

OKI SemiconductorThis version: Sep. 1998
Previous version: Mar. 1996**MSM6546/6546L****Operatable at 0.9 V and Built-in LCD Driver 4-Bit Microcontroller****GENERAL DESCRIPTION**

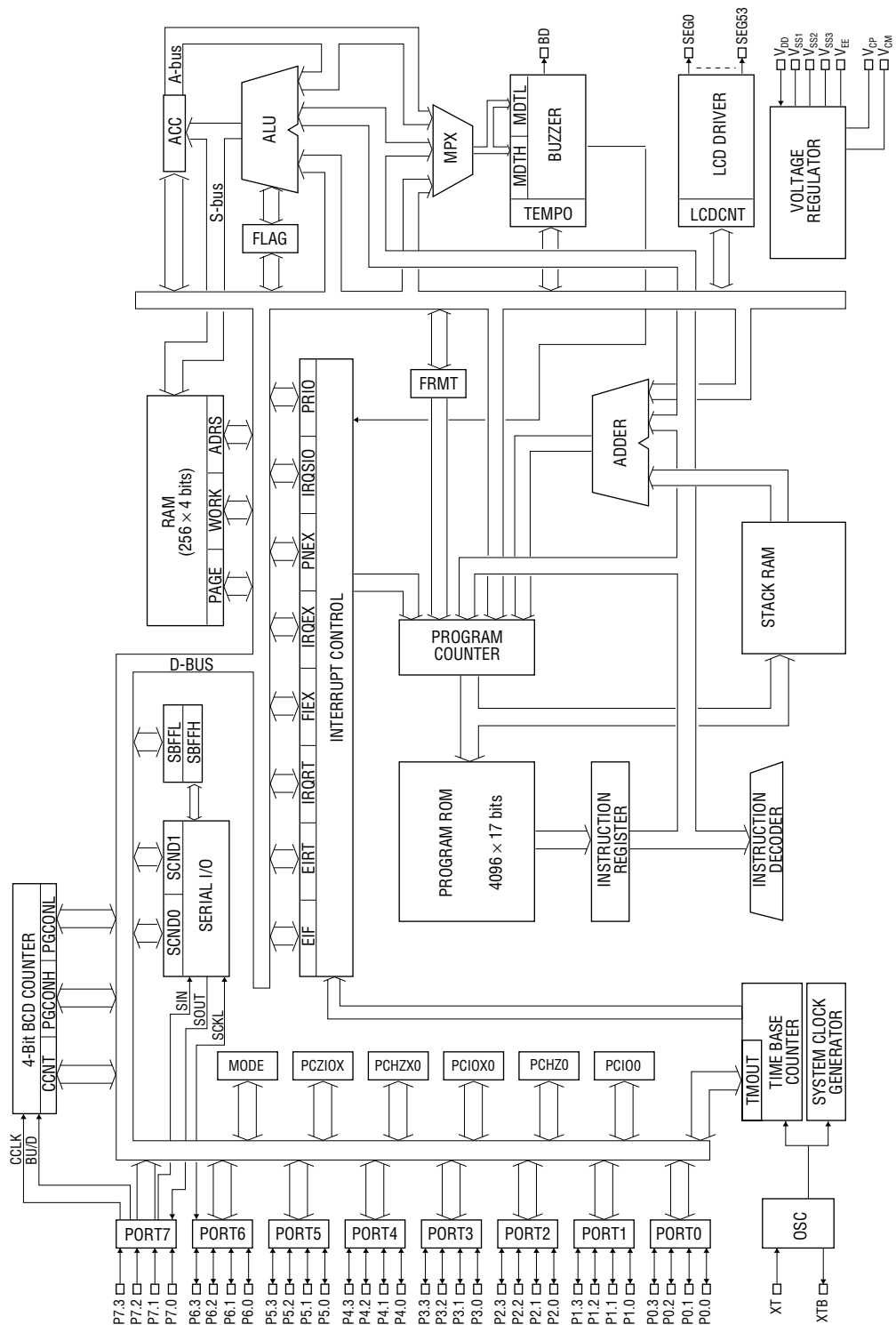
MSM6546/6546L is a 4-bit, low-power microcontroller manufactured in a CMOS silicon gate process. The microcontroller can be initialized and operated at the low supply voltage of 0.9 V. This device contains a crystal oscillator circuit, voltage converter circuits, a time base counter, a ROM, a RAM, a stack RAM, I/O ports, interrupt function components, a serial I/O port, a buzzer output circuit, an up/down counter, and LCD drivers.

This IC can be driven by one battery and is well suited to products that need to be operated with low power consumption.

