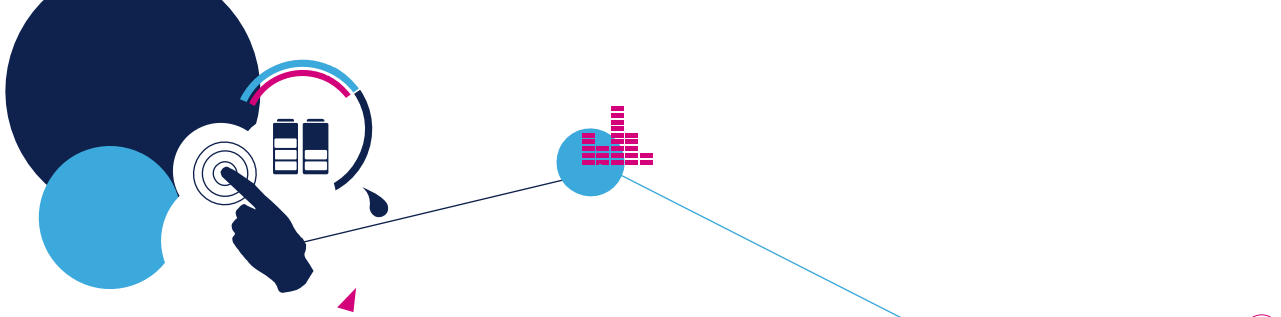


STM32L4 – new peripherals

STM32L4 workshop

life.augmented

High integration

High integration with high memory size in small packages

Parallel Interface
8-/16-bit FSMC (TFT-LCD, SRAM, NOR, NAND)

Display
LCD driver (8 x 40)

Timers
17 timers including:
2 x 16-bit advanced motor control timers
2 x ULP timers
7 x 16-bit-timers
2 x 32-bit timers

I/Os
Up to 114 I/Os
Touch-sensing controller

Cortex-M4
80 MHz
FPU
MPU
ETM

DMA

ART Accelerator™

Up to
1-Mbyte Flash with ECC
Dual Bank

128-Kbyte RAM

Connectivity
USB OTG,
1x SD/SDIO/MMC,
3 x SPI,
3 x I²C,
1x CAN,
1 x Quad-SPI,
5 x USART + 1 x ULP UART,
1 x SWP

Digital
AES (256-bit), TRNG,
2 x SAI,
DFSDM

Analog
3 x 16-bit ADC,
2 x DAC,
2 x comparators,
2 x op amps
1 x temperature sensor

