



## **GPLB37A3**

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### **2000 Dots LCD Controller with 256KB ROM**

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Version 1.1

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## 2000 Dots LCD Controller with 256KB ROM

### 1. GENERAL DESCRIPTION

The GPLB37A3, an 8-bit CMOS microprocessor, contains 1216 bytes working RAM, 256K bytes ROM, 8 I/Os, interrupt/wakeup controller, UART for serial communication and Serial SRAM interface for memory expansion, and automatic display controller/driver for LCD. It also features one PWM/DAC driver with two audio channels to produce attractive sound effects easily. Its large ROM area can be used to store both program and audio data. The built-in UART speeds up data transmission between two devices. Furthermore, a SLEEP (power-down) function is also built in to extend power life. The GPLB37A3 is designed with GENERALPLUS state-of-the-art technology to fulfill LCD application needs, especially for hand-held products.

### 2. FEATURES

- Built in 8-bit processor
  - **1216 bytes SRAM**
  - **256K bytes ROM**
  - Max. operating speed: 4.0MHz @ 2.4V - 3.6V  
5.0MHz @ 3.6V - 5.5V
  - Programmable CPU clock: /1, /2, /4, /8, /16, /32, /64 of ROSC Frequency.
  - 6 wake-up sources
  - 7 interrupt sources
- Universal Asynchronous Receiver and Transmitter (UART)
- Serial SRAM interface
- Key scan function
  - SEG[15:0] can be used to send key scan output
- Programmable LCD driver
  - **74 segments, 16 commons, maximum 1184 dots or 64 segments, 32 commons, maximum 2048 dots**
  - 1/5, 1/6 bias; 1/16, 1/32 duty capability
  - **296 bytes dedicated LCD RAM**
  - Built-in voltage regulator to generate VLCD for LCD driver
  - 32-level contrast control (2.45V - 5.75V, in 1/5 bias)
  - 32-level contrast control (2.95V - 6.85V, in 1/6 bias)
- Power saving SLEEP mode
- Low Voltage Detector
  - **8-level 2.9V - 2.2V/4.35V - 3.3V detection**
  - **2.2V Low voltage reset**
- Low power consumption:
  - 600μA typical @ 3.0V, F<sub>CPU</sub> = 1.0MHz, F<sub>OSC</sub> = 4.0MHz
  - 25μA typical halt current @ 3.0V
  - <1μA typical standby current @ 3.0V

#### ■ Peripherals

- **Max. 28 I/O pins (PA[7:0], PB[5:0], PC[7:0], PD[5:0])**

. Dedicated I/Os: PA[0:5]

. Shared pin I/Os:

PA[6:7] / SEG[63:62]

PC[0:1] / SSRAM SCK, SDA/SEG[61:60]

PC[3:2] / UART Rx/Tx

PC[4:7] / SEG[73:70] / COM[25:22]

PB[0:5] / SEG[69:64] / COM[21:16]

PD[0:5] / COM[31:26]

- 32.768KHz oscillator circuit for RTC

- RC-oscillator (only one resistor is needed)

- Two 16-bit reloadable timer/counters

- **8-bit DAC resolution, 2-channel PWM/DAC audio outputs**

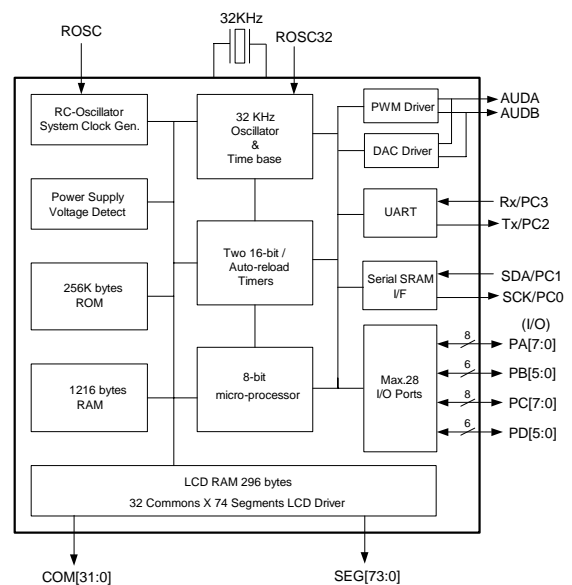
- Watchdog Timer for reliable operation

#### ■ Wide operating voltage range:

- 2.4V - 3.6V

- 3.6V - 5.5V

### 3. BLOCK DIAGRAM



**Note1:** PA [6:7] share pins with SEG [63:62] (mask option).

**Note2:** PC [0:1] share pins with Serial SRAM interface SCK/SDA. Also share pins with SEG [61:60] (mask option).

**Note3:** PC [2:3] share pins with UART Tx/Rx.

**Note4:** PC [4:7] share pins with SEG [73:70]. Also share pins with COM [25:22] (mask option).

**Note5:** PB [0:5] share pins with SEG [69:64]. Also share pins with COM [21:16] (mask option).

**Note6:** PD [0:5] share pins with COM [31:26] (mask option).

## 4. APPLICATION FIELD

- Educational Learning Aids (ELA)
- Handheld game
- Scientific calculator
- Talking calculator, Talking clock
- Talking instrument controller
- General speech synthesizer
- Data bank

