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Addendum for New QFN Package Migration

This addendum provides the changes to the 98A case outline numbers for products covered in this book. Case outlines were changed because of the migration from gold wire to copper wire in some packages. See the table below for the old (gold wire) package versus the new (copper wire) package.

To view the new drawing, go to Freescale.com and search on the new 98A package number for your device.

For more information about QFN package use, see EB806: *Electrical Connection Recommendations for the Exposed Pad on QFN and DFN Packages*.

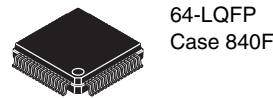
Part Number	Package Description	Original (gold wire) package document number	Current (copper wire) package document number
MC68HC908JW32	48 QFN	98ARH99048A	98ASA00466D
MC9S08AC16			
MC9S908AC60			
MC9S08AC128			
MC9S08AW60			
MC9S08GB60A			
MC9S08GT16A			
MC9S08JM16			
MC9S08JM60			
MC9S08LL16			
MC9S08QE128			
MC9S08QE32			
MC9S08RG60			
MCF51CN128			
MC9RS08LA8	48 QFN	98ARL10606D	98ASA00466D
MC9S08GT16A	32 QFN	98ARH99035A	98ASA00473D
MC9S908QE32	32 QFN	98ARE10566D	98ASA00473D
MC9S908QE8	32 QFN	98ASA00071D	98ASA00736D
MC9S08JS16	24 QFN	98ARL10608D	98ASA00734D
MC9S08QB8			
MC9S08QG8	24 QFN	98ARL10605D	98ASA00474D
MC9S08SH8	24 QFN	98ARE10714D	98ASA00474D
MC9RS08KB12	24 QFN	98ASA00087D	98ASA00602D
MC9S08QG8	16 QFN	98ARE10614D	98ASA00671D
MC9RS08KB12	8 DFN	98ARL10557D	98ASA00672D
MC9S08QG8			
MC9RS08KA2	6 DFN	98ARL10602D	98ASA00735D

An Energy Efficient Solution by Freescale



MC9S08LL16 Series

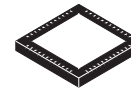
Covers: MC9S08LL16 and MC9S08LL8



64-LQFP
Case 840F



48-LQFP
Case 932



48-QFN
1314

Features

- 8-Bit HCS08 Central Processor Unit (CPU)
 - Up to 20-MHz CPU at 3.6V to 1.8V across temperature range of -40°C to 85°C
 - HC08 instruction set with added BGND instruction
 - Support for up to 32 interrupt/reset sources
- On-Chip Memory
 - Dual Array FLASH read/program/erase over full operating voltage and temperature
 - Random-access memory (RAM)
 - Security circuitry to prevent unauthorized access to RAM and FLASH contents
- Power-Saving Modes
 - Two low power stop modes
 - Reduced power wait mode
 - Low power run and wait modes allow peripherals to run while voltage regulator is in standby
 - Peripheral clock gating register can disable clocks to unused modules, thereby reducing currents.
 - Very low power external oscillator that can be used in stop2 or stop3 modes to provide accurate clock source to real time counter
 - 6 usec typical wake up time from stop3 mode
- Clock Source Options
 - Oscillator (XOSC) — Loop-control Pierce oscillator; Crystal or ceramic resonator range of 31.25 kHz to 38.4 kHz or 1 MHz to 16 MHz
 - Internal Clock Source (ICS) — Internal clock source module containing a frequency-locked-loop (FLL) controlled by internal or external reference; precision trimming of internal reference allows 0.2% resolution and 2% deviation over temperature and voltage; supports bus frequencies from 1MHz to 10 MHz.
- System Protection
 - Watchdog computer operating properly (COP) reset with option to run from dedicated 1-kHz internal clock source or bus clock
 - Low-Voltage Warning with interrupt
 - Low-Voltage Detection with reset or interrupt
 - Illegal opcode and illegal address detection with reset
 - Flash block protection
- Development Support
 - Single-wire background debug interface
 - Breakpoint capability to allow single breakpoint setting during in-circuit debugging (plus two more breakpoints in on-chip debug module)
- On-chip in-circuit emulator (ICE) debug module containing three comparators and nine trigger modes. Eight deep FIFO for storing change-of-flow addresses and event-only data. Debug module supports both tag and force breakpoints
- Peripherals
 - **LCD** — 4x28 or 8x24 LCD driver with internal charge pump and option to provide an internally regulated LCD reference that can be trimmed for contrast control.
 - **ADC** — 8-channel, 12-bit resolution; 2.5 μ s conversion time; automatic compare function; temperature sensor; internal bandgap reference channel; operation in stop3; fully functional from 3.6V to 1.8V
 - **ACMP** — Analog comparator with selectable interrupt on rising, falling, or either edge of comparator output; compare option to fixed internal bandgap reference voltage; outputs can be optionally routed to TPM module; operation in stop3
 - **SCI** — Full duplex non-return to zero (NRZ); LIN master extended break generation; LIN slave extended break detection; wake up on active edge
 - **SPI** — Full-duplex or single-wire bidirectional; Double-buffered transmit and receive; Master or Slave mode; MSB-first or LSB-first shifting
 - **IIC** — IIC with up to 100 kbps with maximum bus loading; Multi-master operation; Programmable slave address; Interrupt driven byte-by-byte data transfer; supports broadcast mode and 10-bit addressing
 - **TPM_x** — Two 2-channel (TPM1 and TPM2); Selectable input capture, output compare, or buffered edge- or center-aligned PWM on each channel;
 - **TOD** — (Time Of Day) 8-bit quarter second counter with match register; External clock source for precise time base, time-of-day, calendar or task scheduling functions; Free running on-chip low power oscillator (1 kHz) for cyclic wake-up without external components.
- Input/Output
 - 38 GPIOs, 2 output-only pins
 - 8 KBI interrupts with selectable polarity
 - Hysteresis and configurable pull up device on all input pins; Configurable slew rate and drive strength on all output pins.
- Package Options
 - 64-LQFP, 48-LQFP and 48-QFN

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Revision History

To provide the most up-to-date information, the revision of our documents on the World Wide Web will be the most current. Your printed copy may be an earlier revision. To verify you have the latest information available, refer to:

<http://freescale.com/>

The following revision history table summarizes changes contained in this document.

Rev	Date	Description of Changes
1	9/2008	Initial Release.
2	10/2008	Updated electrical characteristics.
3	01/2009	Corrected 48-Pin QFN/LQFP pinouts for pins 29, 30, 32, and 32 in Figure 3 . Extracted Stop Mode Adders from the Supply Current table and created a Separate table for the data (See Table 10). Added missing power consumption parameters in Supply Current Characteristics (Table 9).
4	07/21/2009	Completed all the TBDs. Changed V_{DDAD} to V_{DDA} , V_{SSAD} to V_{SSA} , I_{DDAD} to I_{DDA} . Corrected the data in the Table 8 , and added I_{INT} . Completed the Figure in the Section 3.6, "DC Characteristics." Corrected R_{IDD} in FEI mode with all modules on, W_{IDD} at 8 MHz, FEI mode with all modules off, $S2I_{DD}$, $S3I_{DD}$; added $A_{P3I_{DD}}$ in the Table 9 . Corrected E_{TUE} , DNL , INL , E_{ZS} , E_{FS} , E_Q , and E_{IL} in the Table 18 .
5	10/13/2009	Updated R_{PU}/R_{PD} data in the Table 8 . Added Figure 5 .
6	10/27/2010	Changed the Max. of R_{PU}/R_{PD} at PTA[4:5], PTD[0:77] and PTE[0:7] to 69.5 k Ω in the Table 8 .
7	1/23/2013	Updated I_{IN} in the Table 8 .

Related Documentation

Find the most current versions of all documents at: <http://www.freescale.com>

Reference Manual (MC9S08LL16RM)

Contains extensive product information including modes of operation, memory, resets and interrupts, register definition, port pins, CPU, and all module information.

1 Devices in the MC9S08LL16 Series

Table 1 summarizes the feature set available in the MC9S08LL16 series of MCUs.

Table 1. MC9S08LL16 Series Features by MCU and Package

Feature	MC9S08LL16		MC9S08LL8
	64-pin LQFP	48-pin QFN/LQFP	48-pin QFN/LQFP
FLASH	16,384 (Dual 8K Arrays)		10,240 (8K and 2K arrays)
RAM	2080	2080	2080
ACMP	yes	yes	yes
ADC	8-ch	8-ch	8-ch
IIC	yes	yes	yes
IRQ	yes	yes	yes
KBI	8	8	8
SCI	yes	yes	yes
SPI	yes	yes	yes
TPM1	2-ch	2-ch	2-ch
TPM2	2-ch	-	-
TOD	Yes	Yes	Yes
LCD	8x24 4x28	8x16 4x20	8x16 4x20
I/O pins ¹	38	31	31

¹ I/O does not include two output-only port pins.

The block diagram in [Figure 1](#) shows the structure of the MC9S08LL16 series MCU.

