



## **GPF16512A**

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### **16-Channel MIDI Synthesizer with 512K x 16 ROM**

DEC. 04, 2006

Version 1.1

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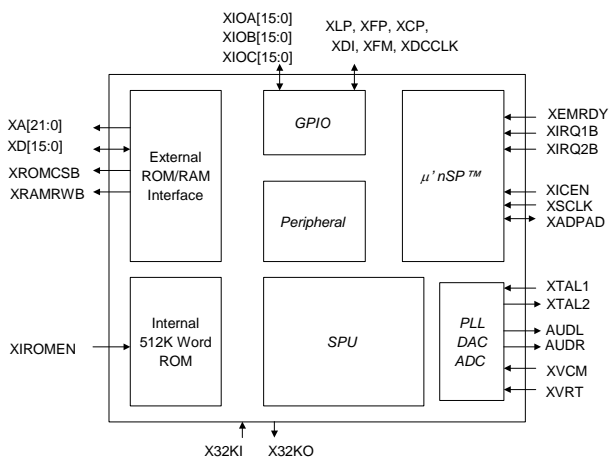
## 16-CHANNEL MIDI SYNTHESIZER WITH 512K x 16 ROM

### 1. GENERAL DESCRIPTION

GPF16512A, a single-chip integrating multi-processors, equips  $\mu'nSP^{\text{TM}}$  (16-bit CPU developed by SUNPLUS Technology) and 16-channel Sound Processor Unit (SPU) for electronic pianos, portable Karaoke or other similar products. With the 16-bit CPU running up to 27MHz, most of the voice compression algorithms can be utilized with MIDI synthesizer applications simultaneously. In addition, it supports the interface with single color LCD panel up to 1024 x 256 dots and standard MIDI interface. Furthermore, it has up to 48 programmable I/Os and 8M bits ROM for electronic instrument applications. Its low power consumption offers the potentials to be used in battery-powered products.

The GPF16512A provides not only the high-speed performance and high quality of 16 channels synthesizer, but it also integrates several powerful tools into the development system, such as development system with C language, assembly compiler, linker, source debugger functions and project management tools.

### 2. BLOCK DIAGRAM



### 3. FEATURES

- $\mu'nSP^{\text{TM}}$  16-bit CPU
- Equips 16-channel Sound Processor Unit (SPU) for MIDI synthesis applications
- 8M bits ROM for both programs and sound fonts (tone colors)
- 2048 words working RAM for programming or delay buffers
- Single color LCD interface up to 1024 x 256 dots
- 16-bit stereo DAC
- ADPCM sound fonts real-time decoding logic for each channel
- 7-bit Master volume control
- Max. 256 piece-wise slopes with repetition for envelope control
- Variable sampling rates play back for sound fonts (tone colors) wave table samples
- Beat event IRQ and Envelope IRQ for MIDI event control
- Unlimited wave table sample sizes
- Channel release control logic
- Built-in PLL to generate 27MHz internal clock with external 6MHz crystal
- 32768Hz real time counter
- Two 16-bit timers/counters (Programmable and Auto Reload)
- 48 general I/Os can be programmed bit by bit
- 14 interrupt sources: SPU, PPU, Timer, Timebase, External Input, Key wakeup, etc.
- Key wakeup capability
- 8 independent channels AD converters with 9-bit resolution
- UART (MIDI) Interface
- Built-in watchdog function
- SPI master interface