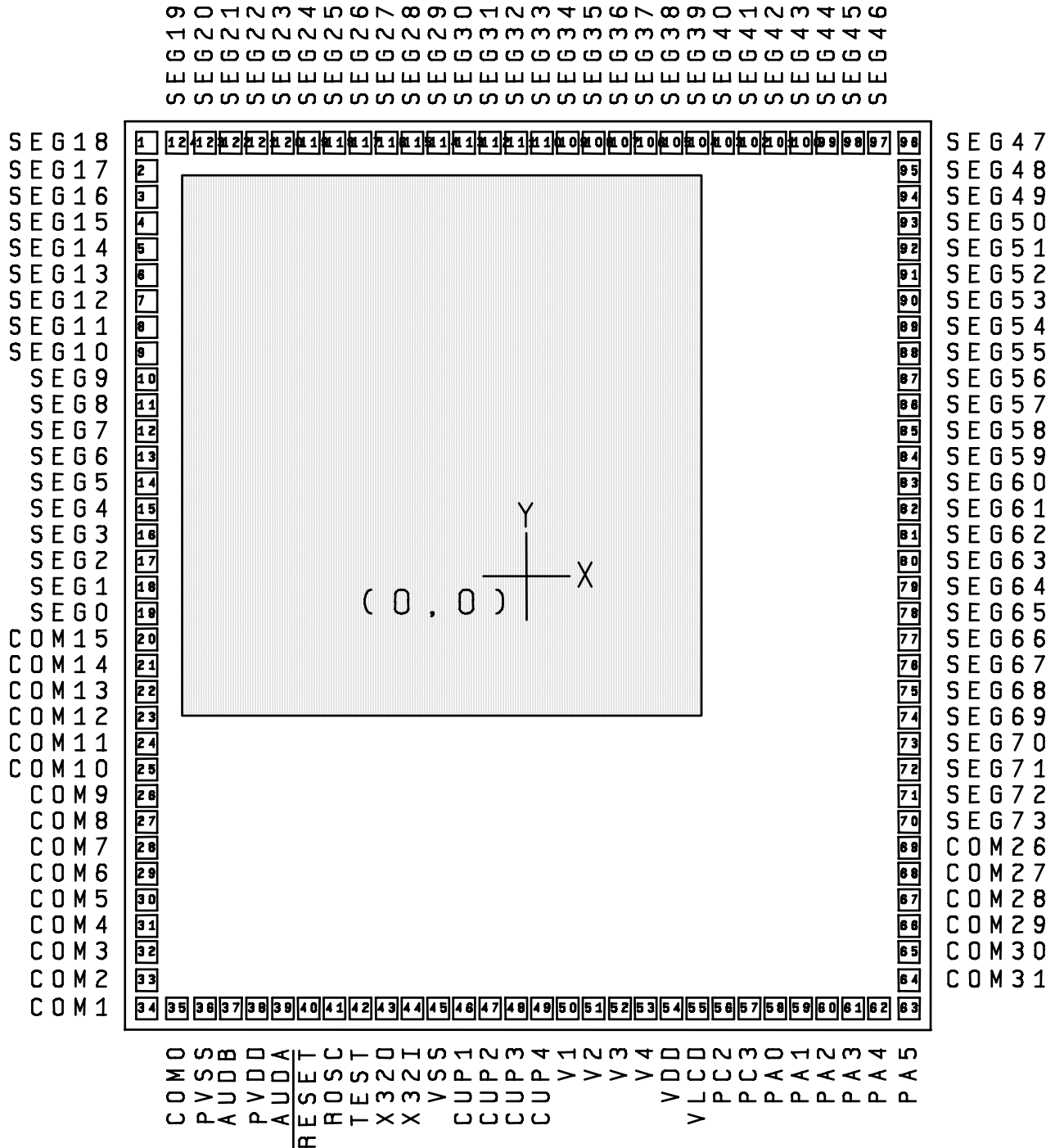
## 5. SIGNAL DESCRIPTIONS

Total: 124 pins

Mnemonic	PIN No.	Type	Description
SEG59 - 19	84-124	O	LCD driver segment output. SEG15 - 0 share pin with key scan port.
SEG18 - 0	1 - 19	O	
SEG63 - 62 / PA6 - 7	80 - 81	I/O	SEG63 - 62 optioned to PA6 - 7.
SEG61 - 60 / PC0 - 1/SCK, SDA	82 - 83	I/O	SEG61 - 60 optioned to PC0 - 1 / SCK, SDA.
SEG73 - 70 / COM25 - 22 / PC4 - 7	70 - 73	I/O	SEG73 - 70 optioned to COM25 - 22 or PC4 - 7(Port C 4, 5 shared with Ext-I, Ext-ck).
SEG69 - 64 / COM21-16 / PB0-5	74 - 79	I/O	SEG69 - 64 optioned to COM21 - 16 or PB0 - 5.
COM15 - 0	20 - 35	O	LCD driver common output.
COM31 - 26 / PD0 - 5	64 - 69	I/O	
PA5 - 0	63 - 58	I/O	Port A is a bi-directional I/O port, which can be software programmed as wake up I/O.
PC3 / Rx	57	I/O	UART input. Share pin with PC3.
PC2 / Tx	56	I/O	UART output. Share pin with PC2.
ROSC	41	I	R-oscillator input, connect to VDD through a resistor.
RESET	40	I	System reset input, low active.
AUDA, AUSB	39, 37	O	PWM/DAC audio output.
X32I	44	I	32.768KHz crystal input or connects to VDD through a resistor (option).
X32O	43	O	32.768KHz crystal output.
TEST	42	I	Test input.
CUP4 - 1	49 - 46	P	LCD voltage generation. Charge pump capacitor inter-connection pins.
VLCD	55	P	LCD voltage generation.
V4 - 1	53 - 50	P	LCD voltage generation.
VDD	54	P	Power supply voltage input.
VSS	45	P	Ground reference.
PVDD	38	P	PWM driver power.
PVSS	36	P	PWM driver ground reference.

Legend: I = Input, O = Output, P = Power

## 5.1. PAD Assignment



This IC substrate should be connected to VSS

**Note1:** The 0.1μF capacitor between VDD and VSS should be placed to IC as close as possible.

**Note2:** The shaped area shows the internal ROM block in order to identify the location of the first pin.

## 6. FUNCATIONAL DESCRIPTIONS

### 6.1. Memories

The GPLB37A3 contains 256K-byte ROM and 1216-byte SRAM. The Serial SRAM interface is provided in GPLB37A3; thus,

SRAM space can be extended by Generalplus Serial SRAM, GPRS256B or GPRS512C.

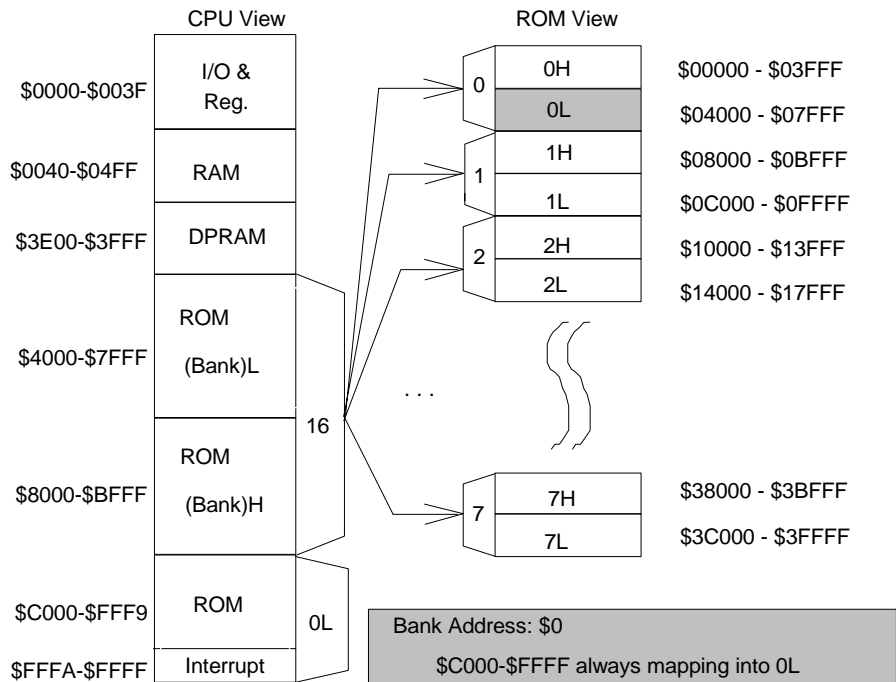
### 6.2. Map of Memory and I/Os

\*NMI SOURCE:

- LV DETECT
- TIMER1

\*INT SOURCE:

- EXT INT
- TBL (2/4/8/16Hz)
- TBH (128/256/512/1KHz)
- TIMER0
- TIMER1
- UART TX
- UART RX



**Note1:** User program should start from \$C800. \$C000-\$C7FF is the test program area.

**Note2:** User program interrupt vector: \$FFFA ~ \$FFFF

**Note3:** Test program interrupt vector: \$FFF2 ~ \$FFF7

### 6.3. Operation Modes

There are three operation modes involved in GPLB37A3: standby, halt and operating. The following table shows the differences between these modes.

	Operating	Halt	Standby
CPU	ON	OFF	OFF
32768Hz oscillator	ON	ON	OFF
LCD driver	ON	ON/OFF	OFF

### 6.4. Operating Mode

In operating state, all functions (CPU, 32768Hz oscillator, timer/counter, LCD driver...) are activated. Generally speaking, this mode consumes the highest power.

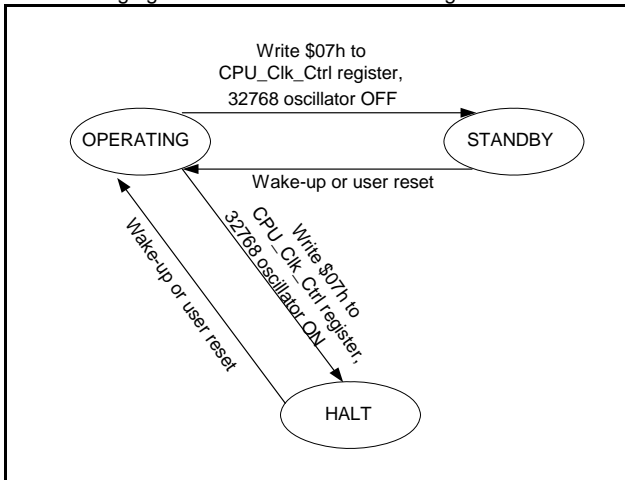
### 6.5. Standby Mode

The standby mode is a mode where the device is placed in its lowest current consumption state. In standby mode, all functions are turned off; in addition, RAM and I/Os will remain in their previous states.

### 6.6. Halt Mode

In halt mode, CPU clock halts and waits for an event (key press, timer overflow) to wake up. The 32768Hz related functions, such as timer/counter and LCD driver, may remain active in the halt mode.

The following figure is the GPLB37A3 state diagram:



GPLB37A3 State Diagram

## 6.7. Speech and Melody

For speech synthesis, the GPLB37A3 provides several timer interrupts for a precise sampling frequency. The sound data can be stored into ROM and be played back. Several algorithms are recommended for high fidelity and good compression of sound such as PCM and ADPCM.

For melody synthesis, the GPLB37A3 provides a dual tone mode. Once in the dual tone mode, users only need to program the tone frequency for each channel by writing to the timer/counter TM0 and TM1, and set the envelope of each channel. The hardware will toggle the tone wave automatically.

## 6.8. LCD Controller/Driver

The GPLB37A3 contains a 2048-dot LCD controller/driver. Programmers are able to define the LCD configuration by setting up the LCD Control Register. Once the LCD configuration is completed, the desired pattern can be displayed by filling the LCD buffer with proper data. The LCD driver can also operate during sleep by keeping 32768 oscillator running. The LCD driver in GPLB37A3 supports 1/16-1/32 duty and 1/5-1/6 bias.

## 6.9. LCD Voltage Generation

The GPLB37A3 offers a voltage regulator and a charge-pumping circuit. The voltage regulator provides a reference voltage ( $V_2$ ) for the charge-pumping circuit to generate  $V_{LCD}$ . Users can get the desired  $V_{LCD}$  by changing the output reference voltage (writing to register) of the voltage regulator. Enabling the voltage regulator and charge-pumping circuit gets a stable  $V_{LCD}$  that will not be affected by  $V_{DD}$ . The  $V_{LCD}$  is adjustable from 2.95V to 6.85V in 1/6 bias and from 2.45V to 5.75V in 1/5 bias.

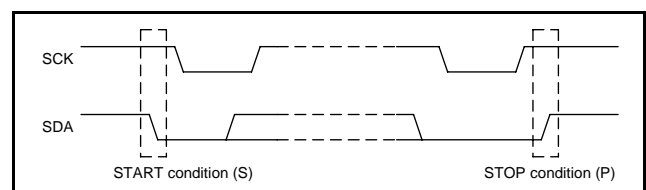
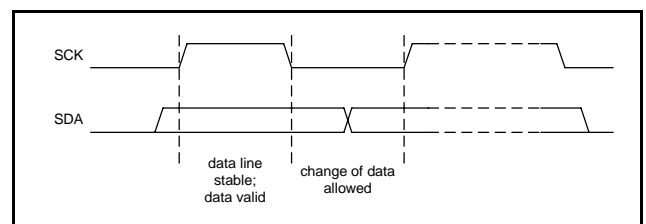
## 6.10. Audio Output

Internally, the GPLB37A3 supports two audio output modes: PWM or DAC. The GPLB37A3 has a pair of PWM drivers, supporting two sound channels. Each channel is able to play speech or tone individually. The PWM drivers can directly drive speaker or buzzer without buffer or amplification circuit.

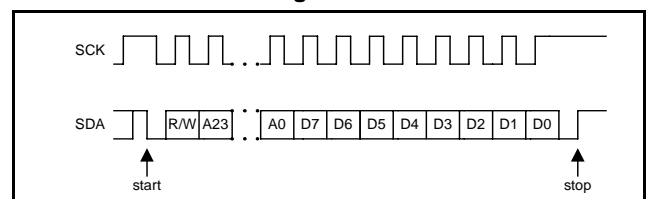
In DAC mode, GPLB37A3 supports 2-channel DAC current output with 8-bit resolution. The DAC current signal of each channel outputs through pin AUDA and AUSB respectively.

