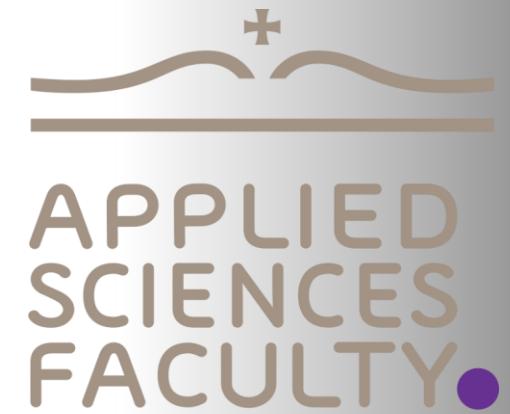


EMBEDDED

л.11

розшиrena та конфігурвана
периферія
(на прикладі родини родини
мікроконтролерів PSoC)

Палій Святослав



PSoC Is Everywhere!

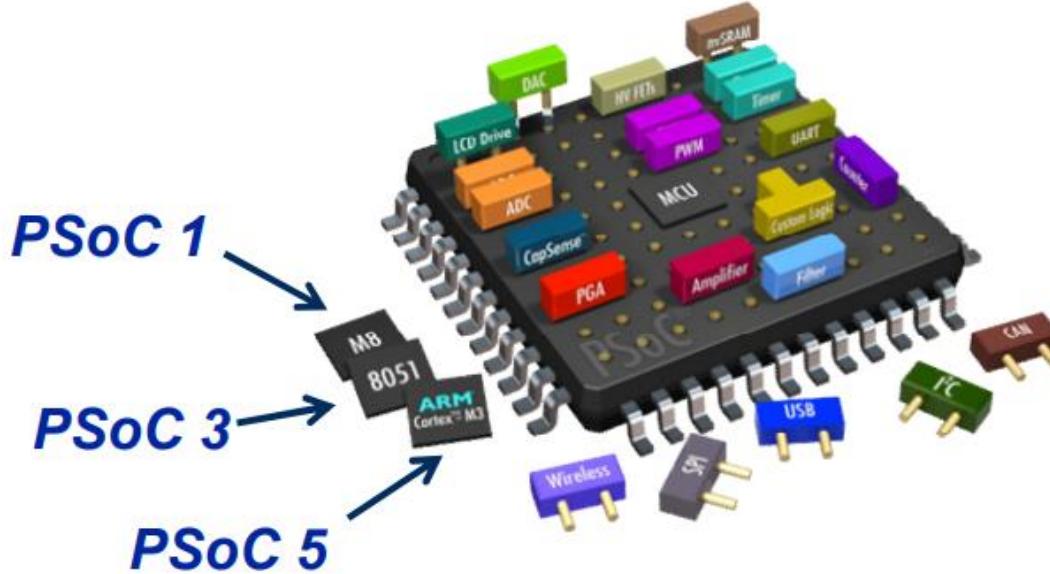


HANDHELD DEVICES		APPLIANCES	INDUSTRIAL	ENTERTAINMENT/ SECURITY/ DISPLAYS	MONITORING
TOYS/GAMING	DIGITAL PHOTOGRAPHY	SPORTS/ FITNESS	COMPUTERS	PRESENTER TOOLS	HOME THEATER

CYPRESS

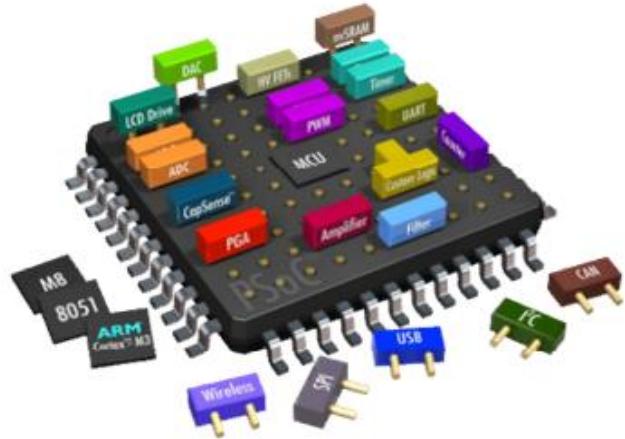
INTRODUCTION TO PSOC 3 AND PSOC 5

PSoC - Future of Embedded Design



PSoC is the world's only programmable embedded SoC integrating configurable analog and digital peripheral functions, memory and a microcontroller on a single chip.

PSoC 1 Device Overview



M8C Microcontroller
Up to 24 MHz, 4 MIPS

Flash Memory
4 KB to 32 KB for program storage

SRAM
256B to 2 KB for data storage

Configurable Analog Functions

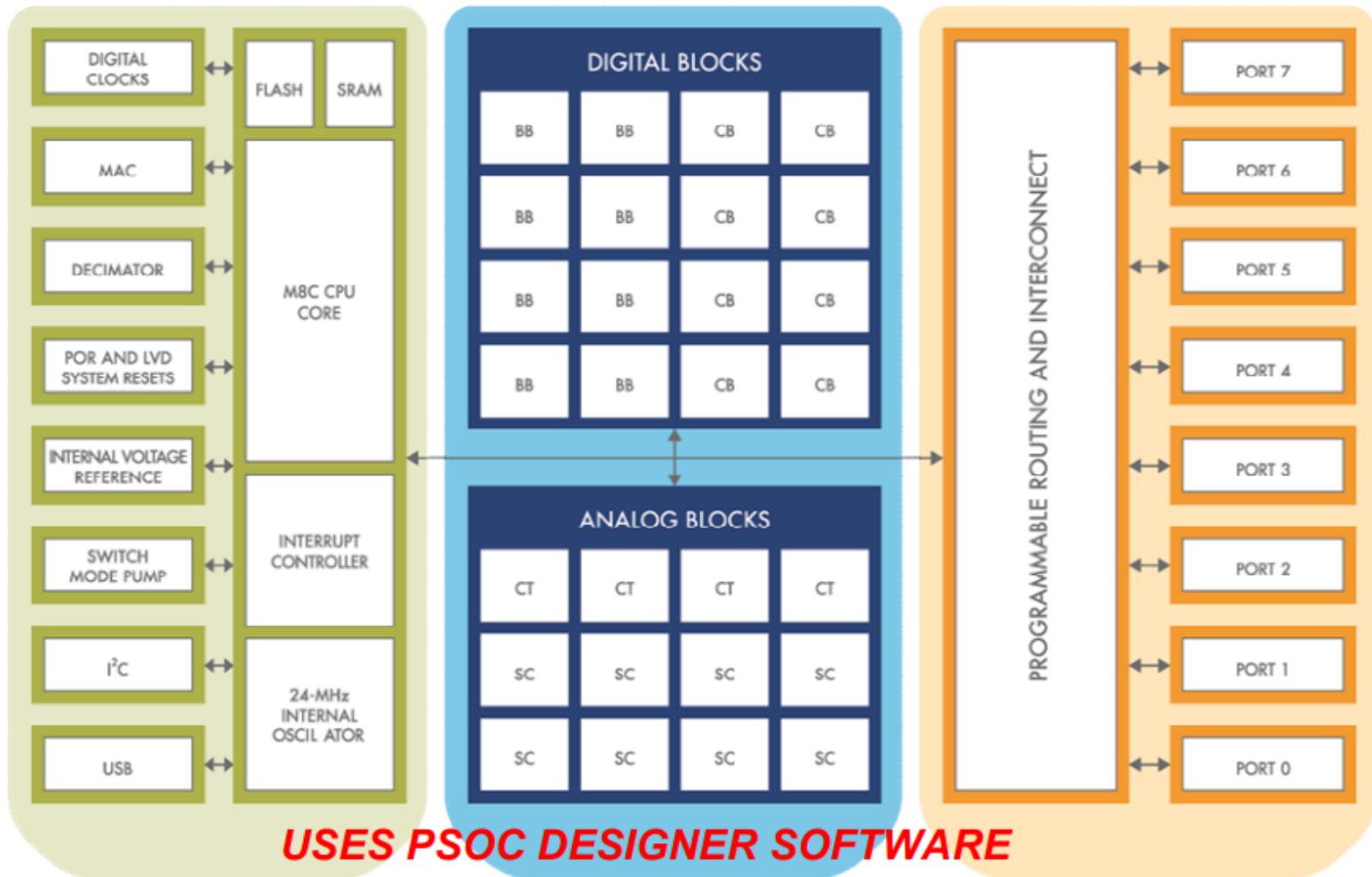
Implement ADCs, DACs, filters, amplifiers, comparators, etc.