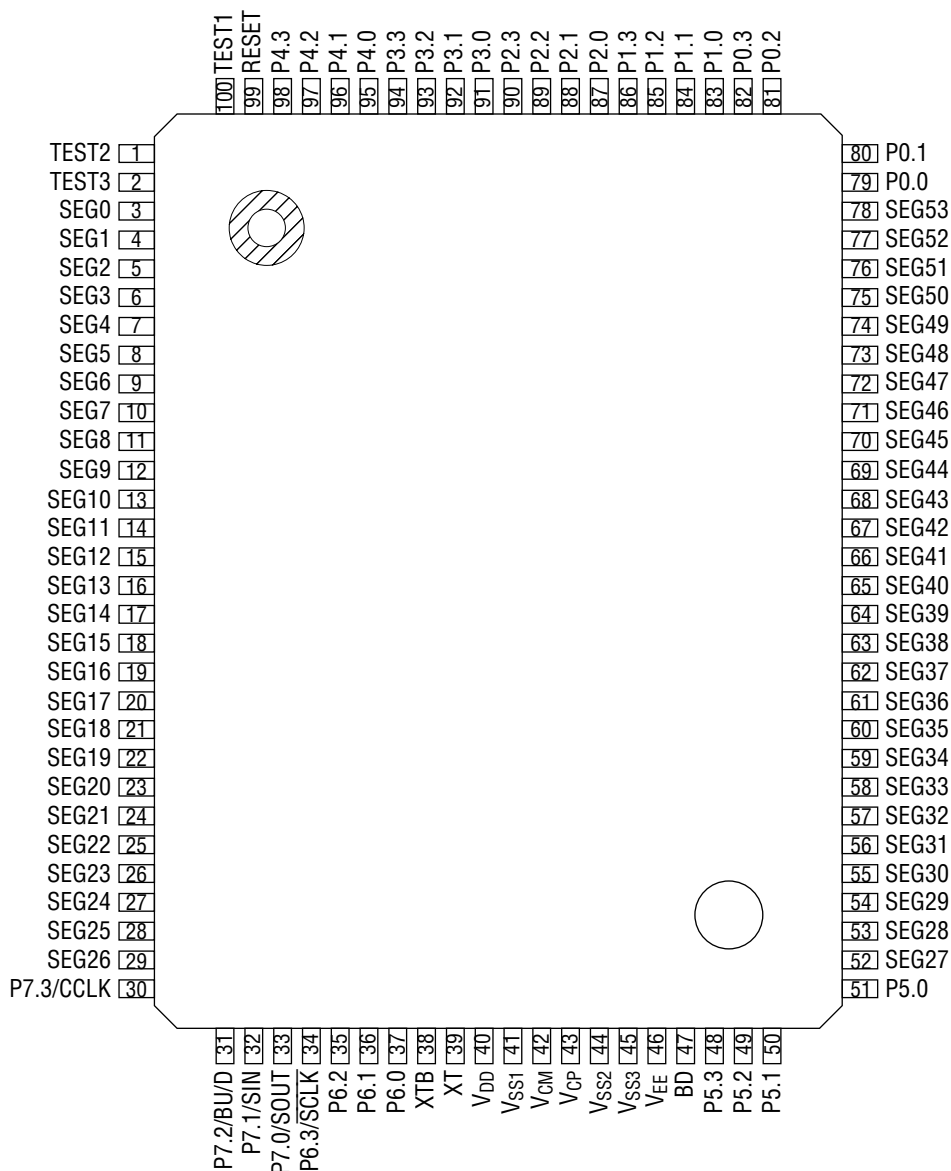
FEATURES

- The IC can be initialized and operated even at a low voltage of 0.9 V.
- Low power consumption
- ROM : 4096 words × 17 bits
- RAM : 256 words × 4 bits
- I/O port
 - Input/output port : 7 ports × 4 bits
 - Input port : 1 port × 4 bits
- Interrupt functions (real-time interrupt, external interrupt, and serial interrupt)
- Serial I/O port : 8-bit sync communication
- Buzzer output circuit
- 4-bit decimal up/down counter
- 54 LCD drivers (up to 200 segments can be displayed)
- 75 instructions
- Minimum instruction execution time : 61 μs
- Operation under single 1.5 V power supply (MSM6546)
 - A mask option allows the 3 V power supply to be used (MSM6546L).
- Built-in 32.768 kHz crystal oscillator circuit
- Package:
 - 100-pin plastic QFP (QFP100-P-1420-0.65-BK)
 - : (Product name : MSM6546-xxGS-BK, MSM6546L-xxGS-BK)
- Chip
 - xx indicates a code number.