## 4. SIGNAL DESCRIPTIONS

Mnemonic	PIN No.	Type	Description
DVDD	9, 50, 80, 113	P	Digital Power input
DVSS	10, 47, 79, 114	P	Digital Ground pin
AVDD1	33	P	Analog power input 1
AVSS1	36, 37	P	Analog ground pin 1
AVDD2	39	P	Analog power input 2
AVSS2	42	P	Analog ground pin 2
AVDD3	43	P	Analog power input 3
AVSS3	44	P	Analog ground pin 3
XA[21:0]	105 - 112 116 - 127 1, 3	I	External ROM/RAM address bus
XD[15:0]	2 4 - 8 11 - 20	I/O	External ROM/RAM data bus
XRAMRWB	115	O	External RAM write enable (Low active)
XROMCSB	127	O	External ROM/RAM chip select (Low active)
XIRQ1B	104	I	External IRQ 1
XIRQ2B	103	I	External IRQ 2
XEMRDY	102	I	External memory ready
XICEN	100	I	Internal ICE enable
XSCLK	98	I	ICE interface clock
XADPAD	99	I/O	ICE data bus
XRESETB	97	I	System reset (Low active)
XICECLK	101	O	System Clock output
XIOA[15:0]	21, 23 25 - 32 51 - 56	I/O	GPIO A, Bit 0-7 could be used as ADC input
XIOB[15:0]	57 - 64 65 - 72	I/O	GPIO B
XIOC[15:0]	81 - 96	I/O	GPIO C
XFP	74	I/O	LCD interface frame pulse, GPIO D0
XLD	77	I/O	LCD interface latch data pulse, GPIO D1
XCP	76	I/O	LCD interface clock signal, GPIO D2
XDI	75	I/O	LCD interface data signal, GPIO D3
XFM	78	I/O	LCD interface frame signal, GPIO D4
XDCCLK	73	I/O	LCD interface DC-DC clock signal, GPIO D5
XTAL1	46	I	External crystal input, should be 6MHz
XTAL2	45	O	External crystal output
X32KI	49	I	External 32768Hz crystal input
X32KO	48	O	External 32768Hz crystal output
XAUDL	40	O	Audio left channel output
XAUDR	38	O	Audio right channel output
XADACVREF	41	I	Audio DAC reference voltage
XVCM	35	O	ADC reference voltage output

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Mnemonic	PIN No.	Type	Description
XVRT	34	I	ADC reference voltage input
XTESTB	24	I	Test enable, NC
XIROMEN	22	I	Internal 512K words ROM enable

## 5. FUNCTIONAL DESCRIPTIONS

### 5.1. CPU

The GPF16512A is equipped with a 16-bit  $\mu'nSP^{TM}$ , the newest 16-bit microprocessor by SUNPLUS and pronounced as *micro-n-SP*. Eight registers are involved in  $\mu'nSP^{TM}$ : R1 - R4 (General-purpose registers), PC (Program Counter), SP (Stack Pointer), Base Pointer (BP) and SR (Segment Register). The interrupt include three FIQs (Fast Interrupt Request) and eight IRQs (Interrupt Request), plus one software-interrupt, BREAK.

Moreover, a high performance hardware multiplier with the Capability of FIR filter is also built in to reduce the software multiplication loading.

### 5.2. Memory

#### 5.2.1. SRAM

The amount of SRAM is 2K-word (including Stack), ranged from \$0000 through \$07FF with access speed of two CPU clock cycles.

#### 5.2.2. ROM memory

ROM memory (\$004000 ~ \$07FFFF) is a high-speed memory with access speed of two CPU clock cycles. The address from \$080000 to \$3FFFFFF can be used as external memory space for extension.

### 5.3. PLL, Clock, Power Mode

#### 5.3.1. PLL (Phase Lock Loop)

The purpose of PLL is to provide a base frequency (6Mhz) and to pump the frequency 27MHz for system clock ( $F_{osc}$ ).

#### 5.3.2. System clock

Basically, the system clock is provided 27Mhz by PLL and programmed by the P\_WaitState\_num\_Ctrl (W) to determine two-six wait-state cycles to access ROM.

### 5.4. Power Savings Mode

The GPF16512A also offers a power savings mode (standby mode) for low power application needs. To enter standby mode, the desired key wakeup port (IOA [15:0], IOB [15:0], IOC [10:0]) must be configured to input first. And read the Port Latch REG to latch the GPIO state before entering the standby mode. Also remember to enable the corresponding interrupt source(s) for wakeup. After that, stop the CPU clock by writing the STOP CLOCK Register P\_Sleep\_Mode(W) to enter standby mode. In such mode, SRAM and I/Os remain in the previous states till CPU being awoken.