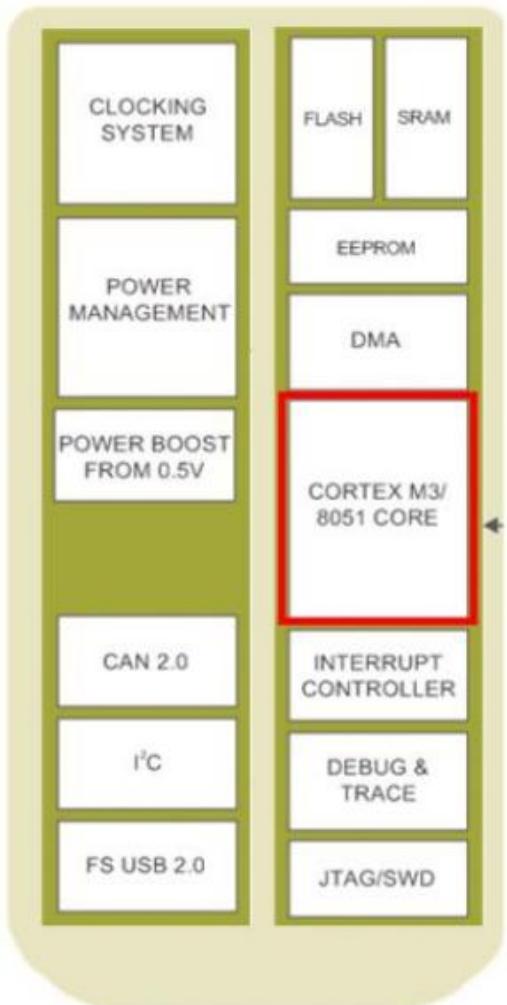
Configurable Digital Functions

Implement timers, counters, PWMs, UART, SPI, IrDA, etc.

USES PSOC DESIGNER SOFTWARE

PSoC 1 Architecture





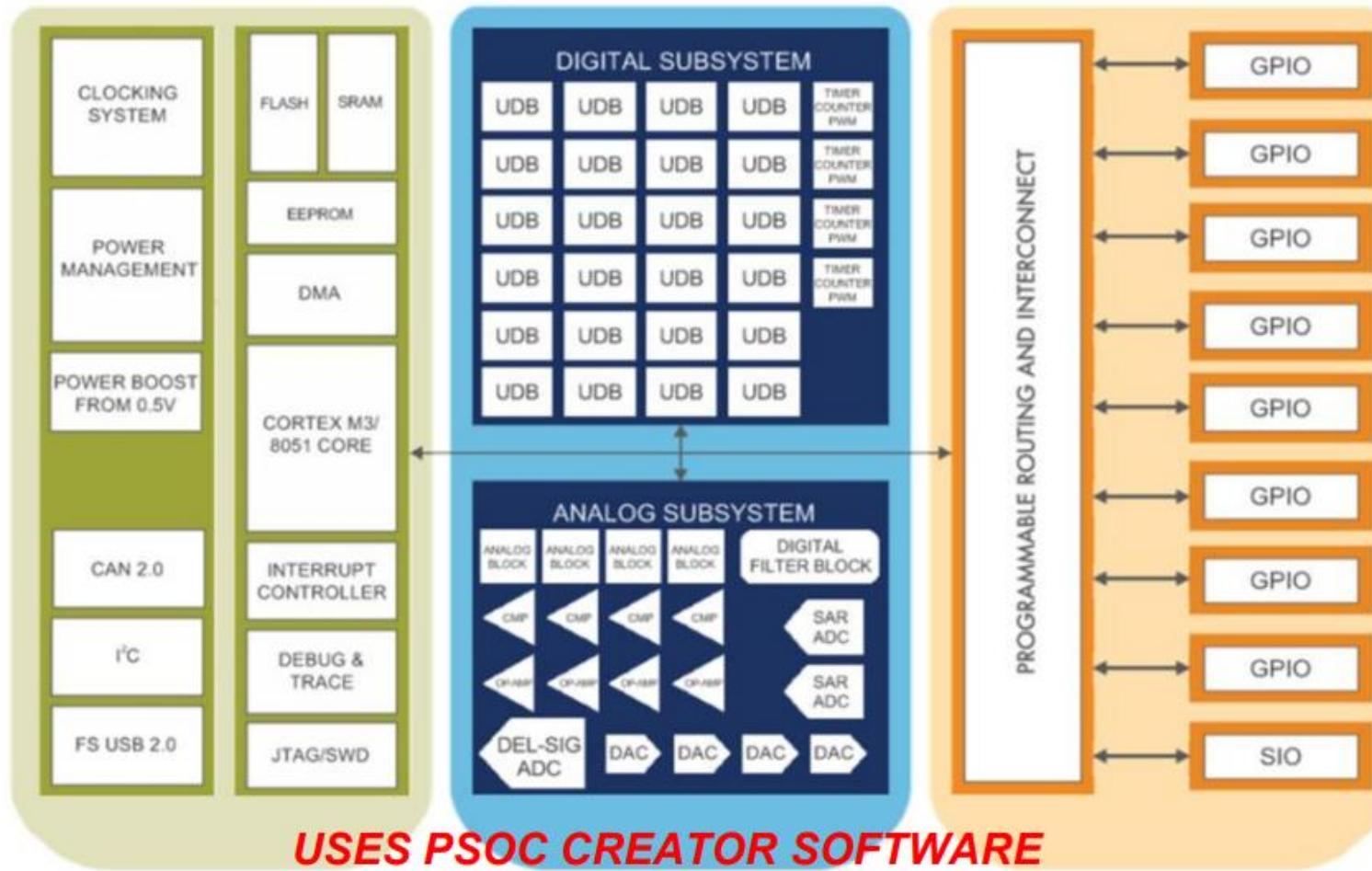
ARM Cortex-M3

- Industry's leading embedded CPU company
- Broad support for middleware and applications
- Up to 67 MHz; 83 DMIPS
- Enhanced v7 ARM architecture
- Thumb2 Instruction Set
- 16- and 32-bit Instructions (no mode switching)
- 32-bit ALU; Hardware multiply and divide
- Single cycle 3-stage pipeline; Harvard architecture