BLOCK DIAGRAM



PIN CONFIGURATION (TOP VIEW)



100-Pin Plastic QFP

PIN DESCRIPTIONS

Symbol	Type	Description		
PORT0 (P0.0 to P0.3)	I/O	4-bit input-output port, I/O switchable, with/without input pull-down resistor		
PORT1 (P1.1 to P1.3)	I/O	4-bit input-output port, I/O switchable, with/without input pull-down resistor		
PORT2 (P2.0 to P2.3)	I/O	4-bit input-output port, I/O switchable, with/without input pull-down resistor	P2.0 to P2.3	External interrupt port
PORT3 (P3.0 to P3.3)	I/O	4-bit input-output port, I/O switchable, with/without input pull-down resistor		
PORT4 (P4.0 to P4.3)	I/O	4-bit input-output port, I/O switchable, with/without input pull-down resistor		
PORT5 (P5.0 to P5.3)	I/O	4-bit input-output port, I/O switchable, with/without input pull-down resistor		
PORT6 (P6.0 to P6.3)	I/O	4-bit input-output port, I/O switchable, with/without input pull-down resistor	P6.3: $\overline{\text{SCLK}}$	Shared with serial port
PORT7 (P7.0 to P7.3)	I	4-bit input port Tie to the negative pole of the battery when not used.	P7.0: SOUT	
			P7.1: SIN	Shared with 4-bit up/down counter
			P7.2: BU/D	
			P7.3: CCLK	
BD	0	Buzzer output pin		
RESET	I	Reset pin with input pull-down resistor		
TEST1 TEST2 TEST3	I	Testing pins with input pull-down resistor; Tie to the negative pole of the battery.		
XT	I	Connection pins for crystal oscillator		
XTB	0			
V _{DD}	—	0 V power supply pin		
V _{SS1}	—	–1.5 V supply pin (power supply pin for –1.5 V operation)		
V _{SS2}	—	–3.0 V supply pin (power supply pin for –3.0 V operation)		
V _{SS3}	—	–4.5 V supply pin		
V _{CP}	—	Connection pins for internal potential development capacitor		
V _{CM}				
V _{EE}	—	Supply pin for internal logic (constant voltage circuit output pin)		
SEG0 to SEG53	0	LCD driver		

ABSOLUTE MAXIMUM RATINGS (MSM6546, 1.5 V, BUF = "0")

Parameter	Symbol	Condition	Rating	Unit
Power Supply Voltage (1)	V _{SS1}	Ta = 25°C	−4.0 to +0.3	V
Power Supply Voltage (2)	V _{SS2}		−7.0 to +0.3	
Power Supply Voltage (3)	V _{SS3}		−7.0 to +0.3	
Input Voltage	V _{IN}		V _{SS1} − 0.3 to +0.3	
Output Voltage (1) *1, *2	V _{O1}		V _{SS1} − 0.3 to +0.3	
Output Voltage (2) *2	V _{O2}		V _{SS2} − 0.3 to +0.3	
Output Voltage (3) *2	V _{O3}		V _{SS3} − 0.3 to +0.3	
Storage Temperature	T _{STG}	—	−55 to +125	°C

*1 Normal output

*2 LCD driver output

Note: The input of the constant voltage circuit is equal to the output of the voltage converter (V_{SS2}).

RECOMMENDED OPERATING CONDITIONS (MSM6546, 1.5 V, BUF = "0")

V_{DD} = 0 V (V_{SS1} = battery voltage)

Parameter	Symbol	Condition	Range	Unit
Operating Voltage	V _{op}	—	−1.75 to −0.9	V
Operating Temperature	T _{op}	—	−20 to +70	°C
Oscillation Frequency	f _{osc}	—	32.768	kHz

Note: The input of the constant voltage circuit is equal to the output of the voltage converter (V_{SS2}).

ELECTRICAL CHARACTERISTICS (MSM6546, 1.5 V, BUF = "0")(V_{DD} = 0 V, V_{SS1} = -1.5 V (battery voltage), V_{SS2} = -3.0 V, V_{SS3} = -4.5 V, f_{OSC} = 32.768 kHz, C_X = 35 pF, T_a = 25°C)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Applied Pin
Power Supply Current	I _{DD}	*1	—	3	—	μA	—
Oscillation Start Voltage	-V _{OSC}	Within 2 seconds	—	—	0.9	V	V _{SS1}
Output Current 1	-I _{OH1}	V _O = -0.5 V	150	—	—	μA	PORT0 to PORT6*2 SOUT, SCLK
	I _{OL1}	V _O = -1.0 V	150	—	—		
Output Current 2	-I _{OH2}	V _O = -0.5 V	20	—	—	μA	BD
	I _{OL2}	V _O = -1.0 V	20	—	—		
Output Current 3 (Common Segment Output)	-I _{OH3}	V _{OH} = -0.2 V	4	—	—	μA	SEG0 to SEG53
	-I _{OMH3}	V _{OMH} = V _{SS1} ±0.2 V	4	—	—		
	-I _{OML3}	V _{OML} = V _{SS2} ±0.2 V	4	—	—		
	-I _{OL3}	V _{OL} = -4.3 V	4	—	—		
Input Current 1	I _{IH1}	V _I = 0 V, in the input state, with pull-down resistor	7	15	30	μA	PORT0 to PORT6 *2
Input Leakage Current	I _{IL}	V _I = 0 V, -1.5 V, in the input state, without pull-down resistor	—	—	1	μA	PORT0 to PORT7*2 SIN, SOUT, SCLK
Input Current 3	I _{IH3}	V _I = 0 V, with pull-down resistor	70	250	500	μA	RESET TEST1 to TEST3
Input Voltage	-V _{IH}	—	—	—	0.3	V	All input pins
	-V _{IL}		1.2	—	—		

*1 Depends on program. (Values in the above table are applied in the case where the software duty is about 5%.)