## 6.11. Serial SRAM Interface

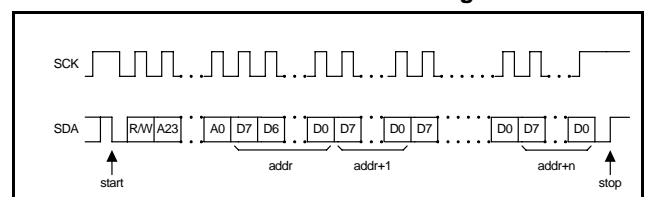
The Serial SRAM interface is able to expand the data storage SRAM. The Control Registers are \$30-\$36. Note that the pins of SDA and SCK are shared with PC [1:0] and therefore, users should set PC [1:0] as Serial SRAM interface.



### 6.11.1. Read/Write timing



### 6.11.2. Continuous READ/WRITE timing





## 6.12. Asynchronous Serial Interface (UART)

The GPLB37A3 supports a 1-channel UART for serial communications. The bit-rate is up to 115.2kbps. UART operation is controlled by UART command registers. Configurations such as Tx/Rx interrupt, parity check, parity even/odd and clock source can be configured in the command registers. Two interrupts are generated by Rx and Tx. The Rx or Tx interrupt activates when a byte is received or transmitted. Reading the status register informs whether the interrupt is generated by Rx or Tx. Frame, overrun and parity errors are detected as each byte is received and the error status can be read from status register.

The UART supports clock auto calibration. If auto calibration is selected, standard baud rate from 1.2kbps to 115.2kbps are available. The baud rate is selected by writing to the baud rate control registers. The supported baud rates and their minimum R-oscillator clock frequency requirements are shown in the table below.

Baud Rate(bps)	Min. Frosc(Hz)
1200	24000
2400	48000
4800	96000
9600	192000
19200	384000
38400	768000
51200	1024000
57600	1152000
102400	2048000
115200	2304000

If the auto calibration is not selected, users can get desired baud rates by writing appropriate values to pre-scalar registers. Non-standard baud rates can be obtained by this method. In the non-calibration mode, users must understand that the R-oscillator frequency may alter due to manufacturing process variations, supply voltage, operating temperature and tolerance of external R components used.

## 6.13. Low Voltage Detection

The GPLB37A3 provides an 8-level (software programmable) low voltage detector to detect a low voltage event. Users can turn on the low detection to monitor VDD periodically to check if it is lower than the given value. In addition, if LV NMI is enabled, a NMI will be issued to notify CPU if power voltage drops below the given value. Also, the voltage detector will generate a system

reset if power supply voltage drops below 2.2V. *When LVR function is enabled, care must be taken not to turn off 32kHz crystal oscillator. Otherwise an unexpected reset may occur when 32kHz crystal is being turned on again.*

## 6.14. Key Scan Function

GPLB37A3 supports key scan function. The LCD driver will generate a key strobe signal in the period of every common. When PA receives this strobe signal, a wake-up is issued. Then, program can send the key scan signal through SEG [15:0] to determine the location of the depressed key.

## 6.15. Watchdog Timer (WDT)

An on-chip watchdog timer is also available in the GPLB37A3. The WDT is designed to recover the system from abnormal operation. In some cases, if WDT is not cleared for one second, the WDT will generate a system reset to restart system. If WDT is enabled, the WDT should be cleared every 0.5 second to avoid accidental reset. The WDT can be cleared through software programming. Note that the WDT only works when 32768Hz clock is activated.

## 6.16. Mask Options

### 6.16.1. 32768 oscillator

- 1). X'TAL
- 2). R-oscillator

### 6.16.2. Watchdog timer

- 1). Enable
- 2). Disable

### 6.16.3. Audio output select

- 1). PWM
- 2). DAC

### 6.16.4. Low voltage reset

- 1). Enable
- 2). Disable

### 6.16.5. PA[6:7] / SEG[63:62]

Each port/segment can be optioned as I/O or LCD segment individually.

### 6.16.6. PC[0:1] / SCK, SDA / SEG[61:60]

Each port/segment can be optioned as I/O or LCD segment individually.

### 6.16.7. PC[4:7] / SEG[73:70] / COM[25:22]

Each port/segment/common can be optioned as I/O or LCD segment/common individually.

### 6.16.8. PB[0:5] / SEG[69:64] / COM[21:16]

Each port/segment/common can be optioned as I/O or LCD segment/common individually.

### 6.16.9. PD[0:5] / COM[31:26]

Each port/common can be optioned as I/O or LCD common individually.

## 7. ELECTRICAL SPECIFICATIONS

### 7.1. Absolute Maximum Ratings

Characteristics	Symbol	Ratings
DC Supply Voltage	$V_+$	< 7.0V
Input Voltage Range	$V_{IN}$	-0.5V to $V_+ + 0.5V$
Operating Temperature	$T_A$	0°C to +60°C
Storage Temperature	$T_{STO}$	-50°C to +150°C

**Note:** Stresses beyond those given in the Absolute Maximum Rating table may cause operational errors or damage to the device. For normal operational conditions, see AC/DC Electrical Characteristics.

### 7.2. DC Characteristics

VDD=3.0V, TA=25°C

Characteristics	Symbol	Limit			Unit	Test Condition
		Min.	Typ.	Max.		
Operating Voltage	VDD	2.4	-	3.6	V	For 2-battery
		3.6	-	5.5	V	For 3-battery
Operating Current	$I_{OP}$	-	600	-	$\mu A$	$F_{CPU} = 1.0MHz @ 3.0V$ $F_{OSC} = 4.0MHz$ , no load
Halt Current	$I_{HALT}$	-	25	-	$\mu A$	VDD = 3.0V, 32K X'TAL ON, LCD ON, no LCD panel
Standby Current	$I_{STBY}$	-	-	1.0	$\mu A$	VDD = 3.0V, all off
Audio Output Current (PWM)	$I_{OH}$	-	-20	-	mA	VDD = 3.0V, $V_{OH} = 2.5V$
		-	-40	-	mA	VDD = 3.0V, $V_{OH} = 2.0V$
Audio Output Current (PWM)	$I_{OL}$	-	20	-	mA	VDD = 3.0V, $V_{OL} = 0.5V$
		-	40	-	mA	VDD = 3.0V, $V_{OL} = 1.0V$
Audio Output Current (DAC)	$I_{DAC}$	-	3.0	-	mA	VDD = 5.0V, full scale
Input High Level	$V_{IH}$	2.0	-	-	V	VDD = 3.0V
Input Low Level	$V_{IL}$	-	-	0.8	V	VDD = 3.0V
Output High Current (I/O)	$I_{OH}$	-1.0	-	-	mA	VDD = 3.0V, $V_{OH} = 2.4V$
Output Sink Current (I/O)	$I_{OL}$	1.0	-	-	mA	VDD = 3.0V, $V_{OL} = 0.8V$
LCD Driver Voltage ( $V_{LCD} - V_{SS}$ )	$V_{LCD}$	2.45	-	5.75	V	VDD = 3.0V, 1/5 bias, no load
		2.95	-	6.85	V	VDD = 3.0V, 1/6 bias, no load
OSC Resistor	$R_{OSC}$	-	180K	-	$\Omega$	$F_{OSC} = 2.0MHz @ 3.0V$
OSC 32KHz Resistor	$R_{32k}$	-	700K	-	$\Omega$	$F_{32k} = 32KHz @ 3.0V$
CPU Clock	$F_{CPU}$	-	-	4.0	MHz	$F_{CPU} = F_{OSC}/1 @ 2.4V$
		-	-	5.0	MHz	$F_{CPU} = F_{OSC}/1 @ 3.6V$