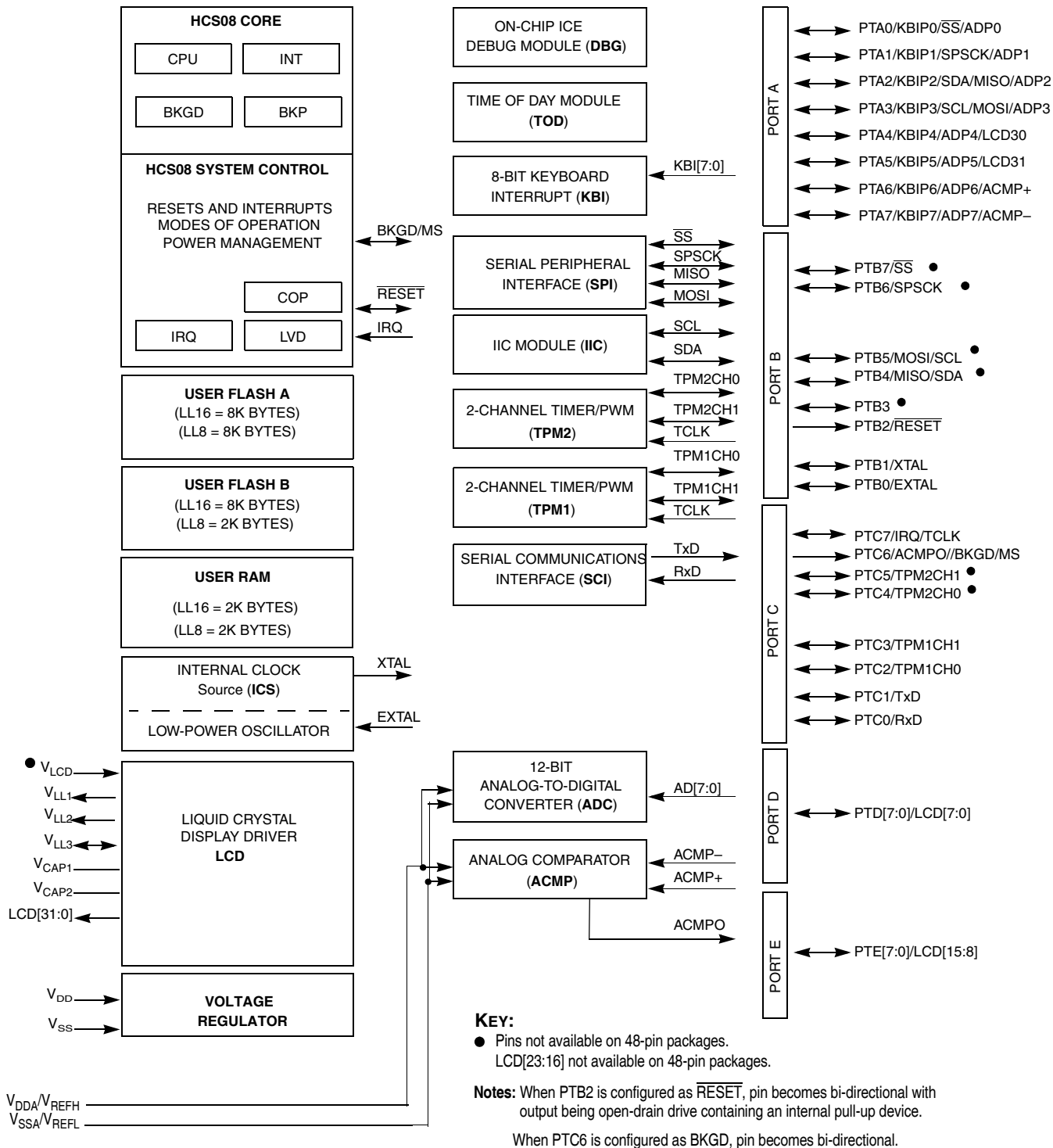
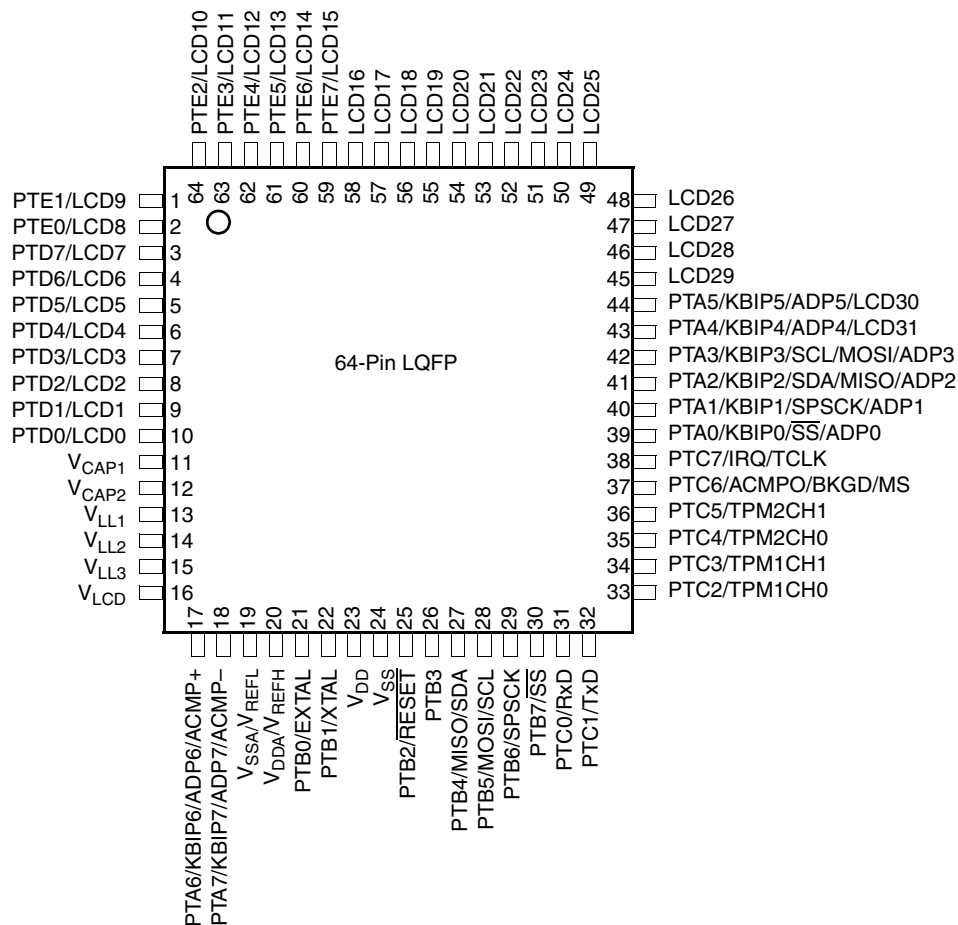


Figure 1. MC9S08LL16 Series Block Diagram

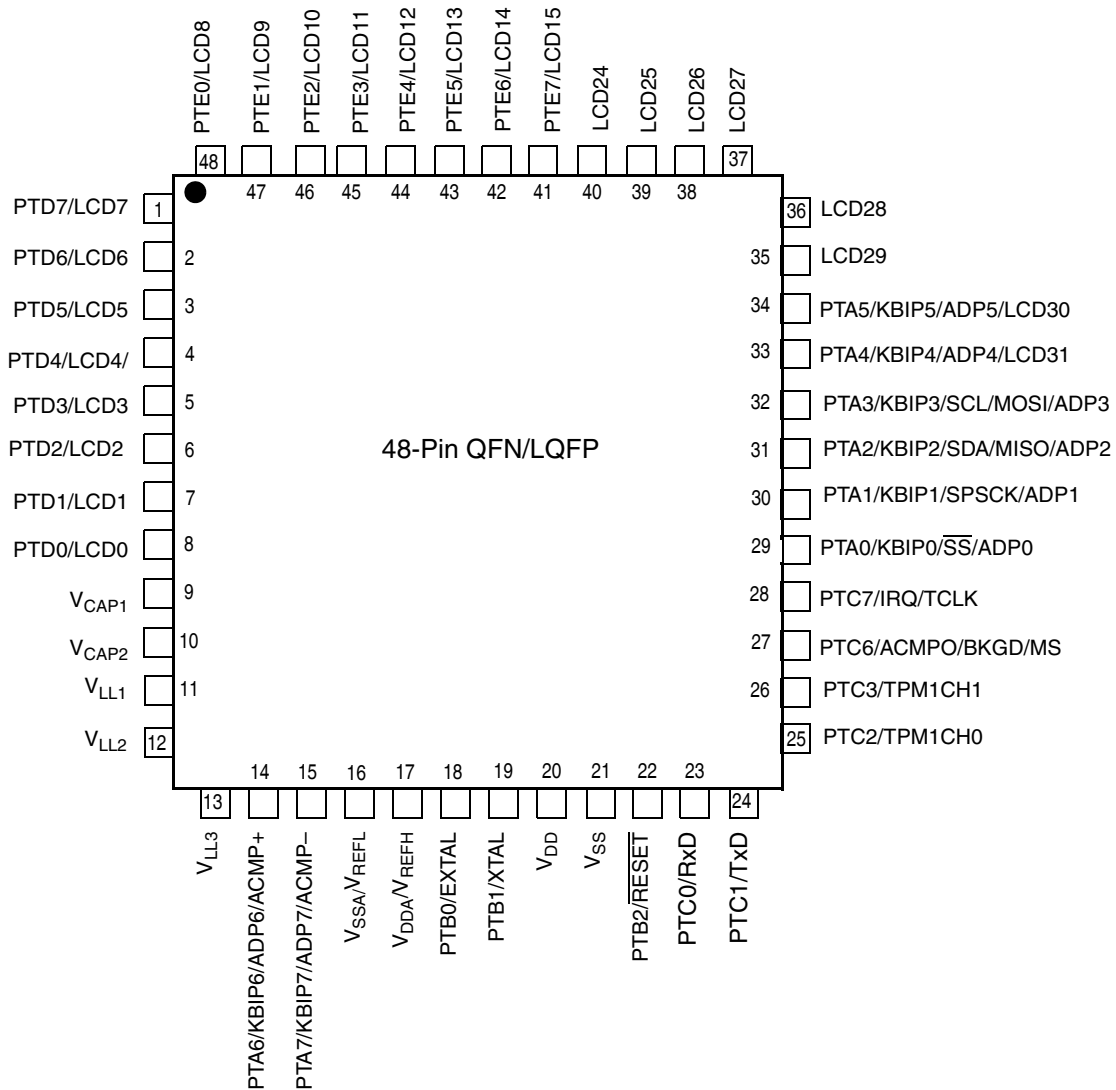
2 Pin Assignments

This section shows the pin assignments for the MC9S08LL16 series devices.



