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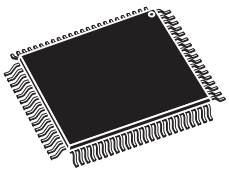
PSD4235G2

Flash in-system programmable (ISP) for 16-bit MCUs (5 V supply)

Features

- Dual bank Flash memories
  - 4 Mbit of Primary Flash memory (8 uniform sectors, 32K x 16)
  - 256 Kbit Secondary Flash memory with 4 sectors
  - Concurrent operation: read from one memory while erasing and writing the other
- 64 Kbit SRAM
- PLD with macrocells
  - Over 3000 gates of PLD: CPLD and DPLD
  - CPLD with 16 output macrocells (OMCs) and 24 input macrocells (IMCs)
  - DPLD - user defined internal chip select decoding
- 7 L/O ports with 52 I/O pins
  - 52 individually configurable I/O port pins that can be used for the following functions:
  - MCU I/Os
  - PLD I/Os
  - Latched MCU address output
  - Special function I/Os
  - I/O ports may be configured as open-drain outputs
- In-system programming (ISP) with JTAG
  - Built-in JTAG compliant serial port allows full-chip In-System Programmability
  - Efficient manufacturing allow easy product testing and programmingUse low cost FlashLINK cable with PC



LQFP80 (U)
80-lead, Thin, Quad, Flat

- Page register
  - Internal page register that can be used to expand the microcontroller address space by a factor of 256
  - Programmable power management
- High endurance
  - 100,000 Erase/write c ycles of Flash memory
  - 1,000 Erase/WRITE Cycles of PLD
  - 15 Year Data Retention
- Single supply voltage
  - 5V ±10%
- Memory speed
  - 70ns Flash memory and SRAM access time
- Packages are ECOPACK®

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1 Summary description

The PSD family of memory systems for microcontrollers (MCUs) brings In-System-Programmability (ISP) to Flash memory and programmable logic. The result is a simple and flexible solution for embedded designs. PSD devices combine many of the peripheral functions found in MCU based applications.

PSD devices integrate an optimized macrocell logic architecture. The macrocell was created to address the unique requirements of embedded system designs. It allows direct connection between the system address/data bus, and the internal PSD registers, to simplify communication between the MCU and other supporting devices.

The PSD family offers two methods to program the PSD Flash memory while the PSD is soldered to the circuit board:

1.1 In-system programming (ISP) via JTAG

An IEEE 1149.1 compliant JTAG in-system programming (ISP) interface is included on the PSD enabling the entire device (Flash memories, PLD, configuration) to be rapidly programmed while soldered to the circuit board. This requires no MCU participation, which means the PSD can be programmed anytime, even when completely blank.

The innovative JTAG interface to Flash memories is an industry first, solving key problems faced by designers and manufacturing houses, such as:

1.1.1 First time programming

How do I get firmware into the Flash memory the very first time? JTAG is the answer. Program the blank PSD with no MCU involvement.

1.1.2 Inventory build-up of pre-programmed devices

How do I maintain an accurate count of pre-programmed Flash memory and PLD devices based on customer demand? How many and what version? JTAG is the answer. Build your hardware with blank PSDs soldered directly to the board and then custom program just before they are shipped to the customer. No more labels on chips, and no more wasted inventory.

1.1.3 Expensive sockets

How do I eliminate the need for expensive and unreliable sockets? JTAG is the answer. Solder the PSD directly to the circuit board. Program first time and subsequent times with JTAG. No need to handle devices and bend the fragile leads.

1.2 In-application programming (IAP)

Two independent Flash memory arrays are included so that the MCU can execute code from one while erasing and programming the other. Robust product firmware updates in the filed are possible over any communication channel (CAN, Ethernet, UART, J1850, etc) using this unique architecture. Designers are relieved of these problems:

1.2.1 Simultaneous READ and WRITE to Flash memory

How can the MCU program the same memory from which it executing code? It cannot. The PSD allows the MCU to operate the two Flash memory blocks concurrently, reading code from one while erasing and programming the other during IAP.

1.2.2 Complex memory mapping

How can I map these two memories efficiently? A programmable Decode PLD (DPLD) is embedded in the PSD. The concurrent PSD memories can be mapped anywhere in MCU address space, segment by segment with extermely high address resolution. As an option, the secondary Flash memory can be swapped out of the system memory map when IAP is complete. A built-in page register breaks the MCU address limit.