### 5.5. Interrupt

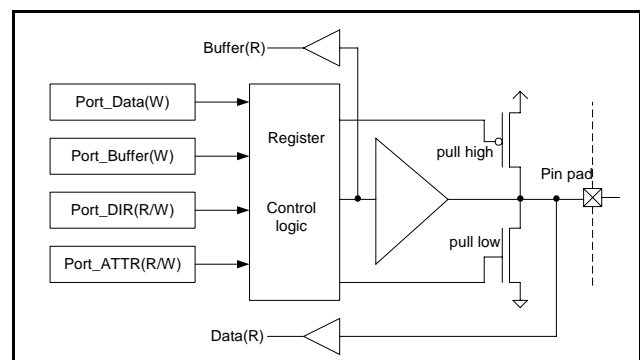
The GPF16512A has 14 interrupt sources, grouped into two types, FIQ (Fast Interrupt Request) and IRQ (Interrupt request). The priority of FIQ is higher than IRQ. FIQ is the high-priority interrupt while IRQ is the low-priority one. An IRQ can be interrupted by a FIQ, but not by another IRQ. A FIQ cannot be interrupted by any other interrupt sources.

Interrupt Source	Interrupt Name	Priority
SPU Channel	FIQ / IRQ1	High(FIQ)
Timer A	FIQ_TMA/ IRQ2_TMA	High(FIQ)
Timer B	FIQ_TMB/ IRQ2_TMB	High(FIQ)
UART, SPI, ADC	IRQ3	Low
SPU Beat, Envelope	IRQ4	Low
EXT2	IRQ5_EXT2	Low
EXT1	IRQ5_EXT1	Low
4096Hz	IRQ6_4KHz	Low
2048Hz	IRQ6_2KHz	Low
1024Hz	IRQ6_1KHz	Low
4Hz	IRQ7_4Hz	Low
Time-base 1	IRQ7_TMB1	Low
Time-base 2	IRQ7_TMB2	Low
Key change wakeup	IRQ7_KEY	Low

### 5.6. I/O

Two I/O ports are built in GPF16512A, PortA, PortB and PortC. The PortA, B, C is an ordinary I/O with programmable wakeup capability. In addition to the regular IO function, the PortB can also perform some special functions in certain pins.

The following diagram is an I/O schematic.



Although data can be written into the same register through Port\_Data and Port\_Buffer, they can be read from different places, Buffer (R) and Data (R). The GPIO is the key wakeup port. To activate key wakeup function, latch data on PORT Latch and

enable the key wakeup function. Wakeup is triggered when the GPIO state is different from at the time latched. In addition to an ordinary I/O port, PortB carries some special functions. A summary of PortB special functions is listed as follows:

### Special function in PortB

PortB	Special Function	Function Description	Note
IOB2	TMB2	Timebase output 2	Output
IOB3	TMB1	Timebase output 1	Output
IOB4	TBPWM	TimeB, Pulse Width Modulation	Output
IOB5	TAPWM	TimeA, Pulse Width Modulation	Output
IOB6	Ext1	External clock source of timer	Input
IOB7	Ext2	External clock source of timer	Input

Default state: Pull Low

### 5.7. Timer / Counter

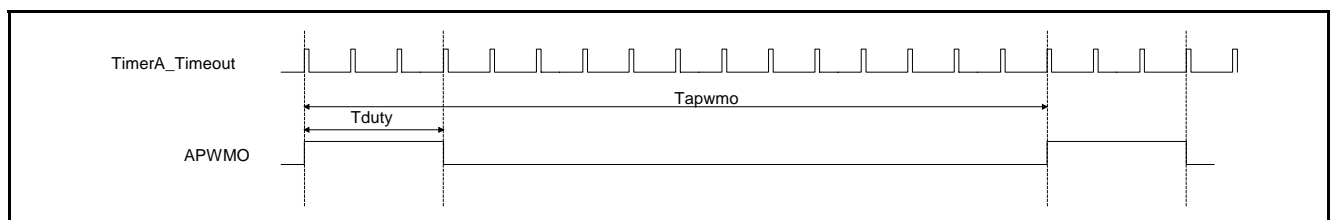
The GPF16512A provides two 16-bit timers/counters, TimerA and TimerB. The TimerA is called a universal counter. TimerB is a general-purpose counter. The clock source of TimerA comes from the combination of clock source A and clock source B. In TimerB, the clock source is given from source C. When timer overflows, an INT signal is sent to CPU to generate a time-out signal.

