FP9929A

Integrated Multi-Channel DC-DC Converters for Panels

Description

The FP9929A offers a compact power supply solution to provide all voltages required by EPD panel. The FP9929A includes 2 high performance PFM DC-DC converters, one is for positive voltage and the other is for negative voltage used by EPD drivers, a VCOM buffer (unity-gain OPA), a positive charge pump and a negative charge pump to provide adjustable regulated output voltages.

The converters provide the regulated positive and negative supply voltage for the panel source driver ICs.

The positive charge pump controller provides regulated EPD gate-on voltage. The negative charge pump controller provides regulated EPD gate-off voltage.

Accurate back-plane biasing is provided by a linear amplifier and can be adjusted either by an external resistor or the I^2C interface. The VCOM driver can source or sink current depending on panel condition. For automatic VCOM adjustment in production line, VCOM can be set from -0.6V to -5V with 8 bit control through the serial interface.

The FP9929A provides precise temperature measurement function to monitor the panel temperature during operation.

Pin Assignments

Package (TQFN-32)(5mm×5mm)

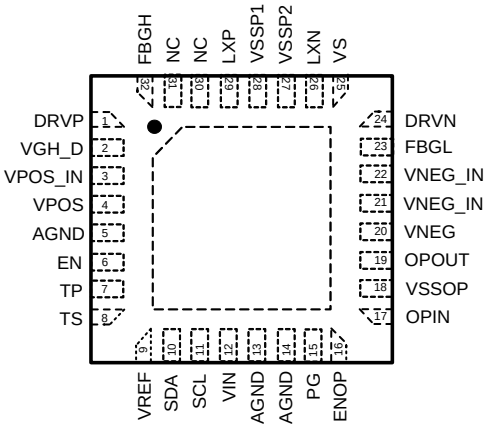


Figure 1. Pin Assignment of FP9929A

Features

- High Efficiency
- Low Power Consumption
- 2.7V to 5.5V Input Supply Voltage
- I^2C Serial Interface
- Over-Temperature Protection

DC-DC Converters

- Fast Transient Response to Pulsed Load
- Built-In 20V, 5A, 0.25Ω MOSFET
- Built-In Soft-Start
- Over-Current Protection

LDO Regulator

- Built-In ±15V LDO with ±0.15V accuracy for Source Driver Supply

Adjustable VCOM Driver for Accurate Panel-Backplane Biasing

- -0.6V to -5V
- 8-bit Control

Regulated Charge Pumps

- Charge Pump for VGH Regulation
- Charge Pump for VGL Regulation
- TQFN-32 (5mm×5mm) Package
- RoHS Compliant

Thermistor Monitoring

- -10°C to +85°C Temperature Range
- ±3°C Accuracy from 0°C to 50°C (IC=25°C)

Applications

- Electro-Phoretic Display (EPD) Panel
- E-Book
- P-DVD
- CAR TV

Ordering Information

FP9929A□

Package Type
WB: TQFN-32 (5mm×5mm)