*2 PORT0 = P0.0 to P0.3, PORT1 = P1.0 to P1.3, PORT2 = P2.0 to P2.3, PORT3 = P3.0 to P3.3, PORT4 = P4.0 to P4.3, PORT5 = P5.0 to P5.3, PORT6 = P6.0 to P6.3, PORT7 = P7.0 to P7.3

Note: The input of the constant voltage circuit is equal to the output of the voltage converter (V_{SS2}).

ABSOLUTE MAXIMUM RATINGS (MSM6546, 1.5 V, BUF = "1")

Parameter	Symbol	Condition	Rating	Unit
Power Supply Voltage (1)	V_{SS1}	$T_a = 25^{\circ}\text{C}$	-4.0 to +0.3	V
Power Supply Voltage (2)	V_{SS2}		-7.0 to +0.3	
Power Supply Voltage (3)	V_{SS3}		-7.0 to +0.3	
Input Voltage	V_{IN}		$V_{SS1} - 0.3$ to +0.3	
Output Voltage (1) *1, *2	V_{O1}		$V_{SS1} - 0.3$ to +0.3	
Output Voltage (2) *2	V_{O2}		$V_{SS2} - 0.3$ to +0.3	
Output Voltage (3) *2	V_{O3}		$V_{SS3} - 0.3$ to +0.3	
Storage Temperature	T_{STG}	—	-55 to +125	$^{\circ}\text{C}$

*1 Normal output

*2 LCD driver output

Note: The input of the constant voltage circuit is directly connected to the power supply (V_{SS1}).

RECOMMENDED OPERATING CONDITIONS (MSM6546, 1.5 V, BUF = "1")

$V_{DD} = 0\text{ V}$ (V_{SS1} = battery voltage)

Parameter	Symbol	Condition	Range	Unit
Operating Voltage	V_{op}	—	-1.75 to -0.9	V
Operating Temperature	T_{op}	—	-20 to +70	$^{\circ}\text{C}$
Oscillation Frequency	f_{OSC}	—	32.768	kHz

Note: The input of the constant voltage circuit is directly connected to the power supply (V_{SS1}).

ELECTRICAL CHARACTERISTICS (MSM6546, 1.5 V, BUF = "1")

($V_{DD} = 0\text{ V}$, $V_{SS1} = -1.5\text{ V}$ (battery voltage), $V_{SS2} = -3.0\text{ V}$, $V_{SS3} = -4.5\text{ V}$, $f_{OSC} = 32.768\text{ kHz}$, $C_X = 35\text{ pF}$, $T_a = 25^\circ\text{C}$)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Applied Pin
Power Supply Current	I_{DD}	*1	—	1.5	—	μA	—
Oscillation Start Voltage	$-V_{OSC}$	Within 2 seconds	—	—	0.9	V	V_{SS1}
Output Current 1	$-I_{OH1}$	$V_O = -0.5\text{ V}$	150	—	—	μA	PORT0 to PORT6 *2 SOUT, SCLK
	I_{OL1}	$V_O = -1.0\text{ V}$	150	—	—		
Output Current 2	$-I_{OH2}$	$V_O = -0.5\text{ V}$	20	—	—	μA	BD
	I_{OL2}	$V_O = -1.0\text{ V}$	20	—	—		
Output Current 3 (Common Segment Output)	$-I_{OH3}$	$V_{OH} = -0.2\text{ V}$	4	—	—	μA	SEG0 to SEG53
	$ -I_{OMH3} $	$V_{OMH} = V_{SS1} \pm 0.2\text{ V}$	4	—	—		
	$ -I_{OML3} $	$V_{OML} = V_{SS2} \pm 0.2\text{ V}$	4	—	—		
	$-I_{OL3}$	$V_{OL} = -4.3\text{ V}$	4	—	—		
Input Current 1	I_{IH1}	$V_I = 0\text{ V}$, in the input state, with pull-down resistor	7	15	30	μA	PORT0 to PORT6 *2
Input Leakage Current	$ I_{IL} $	$V_I = 0\text{ V}, -1.5\text{ V}$, in the input state, without pull-down resistor	—	—	1	μA	PORT0 to PORT7 *2 SIN, SOUT, SCLK
Input Current 3	I_{IH3}	$V_I = 0\text{ V}$, with pull-down resistor	70	250	500	μA	RESET TEST1 to TEST3
Input Voltage	$-V_{IH}$	—	—	—	0.3	V	All input pins
	$-V_{IL}$		1.2	—	—		

*1 Depends on program. (Values in the above table are applied in the case where the software duty is about 5%.)