Clock of Source A	Clock of Source B	Clock of Source C
Fosc/2	2048Hz	Fosc/2
--	1024Hz	--
32768Hz	256Hz	32768Hz
8192Hz	TMB1	8192Hz
4096Hz	4Hz	4096Hz
1	2Hz	1
0	1	0
EXT1	EXT2	EXT1

Initially, write a value of N into a timer and select a desired clock source, timer will start counting from N, N+1, N+2 ... through FFFF.

An INT (TimerA/TimerB) signal is generated at the next clock after reaching "FFFF" and the INT signal is transmitted to INT controller for further processing. At the same time, N will be reloaded into timer and start all over again. The clock source A is a high frequency source and clock source B is a low frequency source. The combination of clock source A and B provides a variety of speeds to TimerA. A "1" represents pass signal and not gating. In contrast, "0" indicates deactivating timer. The EXT1 and EXT2 are the external clock sources. Moreover, counter can generate time-out signal for input clock source to a four bits (16 levels) PWM pulse width counter. A variety of clock duration can be generated and exported from IOB5 (APWMO) and IOB4 (BPWMO).

The following example is a 3/16-duration cycle. The APWMO waveform is made by selecting a pulse width through Port\_TimerA\_Ctrl (W) [9:6]. As a result, each 16 cycles will generate a pulse width defined in control port. These PWM signals can be applied for controlling the speed of motor or other devices.



Generally speaking, the clock source A and C are fast clock sources and source B comes from RTC system (32768Hz). Therefore, clock source B can be utilized as a precise counter for time counting, e.g., the 4Hz clock can be used for real time counting.

### 5.7.1. Timebase

Timebase, generated by 32768Hz, is a combination of frequency selections. The outputs of timebase block are named to TMB1 and TMB2. TMB1 is frequency for TimerA (Clock source B). The TMB1 and TMB2 are the sources for Interrupt (IRQ7). Furthermore, timebases generates additional 4Hz to 4096Hz interrupt sources (IRQ6 and IRQ7) for Real-Time-Clock (RTC).

TMB2	TMB1
128Hz	8Hz
256Hz	16Hz
512Hz	32Hz
1024Hz	64Hz
Default: 128Hz	Default: 8Hz

## 5.8. Sleep, Wakeup and Watchdog

### 5.8.1. Wakeup and sleep

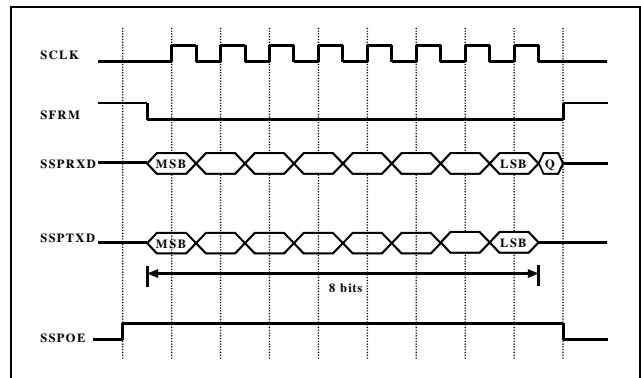
- 1) Sleep: After power-on reset, IC starts running until a sleep command occurs. When a sleep command is accepted, IC will turn the system clock (PLL) off. After all, it enters sleep mode.
- 2) Wakeup: CPU waking up from sleep mode requires a wakeup signal to turn the system clock (PLL) on. The IRQ signal makes CPU to complete the wakeup process and initialization.

### 5.8.2. Watchdog

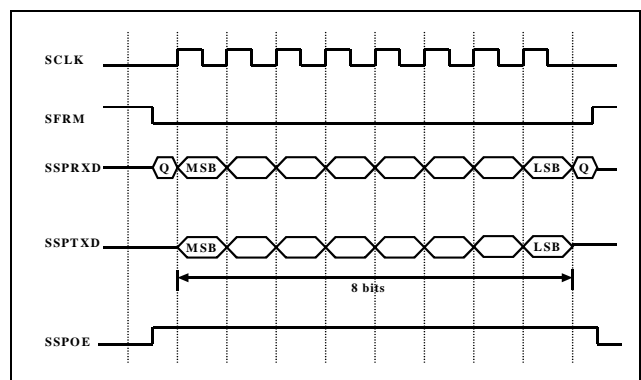
The purpose of watchdog is to monitor if the system operates normally. Within a certain period, watchdog must be cleared. If watchdog is not cleared, CPU assumes the program has been running in an abnormal condition. As a result, the CPU will reset the system to the initial state and start running the program all over again. In GPF16512A, the clear period is 0.75 seconds. If watchdog is cleared within each 0.75 seconds, the system will not be reset. The watchdog function remains enabled during standby mode if the 32768Hz.