Typical Application Circuit

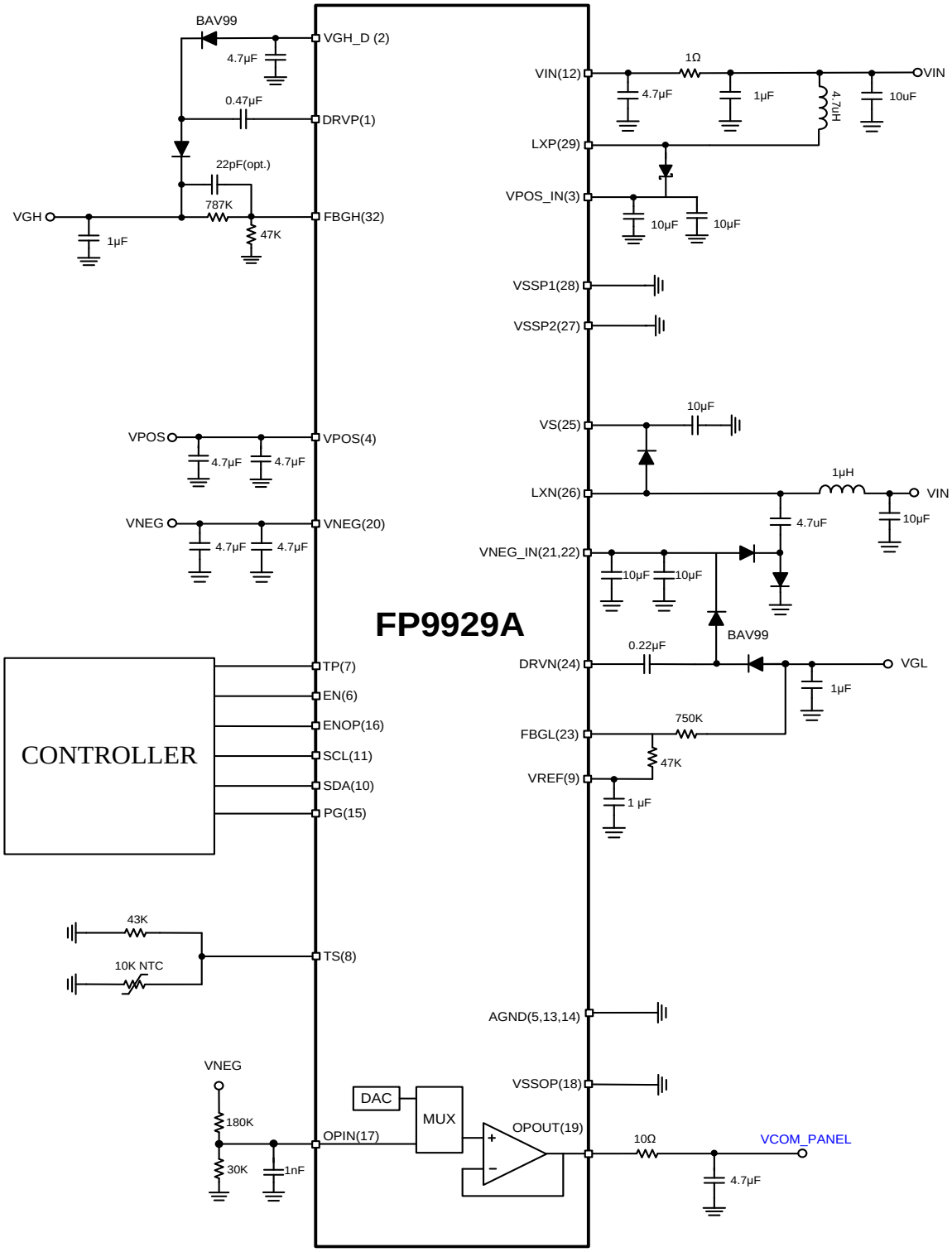


Figure 2. Typical Application Circuit of FP9929A

Functional Pin Description

Pin Name	Pin No.	Pin Function
DRVP	**1**	Switching Pin. Driver for the positive charge pump.
VGH_D	**2**	Base voltage output pin for positive charge pump.
VPOS_IN	**3**	Input pin for VPOS(LDO)
VPOS	**4**	Positive supply output pin.
AGND	**5**	Analog GND
EN	**6**	Enable Pin of Whole CHIP
TP	**7**	Test pin for testing, please do not connect to any signal.
TS	**8**	Thermistor input pin. Connect a 10K NTC thermistor and a 43K linearization resistor between this pin and system GND.
VREF	**9**	Internal Reference Bypass Terminal.
SDA	**10**	Serial interface (I2C) data input/output.
SCL	**11**	Serial interface (I2C) clock input.
VIN	**12**	Power Supply Input. The supply voltage powers all the control circuits.
AGND	**13**	Analog GND
AGND	**14**	Analog GND
PG	**15**	Power Good singal
ENOP	**16**	Enable Pin of Unity-Gain Operational Amplifier, active when EN is high.
OPIN	**17**	Unity-Gain Operational Amplifier Input Pin.
VSSOP	**18**	Positive Supply of Unity-Gain Operational Amplifier.
OPOUT	**19**	Unity-Gain Operational Amplifier Output Pin.
VNEG	**20**	Negative Source Driver Power, also ground of op-amp.
VNEG_IN	**21**	Input pin for LDO (VNEG).
VNEG_IN	**22**	Input pin for LDO (VNEG).
FBGL	**23**	Voltage Feedback to Determine Negative Charge Pump Output Voltage. FBGL is regulated to 0V.
DRVN	**24**	Switching Pin. Driver for the negative charge pump.
VS	**25**	Regulated voltage for internal circuit
LXN	**26**	Switching Pin.Drain of the internal power NMOS for the negative regulator.
VSSP2	**27**	Power Ground. VSSP2 is the source of negative boost converter power NMOS.

