

LR3696

Power Supply IC for PIT LCD System

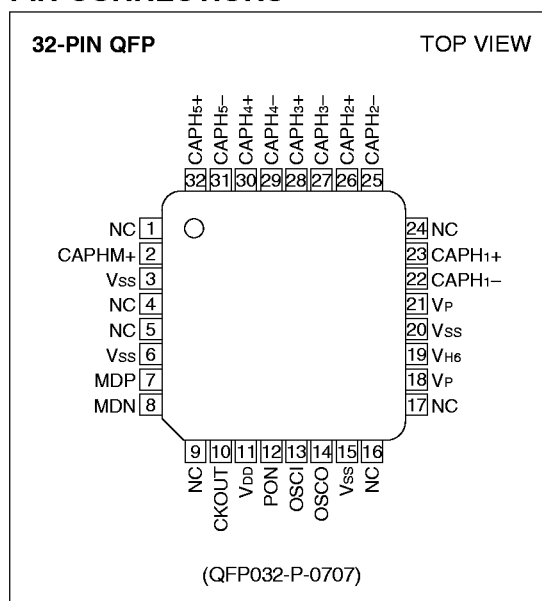
DESCRIPTION

The LR3696 is a power supply IC for driving an LCD system of personal information tools. It consists of a CMOS charge pump type six times positive booster circuit. It can generate the six times positive boosted voltage level with a single 3 V power supply. The LR3696 can also generate negative five times boosted voltage level with respect to V_{ss}, by connecting an external negative booster circuit. When combined with the LH155E segment driver with a built-in RAM, LH1537 common driver and LR3694 power supply IC, it can create a low power consuming LCD system suitable for a battery-operated portable information-oriented equipment.

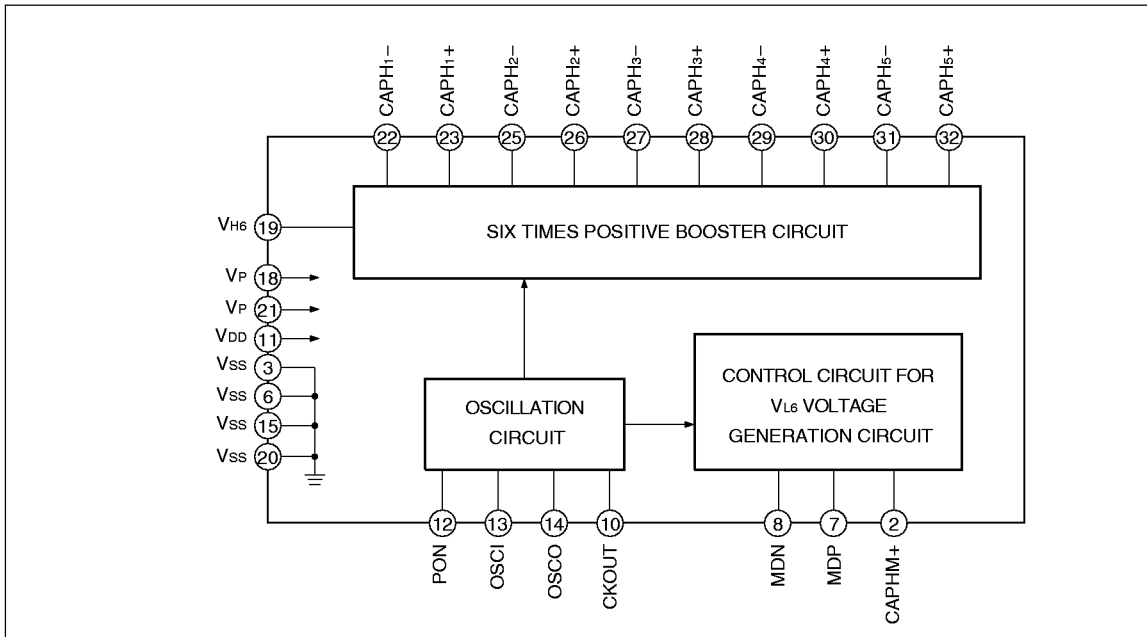
FEATURES

- Supply voltages : V_{DD}, V_P = +2.4 to +3.3 V
- Built-in CMOS charge pump type positive booster circuit (six times positive booster circuit)
- Possible to generate negative five times voltage level ($-5 \times V_P$) with respect to V_{ss} by connecting an external negative booster circuit
- Built-in power off function by external signal (PON)
- Built-in oscillation circuit for the positive booster clock signal (by external feedback resistor)
- Operating temperature : -30 to $+85$ °C
- Package : 32-pin QFP (QFP032-P-0707)