Note: V_{REFH}/V_{REFL} are internally connected to V_{DDA}/V_{SSA}.

Figure 2. MC9S08LL16 Series in 64-pin LQFP Package



Note: V_{REFH}/V_{REFL} are internally connected to V_{DDA}/V_{SSA}

Figure 3. MC9S08LL16 Series in 48-Pin QFN/LQFP Packages

Table 2. Pin Availability by Package Pin-Count

		<-- Lowest Priority --> Highest				
64	48	Port Pin	Alt 1	Alt 2	Alt3	Alt4
1	47	PTE1	LCD9			
2	48	PTE0	LCD8			
3	1	PTD7	LCD7			
4	2	PTD6	LCD6			
5	3	PTD5	LCD5			
6	4	PTD4	LCD4			
7	5	PTD3	LCD3			
8	6	PTD2	LCD2			
9	7	PTD1	LCD1			
10	8	PTD0	LCD0			
11	9		V _{cap1}			
12	10		V _{cap2}			
13	11		V _{LL1}			
14	12		V _{LL2}			
15	13		V _{LL3}			
16	—		V _{LCD}			
17	14	PTA6	KBIP6	ADP6	ACMP+	
18	15	PTA7	KBIP7	ADP7	ACMP-	
19	16				V _{SSA}	
					V _{REFL}	
					V _{REFH}	
20	17				V _{DDA}	
21	18	PTB0		EXTAL		
22	19	PTB1		XTAL		
23	20				V _{DD}	
24	21				V _{SS}	
25	22	PTB2	RESET			
26	—	PTB3				
27	—	PTB4	—	MISO	SDA	
28	—	PTB5	—	MOSI	SCL	
29	—	PTB6	—	SPSCK		
30	—	PTB7	—	SS		
31	23	PTC0		RxD		
32	24	PTC1		TxD		
33	25	PTC2		TPM1CH0		
34	26	PTC3		TPM1CH1		
35	—	PTC4		TPM2CH0		
36	—	PTC5		TPM2CH1		
37	27	PTC6	ACMPO	BKGD	MS	
38	28	PTC7		IRQ	TCLK	
39	29	PTA0	KBIP0	—	SS	ADP0

Table 2. Pin Availability by Package Pin-Count (continued)

		<-- Lowest Priority --> Highest				
64	48	Port Pin	Alt 1	Alt 2	Alt3	Alt4
40	30	PTA1	KBIP1	—	SPSCK	ADP1
41	31	PTA2	KBIP2	SDA	MISO	ADP2
42	32	PTA3	KBIP3	SCL	MOSI	ADP3
43	33	PTA4	KBIP4	ADP4	LCD31	
44	34	PTA5	KBIP5	ADP5	LCD30	
45	35		LCD29			
46	36		LCD28			
47	37		LCD27			
48	38		LCD26			
49	39		LCD25			
50	40		LCD24			
51	—		LCD23			
52	—		LCD22			
53	—		LCD21			
54	—		LCD20			
55			LCD19			
56			LCD18			
57			LCD17			
58			LCD16			
59	41	PTE7	LCD15			
60	42	PTE6	LCD14			
61	43	PTE5	LCD13			
62	44	PTE4	LCD12			
63	45	PTE3	LCD11			
64	46	PTE2	LCD10			

3 Electrical Characteristics

3.1 Introduction

This section contains electrical and timing specifications for the MC9S08LL16 series of microcontrollers available at the time of publication.

3.2 Parameter Classification

The electrical parameters shown in this supplement are guaranteed by various methods. To give the customer a better understanding the following classification is used and the parameters are tagged accordingly in the tables where appropriate:

Table 3. Parameter Classifications

P	Those parameters are guaranteed during production testing on each individual device.
C	Those parameters are achieved by the design characterization by measuring a statistically relevant sample size across process variations.
T	Those parameters are achieved by design characterization on a small sample size from typical devices under typical conditions unless otherwise noted. All values shown in the typical column are within this category.
D	Those parameters are derived mainly from simulations.

NOTE

The classification is shown in the column labeled “C” in the parameter tables where appropriate.

3.3 Absolute Maximum Ratings

Absolute maximum ratings are stress ratings only, and functional operation at the maxima is not guaranteed. Stress beyond the limits specified in Table 4 may affect device reliability or cause permanent damage to the device. For functional operating conditions, refer to the remaining tables in this section.

This device contains circuitry protecting against damage due to high static voltage or electrical fields; however, it is advised that normal precautions be taken to avoid application of any voltages higher than maximum-rated voltages to this high-impedance circuit. Reliability of operation is enhanced if unused inputs are tied to an appropriate logic voltage level (for instance, either V_{SS} or V_{DD}) or the programmable pull-up resistor associated with the pin is enabled.

Table 4. Absolute Maximum Ratings

Rating	Symbol	Value	Unit
Supply voltage	V_{DD}	-0.3 to 3.8	V
Maximum current into V_{DD}	I_{DD}	120	mA
Digital input voltage	V_{In}	-0.3 to $V_{DD} + 0.3$	V
Instantaneous maximum current Single pin limit (applies to all port pins) ^{1, 2, 3}	I_D	± 25	mA
Storage temperature range	T_{stg}	-55 to 150	°C

¹ Input must be current limited to the value specified. To determine the value of the required current-limiting resistor, calculate resistance values for positive (V_{DD}) and negative (V_{SS}) clamp voltages, then use the larger of the two resistance values.

² All functional non-supply pins, except for PTB2 are internally clamped to V_{SS} and V_{DD} .

³ Power supply must maintain regulation within operating V_{DD} range during instantaneous and operating maximum current conditions. If positive injection current ($V_{In} > V_{DD}$) is greater than I_{DD} , the injection current may flow out of V_{DD} and could result in external power supply going out of regulation. Ensure external V_{DD} load will shunt current greater than maximum injection current. This will be the greatest risk when the MCU is not consuming power. Examples are: if no system clock is present, or if the clock rate is very low (which would reduce overall power consumption).

3.4 Thermal Characteristics

This section provides information about operating temperature range, power dissipation, and package thermal resistance. Power dissipation on I/O pins is usually small compared to the power dissipation in on-chip logic and voltage regulator circuits, and it is user-determined rather than being controlled by the MCU design. To take $P_{I/O}$ into account in power calculations, determine the difference between actual pin voltage and V_{SS} or V_{DD} and multiply by the pin current for each I/O pin. Except in cases of unusually high pin current (heavy loads), the difference between pin voltage and V_{SS} or V_{DD} will be very small.

Table 5. Thermal Characteristics

Rating	Symbol	Value	Unit
Operating temperature range (packaged)	T_A	T_L to T_H -40 to 85	°C
Maximum junction temperature	T_{JM}	95	°C
Thermal resistance Single-layer board			
64-pin LQFP	θ_{JA}	72	°C/W
48-pin QFN		84	
48-pin LQFP		81	
Thermal resistance Four-layer board			
64-pin LQFP	θ_{JA}	54	°C/W
48-pin QFN		30	
48-pin LQFP		57	

The average chip-junction temperature (T_J) in °C can be obtained from:

$$T_J = T_A + (P_D \times \theta_{JA}) \quad \text{Eqn. 3-1}$$

where:

T_A = Ambient temperature, °C

θ_{JA} = Package thermal resistance, junction-to-ambient, °C/W

$P_D = P_{int} + P_{I/O}$

$P_{int} = I_{DD} \times V_{DD}$, Watts — chip internal power

$P_{I/O}$ = Power dissipation on input and output pins — user determined

For most applications, $P_{I/O} \ll P_{int}$ and can be neglected. An approximate relationship between P_D and T_J (if $P_{I/O}$ is neglected) is:

$$P_D = K \div (T_J + 273^\circ\text{C}) \quad \text{Eqn. 3-2}$$

Solving Equation 3-1 and Equation 3-2 for K gives:

$$K = P_D \times (T_A + 273^\circ\text{C}) + \theta_{JA} \times (P_D)^2 \quad \text{Eqn. 3-3}$$

Electrical Characteristics

where K is a constant pertaining to the particular part. K can be determined from equation 3 by measuring P_D (at equilibrium) for a known T_A . Using this value of K , the values of P_D and T_J can be obtained by solving Equation 3-1 and Equation 3-2 iteratively for any value of T_A .