VSSP1	**28**	Switching Pin. Drain of the internal power NMOS for the positive regulator.
LXP	**29**	Power Ground. VSSP1 is the source of positive or Inverting boost converter power NMOS.
NC	**30**	Reserved.
NC	**31**	Reserved.
FBGH	**32**	Base voltage output pin for positive charge pump.

Block Diagram

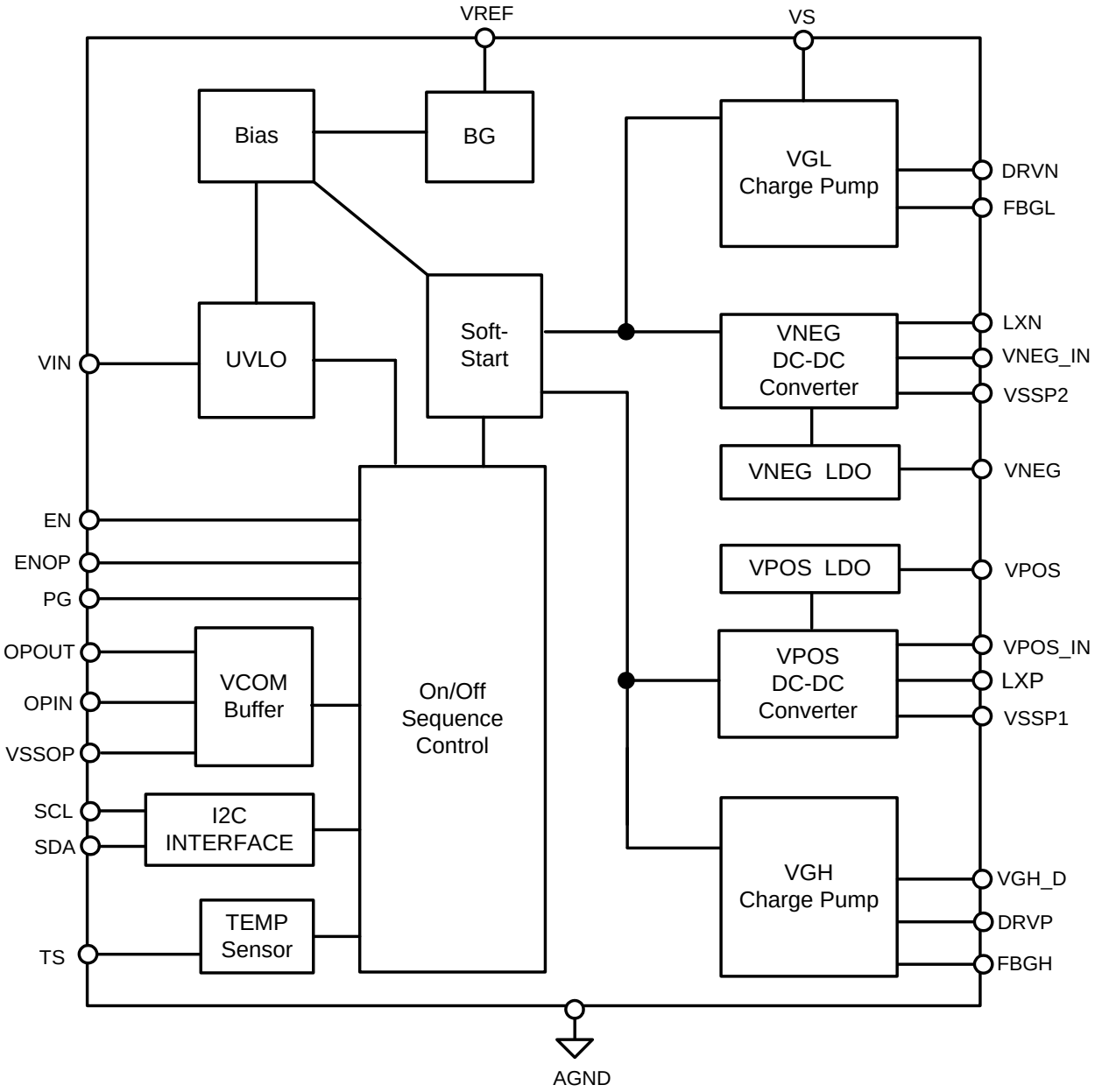


Figure 3. Block Diagram of FP9929A

Absolute Maximum Ratings

- DRVP, DRVN, LXP, LXN, VPOS_IN, VPOS, VGH_D, VS ---------- -0.3V to +22V
- FBGH, TP, TS, VIN, VREF, FBGL, ---------- -0.3V to +6V
- SCL, SDA, EN, ENOP, PG ---------- -0.3V to +6V
- VNEG_IN, VNEG, OPIN, OPOUT ---------- -24V to +0.3V
- VSSP1, VSSOP2, VSSOP ---------- -0.3V to +0.3V
- Power Dissipation @T_A=25°C, (P_D)

  TQFN-32 (5mm×5mm) ---------- 2.3W
- Package Thermal Resistance, (θ_{JA})

  TQFN-32 (5mm×5mm) ---------- 36°C/W
- Lead Temperature (Soldering, 10sec.) ---------- +260°C
- Maximum Junction Temperature (T_J) ---------- +150°C
- Storage Temperature (T_{STG}) ---------- -65°C to +150°C

Note：Stresses beyond those listed under “Absolute Maximum Ratings" may cause permanent damage to the device.

Recommended Operating Conditions

- Supply Voltage (VIN) ---------- +2.7V to +5.5V