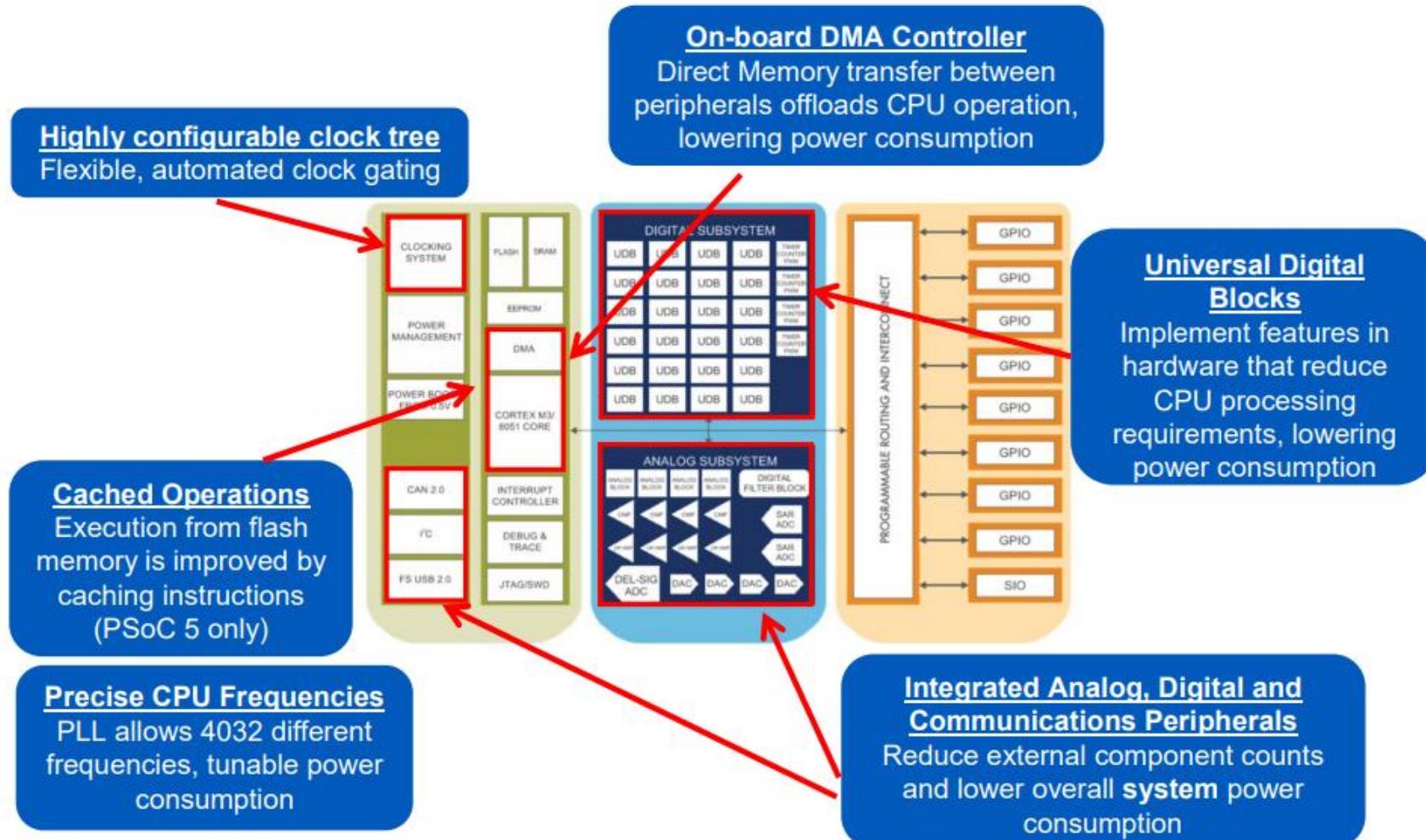
8051

- Broad base of existing code and support
- Up to 67 MHz; 33 MIPS
- Single cycle instruction set

PSoC 3 / PSoC 5 Platform Architecture



Designed for Low Power / Low Voltage

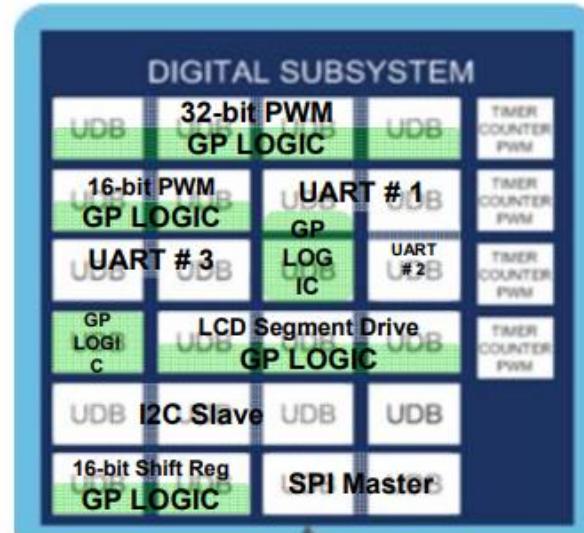


Digital Subsystem



Universal Digital Block Arrays (UDBs)

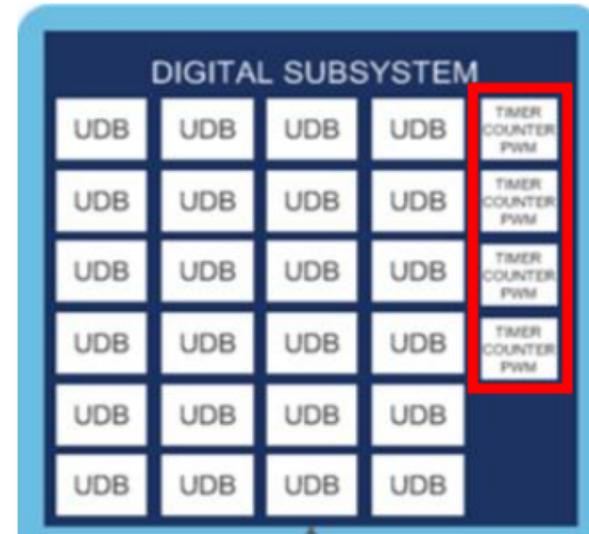
- Flexibility of a PLD integrated with a CPU
- Provides hardware capability to implement components from a rich library of pre-built, documented and characterized components in PSoC Creator
- PSoC Creator will synthesize, place and route components automatically as well as provide static timing analysis
- Fine configuration granularity enables high silicon utilization
- DSI routing mesh allows any function in the UDBs to communicate with any other on-chip function/GPIO pin with 8- to 32-bit data buses



Digital Subsystem

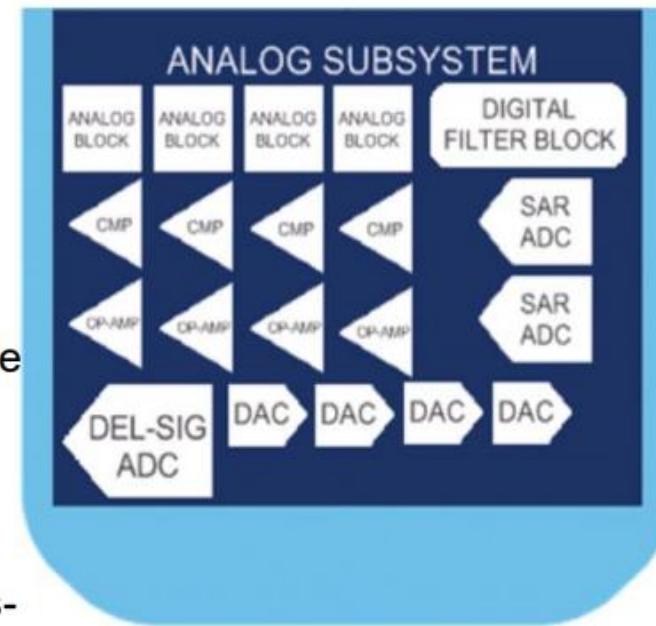
Organized 8/16-bit Timer/Counter/PWM Blocks

- Provides nearly all of the features of a UDB based timer, counter or PWM
- PSoC Creator provides easy access to these flexible blocks
- Each block may be configured as either a full featured 8-bit Timer, Counter or PWM. Two blocks may be combined to make it 16-bit
- Programmable options
 - Clock, enable, reset, capture, kill from any pin or digital signal on chip
 - Independent control of terminal count, interrupt, compare, reset, enable, capture and kill synchronization
- Plus
 - Configurable to measure pulse-widths or periods
 - Buffered PWM with dead band and kill