**Note:**  $V_{LCD}$  should be higher than VDD to prevent forward biasing the p-n junction of I/O output PMOS.

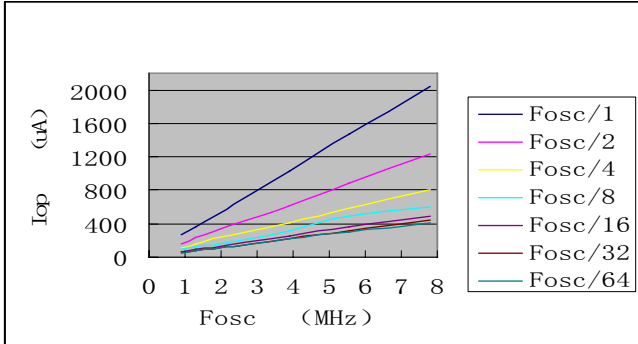
VDD=4.5V, T<sub>A</sub>=25°C

Characteristics	Symbol	Limit			Unit	Test Condition
		Min.	Typ.	Max.		
Operating Voltage	VDD	3.6	-	5.5	V	For 3-battery
Operating Current	I <sub>OP</sub>	-	1400	-	μA	F <sub>CPU</sub> = 1.0MHz @ 4.5V F <sub>OSC</sub> = 4.0MHz, no load
Halt Current	I <sub>HALT</sub>	-	40	-	μA	VDD = 4.5V, 32K X'TAL ON, LCD ON, no LCD panel
Standby Current	I <sub>STBY</sub>	-	-	2.0	μA	VDD = 4.5V, all off
Audio Output Current (PWM)	I <sub>OH</sub>	-	-40	-	mA	VDD = 4.5V, V <sub>OH</sub> = 4.0V
		-	-80	-	mA	VDD = 4.5V, V <sub>OH</sub> = 3.5V
Audio Output Current (PWM)	I <sub>OL</sub>	-	40	-	mA	VDD = 4.5V, V <sub>OL</sub> = 0.5V
		-	80	-	mA	VDD = 4.5V, V <sub>OL</sub> = 1.0V
Audio Output Current (DAC)	I <sub>DAC</sub>	-	3.0	-	mA	VDD = 5.0V, full scale
Input High Level	V <sub>IH</sub>	0.8VDD	-	-	V	VDD = 4.5V
Input Low Level	V <sub>IL</sub>	-	-	0.2VDD	V	VDD = 4.5V
Output High Current (I/O)	I <sub>OH</sub>	-2.0	-	-	mA	VDD = 4.5V, V <sub>OH</sub> = 4.0V
Output Sink Current (I/O)	I <sub>OL</sub>	2.0	-	-	mA	VDD = 4.5V, V <sub>OL</sub> = 0.5V
LCD Driver Voltage (V <sub>LCD</sub> - VSS)	V <sub>LCD</sub>	2.45	-	5.75	V	VDD = 4.5V, 1/5 bias, no load
		2.95	-	6.85	V	VDD = 4.5V, 1/6 bias, no load
OSC Resistor	R <sub>OSC</sub>	-	180K	-	Ω	F <sub>OSC</sub> = 2.0MHz @ 4.5V
OSC 32KHz Resistor	R <sub>32k</sub>	-	780K	-	Ω	F <sub>32k</sub> = 32KHz @ 4.5V
CPU Clock	F <sub>CPU</sub>	-	-	5.0	MHZ	F <sub>CPU</sub> = F <sub>OSC</sub> /1 @ 3.6V~5.5V

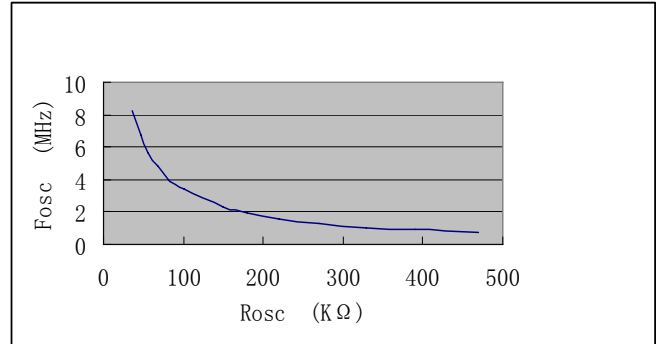
**Note:** V<sub>LCD</sub> should be higher than VDD to prevent forward biasing the p-n junction of I/O output PMOS.