- Operating Junction Temperature Range ---------- -40°C to +85°C

Electrical Characteristics

(V_{IN}=3.7V, typical values are at T_A=25°C, unless otherwise specified)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
System Supply						
Input Voltage Range	V_{IN}		2.7	3.7	5.5	V
V_{IN} UVLO Threshold	V_{UVLO}	V_{IN} Rising	-	2.5	-	V
		Hysteresis	-	0.2	-	
V_{IN} Supply Current	I_{IN}		-	1.5	-	mA
V_{IN} Shutdown Current	I_{SD}		-	0.1	1	μA
REF Output Voltage	V_{REF}		1.225	1.25	1.275	V
Thermal Shutdown Threshold	T_{SD}		-	140	-	°C
		Hysteresis	-	20	-	°C
Boost Regulator						
NMOS Switch ON-Resistance	R_{ONNMOS}		-	0.25	-	Ω
NMOS Switch Current Limit	$I_{LIMNMOS}$		-	5	-	A
NMOS Switch Leakage Current	I_{LXNMOS}	V_{LXP}=18V	-	0.1	-	μA
VPOS LDO						
Input Voltage Range	V_{POS_IN}			17		V
Output Voltage Range	V_{POS}		14.7	15	15.3	V
Current Limit	I_{LIMIT}		200	--	--	mA
Inverting Regulator						
NMOS Switch ON-Resistance	R_{ONNMOS}		-	0.25	-	Ω
NMOS Switch Current Limit	$I_{LIMNMOS}$		-	5	-	A
Switch Leakage Current	I_{LXNMOS}	V_{LXN}=18V	-	0.1	-	μA
VNEG LDO						
Input Voltage Range	V_{NEG_IN}			-17		V
Output Voltage Range	V_{NEG}		-15.3	-15	-14.7	V
Current Limit	I_{LIMIT}		200	--	--	mA