3.5 ESD Protection and Latch-Up Immunity

Although damage from electrostatic discharge (ESD) is much less common on these devices than on early CMOS circuits, normal handling precautions should be taken to avoid exposure to static discharge. Qualification tests are performed to ensure that these devices can withstand exposure to reasonable levels of static without suffering any permanent damage.

All ESD testing is in conformity with AEC-Q100 Stress Test Qualification for Automotive Grade Integrated Circuits. During the device qualification, ESD stresses were performed for the human body model (HBM), the machine model (MM) and the charge device model (CDM).

A device is defined as a failure if after exposure to ESD pulses the device no longer meets the device specification. Complete DC parametric and functional testing is performed per the applicable device specification at room temperature followed by hot temperature, unless instructed otherwise in the device specification.

Table 6. ESD and Latch-up Test Conditions

Model	Description	Symbol	Value	Unit
Human Body Model	Series resistance	R1	1500	Ω
	Storage capacitance	C	100	pF
	Number of pulses per pin	—	3	
Charge Device Model	Series resistance	R1	0	Ω
	Storage capacitance	C	200	pF
	Number of pulses per pin	—	3	
Latch-up	Minimum input voltage limit		-2.5	V
	Maximum input voltage limit		7.5	V

Table 7. ESD and Latch-Up Protection Characteristics

No.	Rating ¹	Symbol	Min	Max	Unit
1	Human body model (HBM)	V_{HBM}	± 2000	—	V
2	Charge device model (CDM)	V_{CDM}	± 500	—	V
3	Latch-up current at $T_A = 85^\circ\text{C}$	I_{LAT}	± 100	—	mA

¹ Parameter is achieved by design characterization on a small sample size from typical devices under typical conditions unless otherwise noted.

3.6 DC Characteristics

This section includes information about power supply requirements and I/O pin characteristics.

Table 8. DC Characteristics

Num	C	Characteristic	Symbol	Condition	Min	Typ ¹	Max	Unit
1		Operating voltage			1.8		3.6	V
2	C	Output high voltage PTA[0:3], PTA[6:7], PTB[0:7], PTC[0:7] ² , low-drive strength	V_{OH}	$V_{DD} > 1.8\text{ V}$ $I_{Load} = -0.6\text{ mA}$	$V_{DD} - 0.5$	—	—	V
	P			$V_{DD} > 2.7\text{ V}$ $I_{Load} = -10\text{ mA}$	$V_{DD} - 0.5$	—	—	
	C			$V_{DD} > 1.8\text{ V}$ $I_{Load} = -3\text{ mA}$	$V_{DD} - 0.5$	—	—	
3	C	Output high voltage PTA[4:5], PTD[0:7], PTE[0:7], low-drive strength	V_{OH}	$V_{DD} > 1.8\text{ V}$ $I_{Load} = -0.5\text{ mA}$	$V_{DD} - 0.5$	—	—	V
	P			$V_{DD} > 2.7\text{ V}$ $I_{Load} = -3\text{ mA}$	$V_{DD} - 0.5$	—	—	
	C			$V_{DD} > 1.8\text{ V}$ $I_{Load} = -1\text{ mA}$	$V_{DD} - 0.5$	—	—	
4	D	Output high current Max total I_{OH} for all ports	I_{OHT}		—	—	100	mA
5	C	Output low voltage PTA[0:3], PTA[6:7], PTB[0:7], PTC[0:7], low-drive strength	V_{OL}	$V_{DD} > 1.8\text{ V}$ $I_{Load} = 0.6\text{ mA}$	—	—	0.5	V
	P			$V_{DD} > 2.7\text{ V}$ $I_{Load} = 10\text{ mA}$	—	—	0.5	
	C			$V_{DD} > 1.8\text{ V}$ $I_{Load} = 3\text{ mA}$	—	—	0.5	
6	C	Output low voltage PTA[4:5], PTD[0:7], PTE[0:7], low-drive strength	V_{OL}	$V_{DD} > 1.8\text{ V}$ $I_{Load} = 0.5\text{ mA}$	—	—	0.5	V
	P			$V_{DD} > 2.7\text{ V}$ $I_{Load} = 3\text{ mA}$	—	—	0.5	
	C			$V_{DD} > 1.8\text{ V}$ $I_{Load} = 1\text{ mA}$	—	—	0.5	
7	D	Output low current Max total I_{OL} for all ports	I_{OLT}		—	—	100	mA
8	P	Input high voltage all digital inputs	V_{IH}	$V_{DD} > 2.7\text{ V}$	$0.70 \times V_{DD}$	—	—	V
	C			$V_{DD} > 1.8\text{ V}$	$0.85 \times V_{DD}$	—	—	
9	P	Input low voltage all digital inputs	V_{IL}	$V_{DD} > 2.7\text{ V}$	—	—	$0.35 \times V_{DD}$	V
	C			$V_{DD} > 1.8\text{ V}$	—	—	$0.30 \times V_{DD}$	
10	C	Input hysteresis all digital inputs	V_{hys}		$0.06 \times V_{DD}$	—	—	mV

Table 8. DC Characteristics (continued)

Num	C	Characteristic	Symbol	Condition	Min	Typ ¹	Max	Unit
11	P	all input only pins except for LCD only pins (LCD 16-29)	I _{IN}	V _{IN} = V _{DD}	—	0.025	1	μA
				V _{IN} = V _{SS}	—	0.025	1	μA
		LCD only pins (LCD 16-29)		V _{IN} = V _{DD}	—	100	150	μA
				V _{IN} = V _{SS}	—	0.025	1	μA
12	P	Hi-Z (off-state) leakage current all input/output (per pin)	I _{OZ}	V _{IN} = V _{DD} or V _{SS}	—	0.025	1	μA
13	P	Total leakage current ³ Total leakage current for all pins	I _{INT}	V _{IN} = V _{DD} or V _{SS}	—	—	2	μA
14	P	Pullup, pull-down resistors when enabled	R _{PU} , R _{PD}	—	17.5	—	52.5	kΩ
	PTA[0:3], PTA[6:7], PTB[0:7], PTC[0:7]						69.5	
15	D	DC injection current ^{4, 5, 6}	I _{IC}	V _{IN} < V _{SS} , V _{IN} > V _{DD}	—0.2	—	0.2	mA
		Single pin limit Total MCU limit, includes sum of all stressed pins					—5	—
16	C	Input capacitance, all pins	C _{IN}		—	—	8	pF
17	C	RAM retention voltage	V _{RAM}		—	0.6	1.0	V
18	C	POR re-arm voltage ⁷	V _{POR}		0.9	1.4	2.0	V
19	D	POR re-arm time	t _{POR}		10	—	—	μs
20	P	Low-voltage detection threshold	V _{LVD}	V _{DD} falling	1.80	1.84	1.88	V
				V _{DD} rising	1.88	1.92	1.96	
21	P	Low-voltage warning threshold	V _{LVW}	V _{DD} falling	2.08	2.14	2.2	V
				V _{DD} rising	2.08	2.14	2.2	
22	P	Low-voltage inhibit reset/recover hysteresis	V _{hys}		—	80	—	mV
23	P	Bandgap voltage reference ⁸	V _{BG}		1.15	1.17	1.18	V

¹ Typical values are measured at 25 °C. Characterized, not tested

² All I/O pins except for LCD pins in open drain mode.

³ Total leakage current is the sum value for all GPIO pins. This leakage current is not distributed evenly across all pins but characterization data shows that individual pin leakage current maximums are less than 250 nA.

⁴ All functional non-supply pins, except for PTB2 are internally clamped to V_{SS} and V_{DD}.

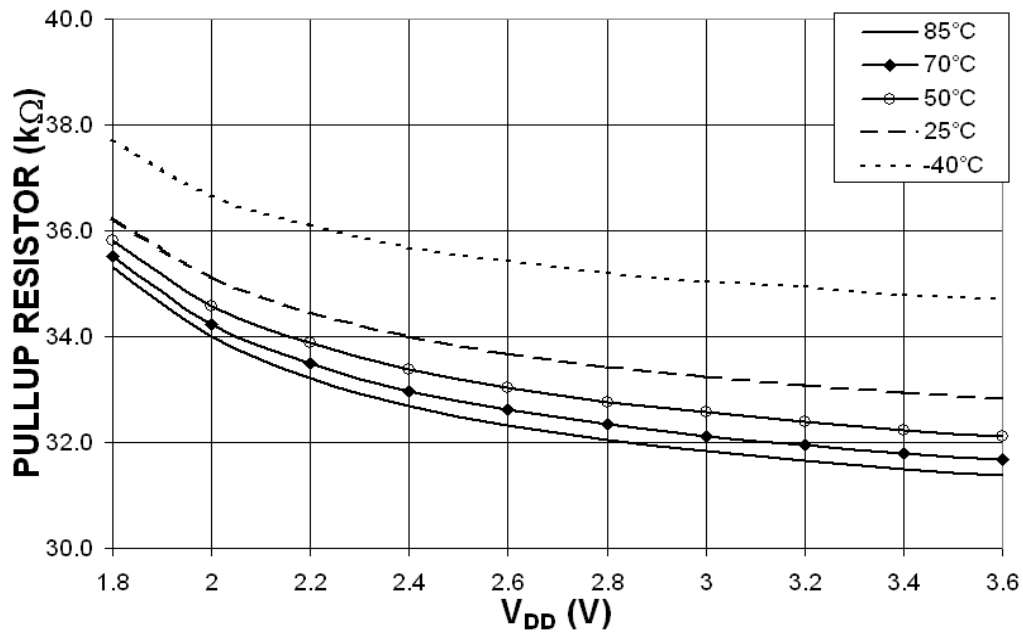
⁵ Input must be current limited to the value specified. To determine the value of the required current-limiting resistor, calculate resistance values for positive and negative clamp voltages, then use the larger of the two values.

