

- STRUCTURE            Silicon monolithic integrated circuit
- PRODUCT NAME     LED Driver IC for Cellular Phone
- MODEL NAME        **BH6941KN**
- FEATURES           • On-chip 1 times (X1), 1.5 times (X1.5), and 2 times (X2)  
                              auto switchable high-efficiency charge pump circuit (80 mA/max)
- 4-channel brightness control constant current LED driver  
                                   $I_o = 0 \text{ mA to } 20 \text{ mA}$   
                                  Relative error: 3% typ ( $I_o=20\text{mA}$ )
- Include Thermal shutdown protection
- Compact package  
                                  VQFN20 (4.2 mm × 4.2 mm, height = 0.8 mm)

**○ Absolute Maximum Ratings**

Parameter	Symbol	Rating	Unit
Maximum applied voltage	$V_{MAX}$	6.5	V
Allowable dissipation *1	$P_d$	350	mW
Allowable dissipation *2	$P_d$	530	mW
Operating temperature range	$T_{opr}$	-30~+80	°C
Storage temperature range	$T_{stg}$	-55~+125	°C

\*1 This is the allowable dissipation of the IC itself. Reduce to 3.5 mW/°C when  $T_a = 25^\circ\text{C}$  or above. When mounted on a PCB, allowable dissipation may vary depending on the PCB's size and other characteristics.

\*2 This is the allowable dissipation when mounted on a standard Rohm PCB (70 mm X 70 mm, 1.6 mm thick, glass epoxy). Reduce to 5.3 mW/°C when  $T_a = 25^\circ\text{C}$  or above.

Caution: If any of these values are exceeded, the device may be damaged and normal operation is not guaranteed.

**○ Recommended Operating Range**

Parameter	Symbol	Rating	Unit
VBAT input voltage	$V_{BAT}$	2.8~4.5	V

Caution: This product is not especially designed to be protected from radioactivity.

**Status of this document**

The English version of this document is the formal specification.

A customer may use this translation version only for a reference to help reading the formal version.

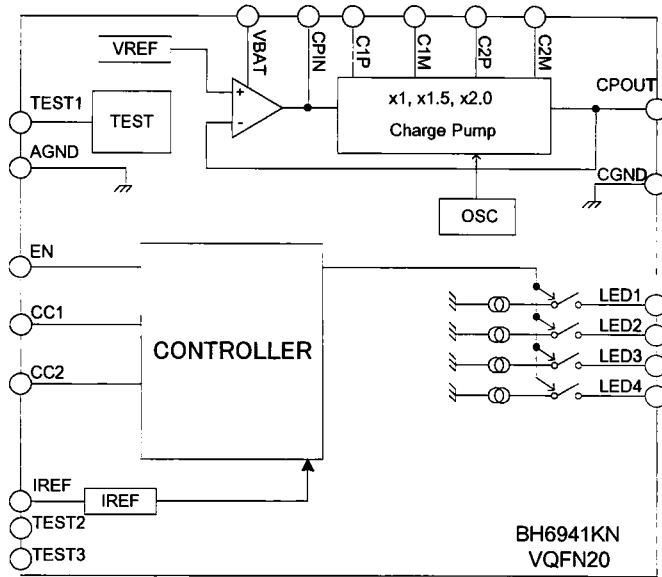
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**○ Electrical Characteristics**

(Unless otherwise noted, Ta = 25°C and VBAT = 3.6 V)