PIN CONNECTIONS



BLOCK DIAGRAM



PIN DESCRIPTION

Six Times Positive Booster Circuit Pins

SYMBOL	I/O	DESCRIPTION
CAPH1+	○	Used to connect the positive side of a capacitor for the internal positive booster circuit. A capacitor must be connected between this pin and CAPH1– pin.
CAPH1–	○	Used to connect the negative side of a capacitor for the internal positive booster circuit. A capacitor must be connected between this pin and CAPH1+ pin.
CAPH2+	○	Used to connect the positive side of a capacitor for the internal positive booster circuit. A capacitor must be connected between this pin and CAPH2– pin.
CAPH2–	○	Used to connect the negative side of a capacitor for the internal positive booster circuit. A capacitor must be connected between this pin and CAPH2+ pin.
CAPH3+	○	Used to connect the positive side of a capacitor for the internal positive booster circuit. A capacitor must be connected between this pin and CAPH3– pin.
CAPH3–	○	Used to connect the negative side of a capacitor for the internal positive booster circuit. A capacitor must be connected between this pin and CAPH3+ pin.
CAPH4+	○	Used to connect the positive side of a capacitor for the internal positive booster circuit. A capacitor must be connected between this pin and CAPH4– pin.
CAPH4–	○	Used to connect the negative side of a capacitor for the internal positive booster circuit. A capacitor must be connected between this pin and CAPH4+ pin.
CAPH5+	○	Used to connect the positive side of a capacitor for the internal positive booster circuit. A capacitor must be connected between this pin and CAPH5– pin.
CAPH5–	○	Used to connect the negative side of a capacitor for the internal positive booster circuit. A capacitor must be connected between this pin and CAPH5+ pin.
V _{H6}	○	Used as an output pin for six times positive boosted voltage. A capacitor must be connected between this pin and the V _{SS} pin.

Control Circuit Pins for V_{L6} Voltage Generation Circuit

SYMBOL	I/O	DESCRIPTION
MDP	○	Used as the control signal output pin for an external V _{L6} voltage generation circuit. This pin outputs the control clock signal for external V _{L6} voltage generation circuit.
MDN	○	Used as the control signal output pin for an external V _{L6} voltage generation circuit. This pin outputs the control clock signal for external V _{L6} voltage generation circuit.
CAPHM+	○	Used to connect the positive side of a capacitor for an external V _{L6} voltage generation circuit. A capacitor must be connected between this pin and external V _{L6} voltage generation circuit.

Power Supply Pins

SYMBOL	I/O	DESCRIPTION
V _{DD}	Power supply	Used as a power supply pin for the oscillation circuit and the control circuit for V _{LE} voltage generator circuit. This pin should be connected to +2.4 to +3.3 V. This pin must be connected to the V _P pin at the outside of this IC and supplied the same voltage of the V _P pin.
V _P	Power supply	Used as a power supply pin for the positive booster circuit. This pin should be connected to +2.4 to +3.3 V. This pin must be connected to the V _{DD} pin at the outside of this IC and supplied the same voltage of the V _{DD} pin.
V _{SS}	Power supply	Used as a ground pin, which must be connected to 0 V.

Pins for Oscillation Circuit and Power ON/OFF Control

SYMBOL	I/O	DESCRIPTION
OSCI	I	Used as an oscillation circuit input pin. (Feedback resistor must be inserted between this pin and the OSCO pin.)
OSCO	I/O	Used as an oscillation circuit input/output pin. (Feedback resistor must be inserted between this pin and the OSCI pin.)
PON	I	Used as an ON/OFF control input pin for the internal power supply circuit. PON = "H" : The oscillation circuit and the internal power supply circuit are active. PON = "L" : The oscillation circuit and the internal power supply circuit are not active.
CKOUT	O	Used as an oscillation clock signal output pin. This pin outputs the clock signal generated by the internal oscillation circuit.