*2 PORT0 = P0.0 to P0.3, PORT1 = P1.0 to P1.3, PORT2 = P2.0 to P2.3, PORT3 = P3.0 to P3.3, PORT4 = P4.0 to P4.3, PORT5 = P5.0 to P5.3, PORT6 = P6.0 to P6.3, PORT7 = P7.0 to P7.3

Note: The input of the constant voltage circuit is directly connected to the power supply (V_{SS1}).

ABSOLUTE MAXIMUM RATINGS (MSM6546L, 3.0 V, BUF = "0")

Parameter	Symbol	Condition	Rating	Unit
Power Supply Voltage (1)	V _{SS1}	Ta = 25°C	-4.0 to +0.3	V
Power Supply Voltage (2)	V _{SS2}		-7.0 to +0.3	
Power Supply Voltage (3)	V _{SS3}		-7.0 to +0.3	
Input Voltage	V _{IN}		V _{SS2} - 0.3 to +0.3	
Output Voltage (1) *2	V _{O1}		V _{SS1} - 0.3 to +0.3	
Output Voltage (2) *1, *2	V _{O2}		V _{SS2} - 0.3 to +0.3	
Output Voltage (3) *2	V _{O3}		V _{SS3} - 0.3 to +0.3	
Storage Temperature	T _{STG}	—	-55 to +125	°C

*1 Normal output

*2 LCD driver output

Note: The input of the constant voltage circuit is equal to the output of the voltage converter (V_{SS1}).

RECOMMENDED OPERATING CONDITIONS (MSM6546L, 3.0 V, BUF = "0")

V_{DD} = 0 V (V_{SS1} = battery voltage)

Parameter	Symbol	Condition	Range	Unit
Operating Voltage	V _{op}	—	-3.5 to -1.8	V
Operating Temperature	T _{op}	—	-20 to +70	°C
Oscillation Frequency	f _{osc}	—	32.768	kHz

Note: The input of the constant voltage circuit is equal to the output of the voltage converter (V_{SS1}).

ELECTRICAL CHARACTERISTICS (MSM6546L, 3.0 V, BUF = "0")(V_{DD} = 0 V, V_{SS1} = -1.5 V, V_{SS2} = -3.0 V (battery voltage), V_{SS3} = -4.5 V, f_{OSC} = 32.768 kHz, C_X = 35 pF, T_a = 25°C)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Applied Pin
Power Supply Current	I _{DD}	*1	—	0.75	—	μA	—
Oscillation Start Voltage	-V _{OSC}	Within 2 seconds	—	—	1.8	V	V _{SS2}
Output Current 1	-I _{OH1}	V _O = -0.5 V	500	—	—	μA	PORT0 to PORT6*2 SOUT, SCLK
	I _{OL1}	V _O = -2.5 V	500	—	—		
Output Current 2	-I _{OH2}	V _O = -0.5 V	20	—	—	μA	BD
	I _{OL2}	V _O = -2.5 V	20	—	—		
Output Current 3 (Common Segment Output)	-I _{OH3}	V _{OH} = -0.2 V	4	—	—	μA	SEG0 to SEG53
	-I _{OMH3}	V _{OMH} = V _{SS1} ±0.2 V	4	—	—		
	-I _{OML3}	V _{OML} = V _{SS2} ±0.2 V	4	—	—		
	-I _{OL3}	V _{OL} = -4.3 V	4	—	—		
Input Current 1	I _{IH1}	V _I = 0 V, in the input state, with pull-down resistor	50	100	200	μA	PORT0 to PORT6 *2
Input Leakage Current	I _{IL}	V _I = 0 V, -3 V, in the input state, without pull-down resistor	—	—	1	μA	PORT0 to PORT7*2 SIN, SOUT, SCLK
Input Current 3	I _{IH3}	V _I = 0 V, with pull-down resistor	200	750	1500	μA	RESET TEST1 to TEST3
Input Voltage	-V _{IH}	—	—	—	0.5	V	All input pins
	-V _{IL}		2.5	—	—		

*1 Depends on program. (Values in the above table are applied in the case where the software duty is about 5%.)

*2 PORT0 = P0.0 to P0.3, PORT1 = P1.0 to P1.3, PORT2 = P2.0 to P2.3, PORT3 = P3.0 to P3.3, PORT4 = P4.0 to P4.3, PORT5 = P5.0 to P5.3, PORT6 = P6.0 to P6.3, PORT7 = P7.0 to P7.3

Note: The input of the constant voltage circuit is equal to the output of the voltage converter (V_{SS2}).