Package size down to 4.4 x 3.8 mm

life.augmented

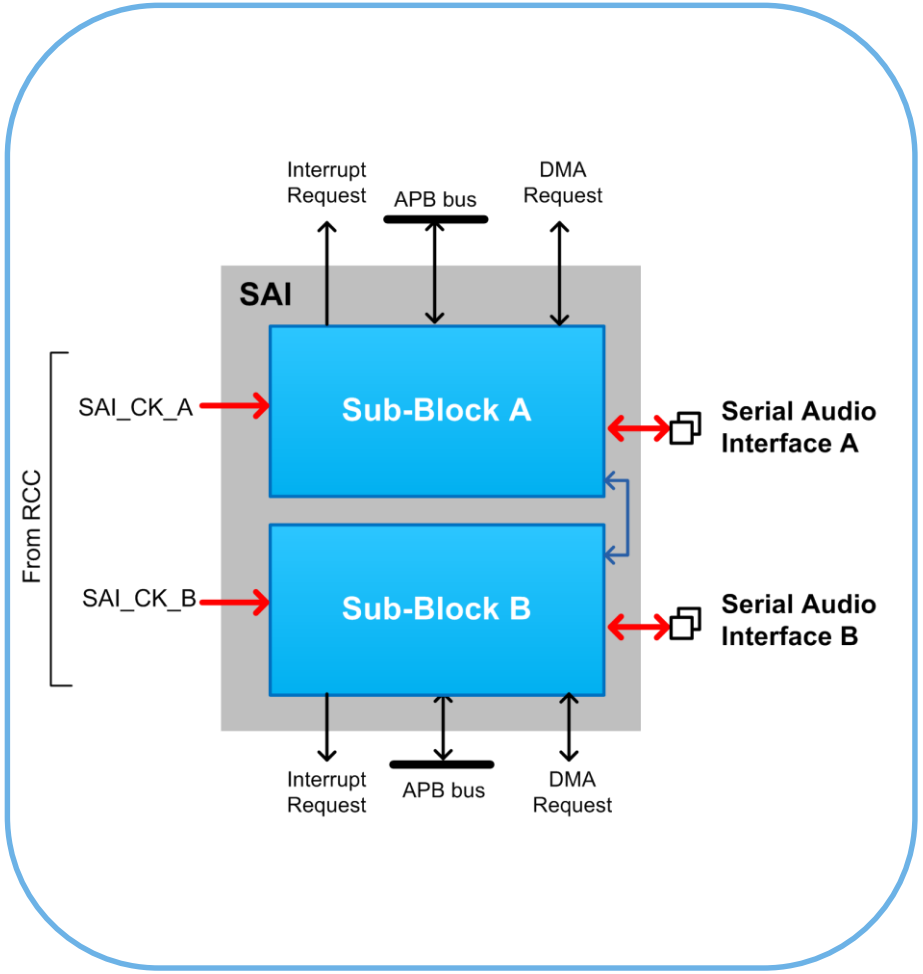
STM32L4 - SAI

Serial Audio Interface

life.augmented

STM32 L4

Overview



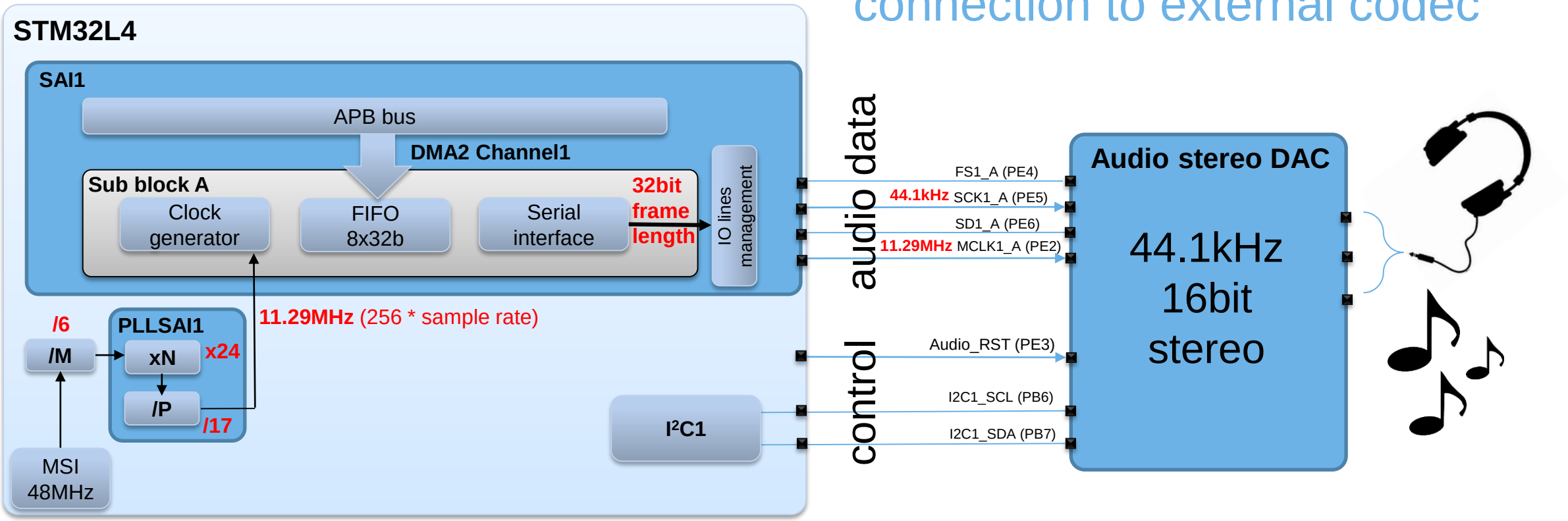
- Provides communication interface with external audio devices
  - Fully configurable
  - Supports standards: I²S, PCM, TDM, SPDIF, AC97
  - Two Independent Sub-Blocks