## 7.3. The Relationships between the $F_{OSC}$ and the $I_{OP}$

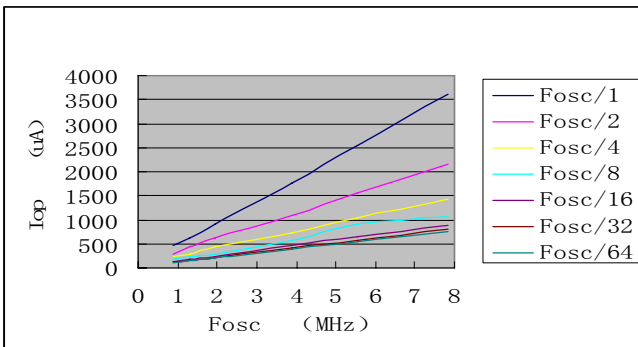
### 7.3.1. VDD = 3.0V



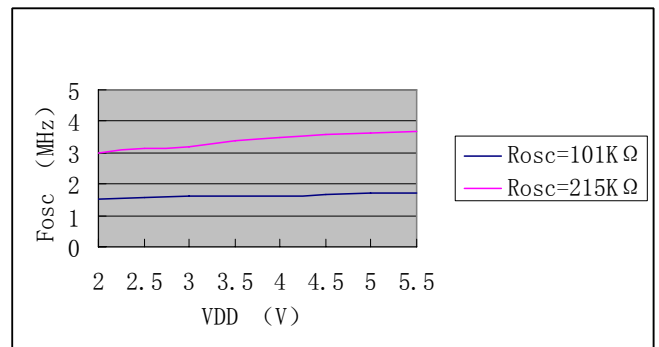
### 7.4.2. VDD= 4.5V



### 7.3.2. VDD = 4.5V

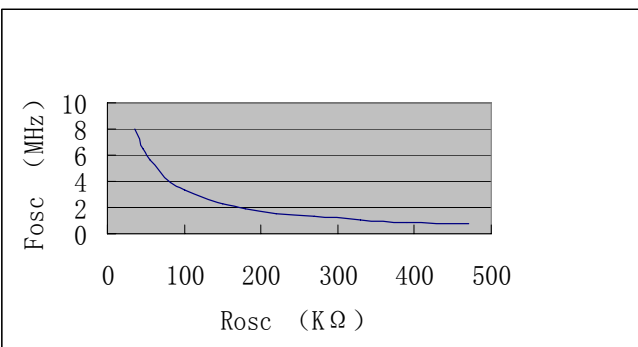


## 7.5. The Relationships between the VDD and the $F_{OSC}$

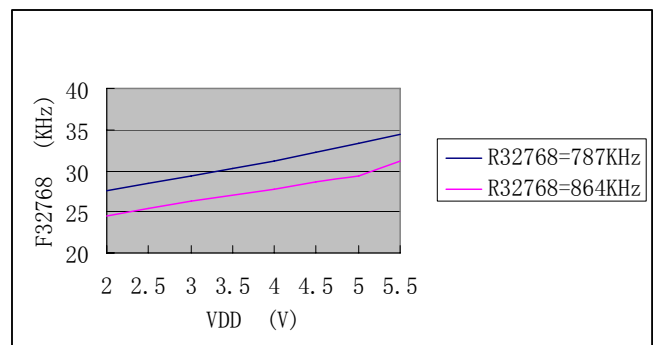


## 7.4. The Relationships between the $R_{OSC}$ and the $F_{OSC}$

### 7.4.1. VDD = 3.0V

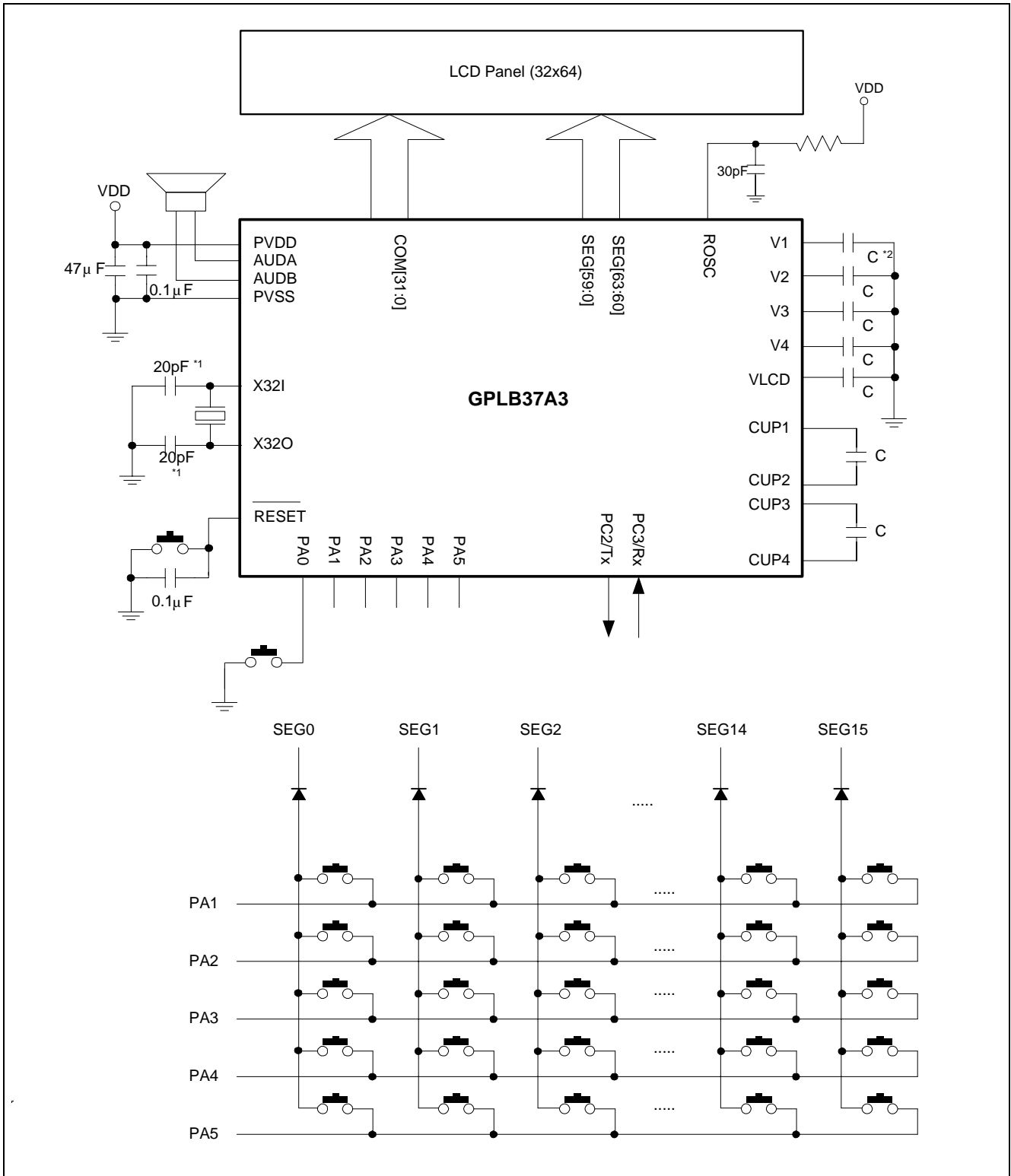


## 7.6. The Relationships between the VDD and the $F_{32768}$



## 8. APPLICATION CIRCUITS

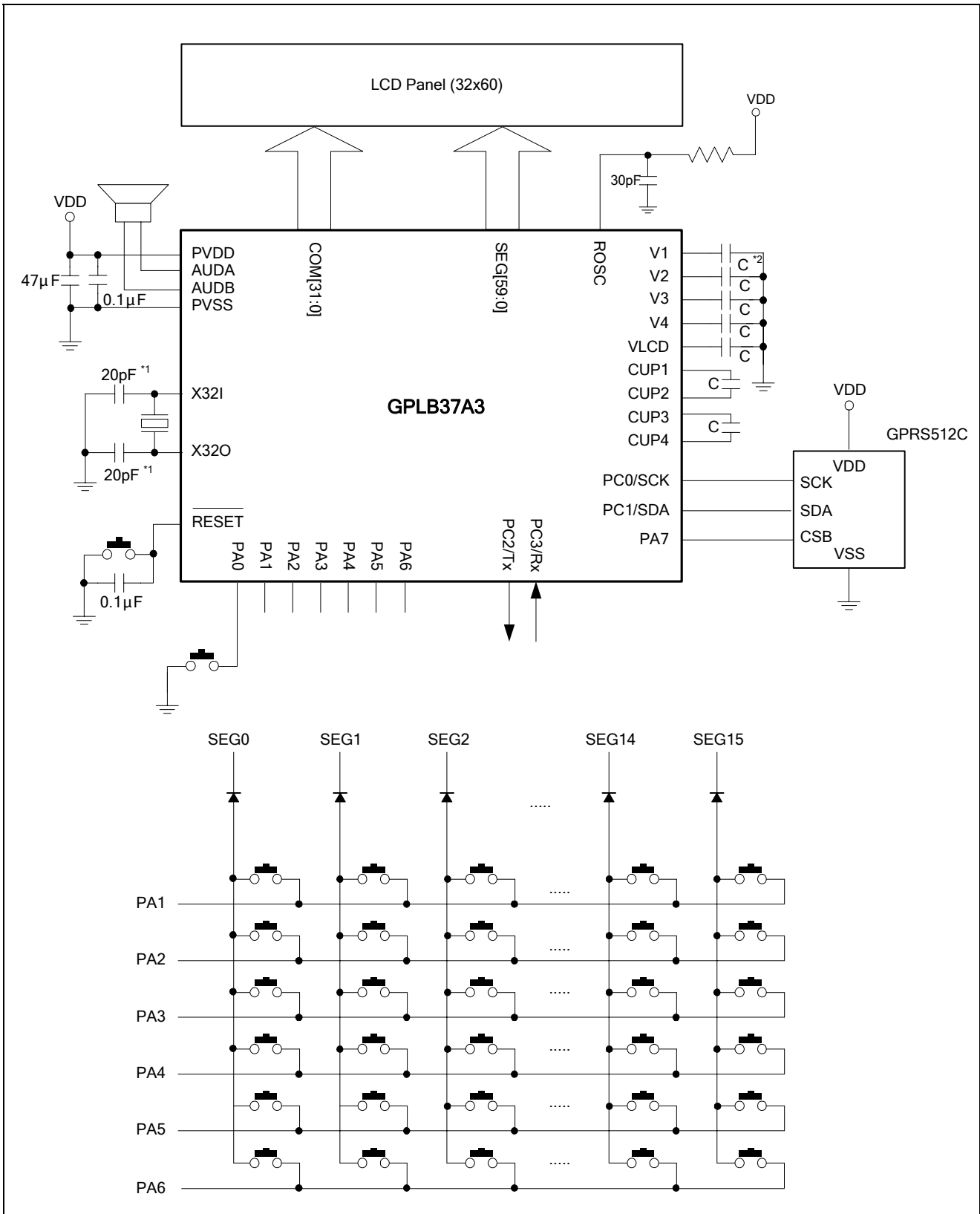