ABSOLUTE MAXIMUM RATINGS (MSM6546L, 3.0 V, BUF = "1")

Parameter	Symbol	Condition	Rating	Unit
Power Supply Voltage (1)	V_{SS1}	$T_a = 25^{\circ}\text{C}$	-4.0 to +0.3	V
Power Supply Voltage (2)	V_{SS2}		-7.0 to +0.3	
Power Supply Voltage (3)	V_{SS3}		-7.0 to +0.3	
Input Voltage	V_{IN}		$V_{SS2} - 0.3$ to +0.3	
Output Voltage (1) *2	V_{O1}		$V_{SS1} - 0.3$ to +0.3	
Output Voltage (2) *1, *2	V_{O2}		$V_{SS2} - 0.3$ to +0.3	
Output Voltage (3) *2	V_{O3}		$V_{SS3} - 0.3$ to +0.3	
Storage Temperature	T_{STG}	—	-55 to +125	$^{\circ}\text{C}$

*1 Normal output

*2 LCD driver output

Note: The input of the constant voltage circuit is directly connected to the power supply (V_{SS2}).

RECOMMENDED OPERATING CONDITIONS (MSM6546L, 3.0 V, BUF = "1")

$V_{DD} = 0\text{ V}$ (V_{SS2} = battery voltage)

Parameter	Symbol	Condition	Range	Unit
Operating Voltage	V_{op}	—	-3.5 to -0.9	V
Operating Temperature	T_{op}	—	-20 to +70	$^{\circ}\text{C}$
Oscillation Frequency	f_{OSC}	—	32.768	kHz

Note: The input of the constant voltage circuit is directly connected to the power supply (V_{SS2}).

ELECTRICAL CHARACTERISTICS (MSM6546L, 3.0 V, BUF = "1")(V_{DD} = 0 V, V_{SS1} = -1.5 V, V_{SS2} = -3.0 V (battery voltage), V_{SS3} = -4.5 V, f_{OSC} = 32.768 kHz, C_X = 35 pF, T_a = 25°C)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Applied Pin
Power Supply Current	I _{DD}	*1	—	1.5	—	μA	—
Oscillation Start Voltage	-V _{OSC}	Within 2 seconds	—	—	0.9	V	V _{SS2}
Output Current 1	-I _{OH1}	V _O = -0.5 V	500	—	—	μA	PORT0 to PORT6*2 SOUT, SCLK
	I _{OL1}	V _O = -2.5 V	500	—	—		
Output Current 2	-I _{OH2}	V _O = -0.5 V	20	—	—	μA	BD
	I _{OL2}	V _O = -2.5 V	20	—	—		
Output Current 3 (Common Segment Output)	-I _{OH3}	V _{OH} = -0.2 V	4	—	—	μA	SEG0 to SEG53
	-I _{OMH3}	V _{OMH} = V _{SS1} ±0.2 V	4	—	—		
	-I _{OML3}	V _{OML} = V _{SS2} ±0.2 V	4	—	—		
	-I _{OL3}	V _{OL} = -4.3 V	4	—	—		
Input Current 1	I _{IH1}	V _I = 0 V, in the input state, with pull-down resistor	50	100	200	μA	PORT0 to PORT6 *2
Input Leakage Current	I _{IL}	V _I = 0 V, -3 V, in the input state, without pull-down resistor	—	—	1	μA	PORT0 to PORT7*2 SIN, SOUT, SCLK
Input Current 3	I _{IH3}	V _I = 0 V, with pull-down resistor	200	750	1500	μA	RESET TEST1 to TEST3
Input Voltage	-V _{IH}	—	—	—	0.5	V	All input pins
	-V _{IL}		2.5	—	—		

*1 Depends on program. (Values in the above table are applied in the case where the software duty is about 5%.)

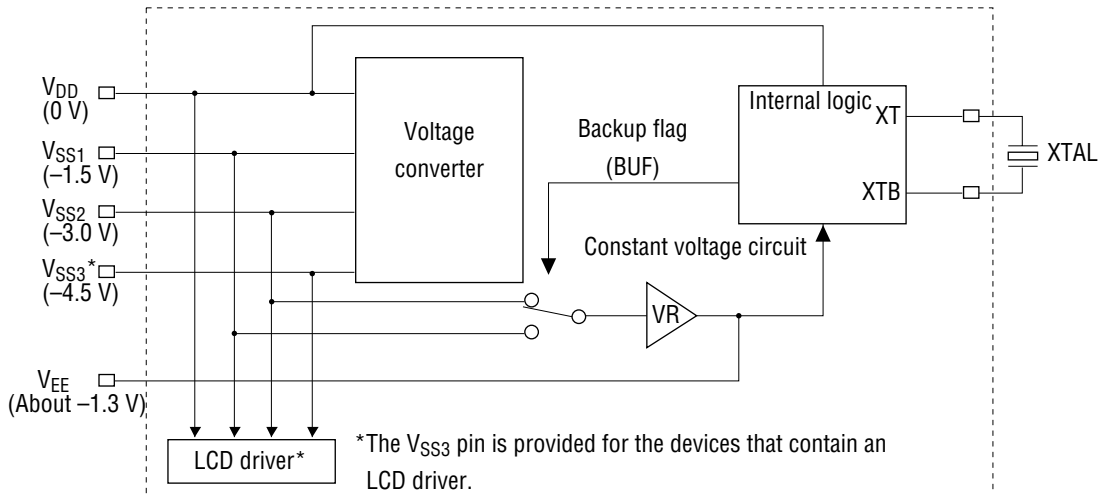
*2 PORT0 = P0.0 to P0.3, PORT1 = P1.0 to P1.3, PORT2 = P2.0 to P2.3, PORT3 = P3.0 to P3.3, PORT4 = P4.0 to P4.3, PORT5 = P5.0 to P5.3, PORT6 = P6.0 to P6.3, PORT7 = P7.0 to P7.3