Electrical Characteristics

(V_{IN}=3.7V, typical values are at T_A=25°C, unless otherwise specified)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
VCOM Buffer						
Accuracy	V_{COMACC}	VCOM_SET[7:0]=0x74h(-2.5V) VIN=3.7V, No load	-1.5		1.5	%
Output voltage range	V_{COM}		-5		-0.6	V
Resolution	V_{RES}	VCOM_ADJ=1, 1 LSB	-	22	--	mV
VCOM Gain (OPOUT/OPIN)	V_G	VCOM_ADJ=0	-	1	--	V/V
POSITIVE CHARGE PUMP						
Input Voltage Range				17		V
Postive Feedback Voltage	V_{FBGH}		--	1.25	--	V
VFB Accuracy	V_{FBGHA}		-2		2	%
Output voltage range	VGH		20		30.5	V
DP ON-R High	$R_{DS(ON)}$		--	5	--	Ω
DP ON-R LOW	$R_{DS(ON)}$		--	3	--	Ω
NEGATIVE CHARGE PUMP						
Input Voltage Range				-17		V
Negative Feedback Voltage	V_{FBGL}		--	0	--	V
VFB Accuracy	V_{FBGLA}		-40		40	mV
Output voltage range	VGL		-25		-20	V
DN ON-R High	$R_{DS(ON)}$		--	5	--	Ω
DN ON-R LOW	$R_{DS(ON)}$		--	3	--	Ω

Electrical Characteristics

(V_{IN}=3.7V, typical values are at T_A=25°C, unless otherwise specified)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
LOGIC LEVELS AND TIMING CHARACTERISTIC (SCL, SDA)						
Input Low Threshold Level	V_{IL}		-	-	0.4	V
Input High Threshold Level	V_{IH}		1.2	-	-	V
Output Low Threshold Level	V_{OL}	I_O=3mA, Sink Current.	-	-	0.4	V
SCL Clock Frequency	f_{SCL}		-	-	400	kHz
Thermal Sensor (Note 1)						
Offset	OffsetTMS	Temperature = 25°C	-	1.18	-	V
Maximum Input Level	VTMS_MAX		-	2.25	-	V
Internal Pull Up Resistor	RNTC_UP		-	7.307	-	KΩ
External Linearization Resistor	RLINEAR		-	43	-	KΩ

Note 1: 10KΩ Murata NCP18XH103F03RB thermistor (1%) in parallel with a linearization resistor (43kΩ, 1%) are used at TS pin for panel temperature measurement.