### 8.1. 2048 Dots LCD Driver, 64 Segments x 32 Commons, 1/5 or 1/6 Bias with External Serial SRAM - (1)



**Note\*1:** These capacitor values are for design guidance only. Different capacitor values may be required for different crystal/resonator used.

**Note\*2:** The value of the capacitance(C) would range from 0.1µF to 4.7µF to stable the output voltage.

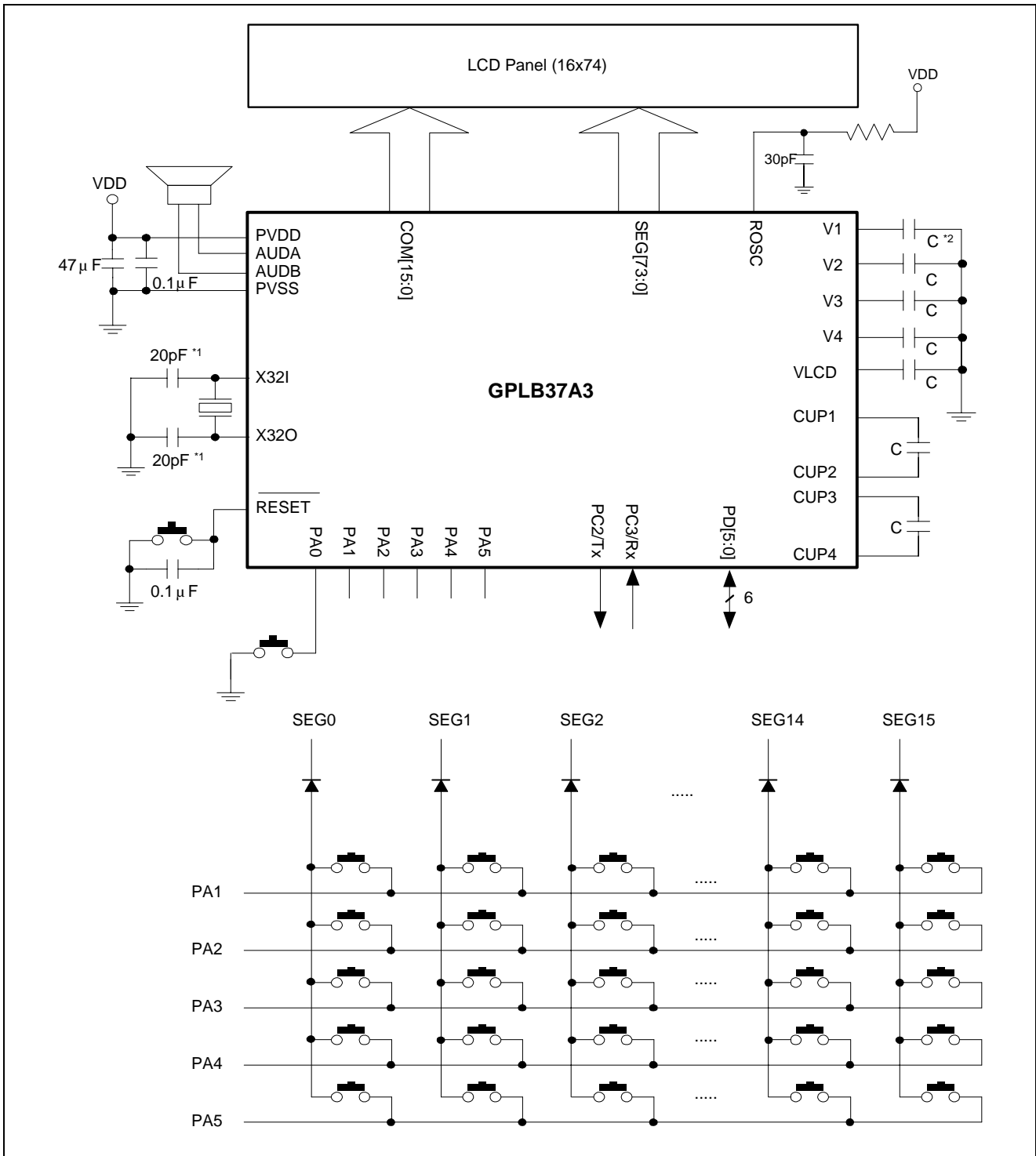
## 8.2. 1920 Dots LCD Driver, 60 Segments x 32 Commons, 1/5 or 1/6 Bias with External Serial SRAM - (2)