Application benefits

- Supports large variety of audio devices
- Full Duplex operation
- Fully Configurable Digital Audio Formats

SAI use case

connection to external codec



- Considering playback the music on external codec with **44.1**kHz sample rate, using **16bit**/channels (Stereo signal) we should connect **11.29**MHz signal clock to SAI module
- Data should be transferred to SAI1 FIFO via DMA2 Channel1 controlled by SAI1_A
- To control external DAC we can use one of I²C interfaces (like I²C1)

life.augmented

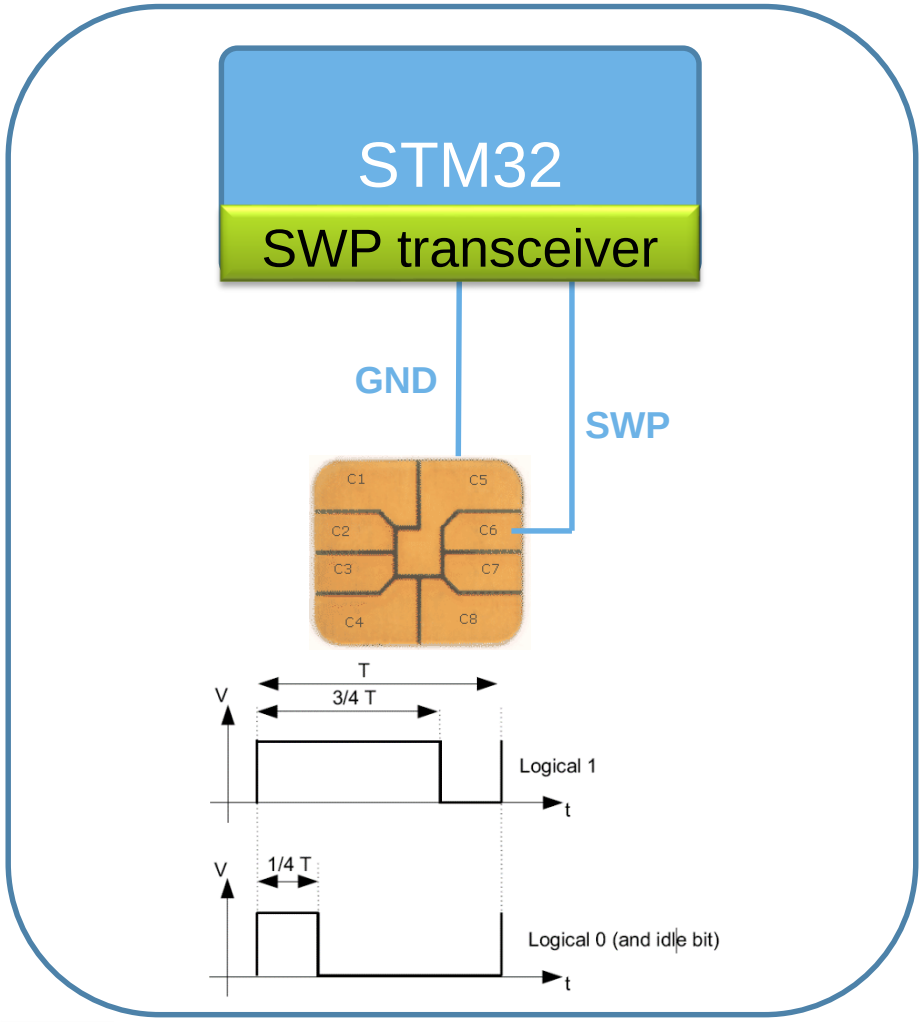
STM32L4 - SWPMI

Single Wire Protocol Master Interface

life.augmented

STM32 L4

Overview



- Implements a full-duplex single-wire communication interface, according to the single-wire protocol defined in the ETSI TS 102 613 standard, in Master mode