Configurable Analog System

- Flexible Routing: All GPIO are Analog Input/Output
- +/- 0.1% Internal Reference Voltage
- Delta-Sigma ADC: Up to 20-bit resolution
 - 16-bit at 48 kspS or 12-bit at 192 kspS
- SAR ADC: 12-bit at 700 kspS
- DAC's: 8-bit resolution, current and voltage mode
- Low Power Comparators
- Opamps (25 mA output buffers)
- Programmable Analog Blocks
 - Configurable PGA (up to X50), Mixer, Trans-Impedance Amplifier, Sample and Hold
- Digital Filter Block: Implement HW IIR and FIR filters
- CapSense Touch Sensing enabled

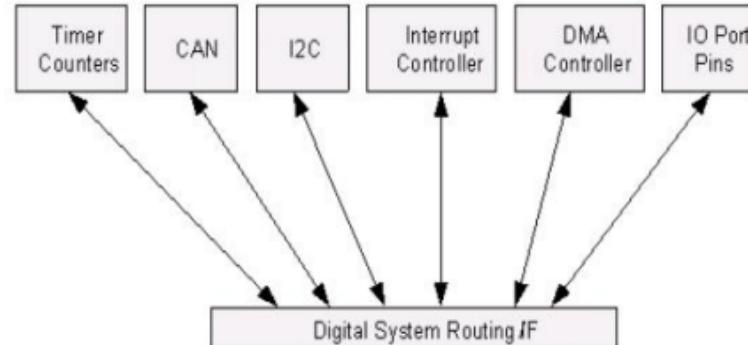


Digital Subsystems