⁶ Power supply must maintain regulation within operating V_{DD} range during instantaneous and operating maximum current conditions. If the positive injection current (V_{IN} > V_{DD}) is greater than I_{DD}, the injection current may flow out of V_{DD} and could result in external power supply going out of regulation. Ensure that external V_{DD} load will shunt current greater than maximum injection current. This will be the greatest risk when the MCU is not consuming power. Examples are: if no system clock is present, or if clock rate is very low (which would reduce overall power consumption).

⁷ POR will occur below the minimum voltage.

⁸ Factory trimmed at V_{DD} = 3.0 V, Temp = 25 °C.

PULLUP RESISTOR TYPICALS - Non LCD Pins



PULLDOWN RESISTOR TYPICALS - Non LCD Pins

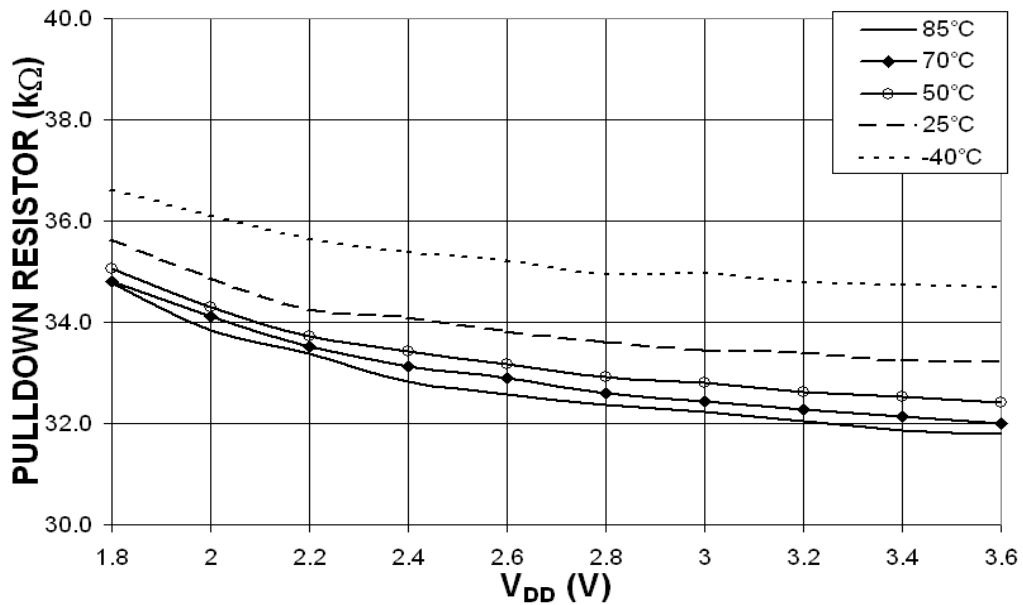


Figure 4. Non-LCD pins I/O Pullup and Pulldown Typical Resistor Values ($V_{DD} = 3.0\text{ V}$)

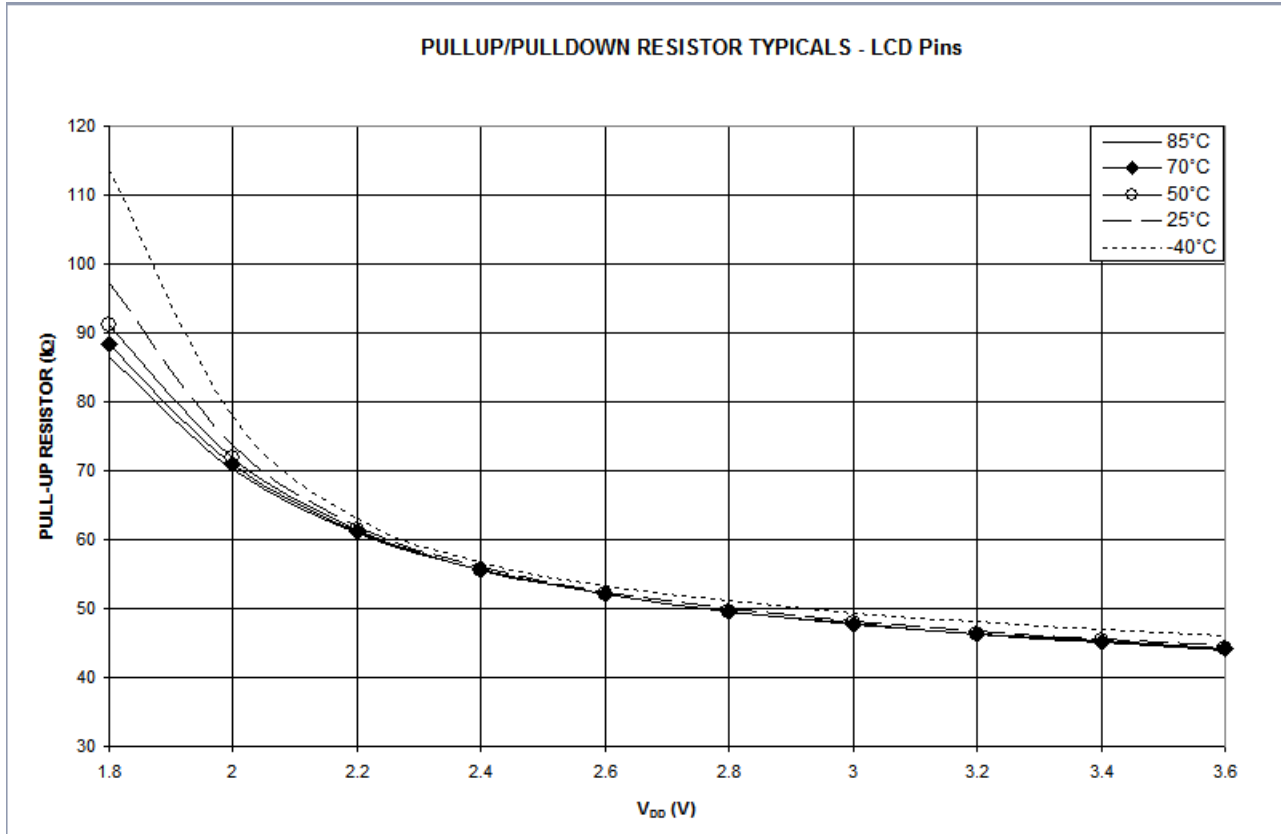
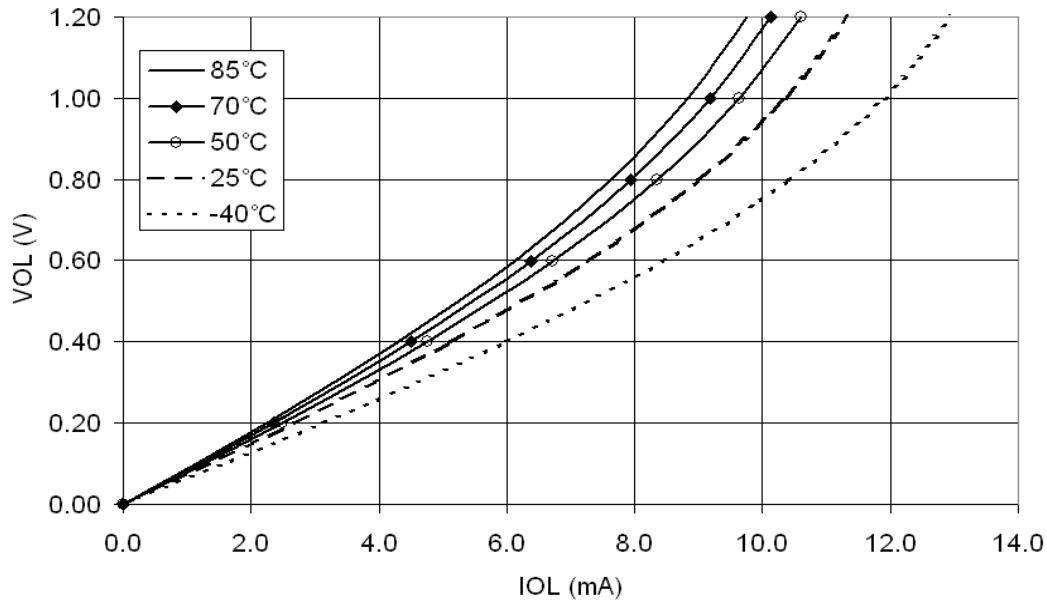