Note: The input of the constant voltage circuit is directly connected to the power supply (V_{SS2}).

NOTES ON USE

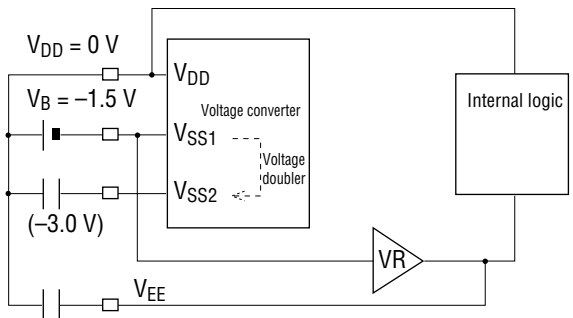
Power Supply for 0.9 V Microcontroller Series (Backup Flag and Constant-Voltage Circuit)

The 0.9 V microcontroller devices have a built-in constant-voltage circuit. The output of this constant-voltage circuit powers the microcontroller's internal logic circuits. Setting a backup flag (BUF) allows the input of the constant-voltage circuit to be switched to either the battery or the output generated in the voltage converter, based on the battery voltage. A battery voltage of 1.5 V or 3.0 V can be selected.



The output (V_{EE}) of the constant-voltage circuit is set at approximately -1.3 V. This allows the current consumed by the internal logic to be limited, irrespective of the battery voltage. However, if the input of the constant voltage circuit is below this set value (approximately -1.3 V), the output (V_{EE}) is equal to the input. The 0.9 V microcontroller can be operated even if the internal voltage (output from the constant voltage circuit) falls to 0.9 V. Setting the backup flag allows a larger operating voltage margin despite changes in internal voltage due to noise. For example, for the 1.5 V specification, setting the backup flag to "0" causes twice the battery voltage to enter the constant-voltage circuit. Thus, even if the battery voltage falls to 0.9 V, the output voltage (V_{EE}) is maintained at -1.3 V to allow a larger margin of operating voltage for the internal logic circuits, because 1.8 V is applied to the input of the constant-voltage circuit. Figures 1 to 4 show the internal status depending on the backup flag settings for the battery, as well as status features.

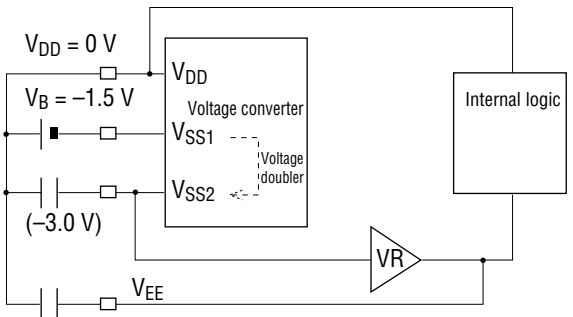
(Figure 1) 1.5 V Operation (Backup Flag = "1")



Internal status	The battery level V_{SS1} is applied to the input of the constant voltage circuit.
Operating range	-0.9 to -1.75 V
Current consumption	1.5 μ A*
Feature	When the battery level is powered down, the internal circuit is powered directly by the battery.

* When the software duty is about 5%

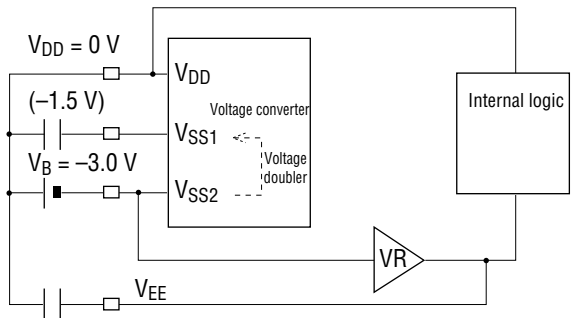
(Figure 2) 1.5 V Operation (Backup Flag = "0")



Internal status	A doubled level of V_{SS2} is applied to the input of the constant voltage circuit.
Operating range	-0.9 to -1.75 V
Current consumption	3 μ A*
Feature	When the battery level is powered down, a larger operating voltage margin is gained, compared to the case of Figure 1.