## 5.9. Serial Peripheral Interface (SPI)

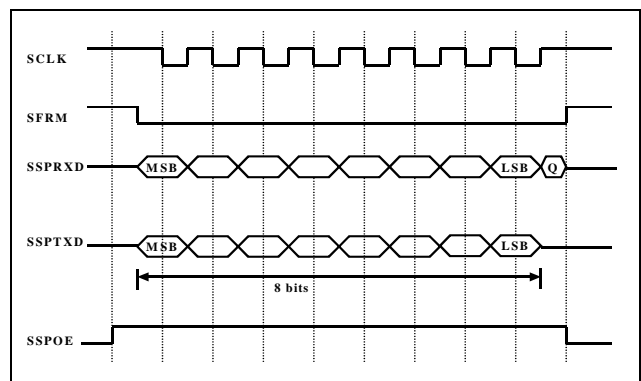
The SPI interface is a master-only interface that enables synchronous serial communication with slave peripherals.



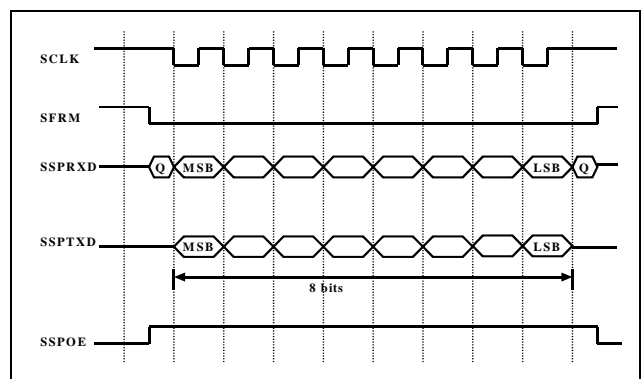
Single transfer Data Change at Falling, Latch at Rising.



Continuous transfer



Single transfer



Continuous transfer



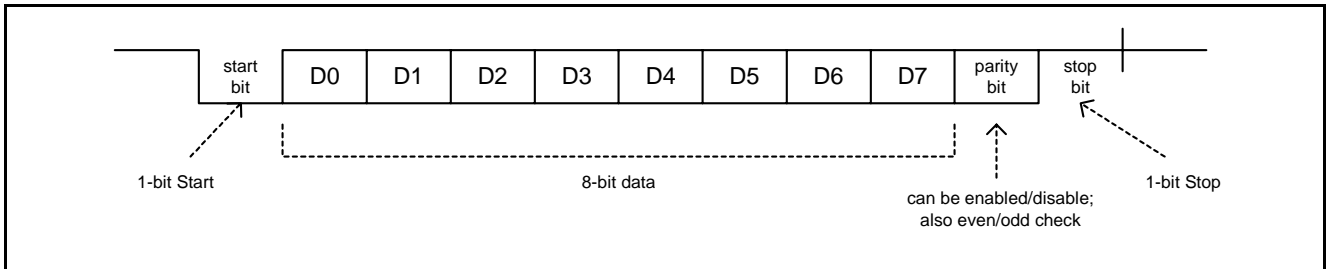
## 5.10. IDE Tools Function

The functions of IDE include the follows:

- 1). C compiler, Assembly, and Linker
- 2). Single step trace
- 3). Break point (break point for debugging)
- 4). Run (execute)

## 5.11. UART Function

UART block provides a full-duplex standard interface that facilitates the communication with other devices. With this interface, GPF16512A can transmit and receive simultaneously. The maximum baud-rate can be up to 57600bps. The Rx and Tx of UART are shared with IOA14 and IOA15.