Figure 5. LCD/GPIO Pins I/O Pullup/Pulldown Typical Resistor Values

Typical VOL vs IOL at VDD = 3V
 Low Drive (PTxDSN = 0) - Non LCD Pins



Typical VOL vs VDD
 Low Drive (PTxDSN = 0) - Non LCD Pins

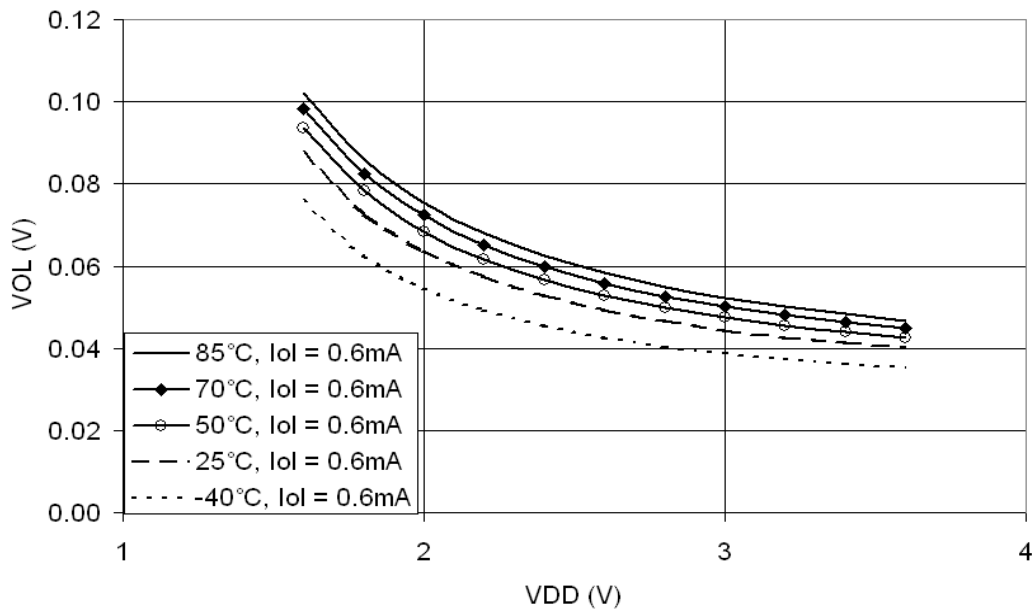
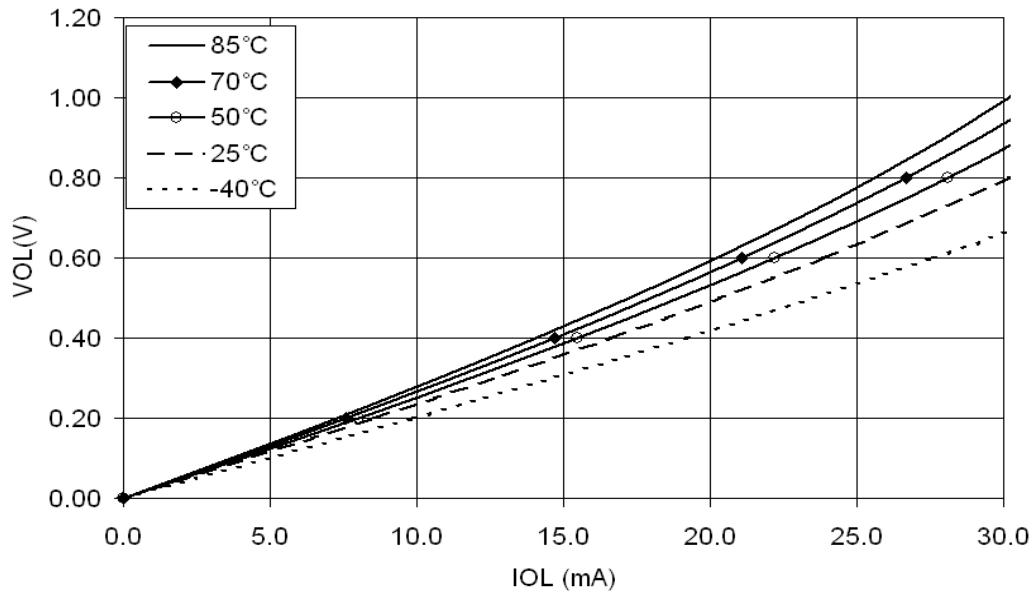


Figure 6. Typical Low-Side Driver (Sink) Characteristics (Non-LCD pins) — Low Drive (PTxDSn = 0)

Typical VOL vs IOL at VDD = 3V
High Drive (PTxDSN = 1) - Non LCD Pins



Typical VOL vs VDD
High Drive (PTxDSN = 1) - Non LCD Pins

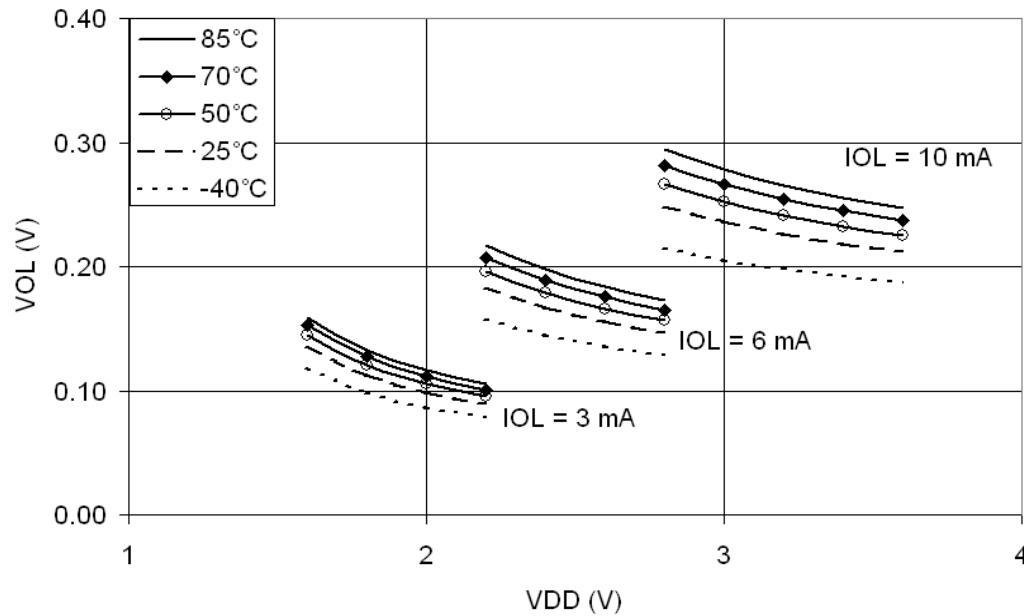


Figure 7. Typical Low-Side Driver (Sink) Characteristics(Non-LCD pins) — High Drive (PTxDSn = 1)