INPUT/OUTPUT CIRCUITS

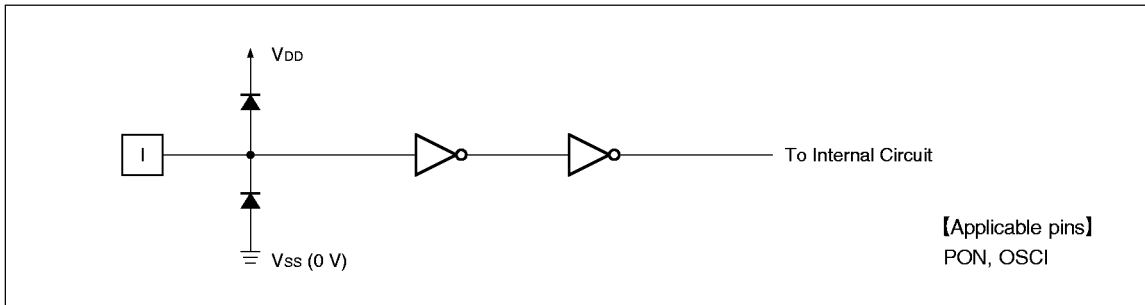


Fig. 1 Input Circuit

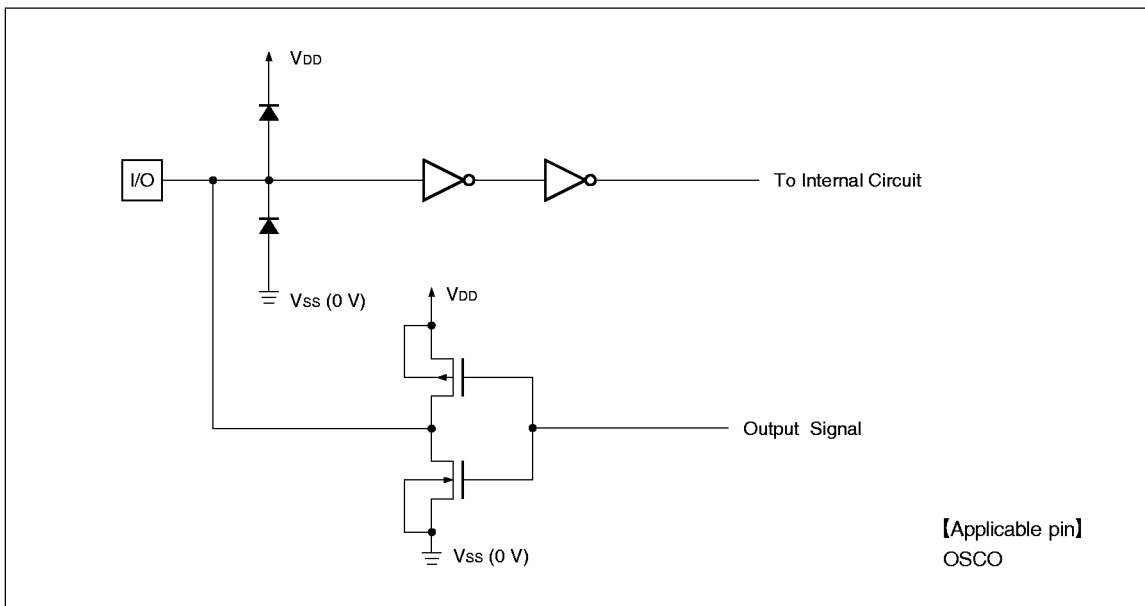


Fig. 2 Input/Output Circuit

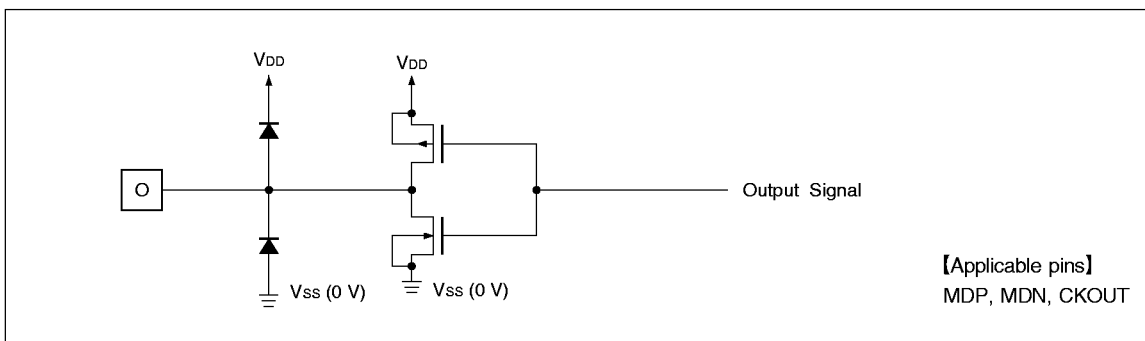


Fig. 3 Output Circuit

FUNCTIONAL DESCRIPTION

Six Times Positive Booster Circuit

With capacitors of C_1 set up between $CAPH_{1+}$ and $CAPH_{1-}$, between $CAPH_{2+}$ and $CAPH_{2-}$, between $CAPH_{3+}$ and $CAPH_{3-}$, between $CAPH_{4+}$ and $CAPH_{4-}$, between $CAPH_{5+}$ and $CAPH_{5-}$ and between V_{H6} and V_{SS} , a potential difference between V_P and V_{SS} is positive boosted by six times and then is output to V_{H6} pin.

The six times positive booster circuit is active when an oscillation circuit is active, that is a time when an input signal to PON pin is "H", because a clock signal generated by the oscillation circuit is used as the booster clock.

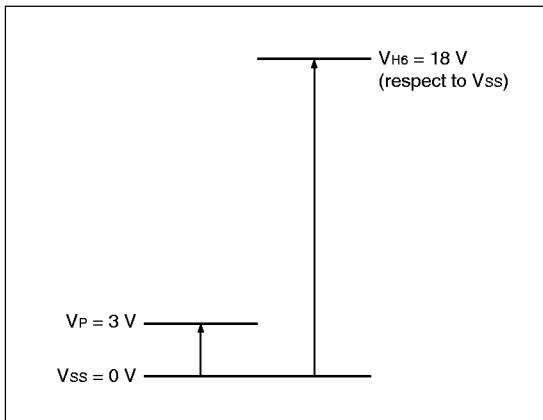


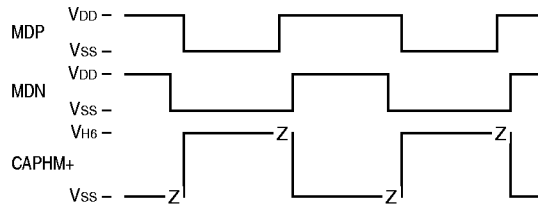
Fig. 4 Six Times Positive Booster Circuit

Control Circuit for V_{L6} Voltage Generation Circuit

This power supply IC with external negative booster circuit can generate a negative five times level V_{L6} with respect to V_{SS} .

Output waves of MDP , MDN and $CAPHM+$ pins are shown below. These signals are output to control the external negative booster circuit. Use these signals according to necessity in consideration for construction of the external negative booster circuit.

When $CAPHM+$ pin is used, connect it to the positive side of a capacitor pin of the external negative booster circuit.



Oscillation Circuit

This is a CR oscillation circuit with the external feedback resistor R_F . This circuit is used for generating clock signal of the positive booster circuit.

CKOUT pin outputs the clock signal that is generated by this oscillation circuit.