## 6. ELECTRICAL SPECIFICATIONS

### 6.1. Absolute Maximum Rating

Rating	Symbol	Value	Unit
Supply Voltage	VDD	0 to 3.6	V
Input Voltage	V <sub>IN</sub>	-0.3 to VDD +0.3	V
Operating Temperature	T <sub>A</sub>	0 to 85	°C
Storage Temperature	T <sub>STG</sub>	-55 to +125	°C

### 6.2. DC Characteristics

Characteristic	Symbol	Limits			Unit	Condition
		Min.	Typ.	Max.		
Operating Voltage	VDD	3.0	3.3	3.6	V	@ 27MHz
Operating Current	I <sub>OP</sub>	37.21	42.93	51.60	mA	@ 27MHz with IROMON
Power Down Current	I <sub>STBY</sub>	-30	-	30	μA	Sleep Mode
High Input Voltage	V <sub>IH</sub>	0.7VDD	-	VDD	V	
Low Input Voltage	V <sub>IL</sub>	VSS	-	0.8	V	
Crystal Frequency	F <sub>CRYSTAL</sub>	-	-	6.0	MHz	
System Clock	F <sub>SYS</sub>	27	27	27	MHz	

### 6.3. DAC Characteristics

Characteristic	Limits			Unit	Condition
	Min.	Typ.	Max.		
Resolution	-	16	-	Bit	
Full Scale Output Voltage	-	1.2	-	Vp-p	
THD+N (f = 1kHz)	-	0.094	-	%	
Noise at No Signal	-	-102	-98	dBv	
Frequency Response (f = 50Hz to 20 kHz)	-0.04	-	0.01	dB	

### 6.4. ADC Characteristics (VDD = 3.3V, T<sub>A</sub> = 25°C)

Characteristics	Symbol	Unit			Unit
		Min.	Typ.	Max.	
ADC Power Dissipation	IADC	-	1.8	-	mA
ADC Input Voltage Range	VINL (Note 1)	VSS-0.3	-	VDD+0.3	V
Resolution of ADC	RESO	-	-	10	bits
Signal-to-Noise Plus Distortion of ADC from Line In	SINAD (Note 3)	-	56	-	dB
Effective Number of Bit	ENOB (Note 4)	8.0	9.0	-	bits
Integral Non-Linearity of ADC	INL	-	±4.0	-	LSB (Note 2)
Differential Non-Linearity of ADC	DNL (Note 5)	-	±0.5	-	LSB
AD Conversion Rate	F <sub>CONV</sub>	F <sub>CPU</sub> /2048	-	F <sub>CPU</sub> /256	Hz

**Note1:** Internal protection diodes clamp the analog input to VDD and VSS. These diodes allow the analog input to swing from (VSS-0.3V) to (VDD+0.3V) without causing damage to the devices.

**Note2:** LSB means Least Significant Bit. With VINL = 2.0V, 1LSB = 2.0V/2<sup>10</sup> = 1.953mV.

**Note3:** The SINAD testing condition at VINLp-p = 0.8\*VDD, FCONV = Fcpu/512 = 54MHz/256 = 211KHz, Fin=1.0KHz Sine waves at VDD = 3.0V from the ADC input.

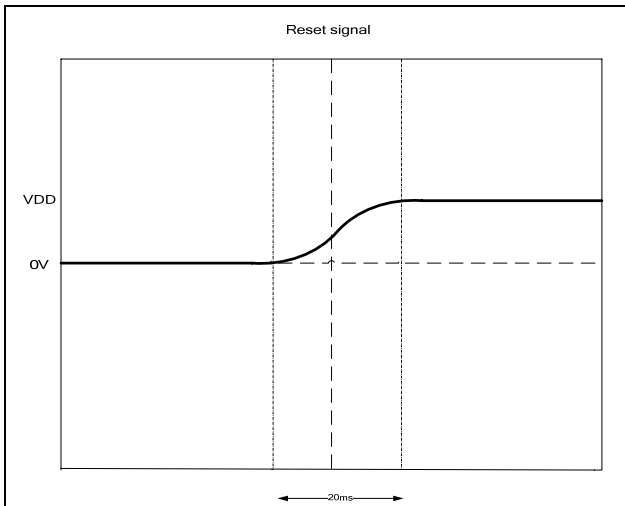
**Note4:** ENOB = (SINAD-1.76)/6.02.