**Note\*1:** These capacitor values are for design guidance only. Different capacitor values may be required for different crystal/resonator used.

**Note\*2:** The value of the capacitance(C) would range from 0.1µF to 4.7µF to stable the output voltage.

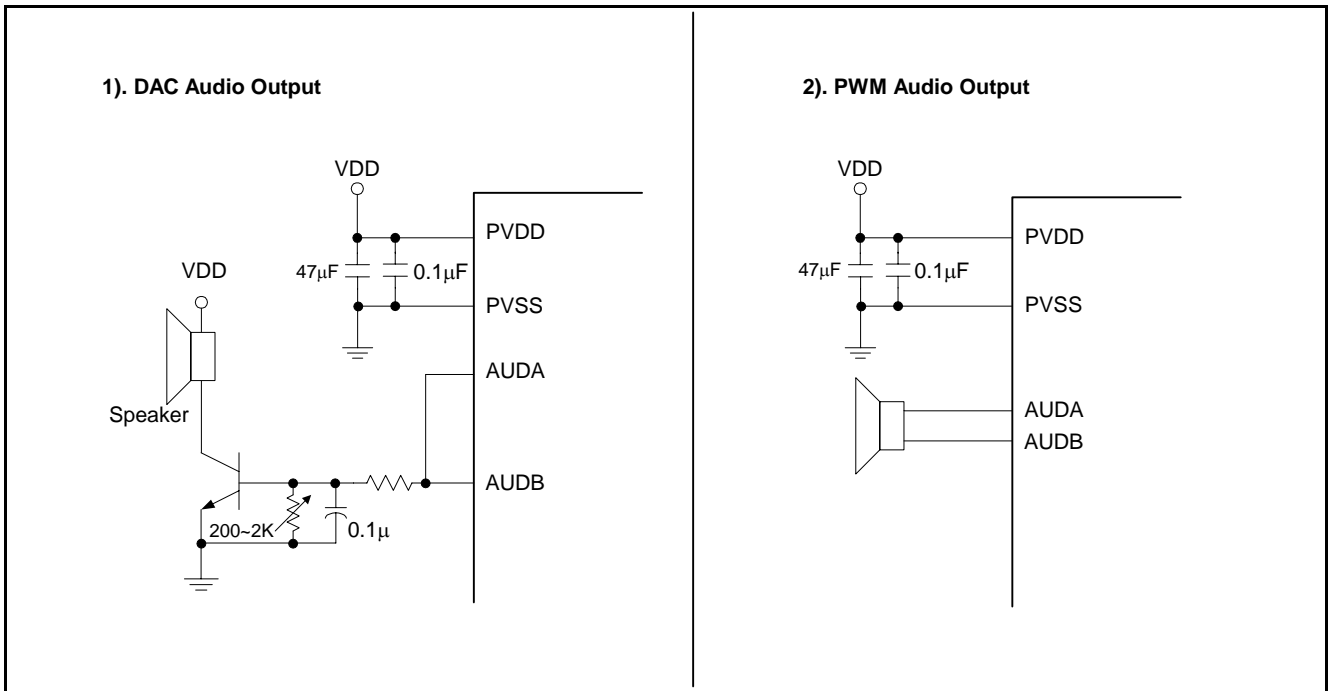
## 8.3. 1184 Dots LCD Driver, 74 Segments x 16 Commons, 1/5 Bias - (3)



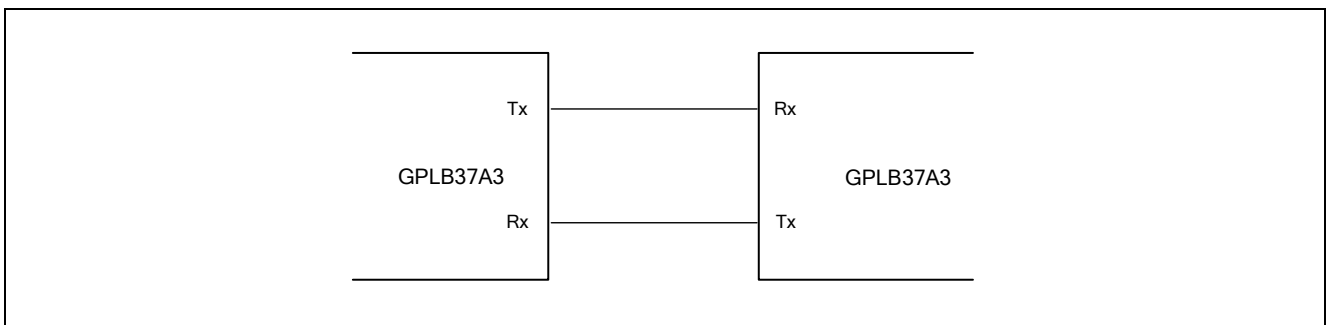
**Note\*1:** These capacitor values are for design guidance only. Different capacitor values may be required for different crystal/resonator used.

**Note\*2:** The value of the capacitance(C) would range from 0.1µF to 4.7µF to stable the output voltage.

## 8.4. Audio Output Connections - (4)



## 8.5. Serial Communications between Two GPLB37A3s- (5)







## 9. PACKAGE/PAD LOCATIONS

### 9.1. Ordering Information

Product Number	Package Type
GPLB37A3-NnnV-C	Chip form

**Note1:** Code number is assigned for customer.

**Note2:** Code number (N = A - Z or 0 - 9, nn = 00 - 99); version (V = A - Z).

## 10. DISCLAIMER

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**11. REVISION HISTORY**

<b>Date</b>	<b>Revision #</b>	<b>Description</b>	<b>Page</b>
MAR. 04, 2009	1.1	Modify the document title.	1, 3
JAN. 08, 2009	1.0	Original	19