1.2.3 Separate Program and Data space

How can I write to Flash memory while it resides in Program space during field firmware updates? My 80C51XA will not allow it. The PSD provides means to reclassify Flash memory as Data space during IAP, then back to Program space when complete.

1.3 PSDsoft™ Express

PSDsoft Express, a software development tool from ST, guides you through the design process step-by-step making it possible to complete an embedded MCU design capable of ISP/IAP in just hours. Select your MCU and PSDsoft Express takes you through the remainder of the design with point and click entry, covering PSD selection, pin definitions, programmable logic inputs and outpus, MCU memory map definition, ANSI-C code generation for your MCU, and merging your MCU firmware with the PSD design. When complete, two different device programmers are supported directly from PSDsoft Express: FlashLINK (JTAG) and PSDpro.

Figure 1. Logic diagram

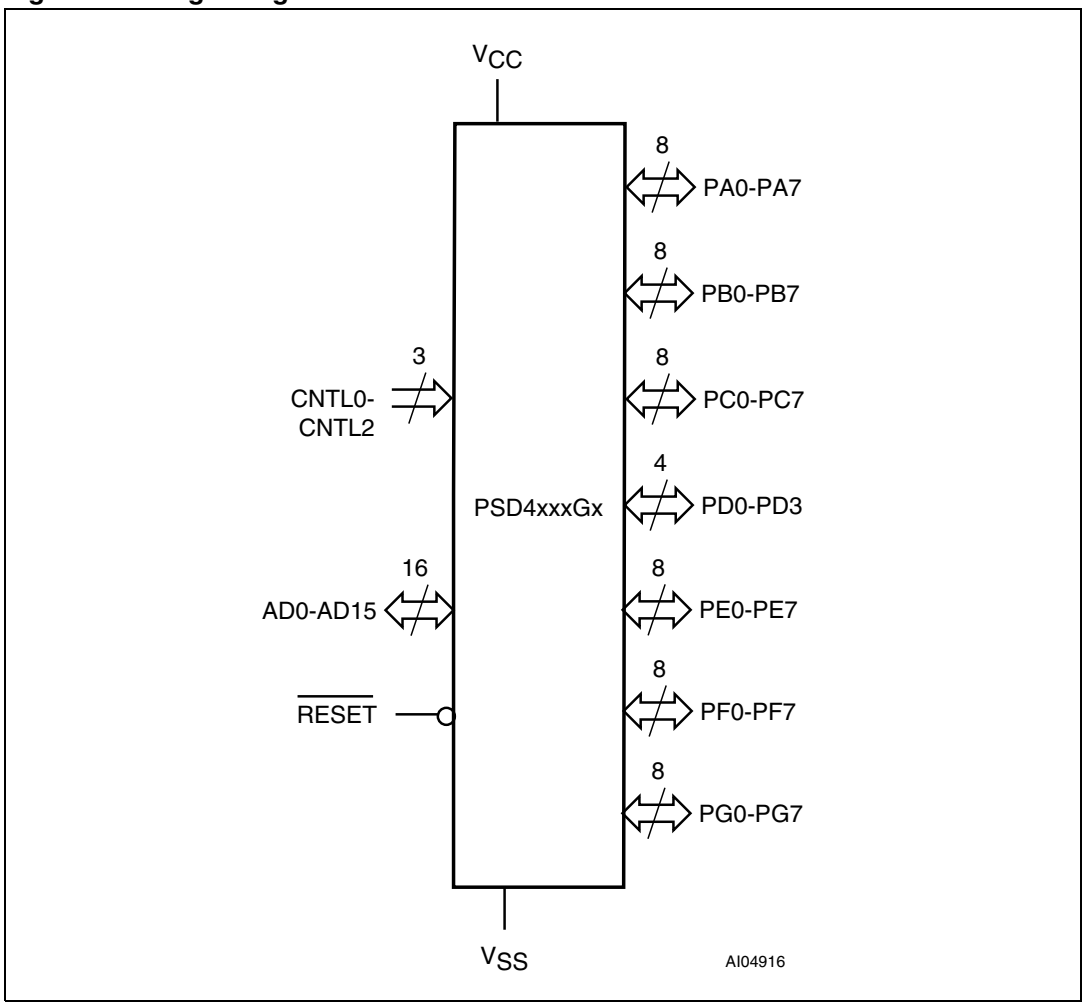


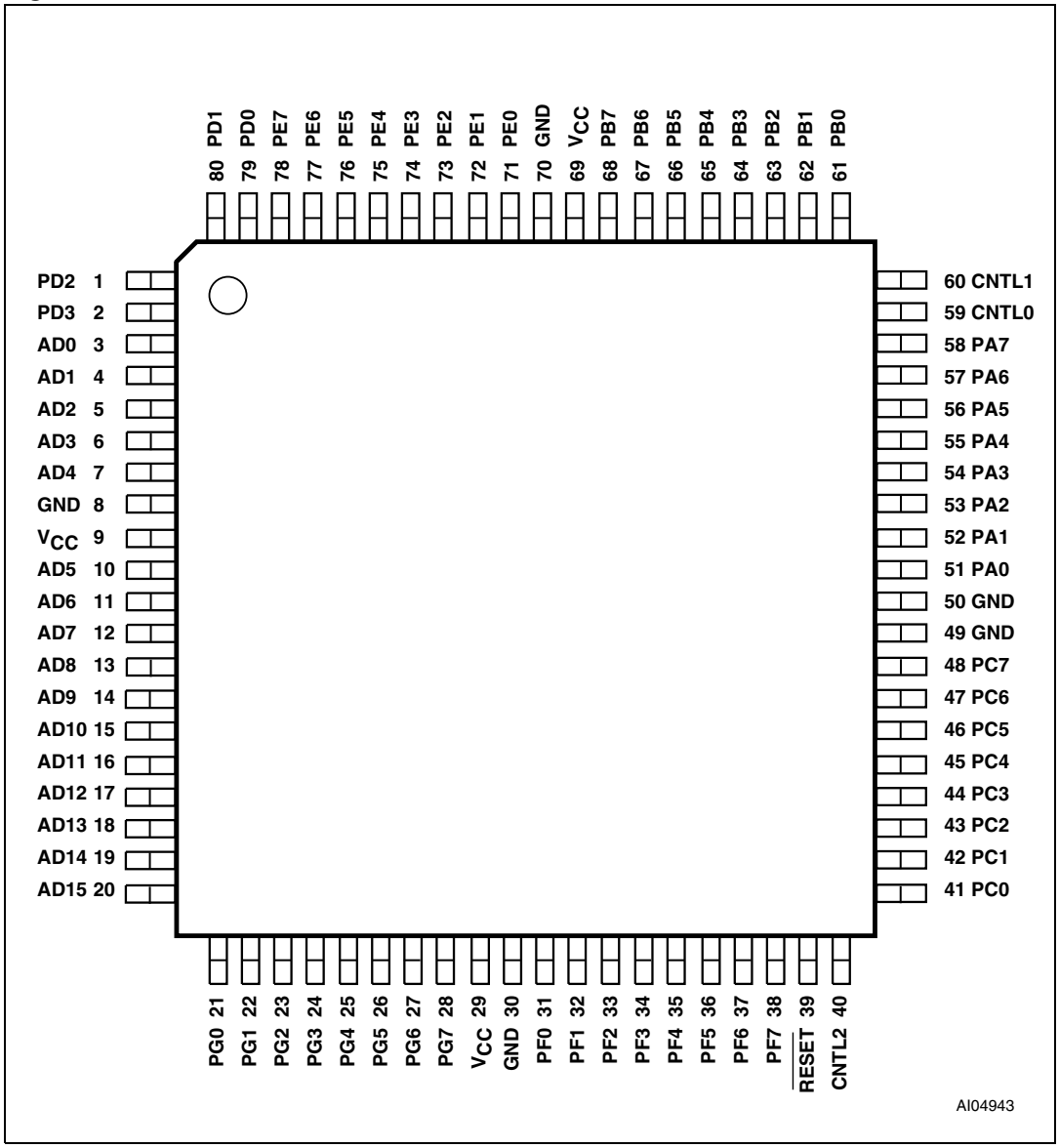
Table 1. Pin names

Pin	Description
PA0-PA7	Port-A
PB0-PB7	Port-B
PC0-PC7	Port-C
PD0-PD3	Port-D
PE0-PE7	Port-E
PF0-PF7	Port-F
PG0-PG7	Port-G
AD0-AD15	Address/Data
CNTL0-CNTL2	Control
$\overline{\text{RESET}}$	Reset

Table 1. Pin names (continued)

Pin	Description
V_{CC}	Supply voltage
V_{SS}	Ground

Figure 2. LQFP connections



2 Pin description

Table 2. Pin description (for the LQFP package)

