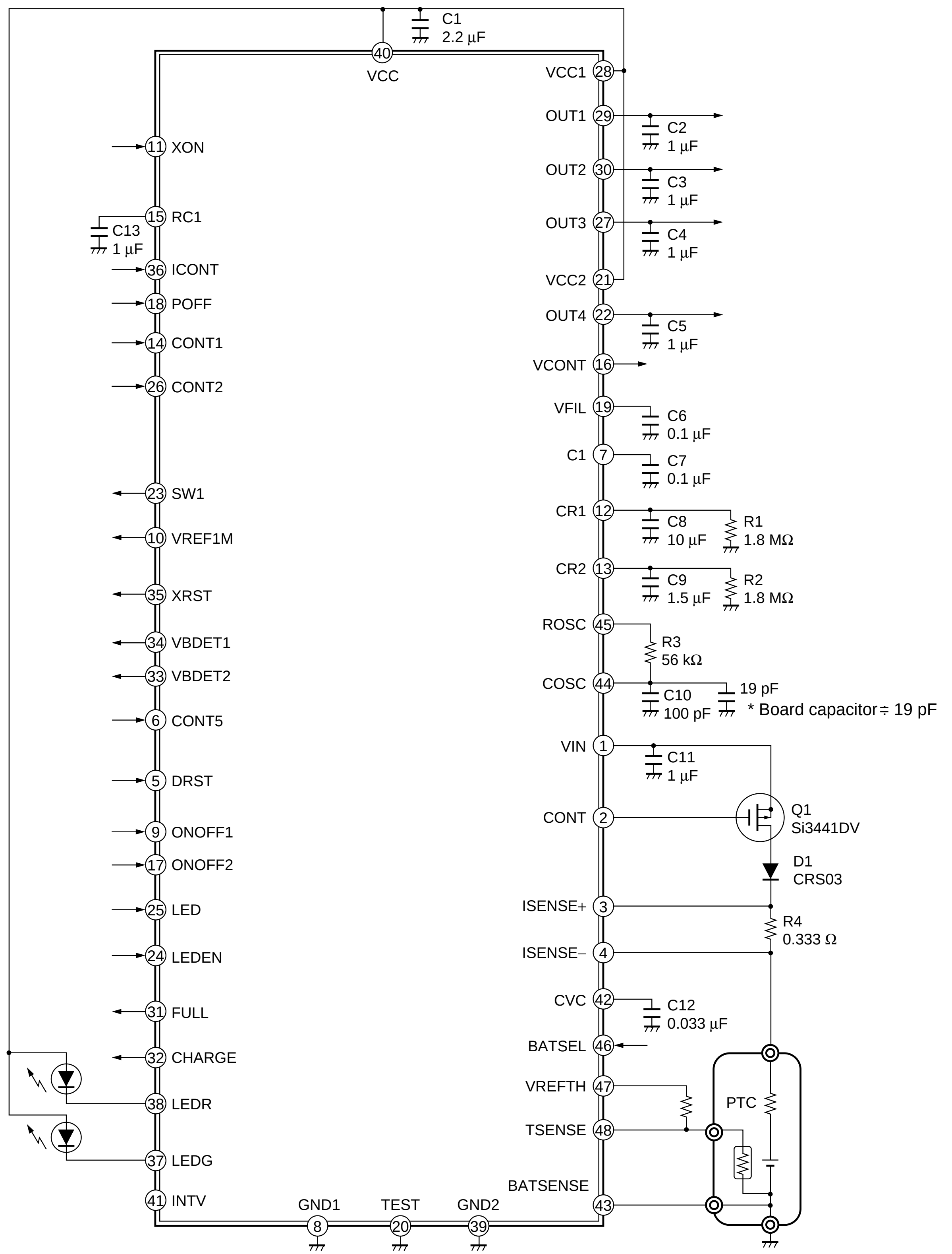
LED	LEDG
L	H
H	L

LEDG = L : ON, H : OFF
LED, LEDG: Power supply is OUT1, therefore undefined when OUT1 = OFF.