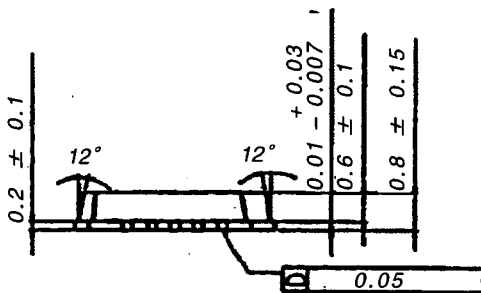
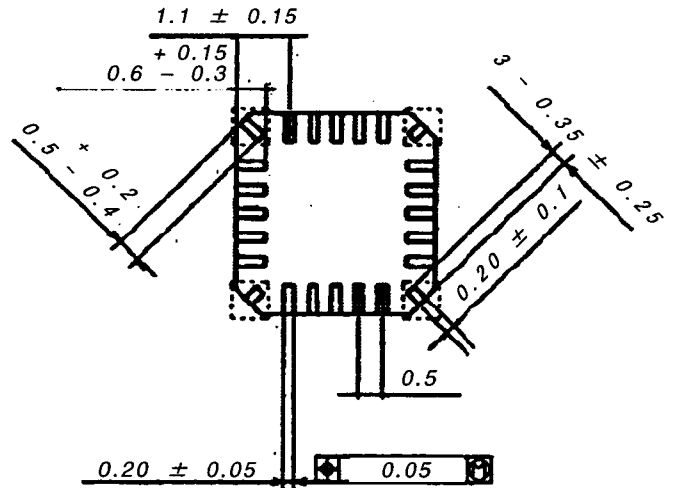
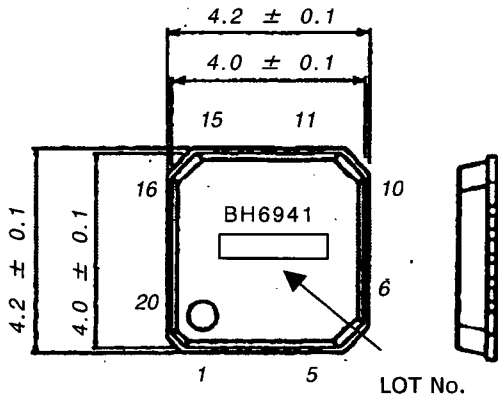
Parameter	Symbol	Spec			Units	Condition
		MIN	TYP	MAX		
<b>• Circuit Current</b>						
Circuit Current0	I <sub>Q0</sub>	-	0	2	uA	Stand-by mode EN, CC1, CC2="L"
Circuit Current1.0	I <sub>Q1.0</sub>	-	1.2	-	mA	DC/DC CONVERTER ON, 1.0times mode, I <sub>o</sub> =0mA ALL LED drivers are active
Circuit Current1.5	I <sub>Q1.5</sub>	-	3.6	-	mA	DC/DC CONVERTER ON, 1.5times mode, I <sub>o</sub> =0mA ALL LED drivers are active
Circuit Current2.0	I <sub>Q2.0</sub>	-	3.4	-	mA	DC/DC CONVERTER ON, 2.0times mode, I <sub>o</sub> =0mA ALL LED drivers are active
<b>• DC-DC Converter</b>						
CPOUT Voltage 1.0	V <sub>CP1.0</sub>	-	4.0	-	V	1.0 times mode ICPOUT=80mA VBAT=4.2V
CPOUT Voltage1.5	V <sub>CP1.5</sub>	4.35	4.5	4.65	V	1.5times mode ICPOUT=1mA
CPOUT Output Current1.5	I <sub>CP1.5</sub>	-	-	80	mA	1.5times mode VCPOUT>4V, VBAT=3.6V
CPOUT Voltage2.0	V <sub>CP2.0</sub>	4.35	4.5	4.65	V	2.0times mode ICPOUT=1mA
CPOUT Output Current2.0	I <sub>CP2.0</sub>	-	-	80	mA	2.0times mode VCPOUT>4V, VBAT=3.0V
Oscillator Frequency	fosc	-	1.2	-	MHz	
<b>• Current Driver</b>						
Output Current1	I <sub>O1</sub>	-	1	-	mA	MIN Setting, Rref=100kΩ
Output Current2	I <sub>O2</sub>	-	10	-	mA	MID Setting, Rref=100kΩ
Output Current3	I <sub>O3</sub>	-	20	-	mA	MAX Setting, Rref=100kΩ
Output Current4	I <sub>O4</sub>	-	15	-	mA	LED1-4 All ON, Rref=100kΩ
Leak Current when OFF	I <sub>LEAK</sub>	-	-	±1	uA	When OFF, V <sub>LED</sub> =V <sub>cp</sub>
<b>•Current Control(EN,CC1,CC2)</b>						
Input "H" Level	V <sub>IH</sub>	1.4	-	VBAT +0.3	V	
Input "L" Level	V <sub>IL</sub>	-0.3	-	0.4	V	
"H" Level Current Influx	I <sub>IH</sub>	-	0	±1	uA	
"L" Level Current Influx	I <sub>IL</sub>	-	0	±1	uA	
<b>• Under Voltage Lockout</b>						
UVLO Threshold	V <sub>UVLO</sub>	2.1	-	2.6	V	VBAT rising or falling
<b>• Soft-Start</b>						
SS Mode Time	T <sub>SS</sub>	-	2.5	-	ms	
SS Mode Input Current	I <sub>SS</sub>	-	250	-	mA	
<b>• Short Circuit Protector</b>						
SCP Threshold	V <sub>SCP</sub>	0.8	1.0	1.2	V	CPOUT falling
Delay Time	T <sub>DLY</sub>	-	10	-	mS	
Reset Time	T <sub>RST</sub>	-	100	-	mS	
<b>• LED Dropout Detector</b>						
Detect Voltage	V <sub>DR</sub>	-	0.18	-	V	

○ BLOCK DIAGRAM



Pin No.	Pin Name
1	EN
2	CC1
3	CC2
4	TEST1
5	LED1
6	LED2
7	LED3
8	LED4
9	TEST2
10	TEST3
11	AGND
12	IREF
13	VBAT
14	CGND
15	C1M
16	CPIN
17	C2P
18	C2M
19	C1P
20	CPOUT

○ EXTERNAL VIEW(VQFN20)



Note. Items indicated by broken lines are not recommended for implementation.