Power On Sequence

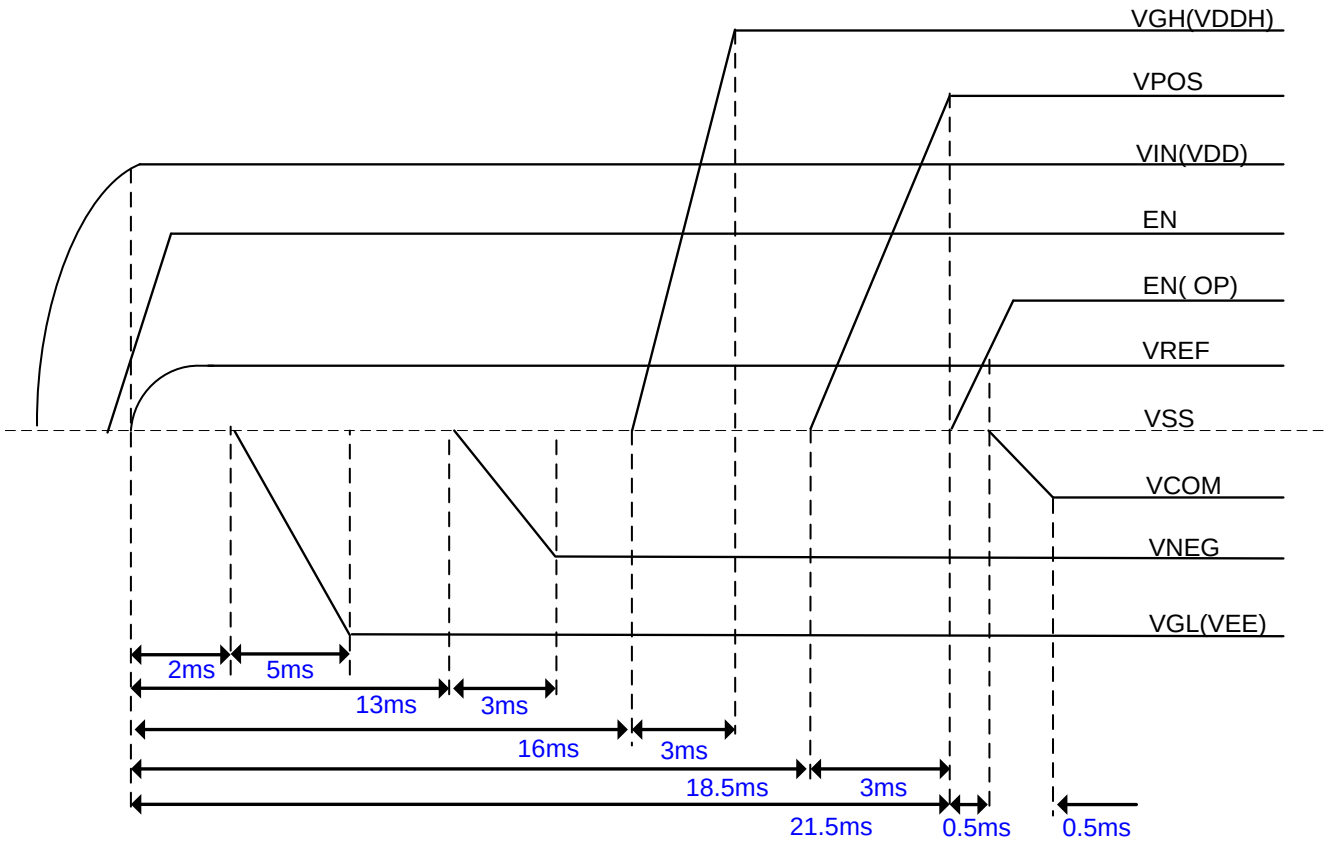


Figure 4. Power-on Sequence

Power Off Sequence

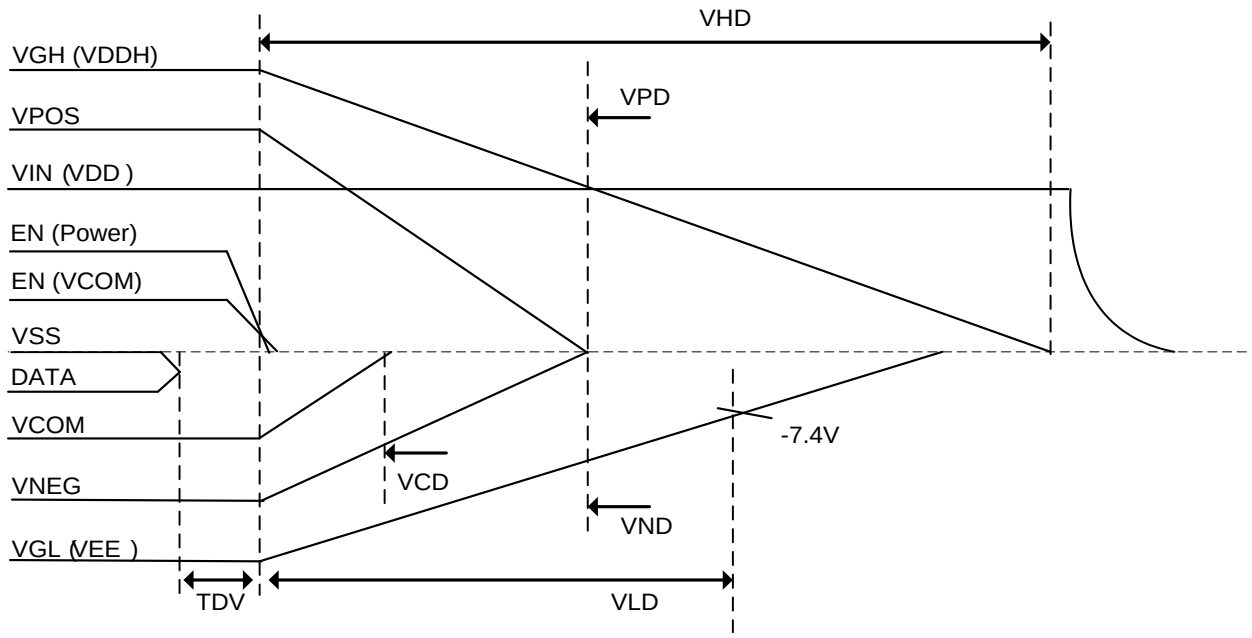


Figure 5. Power-Off Sequence

Variables	Min	max	Remark
TDV	100us	-	
VHD	0s	-	
VPD	0s	-	
VND	0s	-	
VCD	0s	-	
VLD	500ms	-	Discharge point at -7.4V

I2C Address

The IC is a slave-only device and responds to the 7-bit address 90h. A0 :1 indicating read(91h), and 0 indicating write(90h)

D7	D6	D5	D4	D3	D2	D1	D0
1	0	0	1	0	0	0	R/W

Register Address Map

Register	Address (Hex)	Name	*Default Value*	Description
0	0x00	TMST_VALUE	N/A	Thermistor value read by ADC
1	0x01	FUNC_ADJUST	0000 0001	Vcom output adjustment method and I^2C read pointer control
2	0x02	VCOM_SETTING	0111 0100	Voltage setting for Vcom

THERMISTOR READOUT (TMST_VALUE)