**Note5:** This ADC can guarantee no missing code.

## 7. RESET AND POWER DOWN

### 7.1. Reset

During power-up, the RESET input should be held low until the crystal oscillator and PLL are stabilized, which can take about 20 ms. A typical RC/diode power-up network can be used.



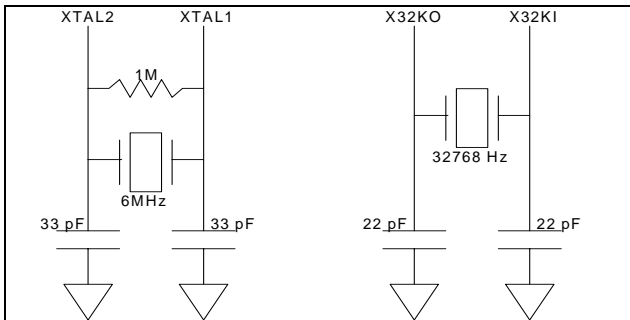
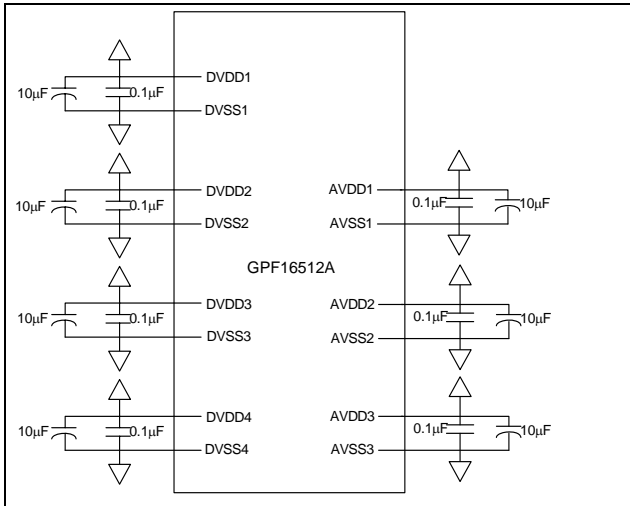
### 7.2. Power Down

Sleep mode can be entered by write the control register. But system can wake up only when 32768Hz is existed. In order to minimize the power consumption during sleep mode, the program counter should stay in internal SRAM and the pin XIROMEN can be switch to low after sleep.

## 8. RECOMMENDED BOARD LAYOUT

### 8.1. Digital Section

All digital VDD VSS should be connected. The decoupling capacitor of  $0.1\mu\text{F}$  and  $10\mu\text{F}$  should be connected to each power pin of the IC as the following diagram.



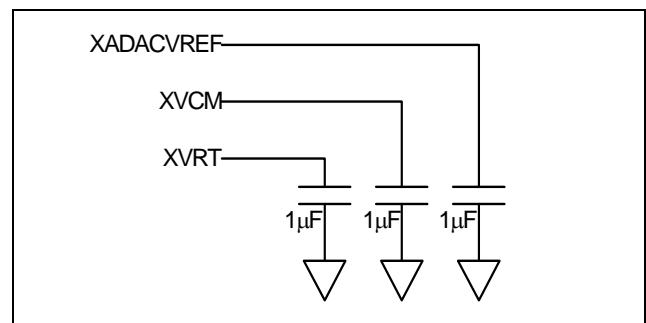
**Note:** These capacitor values are for design guidance only. Different capacitor values may be needed for different crystal used.