* When the software duty is about 5%

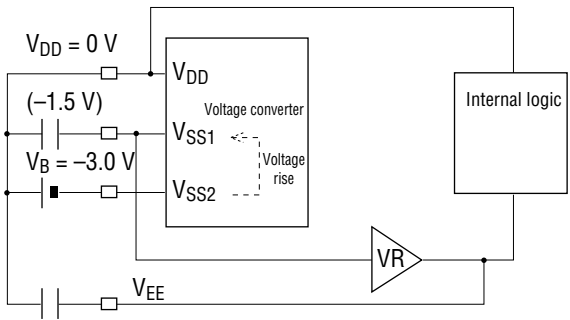
(Figure 3) 3.0 V Operation (Backup Flag = "1")



Internal status	The battery level V_{SS2} is applied to the input of the constant voltage circuit.
Operating range	-0.9 to -3.5 V
Current consumption	1.5 μ A*
Feature	When the battery level is powered down, the internal circuit is powered directly by the battery.

* When the software duty is about 5%

(Figure 4) 3.0 V Operation (Backup Flag = "0")

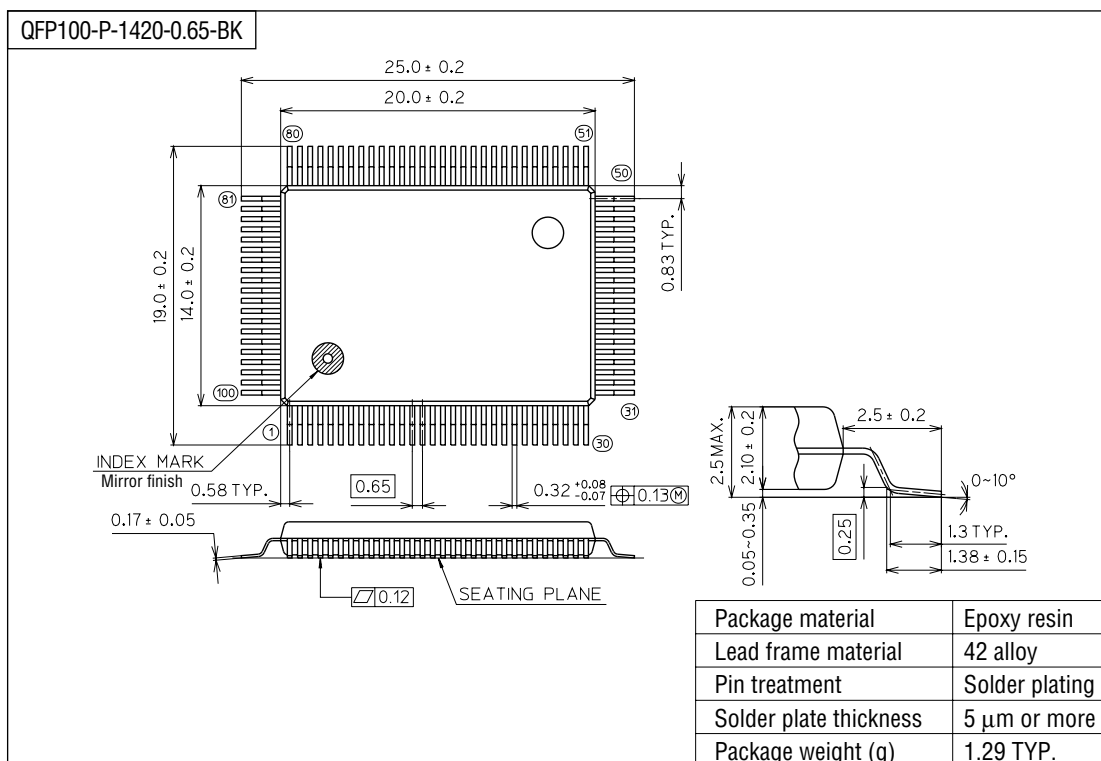


Internal status	A doubled level of V_{SS1} is applied to the input of the constant voltage circuit.
Operating range	-1.8 to -3.5 V
Current consumption	0.75 μA *
Feature	When the battery level is powered down, a smaller operating voltage margin is gained, compared to the case of Figure 3.

* When the software duty is about 5%

PACKAGE DIMENSIONS

(Unit : mm)



Notes for Mounting the Surface Mount Type Package

The SOP, QFP, TSOP, SOJ, QFJ (PLCC), SHP and BGA are surface mount type packages, which are very susceptible to heat in reflow mounting and humidity absorbed in storage.

Therefore, before you perform reflow mounting, contact Oki's responsible sales person for the product name, package name, pin number, package code and desired mounting conditions (reflow method, temperature and times).