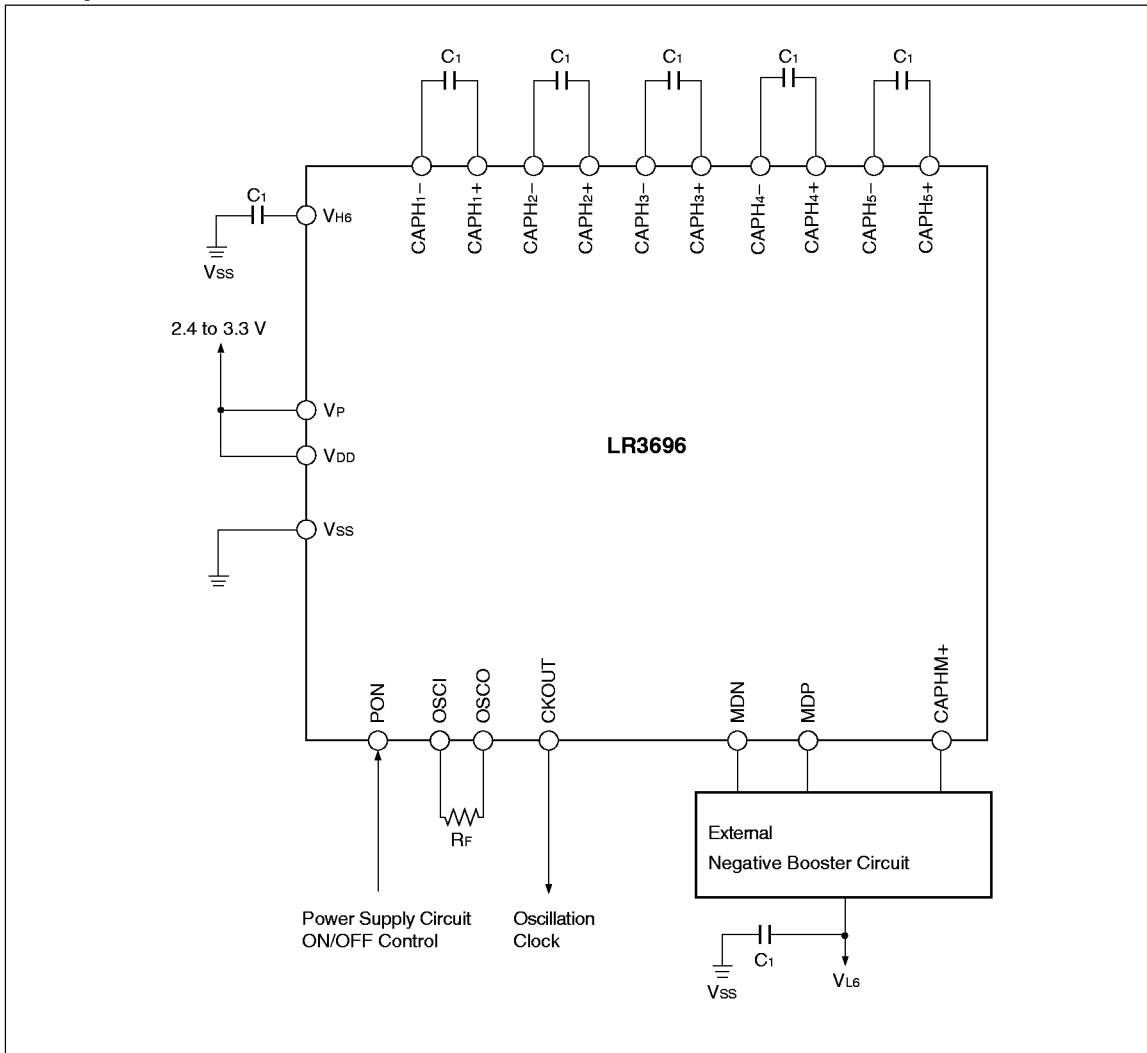
Power Supply Circuit ON/OFF Control

With control of the input voltage of PON pin, the states of the internal power supply circuit can be controlled. When the input level of PON pin is "L" level, the internal power supply circuit of the LR3696 is not active. When the input level of PON pin is "H" level, the internal power supply circuit of the LR3696 is active.

PARAMETER	CONDITION
V_{H6}	Output V_P level
MDP	Output V_{DD} level
MDN	Output V_{SS} level
CKOUT	Output V_{SS} level
Oscillation circuit	Not active
Positive booster circuit	Not active

Each shown condition with OFF state of the internal power supply circuit. (PON = "L")