■ ABOUT CAPACITOR CONNECTED TO VCC PIN

When the VCC voltage exceeds 2.75 V (Typ.), the VCONT terminal (pin 16) goes to “H” level, and the OUT1 (pin 29), OUT2 (pin 30), and OUT4 (pin 22) terminals rise. When each of these respective OUT terminals rises, a rush current flows to the capacitor connected to that OUT terminal. At this time the internal impedance of the battery causes VCC to drop, and if VCC voltage goes below 2.5 V (Typ.), the OUT terminal voltage regurns to “L” level (regulator OFF mode).t is necessary to set the capacitor connected between VCC and GND taking into consideration the internal impedance of the battery, so that the VCC drop does not go below 2.5 V.

■ APPLICATION EXAMPLE



Si3441DV : VISHAY Intertechnology, Inc.
CRS03 : TOSHIBA CORPORATION

■ USAGE PRECAUTIONS

1. Never use settings exceeding maximum rated conditions.

Exceeding maximum rated conditions may cause permanent damage to the LSI.
Also, it is recommended that recommended operating conditions be observed in normal use.
Exceeding recommended operating conditions may adversely affect LSI reliability.

2. Use this device within recommended operating conditions.

Recommended operating conditions are values within which normal LSI operation is warranted. Standard electrical characteristics are warranted within the range of recommended operating conditions and within the listed conditions for each parameter.

3. Printed circuit board ground lines should be set up with consideration for common impedance.

4. Take appropriate static electricity measures.

- Containers for semiconductor materials should have anti-static protection or be made of conductive material.
- After mounting, printed circuit boards should be stored and shipped in conductive bags or containers.
- Work platforms, tools, and instruments should be properly grounded.
- Working personal should be grounded with resistance of 250 kΩ to 1 MΩ between body and ground.

5. Do not apply negative voltages.

The use of negative voltages below –0.3 V may create parasitic transistors on LSI lines, which can cause abnormal operation.

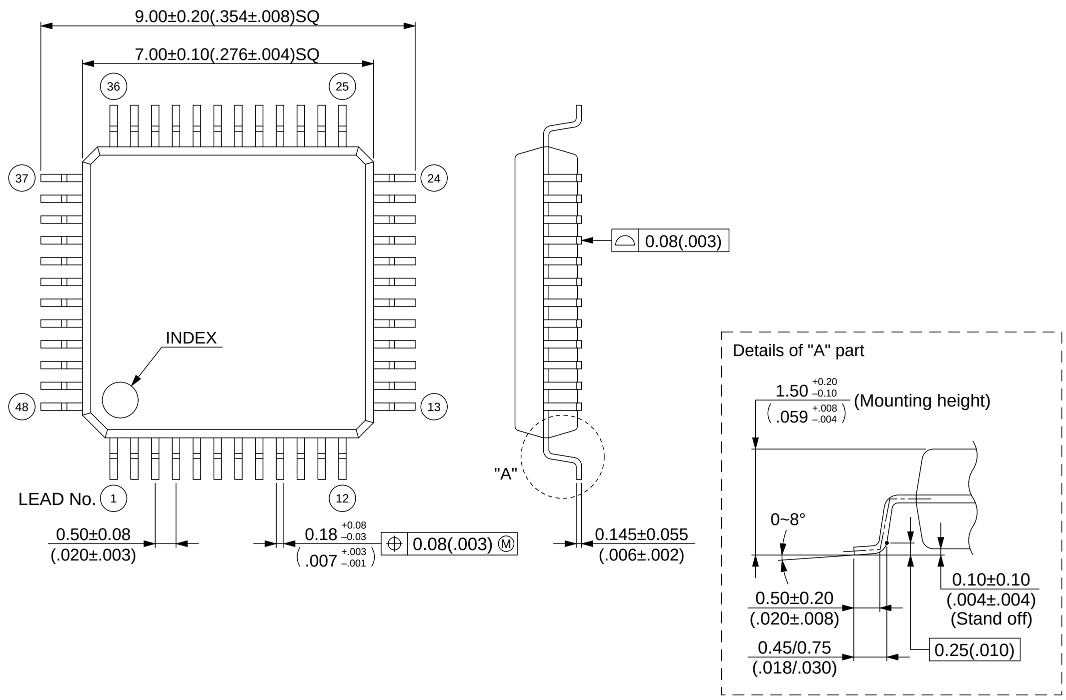
■ ORDERING INFORMATION

Part number	Package	Remarks
MB3893APFV	48-pin plastic LQFP (FPT-48P-M05)	
MB3893APFT	48-pin plastic TQFP (FPT-48P-M24)	

■ PACKAGE DIMENSIONS

48-pin plastic LQFP
(FPT-48P-M05)

Note: Pins width and pins thickness includes plating thickness.