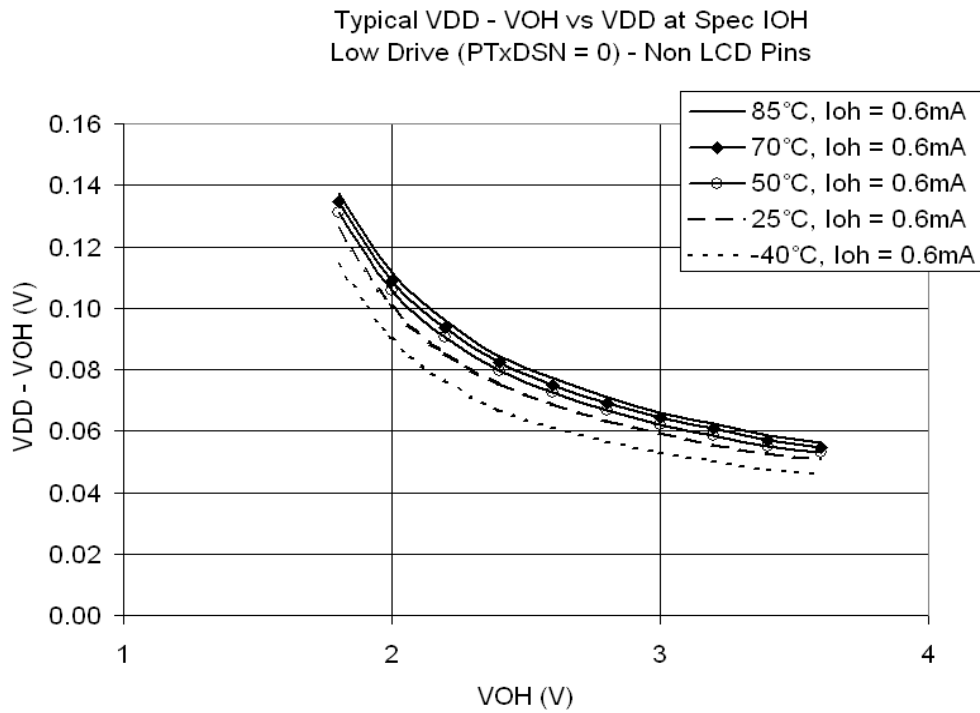
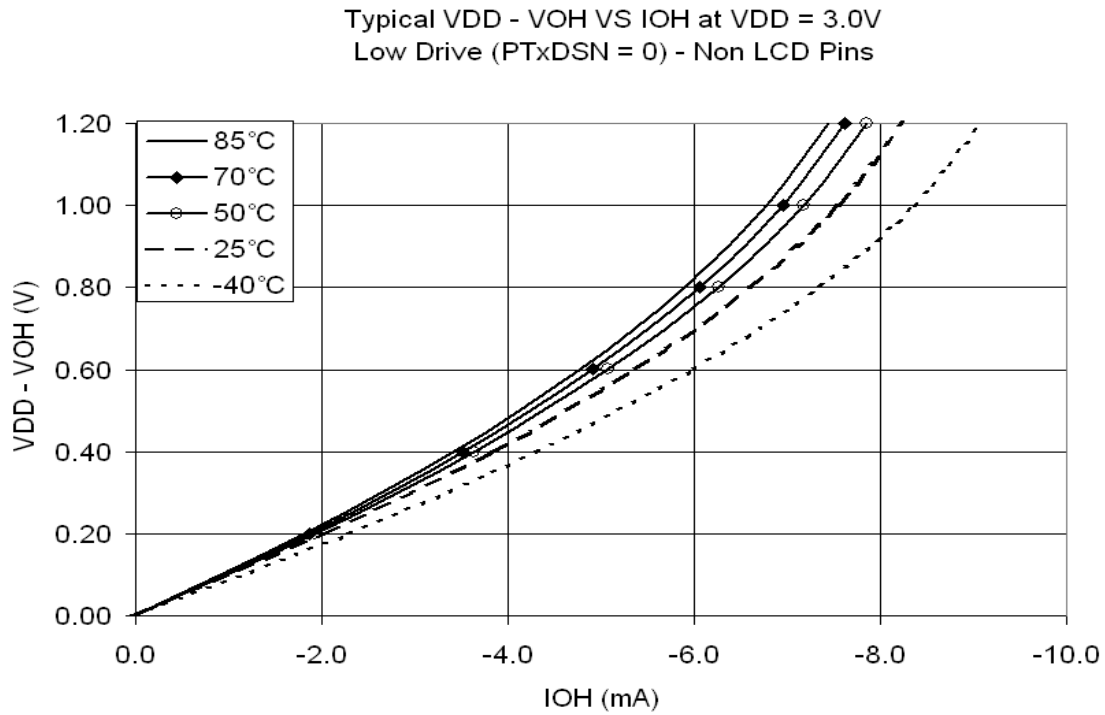


Figure 8. Typical High-Side (Source) Characteristics (Non-LCD Pins) — Low Drive (PTxDSn = 0)

TYPICAL VDD - VOH VS IOH at VDD = 3.0V
 High Drive (PTxDSN = 1) - Non LCD Pins

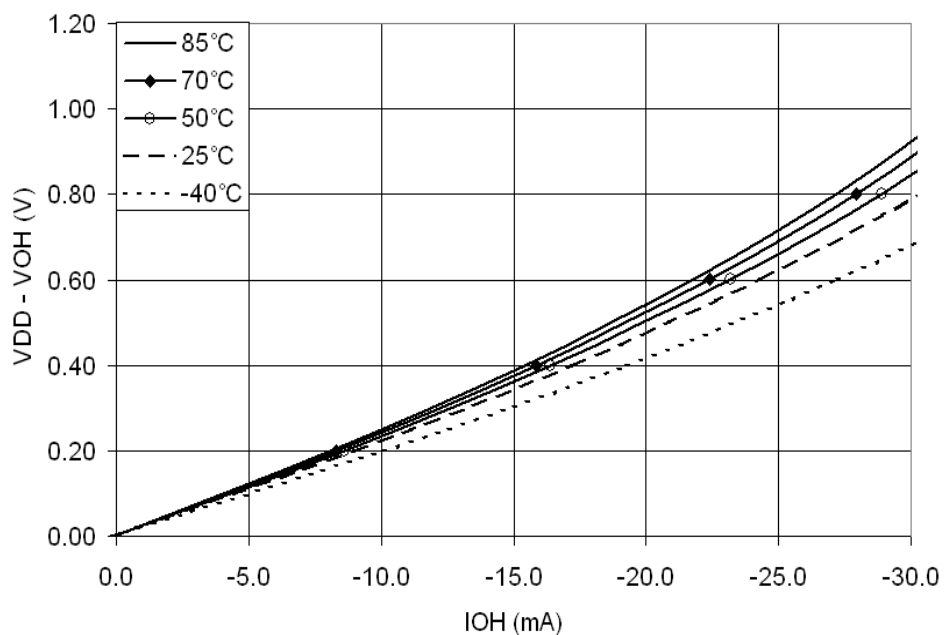
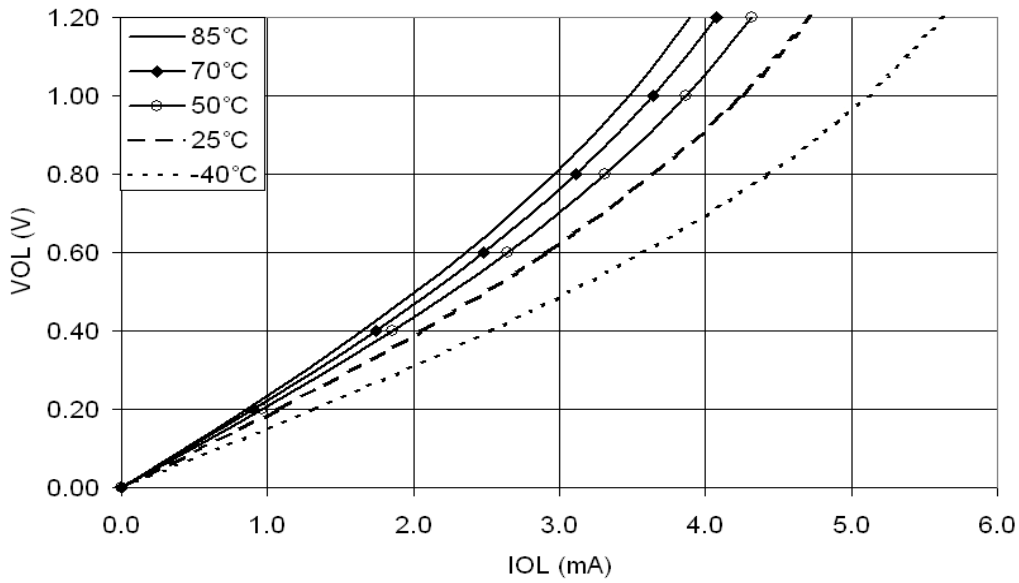


Figure 9. Typical High-Side (Source) Characteristics(Non-LCD Pins) — High Drive (PTxDSn = 1)

TYPICAL VOL VS IOL at VDD = 3.0V
 Low Drive (PTxDSN = 0) - LCD/GPIO pins



TYPICAL VOL VS VDD
 Low Drive (PTxDSN = 0) - LCD/GPIO pins

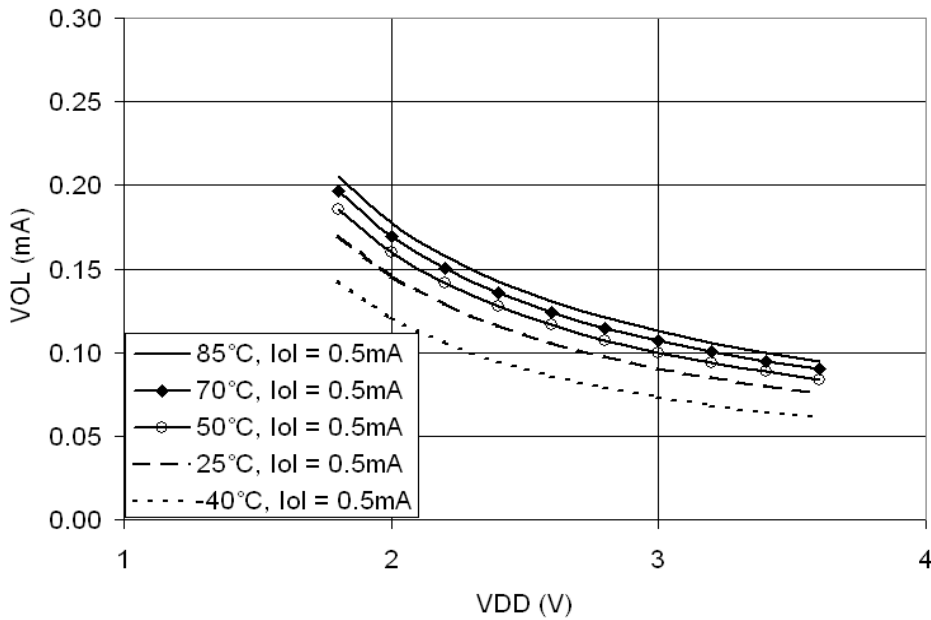


Figure 10. Typical Low-Side Driver (Sink) Characteristics (LCD/GPIO Pins) — Low Drive (PTxDSn = 0)