Example of External Circuit Connection



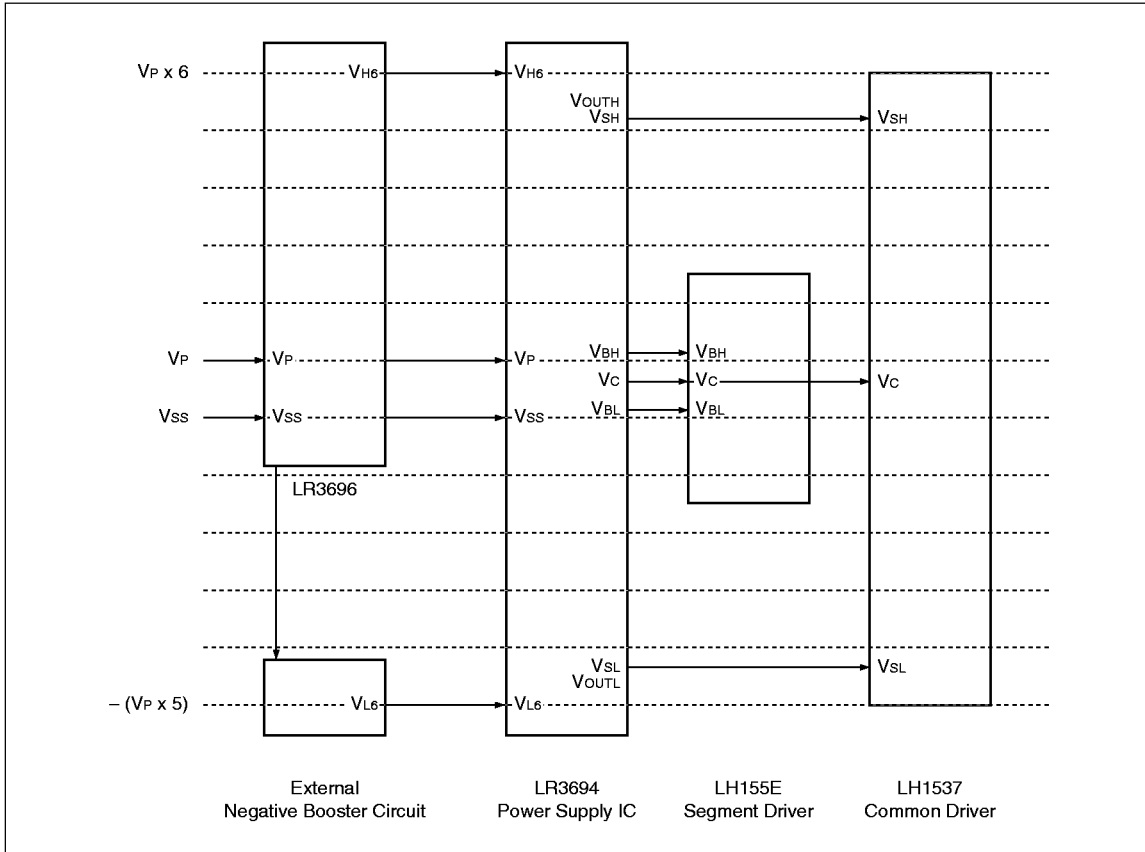
Recommended value (NOTE 1, 2)

C_1	4.7 μF
R_F	1.8 $M\Omega$

NOTES :

1. When selecting the external parts, select the suitable constants of the external parts to stabilize LCD drive voltage according to the LCD panel condition and the operation on the actual LCD system.
2. LR3696 can generate negative five times voltage of V_P with respect to V_{SS} with external circuits connected to pins of control signals (MDP , MDN , $CAPHM+$) for generation of V_{L6} level. Output timing of control signals for generation of V_{L6} level is shown in "Control Circuit for V_{L6} Voltage Generation Circuit" in Functional Description.

Relation of Each Voltage on A Display System



PRECAUTIONS

This power supply IC connected to external circuits can generate negative five times voltage level VL6 with respect to Vss. But when this IC changes from active state to inactive state with no discharge route of stabilizing capacitor, it is possible that the remaining charge maintain the VH6 level. Because

the remaining charge may exert a harmful influence on the LCD panel or other circuits, be sure to construct a discharge circuit that discharge the remaining charge on stabilizing capacitor and make a level of VL6 pin Vss level, only when the IC is not active.

ABSOLUTE MAXIMUM RATINGS

PARAMETER	SYMBOL	APPLICABLE PINS	RATING	UNIT	NOTE
Supply voltage (1)	VDD	VDD	-0.3 to +3.5	V	1, 2, 3
Supply voltage (2)	VP	VP	-0.3 to +3.5	V	
Input voltage	VI1	PON	-0.3 to VDD +0.3	V	
Storage temperature	TSTG		-45 to +125	°C	

NOTES :

1. TA = +25 °C
2. The maximum applicable voltage on any pin with respect to Vss (0 V).
3. Don't supply external voltage to the output pins and the pins that connect a capacitor for the positive booster circuit.

RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	APPLICABLE PINS	MIN.	TYP.	MAX.	UNIT	NOTE
Supply voltage	VDD	VDD	+2.4		+3.3	V	1
	VP	VP	+2.4		+3.3	V	
Operating temperature	TOPR		-30		+85	°C	

NOTE :

1. The applicable voltage on any pin with respect to Vss (0 V).

ELECTRICAL CHARACTERISTICS

(Unless otherwise specified, $V_{SS} = 0\text{ V}$, $V_{DD} = V_P = +2.4\text{ to }+3.3\text{ V}$, $T_{OPR} = -30\text{ to }+85\text{ }^\circ\text{C}$)

PARAMETER	SYMBOL	CONDITIONS	APPLICABLE PINS	MIN.	TYP.	MAX.	UNIT	NOTE
Input "Low" voltage	V_{IL}		PON	0		$0.2V_{DD}$	V	
Input "High" voltage	V_{IH}			$0.8V_{DD}$		V_{DD}	V	
Output "Low" voltage	V_{OL}	$I_{OL} = +0.4\text{ mA}$	MDN, MDP, CKOUT			+0.4	V	
Output "High" voltage	V_{OH}	$I_{OH} = -0.4\text{ mA}$		$V_{DD} - 0.4$			V	
Input leakage current	I_{LI}	$V_i = V_{SS}\text{ or }V_{DD}$	PON	-10		+10	μA	
Standby current (1)	I_{STB1}	$V_{DD} = V_P = 3\text{ V}$	V_{DD}			20	μA	1
Standby current (2)	I_{STB2}	$V_{DD} = V_P = 3\text{ V}$	V_P			20	μA	2
Oscillation frequency	f_{OSC}	$R_F = 1.8\text{ M}\Omega \pm 2\%$ $V_{DD} = 3\text{ V}$			59		kHz	3
Supply current (1)	I_{DD}	$V_{DD} = V_P = 3\text{ V}$ No-load	V_{DD}			30	μA	4
Supply current (2)	I_P	$V_{DD} = V_P = 3\text{ V}$ No-load	V_P			600	μA	5
Six times positive boosted output voltage	V_{OH6}	$V_{DD} = V_P = 3\text{ V}$ $I_{VH6} = 30\text{ }\mu\text{A}$	V_{H6}	$V_{H6} - 1.0$			V	6

NOTES :

- Current at V_{DD} pin on condition that oscillation circuit is not active and the internal power supply circuit is set OFF (PON = V_{SS}).
- Current at V_P pin on condition that oscillation circuit is not active and the internal power supply circuit is set OFF (PON = V_{SS}).
- Oscillation frequency on condition that feedback resistor ($R_F = 1.8\text{ M}\Omega$) is set between OSCI pin and OSCO pin.
- Supply current on condition that the internal power supply circuit is set ON (PON = "H"). CKOUT pin and V_{H6} pin are no-load. V_{L6} voltage generation circuit is not connected. (CAPHM+ pin, MDN pin and MDP pin are no-load.)
Measuring conditions :
 $R_F = 1.8\text{ M}\Omega$, $V_{DD} = V_P = 3\text{ V}$, $C_1 = 4.7\text{ }\mu\text{F}$
- Supply current on condition that the internal power supply circuit is set ON (PON = "H"). CKOUT pin and V_{H6} pin are no-load. V_{L6} voltage generation circuit is not connected. (CAPHM+ pin, MDN pin and MDP pin are no-load.)
Measuring conditions :
 $R_F = 1.8\text{ M}\Omega$, $V_{DD} = V_P = 3\text{ V}$, $C_1 = 4.7\text{ }\mu\text{F}$
- Output voltage of V_{H6} pin on condition that current of $30\text{ }\mu\text{A}$ flow out from V_{H6} pin, $V_{DD} = V_P = 3\text{ V}$, and six times positive booster circuit is active. V_{L6} voltage generation circuit is not connected. (CAPHM+ pin, MDN pin and MDP pin are no-load.)
Measuring conditions :
 $R_F = 1.8\text{ M}\Omega$, $V_{DD} = V_P = 3\text{ V}$, $C_1 = 4.7\text{ }\mu\text{F}$