Fixed-function Peripherals

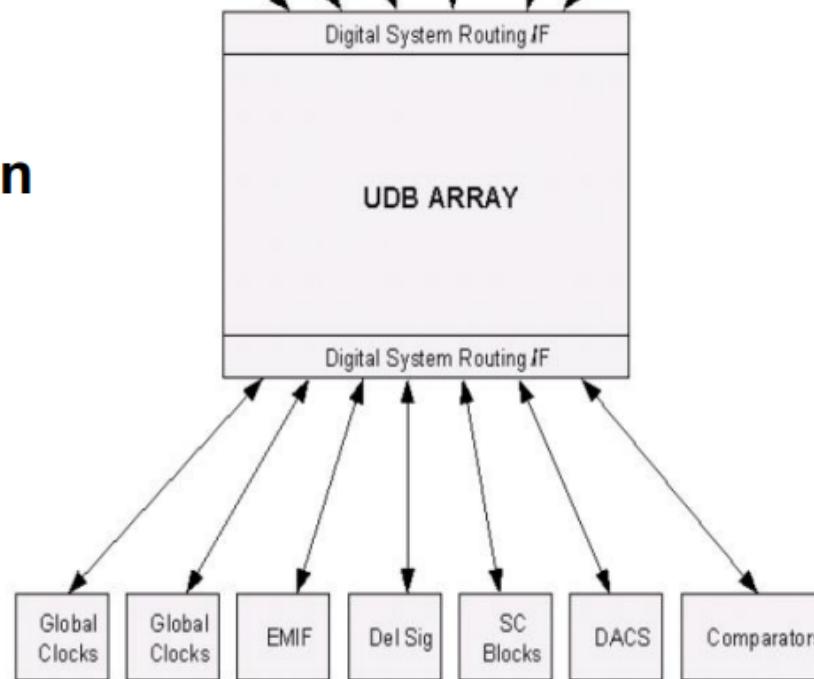
- Counter/Timer/PWMs, I2C, USB, CAN



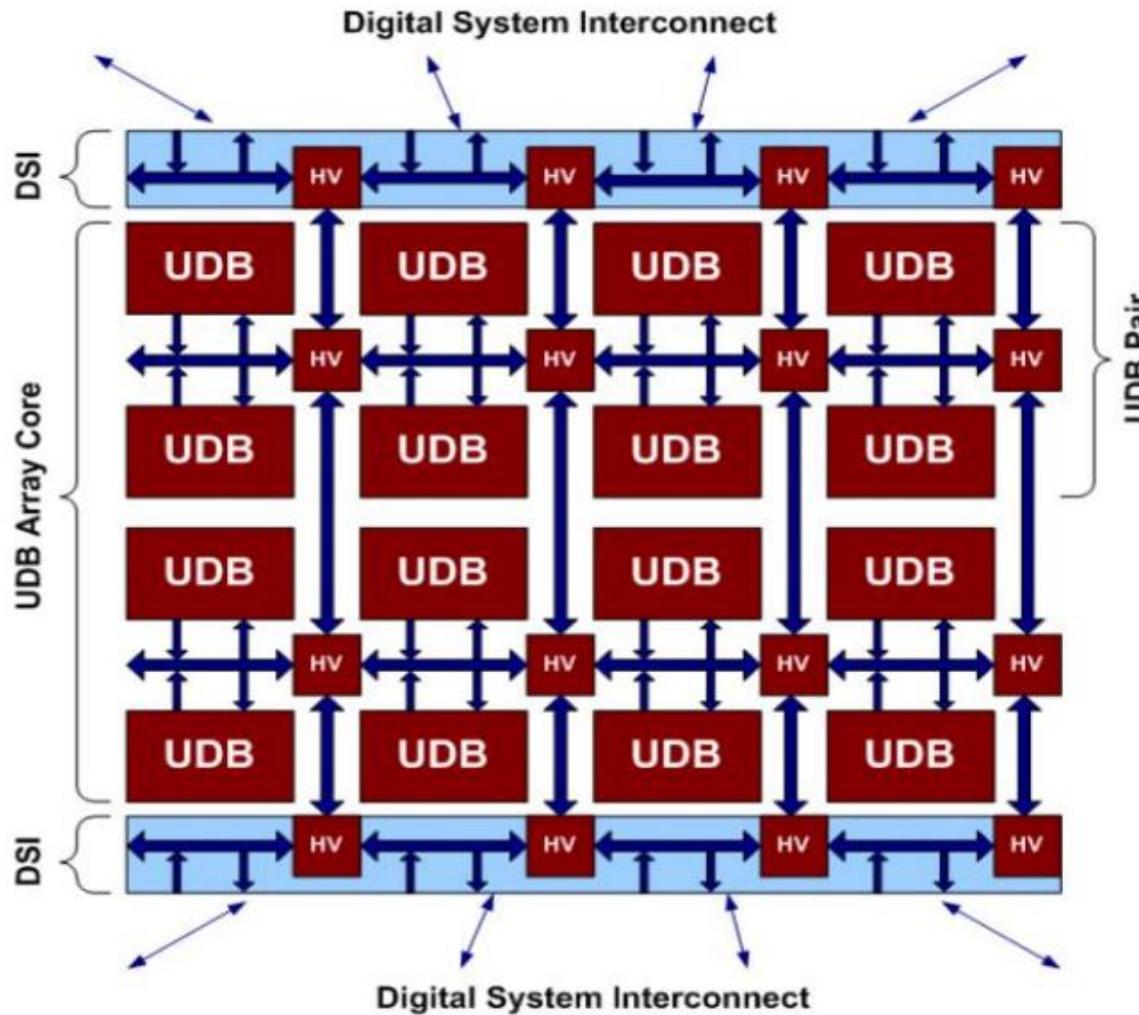
Universal Digital Blocks

Digital Interconnects Between

- Clocks
- IO pins
- Interrupts
- DMA
- External Memory
- Analog system



UDB Array

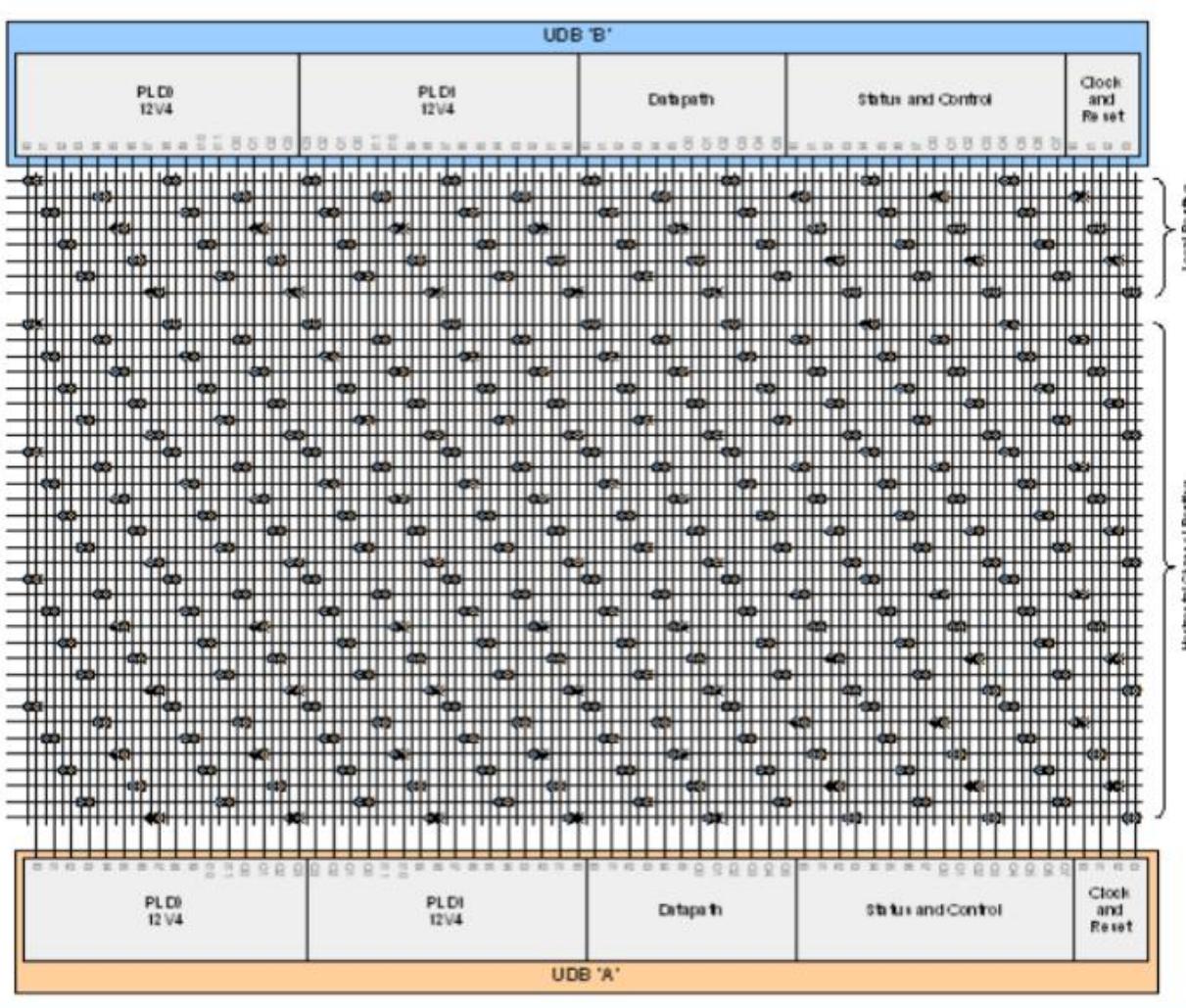


Digital Signal Interconnects (DSI)



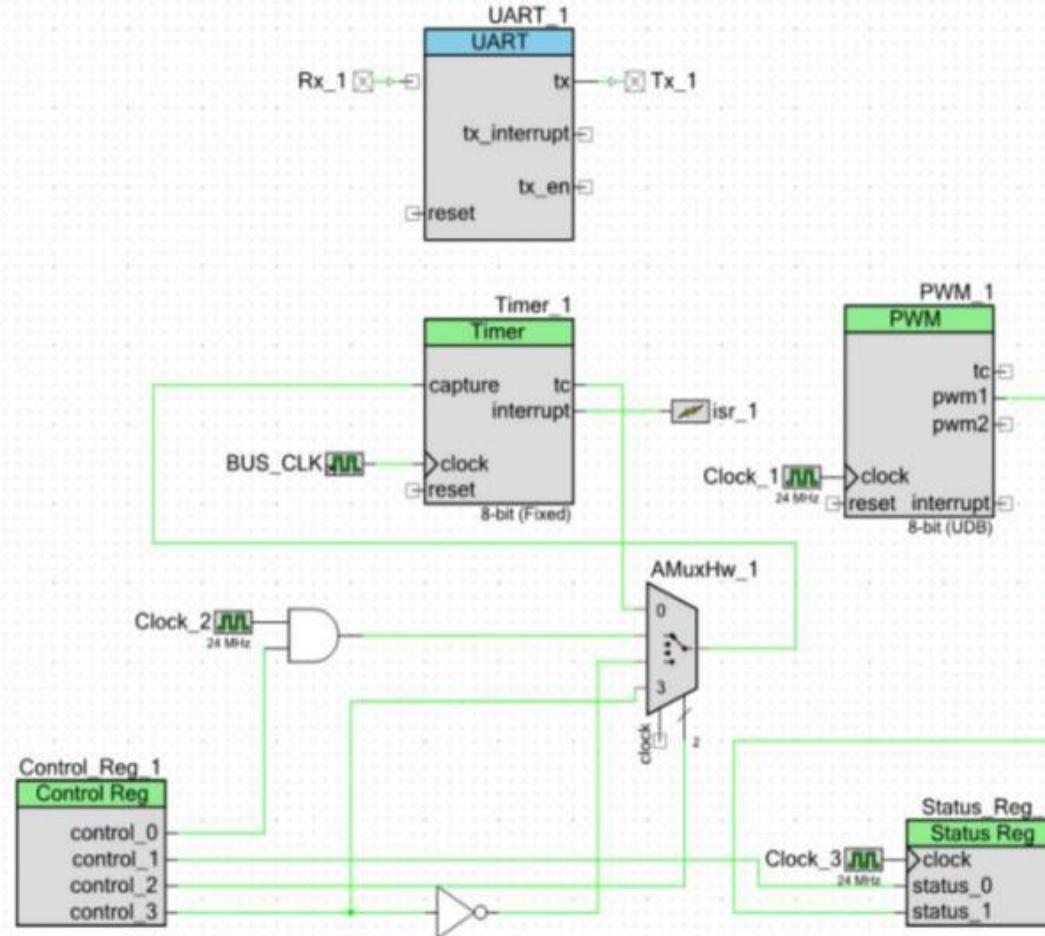
Routing Example:

- Single UDB Pair
- 7000 DSI registers



PSoC Creator enables:

- Schematic entry
- Automatic place and route
- Optimizations for analog and digital routing