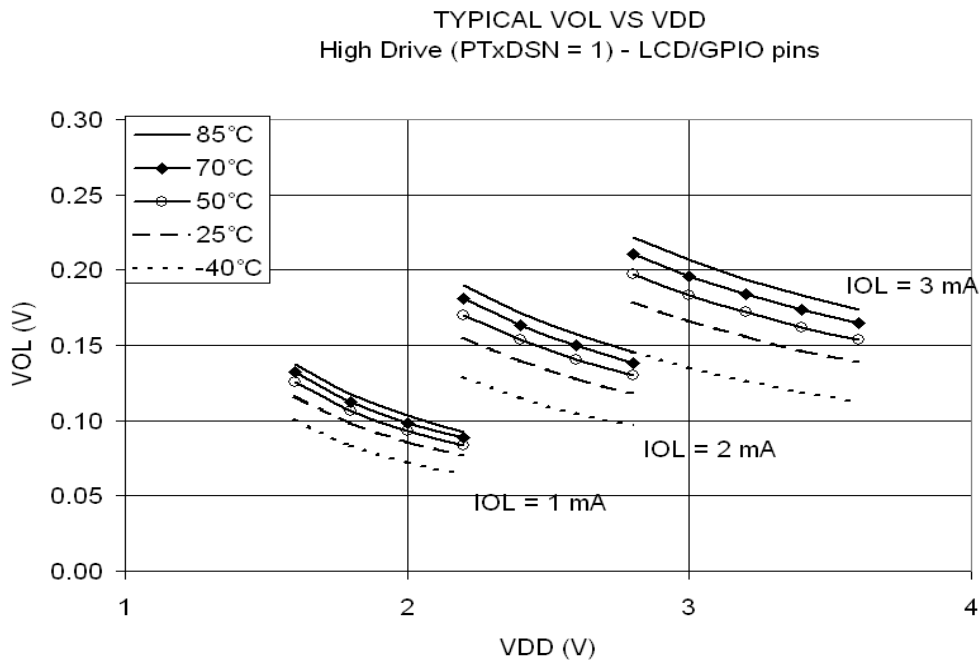
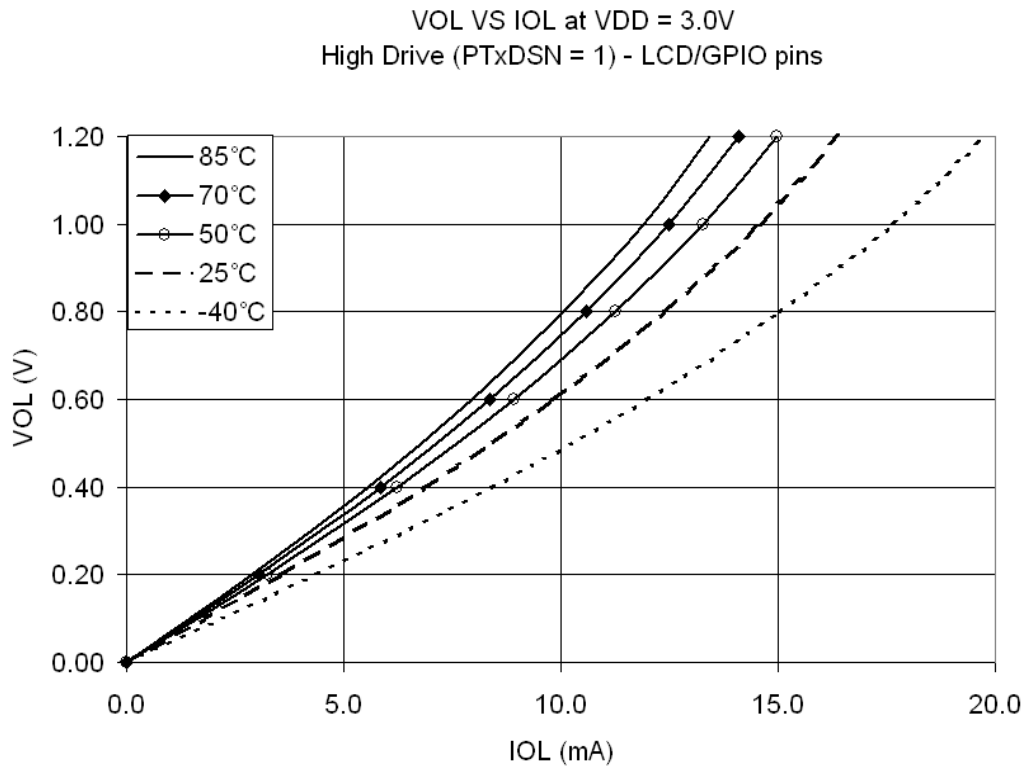


Figure 11. Typical Low-Side Driver (Sink) Characteristics(LCD/GPIO Pins) — High Drive (PTxDSn = 1)

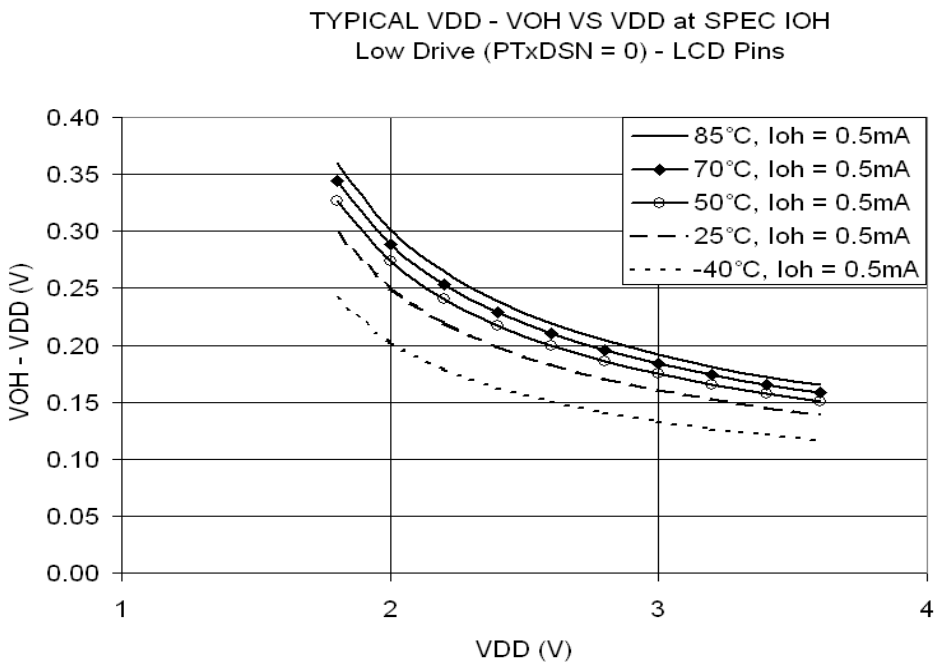
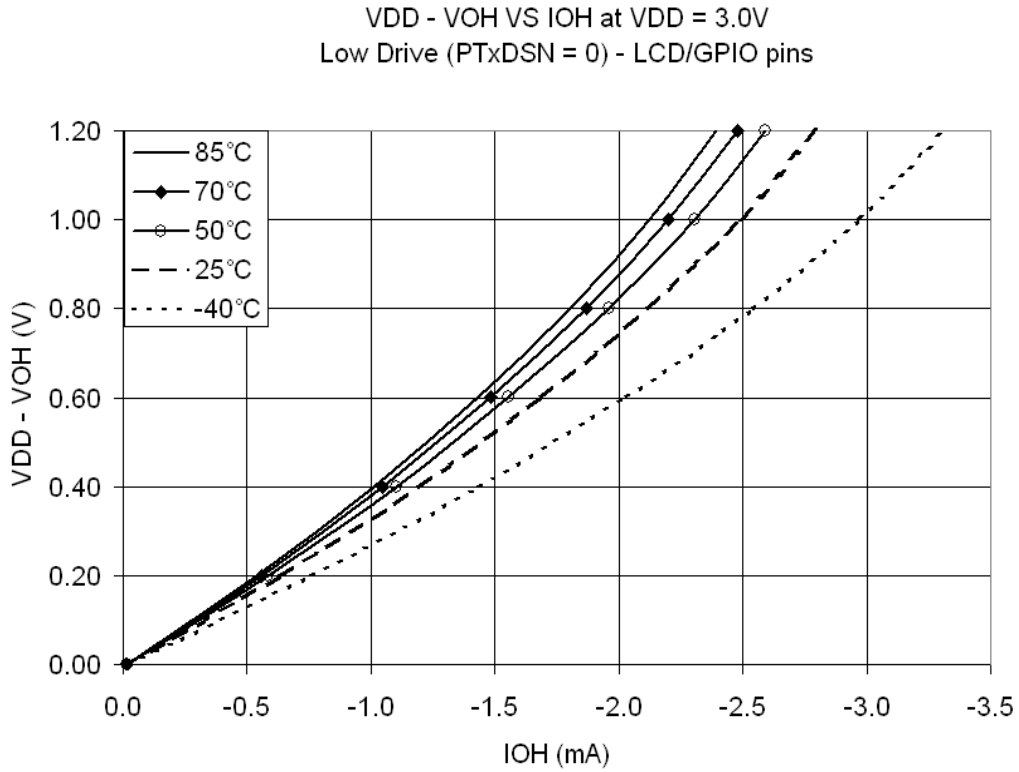


Figure 12. Typical High-Side (Source) Characteristics (LCD/GPIO Pins) — Low Drive (PTxDSn = 0)