Pin name	Pin	Type	Description
ADIO0-ADIO7	3-7 10-12	I/O	This is the lower Address/Data port. Connect your MCU address or address/data bus according to the following rules: 1. If your MCU has a multiplexed address/data bus where the data is multiplexed with the lower address bits, connect AD0-AD7 to this port. 2. If your MCU does not have a multiplexed address/data bus, connect A0-A7 to this port. 3. If you are using an 80C51XA in burst mode, connect A4/D0 through A11/D7 to this port. ALE or AS latches the address. The PSD drives data out only if the READ signal is active and one of the PSD functional blocks has been selected. The addresses on this port are passed to the PLDs.
ADIO8-ADIO15	13-20	I/O	This is the upper Address/Data port. Connect your MCU address or address/data bus according to the following rules: 1. If your MCU has a multiplexed address/data bus where the data is multiplexed with the upper address bits, connect A8-A15 to this port. 2. If your MCU does not have a multiplexed address/data bus, connect A8-A15 to this port. 3. If you are using an 80C51XA in burst mode, connect A12/D8 through A19/D15 to this port. ALE or AS latches the address. The PSD drives data out only if the READ signal is active and one of the PSD functional blocks has been selected. The addresses on this port are passed to the PLDs.
CNTL0	59	I	The following control signals can be connected to this pin, based on your MCU: 1. $\overline{WR}$ - active low, Write Strobe input. 2. R_$\overline{W}$ - active high, READ/active low WRITE input. 3. $\overline{WRL}$ - active low, WRITE to low-byte. This pin is connected to the PLDs. Therefore, these signals can be used in decode and other logic equations.
CNTL1	60	I	The following control signals can be connected to this pin, based on your MCU: 1. $\overline{RD}$ - active low, Read Strobe input. 2. E - E clock input. 3. $\overline{DS}$ - active low, Data Strobe input. 4. $\overline{LDS}$ - active low, Strobe for low data byte. This pin is connected to the PLDs. Therefore, these signals can be used in decode and other logic equations.

Table 2. Pin description (for the LQFP package) (continued)

Pin name	Pin	Type	Description
CNTL2	40	I	READ or other Control input pin, with multiple configurations. Depending on the MCU interface selected, this pin can be: 1. $\overline{\text{PSEN}}$ - Program Select Enable, active low in code fetch bus cycle (80C51XA mode). 2. BHE - high-byte enable, 16-bit data bus. 3. $\overline{\text{UDS}}$ - active low, Strobe for high data byte, 16-bit data bus mode. 4. SIZ0 - Byte enable input. 5. LSTRB - low Strobe input. This pin is also connected to the PLDs.
$\overline{\text{RESET}}$	39	I	Active low input. Resets I/O Ports, PLD macrocells and some of the Configuration registers and JTAG registers. Must be low at Power-up. Reset also aborts any Flash memory Program or Erase cycle that is currently in progress.
PA0-PA7	51-58	I/O CMOS or Open Drain	These pins make up Port A. These port pins are configurable and can have the following functions: 1. MCU I/O - standard output or input port. 2. CPLD macrocell (McellA0-McellA7) outputs. 3. Latched, transparent or registered PLD inputs (can also be PLD input for address A16 and above).
PB0-PB7	61-68	I/O CMOS or Open Drain	These pins make up Port B. These port pins are configurable and can have the following functions: 1. MCU I/O - standard output or input port. 2. CPLD macrocell (McellB0-McellB7) outputs. 3. Latched, transparent or registered PLD inputs (can also be PLD input for address A16 and above).
PC0-PC7	41-48	I/O CMOS or Slew Rate	These pins make up Port C. These port pins are configurable and can have the following functions: 1. MCU I/O - standard output or input port. 2. External Chip Select (ECS0-ECS7) outputs. 3. Latched, transparent or registered PLD inputs (can also be PLD input for address A16 and above).
PD0	79	I/O CMOS or Open Drain	PD0 pin of Port D. This port pin can be configured to have the following functions: 1. ALE/AS input - latches address on ADIO0-ADIO15. 2. $\overline{\text{AS}}$ input - latches address on ADIO0-ADIO15 on the rising edge. 3. MCU I/O - standard output or input port. 4. Transparent PLD input (can also be PLD input for address A16 and above).
PD1	80	I/O CMOS or Open Drain	PD1 pin of Port D. This port pin can be configured to have the following functions: 1. MCU I/O - standard output or input port. 2. Transparent PLD input (can also be PLD input for address A16 and above). 3. CLKIN - clock input to the CPLD macrocells, the APD Unit's Power-down counter, and the CPLD AND Array.