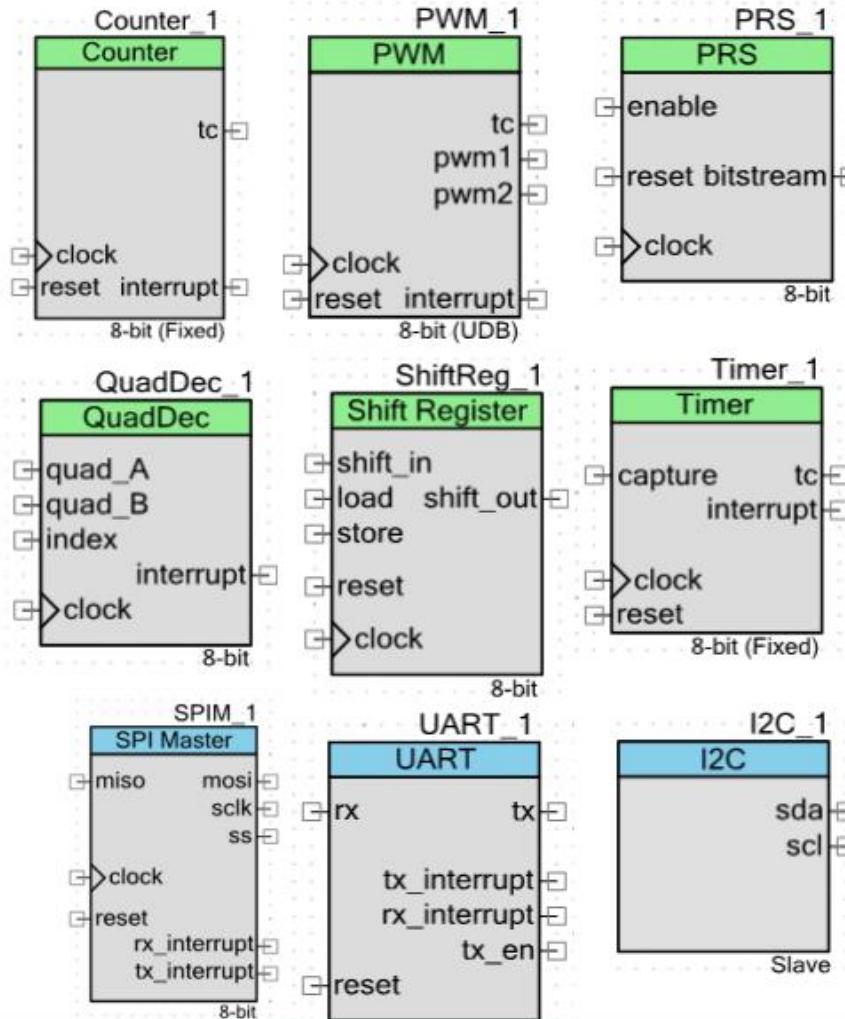


Digital Peripherals



Sample of Digital Peripherals:

- Counter
- Timer
- PWM
- PRS
- I2C
- USB
- UART
- SPI
- CAN
- Char/Segment LCD Drive



Counter



Fixed/UDB Counters:

- General-Purpose counter
- Continuous, reload on reset, terminal count, or one shot mode
- Compare options: < <= > >= =
- Enable, reset, capture inputs
- Compare, TC, interrupt outputs
- Interrupts on various events

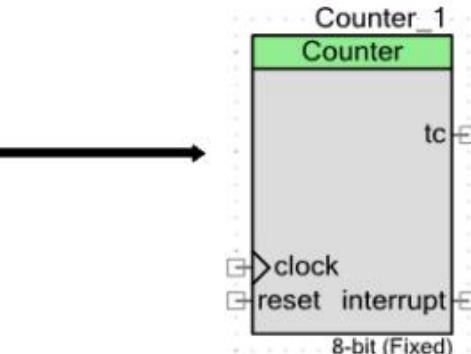
Fixed-Function Counters:

- 4 Available
- 8- or 16-bit
- Down counter only
- Single capture register

UDB-Based:

- 8-, 16-, 24- or 32-bit
- Many options:
 - Enable, count, capture, compare
 - 4-deep capture FIFO

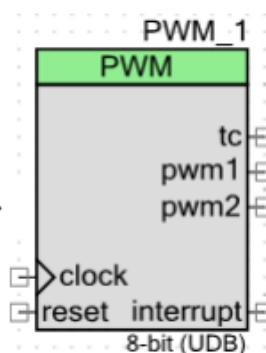
Double Click
Counter to configure



Fixed/UDB PWMs:

- General-Purpose PWM for motor control, LED brightness, etc.
- 8- or 16-bit
- Compare options: < <= > >= =
- Configurable deadbands
- Enable, trigger and kill inputs
- Biphase, TC and interrupt outputs
- Interrupts on various events

Double Click PWM
to configure



Fixed-Function PWMs:

- 4 Available
- 1 PWM output
- Left-aligned
- Hardware deadband and output kill

UDB-Based:

- 1 or 2 PWM outputs
- Left, right, center or dual-edge align
- Many options:
 - Enable, trigger, kill and compare

Fixed/UDB I2Cs:

- I2C slave, master or multi-master
- Hardware or firmware address decode
- 7- or 10-bit addressing (10-bit F/W only)
- Bus stalling / clock stretching
- SMBus supported w/additonal firmware
- Routes SDA/SCL to any GPIO/SIO pins
- Interrupts for variety of bus events

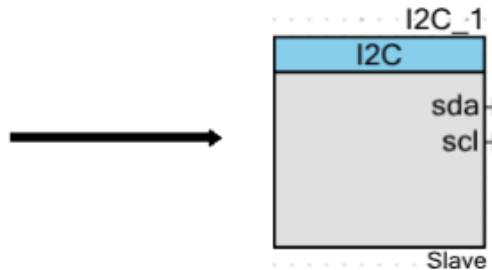
Fixed-Function I2C:

- 1 Available
- Standard 100 Kbps or Fast 400 Kbps
- Responds Sleep Low-Power mode if dedicated SIO connections used

UDB-Based:

- Adds high-speed mode; up to 3.4 Mbps

Double Click I2C to configure



Pseudo Random Sequencer

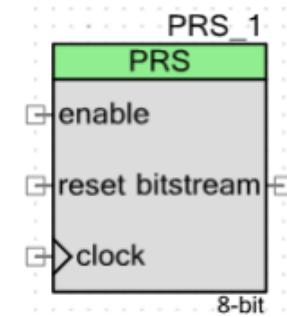


Pseudo Random Sequencer (PRS)

Specs:

- 2- to 64-bit sequence length
- Serial output bit stream
- Continuous or single step run modes
- Standard or custom polynomial
- Standard or custom seed value
- Enable input provides synchronized operation with other components
- Computed pseudo-random number can be read directly from the linear feedback shift register (LFSR)

Double Click PRS
to configure

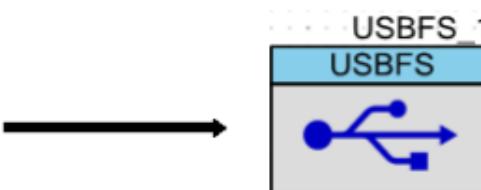


USB

Specs:

- Fixed-function, USB 2.0 Full Speed (12 Mbps) peripheral
- 8 unidirectional endpoints
- Shared 512 byte buffer
- Transfer Types: Control, Interrupt, Bulk, Isochronous
- DMA access / capable
- Wake from sleep

Double Click USB to configure



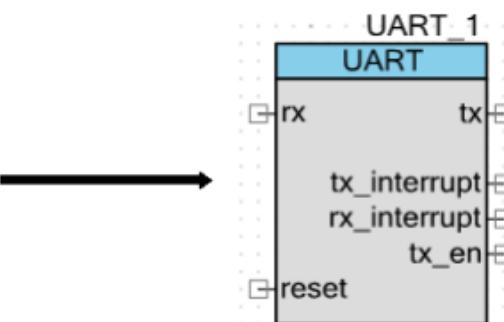
UART



Specs:

- Full-Duplex, Tx only and Rx only
- 5- to 9-data bits
- 110- to 921600-bps or arbitrary up to 4 Mbps
- Rx and Tx buffers 1- to 255-bytes
- Framing, Parity and Overrun error detection
- 9-bit address mode with hardware address detection
- Optional Tx enable for RS-485

Double Click UART
to configure



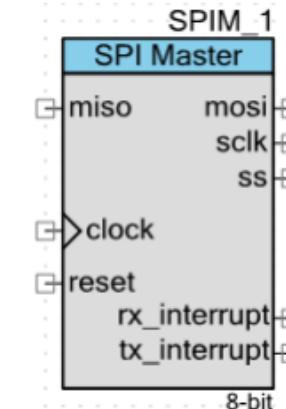
SPI



Specs:

- Master or Slave
- Data rates to 33 Mbps
- 2- to 16-bit data width
- 4 SPI modes
- LSB or MSB first
- 1- to 255-byte Rx and Tx buffers
- Hardware Slave Select generation
- Supports 3-wire mode

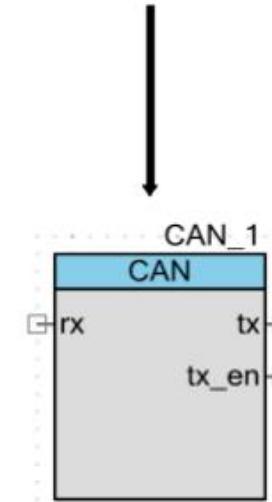
Double Click SPI to
configure



Specs:

- CAN 2.0A/B spec. compliant
 - Remote Transmission Request (RTR) support
 - Programmable bit rate up to 1Mbps
 - External CAN PHY connects to any GPIO
- Transmit path:
 - 8 transmit message buffers
 - Programmable priority for each
- Receive path:
 - 16 receive message buffers
 - 16 acceptance filters/masks
 - DeviceNet addressing support
 - Option to link multiple receive buffers to/from a hardware FIFO

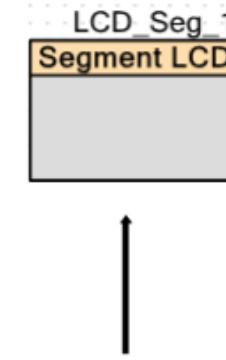
Double Click CAN to configure



LCD Drive

Specs:

- Drives up to 736-segments (16-commons/46-front plane)
- Up to 62 total LCD drive pins; commons and segment lines mapped to any GPIO
- High multiplex ratio of up to 1/16 for max 16 segments
- Type A (standard) and Type B (low power) waveforms supported
- Wide operating voltage range supported (2V to 5.2V) for LCD panels
- Static, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$ bias voltage levels
- Vias voltage generation using dedicated DAC, and internal resistor leader
- Up to 128 levels of software controlled contrast
- Ability to move display data from memory to LCD via DMA
- Adjustable LCD refresh rate from 10 Hz to 150 Hz



Double Click LCD to
configure

Analog Subsystem

Routing

Multiplexers

Comparators

Opamps

DACs (V & I)