Address – 0x00h

Data Bit	D7	D6	D5	D4	D3	D2	D1	D0
Field Name	TMST_VALUE [7:0]							
Read/Write	R	R	R	R	R	R	R	R
Reset Value	NA	NA	NA	NA	NA	NA	NA	NA

Field Name	Bit Definition
TMST_VALUE [7:0]	Temperature read-out 1111 0110 – < -10°C 1111 0110 – -10°C 1111 0111 – -9°C --- 1111 1110 – -2°C 1111 1111 – -1°C 0000 0000 – 0°C 0000 0001 – 1°C 0000 0010 – 2°C --- 0001 1001 – 25°C --- 0101 0101 – 85°C 0101 0101 – > 85°C

VCOM ADJUSTMENT METHOD and I^{2}C read pointer control (FUNC_ADJUST)

Address – 0x01h

Data Bit	D7	D6	D5	D4	D3	D2	D1	D0
Field Name	Not Used							VCOM_ADJ[0]
Read/Write	R	R	R	R	R	R	R	R./W
Reset Value	NA	NA	NA	NA	NA	NA	NA	1

Field Name	Bit Definition
VCOM_ADJ	VCOM output adjustment method 0 – OPIN pin **1 – I^{2}C interface (Default)**

VCOM ADJUSTMENT (VCOM_SETTING)