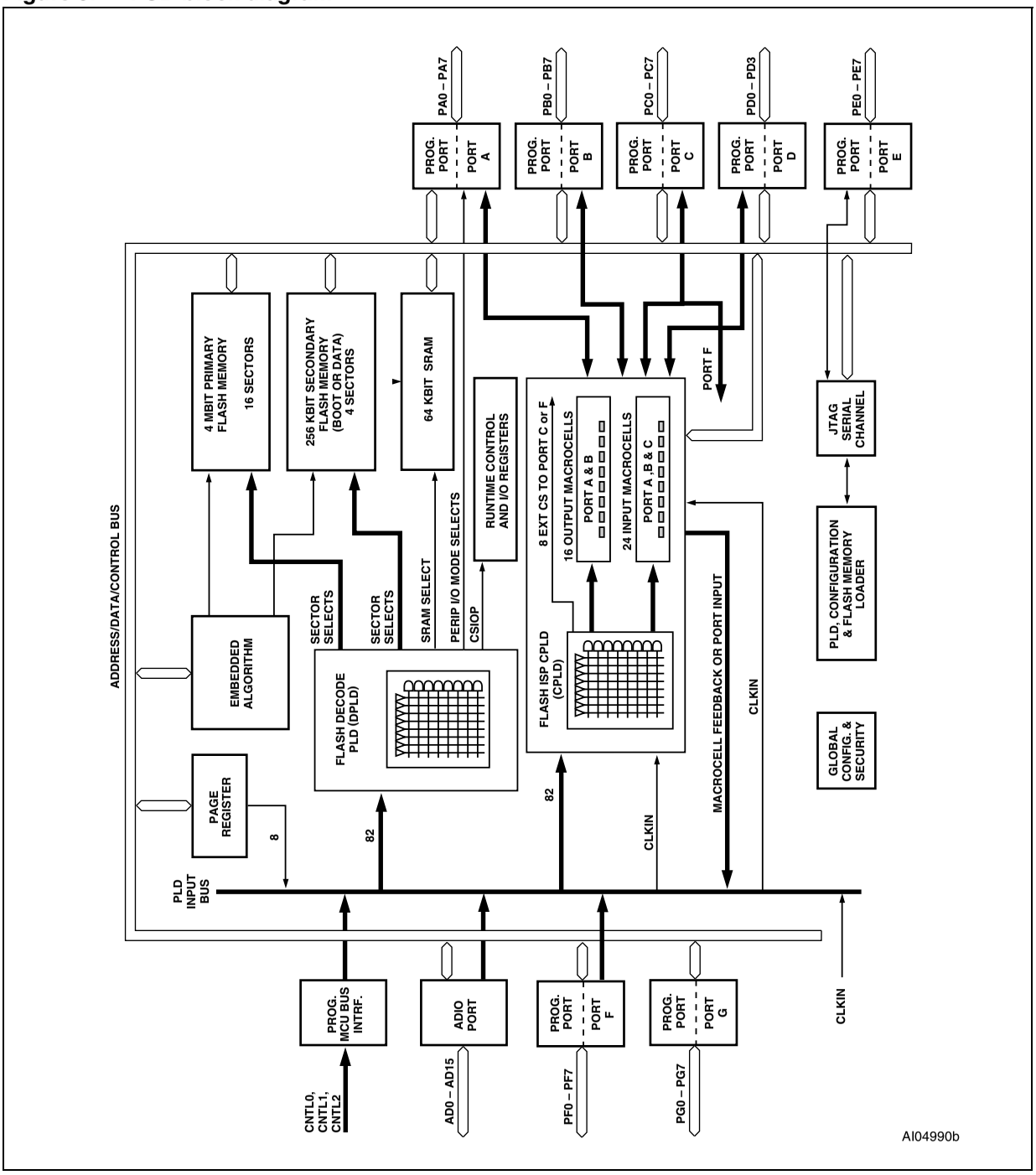
Table 2. Pin description (for the LQFP package) (continued)