### 8.2. Crystal

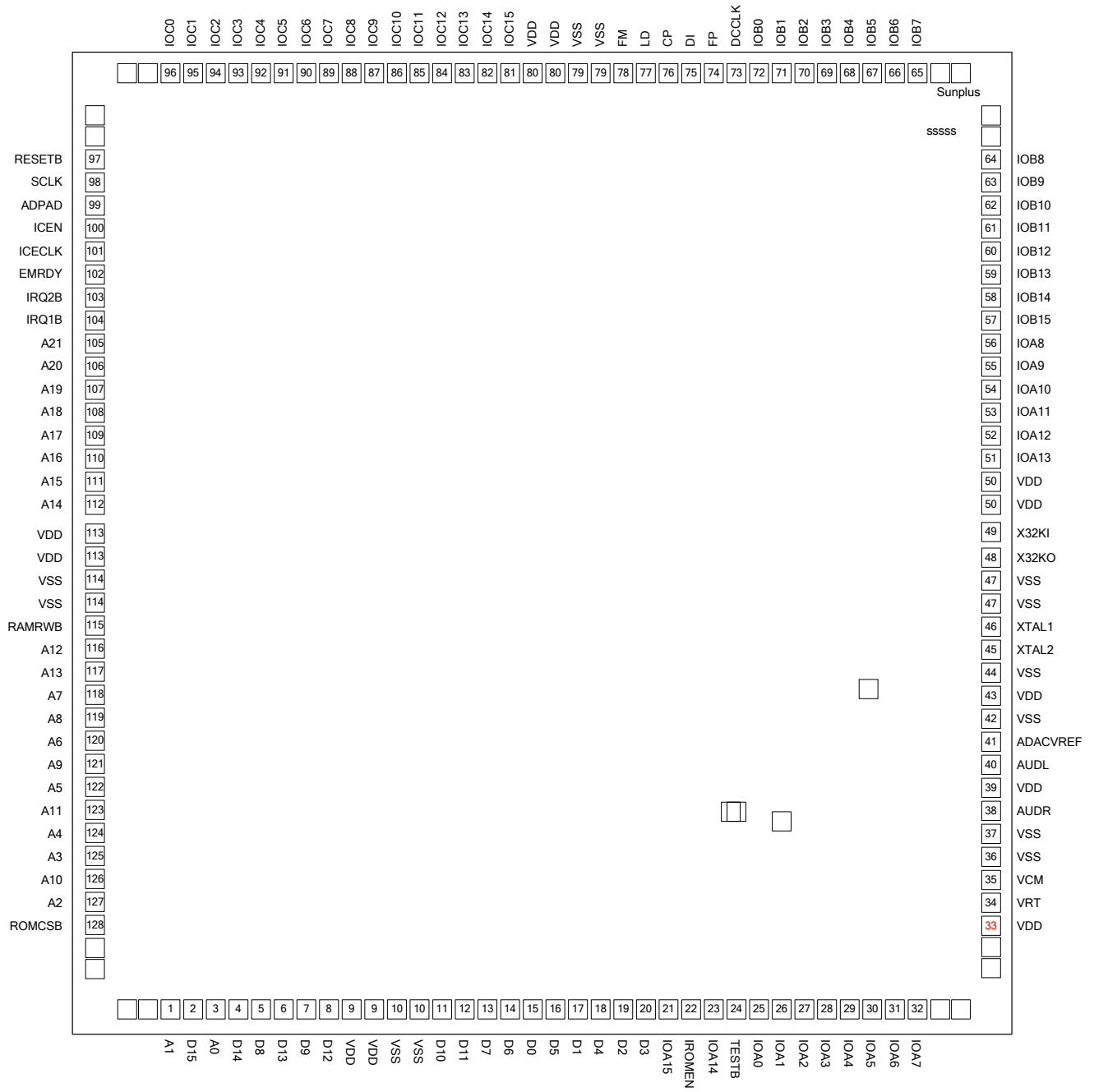
Please refer to following diagram to connect the crystal circuit.

### 8.3. Analog Section

A specific AGND ground plane should be provided, which connects by a single trace to the GND ground. No digital signals should cross the AGND plane. Each of XADACVREF, XVCM, and XVRT should be connected to a  $1\mu\text{F}$  capacitor as the following diagram.



## 9. PACKAGE/PAD LOCATIONS



This IC substrate should be connected to VSS

**Note1:** To ensure that the IC functions properly, please bond all of VDD and VSS pins.

**Note2:** The 0.1μF capacitor between VDD and VSS should be placed to IC as close as possible.

### 9.1. Ordering Information

Product Number	Package Type
GPF16512A-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

Date	Revision #	Description	Page
DEC. 04, 2006	1.1	1. Modify the "Reset" in section 7.1.	11
		2. Add Note in section 8.1.Digital Section.	12
		3. Modify the "Pad Assignment and Locations" in section9.1.	13
JAN. 18, 2006	1.0	Original Note: The GPF16512A data sheet v1.0 is a continued version of SPF16512A data sheet v0.1.	15