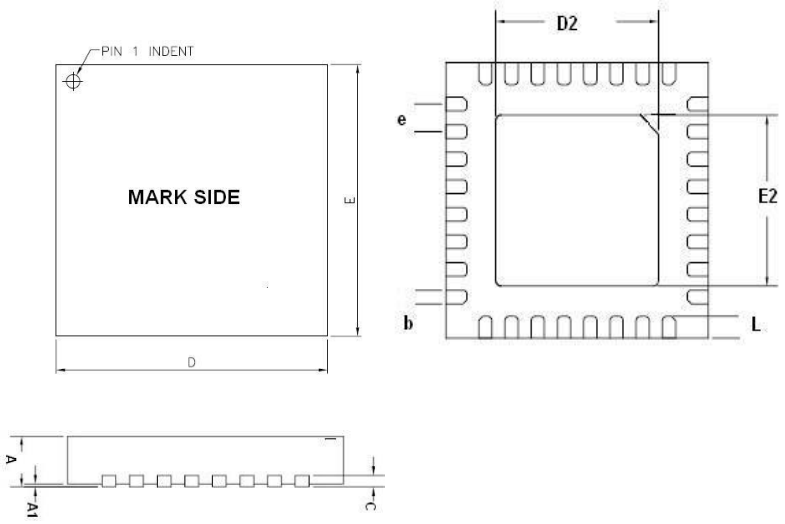
Address – 0x02h

Data Bit	D7	D6	D5	D4	D3	D2	D1	D0
Field Name	VCOM_SET[7:0]							
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset Value	0	1	1	1	0	1	0	0

VCOM DAC	Seting Voltage	VCOM DAC	Seting Voltage	VCOM DAC	Seting Voltage
00H	Reserved	....	....	....	....
01H	Reserved	....	....	....	....
02H	Reserved	....	....	....	....
03H	Reserved	....	....	E8H	-5002mV
04H	Reserved	....	....	....	Reserved
05H	Reserved	....	....	....	Reserved
06H	Reserved	....	....	....	Reserved
07H	Reserved	73H	-2478mV	....	Reserved
08H	Reserved	**74H**	**-2500mV**	....	Reserved
18H	Reserved	75H	-2522mV	....	Reserved
19H	Reserved	....	....	....	....
1CH	-604mV	....	....	....	....
1DH	-626mV	....	....	....	Reserved
1EH	-648mV	....	....	FE	Reserved

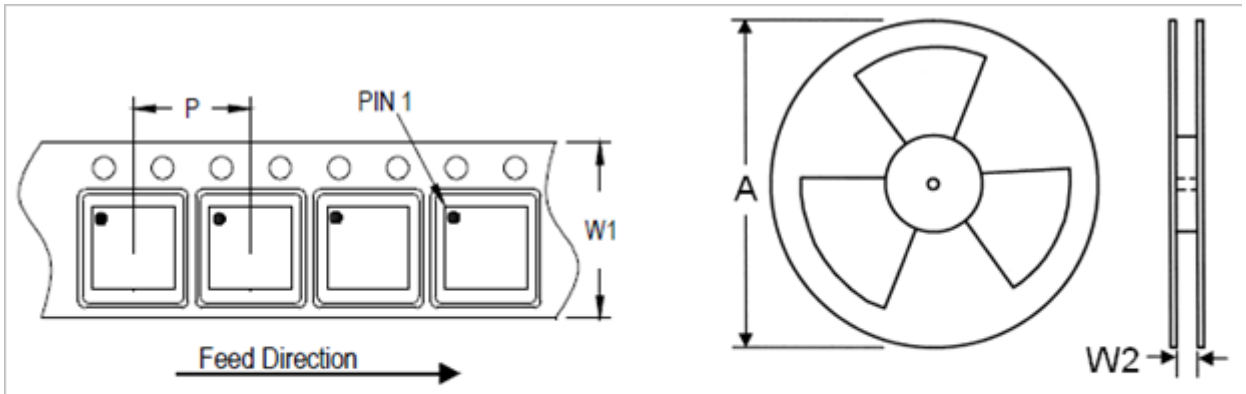
Outline Information

TQFN- 32 5mm×5mm (pitch 0.5mm)Package (Unit: mm)



SYMBOLS UNIT	DIMENSION IN MILLIMETER	
	MIN	MAX
A	0.70	0.80
A1	0.00	0.05
C	0.18	0.25
E	4.90	5.10
D	4.90	5.10
L	0.30	0.45
b	0.18	0.30
e	0.45	0.55
E2	3.10	3.30
D2	3.10	3.30

Carrier dimensions



Tape Size (W1) mm	Pocket Pitch (P) mm	Reel Size (A) in	Reel Size (A) mm	Reel Width (W2) mm	Empty Cavity Length mm	Units per Reel
12	8	13	330	12.4	400~1000	3,000