Pin name	Pin	Type	Description
PD2	1	I/O CMOS or Open Drain	PD2 pin of Port D. This port pin can be configured to have the following functions: 1. MCU I/O - standard output or input port. 2. Transparent PLD input (can also be PLD input for address A16 and above). 3. PSD Chip Select input ($\overline{CSI}$). When low, the MCU can access the PSD memory and I/O. When high, the PSD memory blocks are disabled to conserve power. The falling edge of this signal can be used to get the device out of Power-down mode.
PD3	2	I/O CMOS or Open Drain	PD3 pin of Port D. This port pin can be configured to have the following functions: 1. MCU I/O - standard output or input port. 2. Transparent PLD input (can also be PLD input for address A16 and above). 3. $\overline{WRH}$ - for 16-bit data bus, WRITE to high byte, active low.
PE0	71	I/O CMOS or Open Drain	PE0 pin of Port E. This port pin can be configured to have the following functions: 1. MCU I/O - standard output or input port. 2. Latched address output. 3. TMS input for the JTAG Serial Interface.
PE1	72	I/O CMOS or Open Drain	PE1 pin of Port E. This port pin can be configured to have the following functions: 1. MCU I/O - standard output or input port. 2. Latched address output. 3. TCK input for the JTAG Serial Interface.
PE2	73	I/O CMOS or Open Drain	PE2 pin of Port E. This port pin can be configured to have the following functions: 1. MCU I/O - standard output or input port. 2. Latched address output. 3. TDI input for the JTAG Serial Interface.
PE3	74	I/O CMOS or Open Drain	PE3 pin of Port E. This port pin can be configured to have the following functions: 1. MCU I/O - standard output or input port. 2. Latched address output. 3. TDO output for the JTAG Serial Interface.
PE4	75	I/O CMOS or Open Drain	PE4 pin of Port E. This port pin can be configured to have the following functions: 1. MCU I/O - standard output or input port. 2. Latched address output. 3. TSTAT output for the JTAG Serial Interface. 4. Ready/$\overline{Busy}$ output for parallel in-system programming (ISP).
PE5	76	I/O CMOS or Open Drain	PE5 pin of Port E. This port pin can be configured to have the following functions: 1. MCU I/O - standard output or input port. 2. Latched address output. 3. $\overline{TERR}$ active low output for the JTAG Serial Interface.
PE6	77	I/O CMOS or Open Drain	PE6 pin of Port E. This port pin can be configured to have the following functions: 1. MCU I/O - standard output or input port. 2. Latched address output.

Table 2. Pin description (for the LQFP package) (continued)

Pin name	Pin	Type	Description
PE7	78	I/O CMOS or Open Drain	PE7 pin of Port E. This port pin can be configured to have the following functions: 1. MCU I/O - standard output or input port. 2. Latched address output.
PF0-PF7	31-38	I/O CMOS or Open Drain	These pins make up Port F. These port pins are configurable and can have the following functions: 1. MCU I/O - standard output or input port. 2. External Chip Select (ECS0-ECS7) outputs, or inputs to CPLD. 3. Latched address outputs. 4. Address A1-A3 inputs in 80C51XA mode (PF0 is grounded) 5. Data bus port (D0-D7) in a non-multiplexed bus configuration. 6. Peripheral I/O mode. 7. MCU reset mode.
PG0-PG7	21-28	I/O CMOS or Open Drain	These pins make up Port G. These port pins are configurable and can have the following functions: 1. MCU I/O - standard output or input port. 2. Latched address outputs. 3. Data bus port (D8-D15) in a non-multiplexed bus configuration. 4. MCU reset mode.
V_{CC}	9, 29, 69		Supply voltage
GND	8, 30, 49, 50, 70		Ground pins

Figure 3. PSD block diagram



1. Additional address lines can be brought in to the device via Port A, B, C, D or F.

3 PSD architectural overview

PSD devices contain several major functional blocks. *Figure 3* shows the architecture of the PSD device family. The functions of each block are described briefly in the following sections. Many of the blocks perform multiple functions and are user configurable.

3.1 Memory

Each of the memory blocks is briefly discussed in the following paragraphs. A more detailed discussion can be found in *Section 7.1: Memory blocks on page 35*.

The 4 Mbit primary Flash memory is the main memory of the PSD. It is divided into 8 equally-sized sectors that are individually selectable.

The 256 Kbit secondary Flash memory is divided into 4 equally-sized sectors. Each sector is individually selectable.

The 64 Kbit SRAM is intended for use as a scratch-pad memory or as an extension to the MCU SRAM.

Each memory block can be located in a different address space as defined by the user. The access times for all memory types includes the address latching and DPLD decoding time.