Application benefits

- SWP transceiver embedded inside STM32
- Single-wire full-duplex communications via C6 contact of a smartcard from 100 kbit/s to 2 Mbit/s

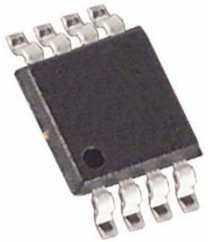
STM32L4 – QSPI

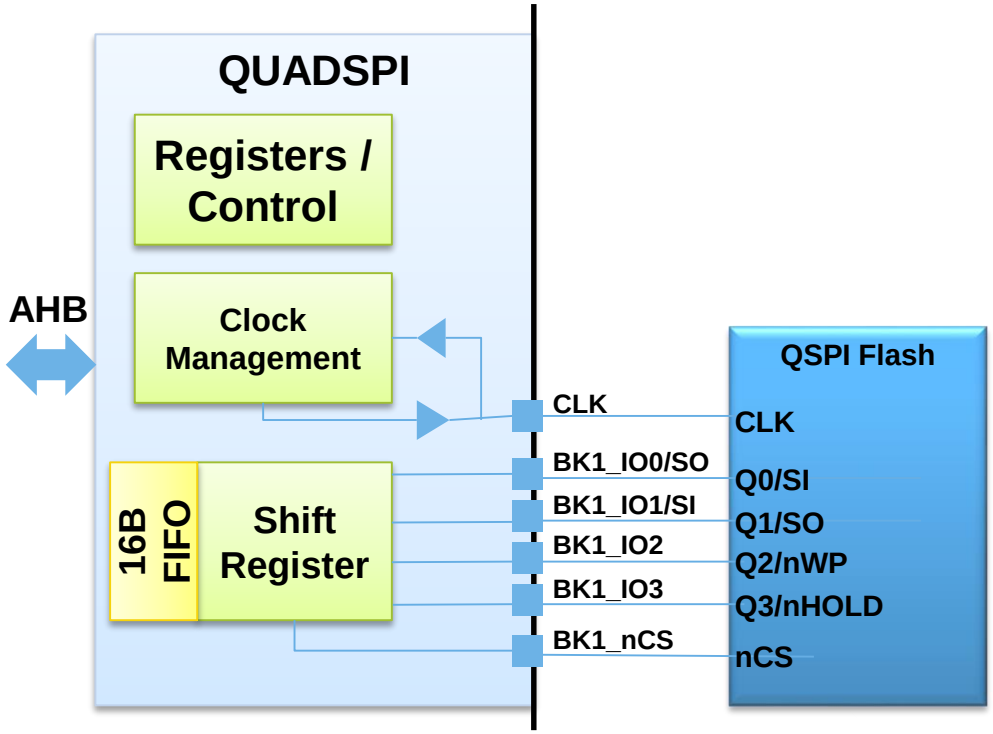
Quad SPI memory interface

life.augmented

STM32 L4

Overview





- The Quad-SPI memory interface provides a communication interface with **external serial Flash** memories
  - Fully configurable
  - Supports Execute in Place (XiP)
  - Memory mapped