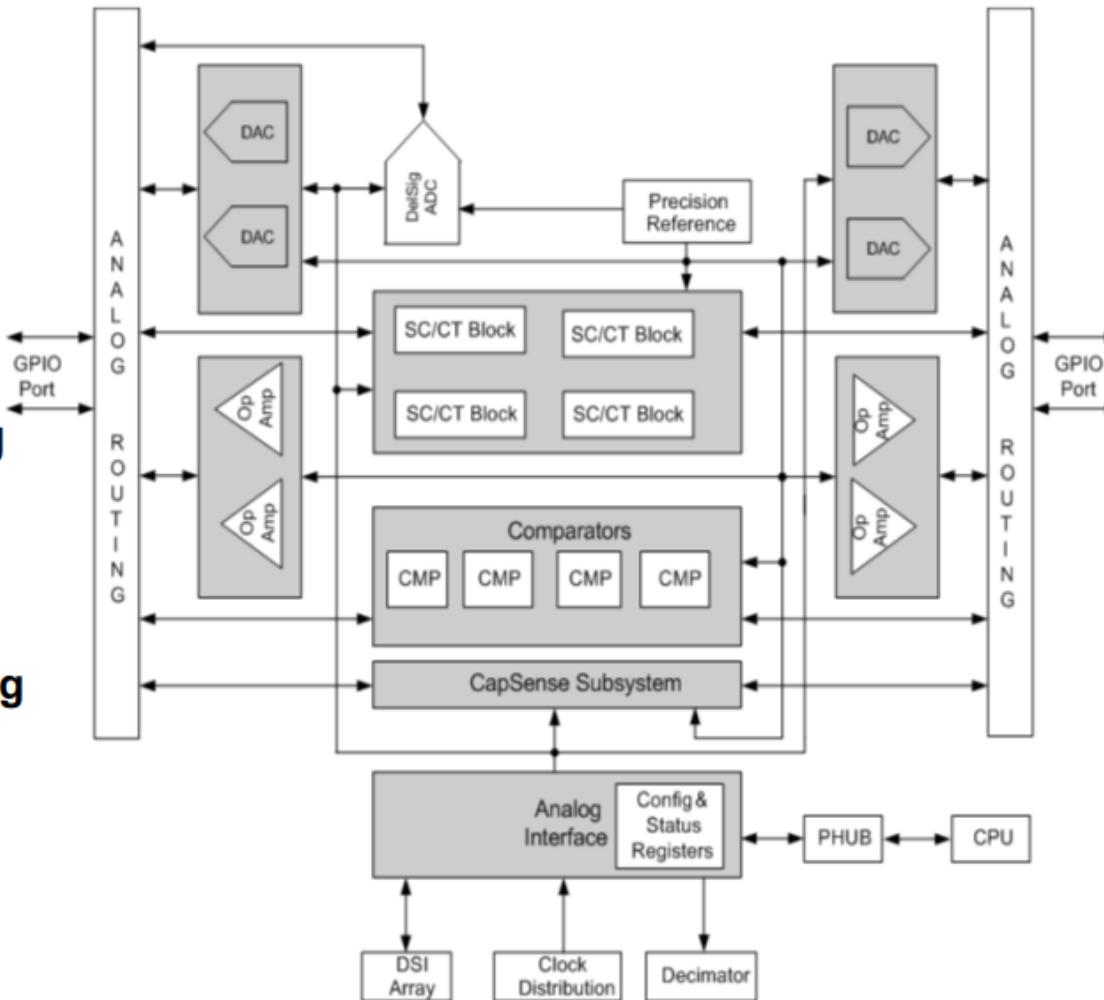
DeltaSigma ADC

Programmable Analog

- PGA
- TIA
- Mixer

CapSense Touch Sensing

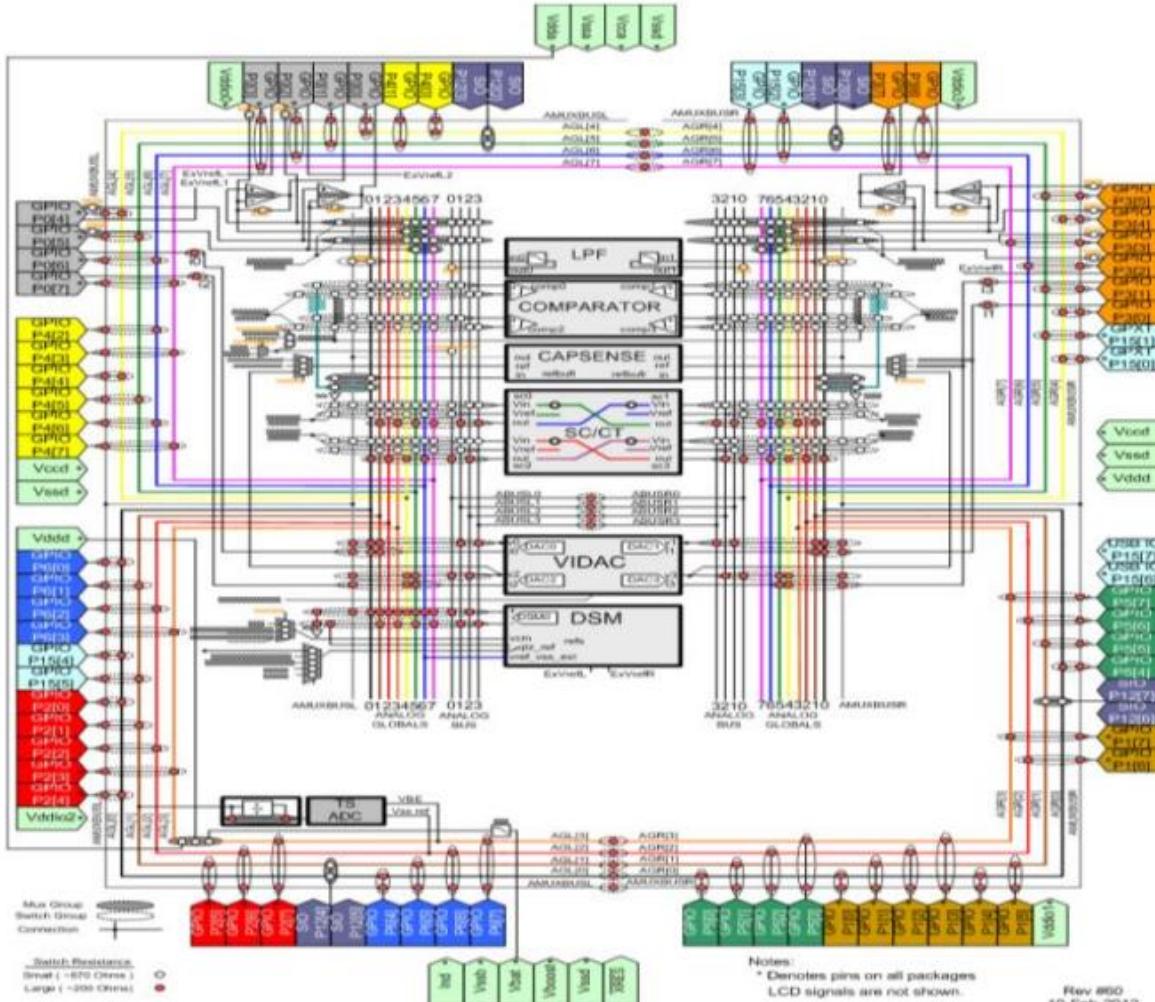
Digital Filters



Analog Matrix

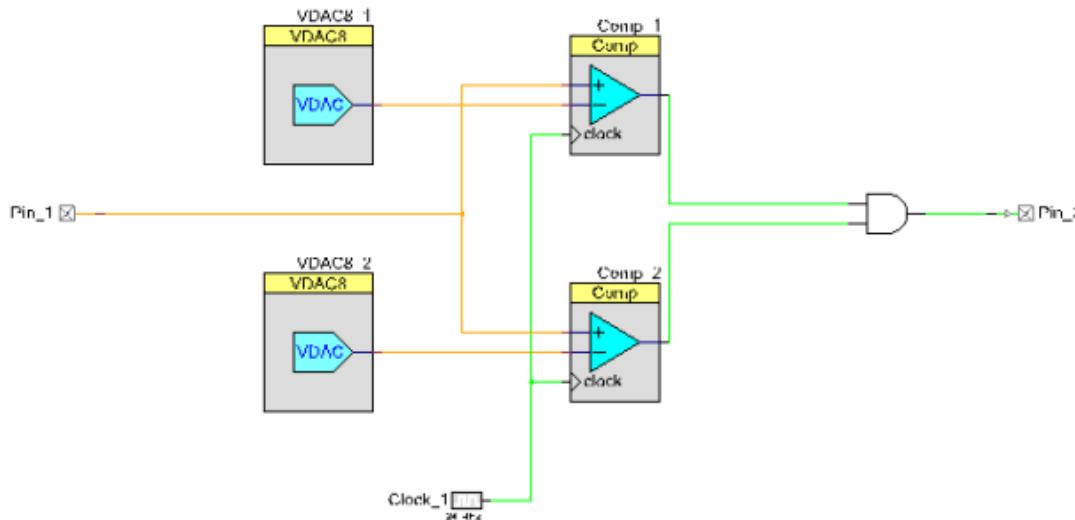


More than 320
switches !



PSoC Creator enables:

- Schematic Entry
- Automatic place and route
- Optimizations for analog and digital routing



Window comparitor example

Analog Multiplexer Specs:

- Bi-directional
- Either single ended or differential
- Actual routing hidden from user
- May have more than one connection at a time
- Analog routing may be controlled by digital subsystem



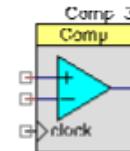
Double Click MUX to configure

Analog Peripheral: Comparator



Specs:

- Up to four per device
- Speeds:
 - Fast – 80 ns / 250 uA
 - Slow – 55 us / 6 uA
- Accuracy:
 - 2 mV fast mode
 - Zero-adjust; Internal VDAC
- Hysteresis:
 - 10 mV nominal
 - May be enabled or disabled



Double click to configure comparator

Analog Peripheral: Opamp



Specs:

- Up to four per device
- Speeds:
 - Fast – 80 ns / 250 uA
 - Slow – 55 us / 6 uA

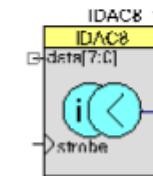
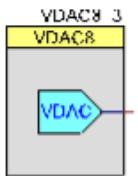
- Accuracy:
 - 2 mV fast mode
 - Zero-adjust; Internal VDAC
- Hysteresis:
 - 10 mV nominal
 - May be enabled or disabled



Double click to configure Opamp

Features

- DAC data source may be data register or DAC Bus
- CPU or DMA may write to data register
- Data Strobe from data register write or Strobe input
- Clock or UDB may be used for Strobe
- IDAC8 and VDAC8 are the same block with V and I inputs



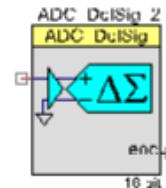
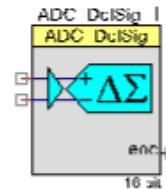
Double click to configure DAC, also show data source

Analog Peripheral: Delta Sigma ADC



Specs:

- High speed, high resolution ADC
- Selectable resolutions (8- to 20-bit)
- Several input ranges
- High-impedance input buffers
 - Programmable gain (1,2,4,8)
 - Chopper mode for low offset
 - Internal reference may be bypassed
- Single and differential input modes
- Wide range of sample rates 10 to 375K
- Multiple reference sources
- Drop, connect, and go!

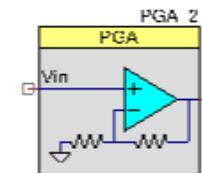
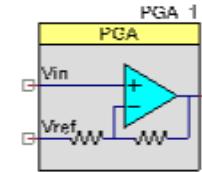


Double click to configure ADC

Analog Peripheral: PGA

Specs:

- Programmable Gain Amplifier
- Amplify signals without external components
- Gain: 1x to 50x
- Vin and Vref to any pin



Accuracy:

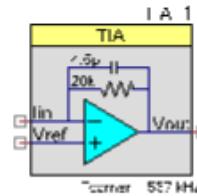
- Gain: +/- 5%
- Vos: 10 mV

Double click to configure PGA

Analog Peripheral: TIA

Specs:

- Trans-Impedance Amplifier
- Conversion gain is a “resistor”
 - Current IN \rightarrow Volts OUT
 - $V_{out} = V_{ref} - I_{in} \cdot R_{fb}$
 - Adjustable R_{fb} = Programmable gain (20k to 1M)
 - Adjustable C_{fb} = Programmable bandwidth (up to 4.7 pF)
 - Calibrated with on-chip IDAC (internal resistors +/- 30%)
- Applicable to current output sensors
 - Glucose meters
 - Photo-diodes – light meters, medium speed IR receiver



Double click to configure TIA

Specs:

- CapSense peripheral uses configuration of existing system resources
- Two simultaneous CapSense systems possible
- CapSense Configurations
 - All have similar configuration patterns
 - Buttons: Basic CapSense sensor with On/Off detection
 - Sliders: Linear and radial with interpolated positioning (also supports diplexing to reduce pin count)
 - Touch Pads: X, Y interpolated positioning
 - Matrix Buttons
 - Proximity Sensors
 - Generic Sensors



Double click to configure Capsense



Щиро дякую!