3.2 PLDs

The device contains two PLD blocks, the Decode PLD (DPLD) and the Complex PLD (CPLD), as shown in *Table 3*, each optimized for a different function. The functional partitioning of the PLDs reduces power consumption, optimizes cost/performance, and eases design entry.

The DPLD is used to decode addresses and to generate Sector Select signals for the PSD internal memory and registers. The DPLD has combinatorial outputs, while the CPLD can implement more general user-defined logic functions. The CPLD has 16 output macrocells (OMC) and 8 combinatorial outputs. The PSD also has 24 input macrocells (IMC) that can be configured as inputs to the PLDs. The PLDs receive their inputs from the PLD input Bus and are differentiated by their output destinations, number of product terms, and macrocells.

The PLDs consume minimal power. The speed and power consumption of the PLD is controlled by the Turbo bit in PMMR0 and other bits in PMMR2. These registers are set by the MCU at run-time. There is a slight penalty to PLD propagation time when not in the Turbo mode.

3.3 I/O ports

The PSD has 52 I/O pins divided among seven ports (Port A, B, C, D, E, F and G). Each I/O pin can be individually configured for different functions. Ports can be configured as standard MCU I/O ports, PLD I/O, or latched address outputs for MCUs using multiplexed address/data buses

The JTAG pins can be enabled on Port E for in-system programming (ISP).

3.4 MCU bus interface

The PSD easily interfaces easily with most 16-bit MCUs, either with multiplexed or non-multiplexed address/data buses. The device is configured to respond to the MCU's control pins, which are also used as inputs to the PLDs.

3.5 ISP via JTAG port

In-System Programming (ISP) can be performed through the JTAG signals on Port E. This serial interface allows complete programming of the entire PSD device. A blank device can be completely programmed. The JTAG signals (TMS, TCK, TSTAT, $\overline{\text{TERR}}$, TDI, TDO) can be multiplexed with other functions on Port E. *Table 4* indicates the JTAG pin assignments.

Table 3. PLD I/O

Name	Inputs	Outputs	Product Terms
Decode PLD (DPLD)	82	17	43
Complex PLD (CPLD)	82	24	150

Table 4. JTAG signals on port E

Port E pins	JTAG signal
PE0	TMS
PE1	TCK
PE2	TDI
PE3	TDO
PE4	TSTAT
PE5	TERR

3.6 In-System Programming (ISP)

Using the JTAG signals on Port E, the entire PSD device (memory, logic, configuration) can be programmed or erased without the use of the MCU.

3.7 In-application programming (IAP)

The primary Flash memory can also be programmed, or re-programmed, in-system by the MCU executing the programming algorithms out of the secondary Flash memory, or SRAM. The secondary Flash memory can be programmed the same way by executing out of the primary Flash memory. *Table 5* indicates which programming methods can program different functional blocks of the PSD.

3.8 Page register

The 8-bit Page register expands the address range of the MCU by up to 256 times. The paged address can be used as part of the address space to access external memory and

peripherals, or internal memory and I/O. The Page register can also be used to change the address mapping of the Flash memory blocks into different memory spaces for IAP.

3.9 Power management unit (PMU)

The power management unit (PMU) gives the user control of the power consumption on selected functional blocks based on system requirements. The PMU includes an Automatic Power-down (APD) Unit that turns off device functions during MCU inactivity. The APD Unit has a Power-down mode that helps reduce power consumption.

The PSD also has some bits that are configured at run-time by the MCU to reduce power consumption of the CPLD. The Turbo bit in PMMR0 can be reset to '0' and the CPLD latches its outputs and goes to Standby mode until the next transition on its inputs.

Additionally, bits in PMMR2 can be set by the MCU to block signals from entering the CPLD to reduce power consumption. See *Section 21: Power management on page 94* for more details.

Table 5. Methods of programming different functional blocks of the PSD

Functional block	JTAG-ISP	Device programmer	IAP
Primary Flash memory	Yes	Yes	Yes
Secondary Flash memory	Yes	Yes	Yes
PLD Array (DPLD and CPLD)	Yes	Yes	No
PSD configuration	Yes	Yes	No

4 Development system

The PSD family is supported by PSDsoft Express, a Windows-based software development tool (Windows-95, Windows-98, Windows-2000, Windows-NT). A PSD design is quickly and easily produced in a point and click environment. The designer does not need to enter Hardware Description Language (HDL) equations, unless desired, to define PSD pin functions and memory map information. The general design flow is shown in *Figure 4*. PSDsoft Express is available from our web site (the address is given on the back page of this data sheet) or other distribution channels.