## ○ Use-related Cautions

### (1) Absolute maximum ratings

If applied voltage (VDD, VIN), operating temperature range (Topr), or other absolute maximum ratings are exceeded, there is a risk of damage. Since it is not possible to identify short, open, or other damage modes, if special modes in which absolute maximum ratings are exceeded are assumed, consider applying fuses or other physical safety measures.

### (2) Recommended operating range

This is the range within which it is possible to obtain roughly the expected characteristics. For electrical characteristics, it is those that are guaranteed under the conditions for each parameter. Even when these are within the recommended operating range, voltage and temperature characteristics are indicated.

### (3) Reverse connection of power supply connector

There is a risk of damaging the LSI by reverse connection of the power supply connector. For protection from reverse connection, take measures such as externally placing a diode between the power supply and the power supply pin of the LSI.

### (4) Power supply lines

In the design of the board pattern, make power supply and GND line wiring low impedance.

When doing so, although the digital power supply and analog power supply are the same potential, separate the digital power supply pattern and analog power supply pattern to deter digital noise from entering the analog power supply due to the common impedance of the wiring patterns. Similarly take pattern design into account for GND lines as well.

Furthermore, for all power supply pins of the LSI, in conjunction with inserting capacitors between power supply and GND pins, when using electrolytic capacitors, determine constants upon adequately confirming that capacitance loss occurring at low temperatures is not a problem for various characteristics of the capacitors used.

### (5) GND voltage

Make the potential of a GND pin such that it will be the lowest potential even if operating below that. In addition, confirm that there are no pins for which the potential becomes less than a GND by actually including transition phenomena.

### (6) Shorts between pins and misinstallation

When installing in the set board, pay adequate attention to orientation and placement discrepancies of the LSI. If it is installed erroneously, there is a risk of LSI damage. There also is a risk of damage if it is shorted by a foreign substance getting between pins or between a pin and a power supply or GND.

### (7) Operation in strong magnetic fields

Be careful when using the LSI in a strong magnetic field, since it may malfunction.

### (8) Inspection in set board

When inspecting the LSI in the set board, since there is a risk of stress to the LSI when capacitors are connected to low impedance LSI pins, be sure to discharge for each process. Moreover, when getting it on and off of a jig in the inspection process, always connect it after turning off the power supply, perform the inspection, and remove it after turning off the power supply. Furthermore, as countermeasures against static electricity, use grounding in the assembly process and take appropriate care in transport and storage.

### (9) Input pins

Parasitic elements inevitably are formed on an LSI structure due to potential relationships. Because parasitic elements operate, they give rise to interference with circuit operation and may be the cause of malfunctions as well as damage. Accordingly, take care not to apply a lower voltage than GND to an input pin or use the LSI in other ways such that parasitic elements operate. Moreover, do not apply a voltage to an input pin when the power supply voltage is not being applied to the LSI. Furthermore, when the power supply voltage is being applied, make each input pin a voltage less than the power supply voltage as well as within the guaranteed values of electrical characteristics.

### (10) Ground wiring pattern

When there is a small signal GND and a large current GND, it is recommended that you separate the large current GND pattern and small signal GND pattern and provide single point grounding at the reference point of the set so that voltage variation due to resistance components of the pattern wiring and large currents do not cause the small signal GND voltage to change. Take care that the GND wiring pattern of externally attached components also does not change.

### (11) Externally attached capacitors

When using ceramic capacitors for externally attached capacitors, determine constants upon taking into account a lowering of the rated capacitance due to DC bias and capacitance change due to factors such as temperature.

### (12) Thermal shutdown circuit (TSD)

When junction temperatures become 150°C (typ) or higher, the thermal shutdown circuit operates and turns a switch OFF. The thermal shutdown circuit, which is aimed at isolating the LSI from thermal runaway as much as possible, is not aimed at the protection or guarantee of the LSI. Therefore, do not continuously use the LSI with this circuit operating or use the LSI assuming its operation.

### (13) Thermal design

Perform thermal design in which there are adequate margins by taking into account the permissible dissipation (Pd) in actual states of use.

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