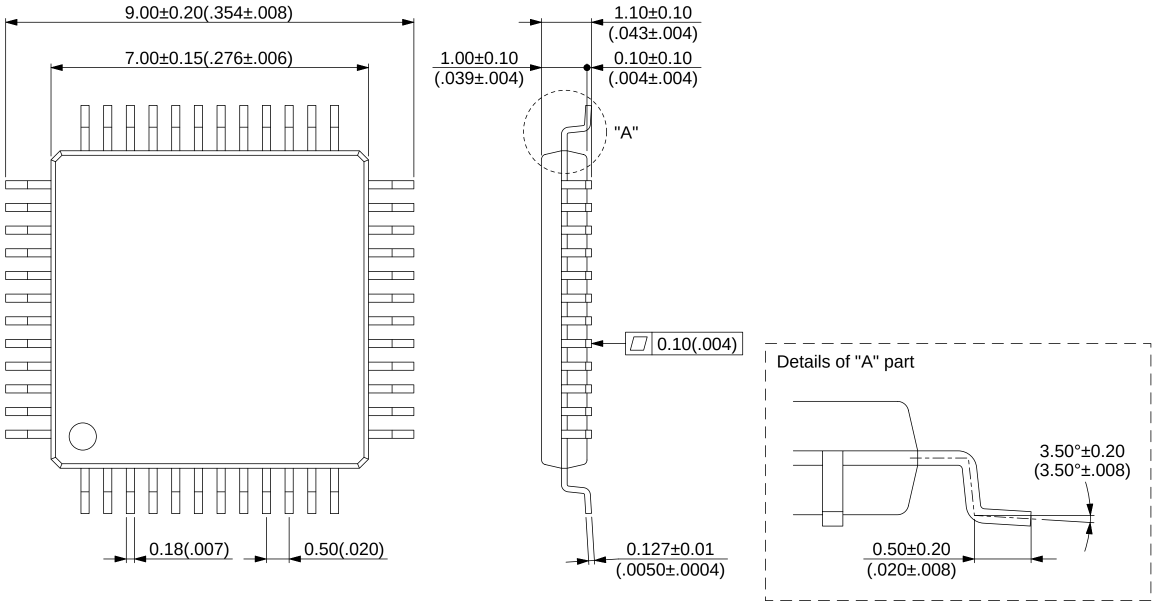


Dimensions in mm (inches)

(Continued)

(Continued)

48-pin plastic TQFP
(FPT-48P-M24)



Dimensions in: mm (inches)

FUJITSU LIMITED

For further information please contact:

Japan

FUJITSU LIMITED
Corporate Global Business Support Division
Electronic Devices
Shinjuku Dai-Ichi Seimei Bldg. 7-1,
Nishishinjuku 2-chome, Shinjuku-ku,
Tokyo 163-0721, Japan
Tel: +81-3-5322-3347
Fax: +81-3-5322-3386

http://edevice.fujitsu.com/

North and South America

FUJITSU MICROELECTRONICS, INC.
3545 North First Street,
San Jose, CA 95134-1804, U.S.A.
Tel: +1-408-922-9000
Fax: +1-408-922-9179

Customer Response Center
Mon. - Fri.: 7 am - 5 pm (PST)
Tel: +1-800-866-8608
Fax: +1-408-922-9179

http://www.fujitsumicro.com/

Europe

FUJITSU MICROELECTRONICS EUROPE GmbH
Am Siebenstein 6-10,
D-63303 Dreieich-Buchschlag,
Germany
Tel: +49-6103-690-0
Fax: +49-6103-690-122

http://www.fujitsu-fme.com/

Asia Pacific

FUJITSU MICROELECTRONICS ASIA PTE. LTD.
#05-08, 151 Lorong Chuan,
New Tech Park,
Singapore 556741
Tel: +65-281-0770
Fax: +65-281-0220

http://www.fmap.com.sg/

Korea

FUJITSU MICROELECTRONICS KOREA LTD.
1702 KOSMO TOWER, 1002 Daechi-Dong,
Kangnam-Gu,Seoul 135-280
Korea
Tel: +82-2-3484-7100
Fax: +82-2-3484-7111

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