PSDsoft Express directly supports two low cost device programmers form ST: PSDpro and FlashLINK (JTAG). Both of these programmers may be purchased through your local distributor/representative, or directly from our web site using a credit card. The PSD is also supported by thid party device programmers. See our web site for the current list.

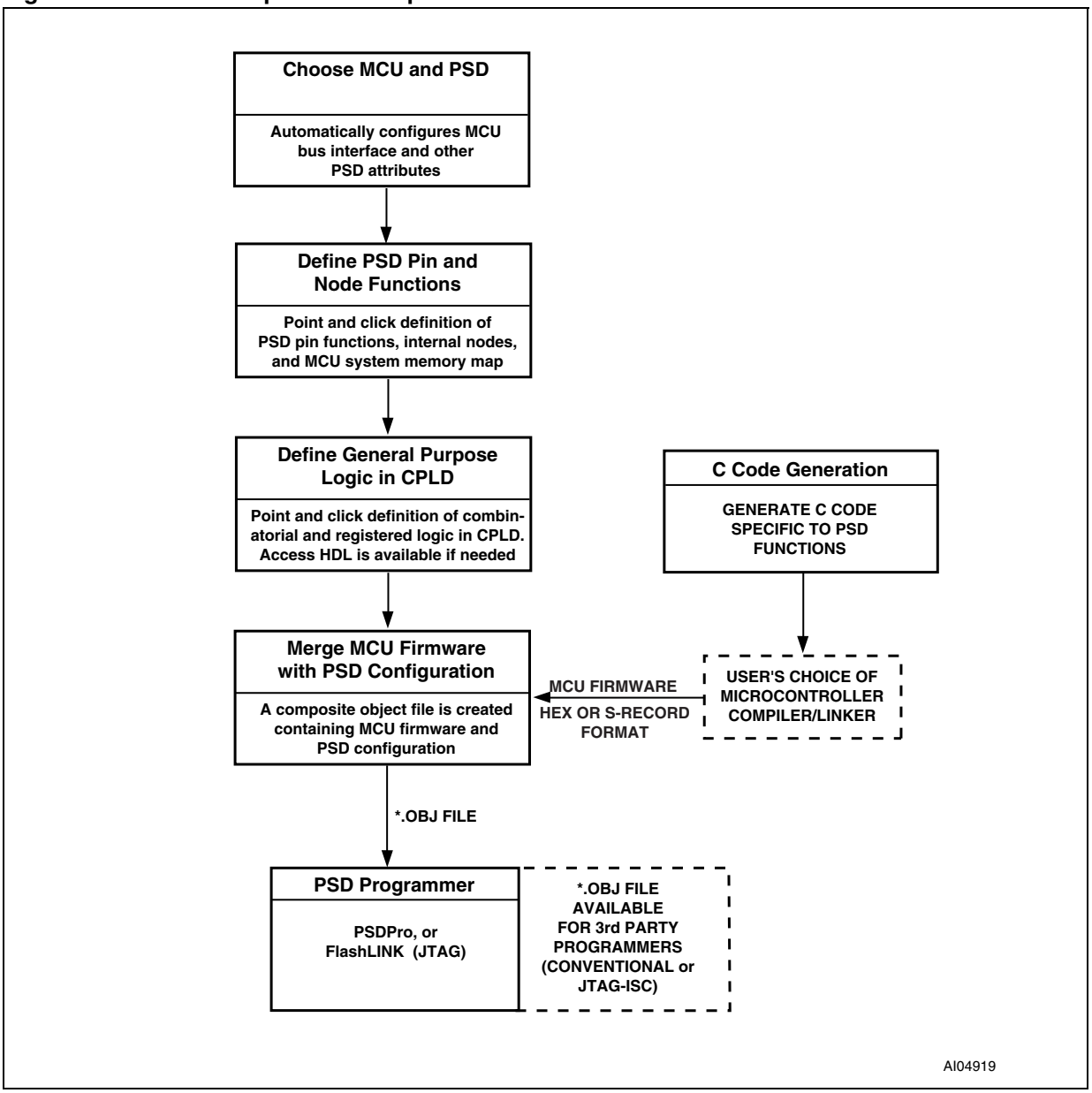



Figure 4. PSDsoft Express development tool