Application benefits

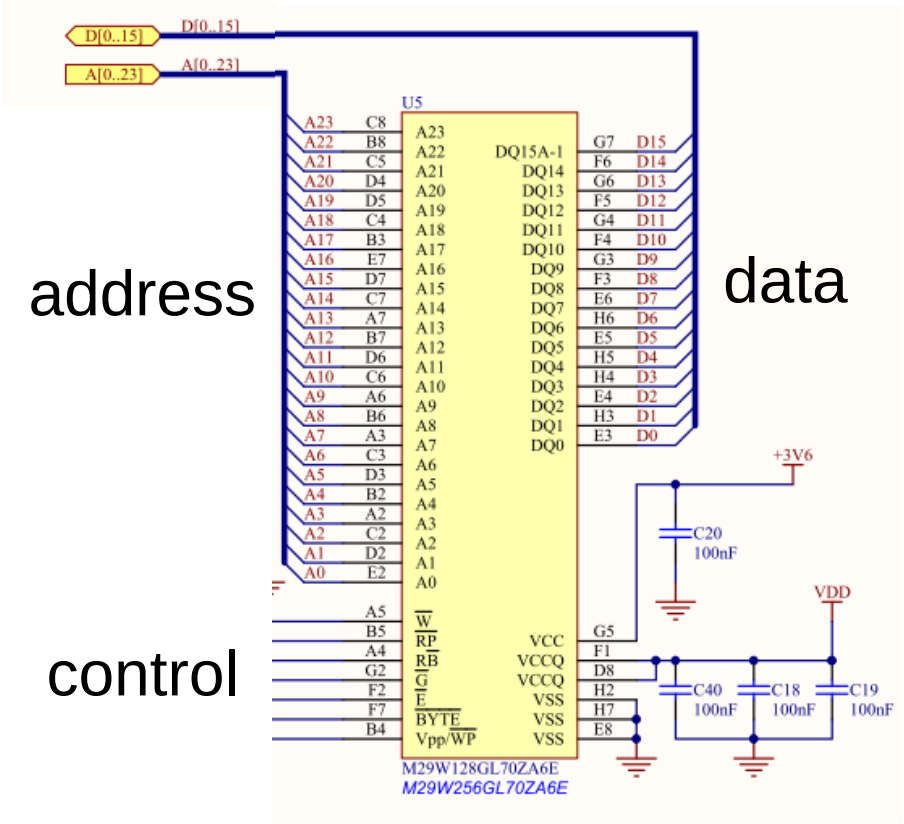
- Supports all SPI Flash memories
- Only a few (4+2) pins needed
- Easy memory expansion in existing project

QSPI vs. NOR Flash memories pin hunger

address

data

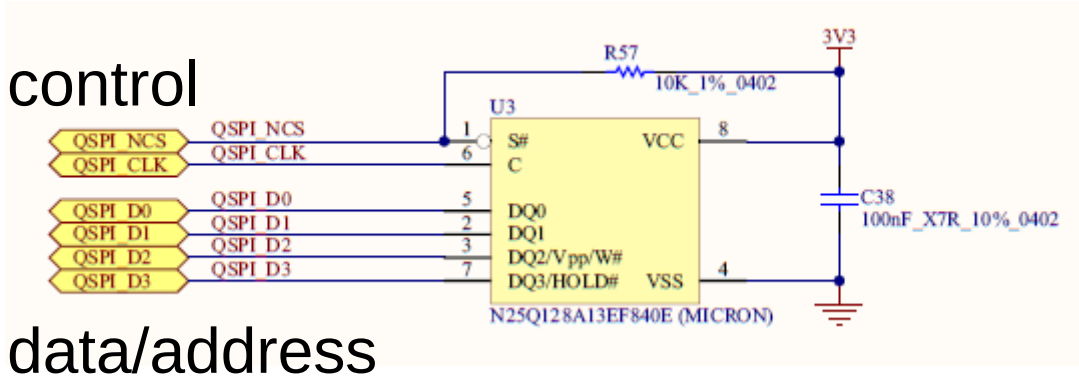
control



22 lines for address,
16 lines for data,
5 lines for control

control

data/address



4 lines for data,
2 lines for control

life.augmented

Performance & power consumption

- Data fetch performance comparison
  - Time to read a 10kB table from external Quad-SPI Flash / internal Flash / internal SRAM
  - Code execution from internal Flash memory

Conditions	External QSPI	Internal Flash	Internal SRAM
CPU @ 80 MHz – QSPI SDR 4 lanes @ 40 MHz	257 µs	152 µs	88 µs
CPU @ 48 MHz - QSPI DDR 4 lanes @ 48 MHz	**214 µs**	227 µs	147 µs

External Quad-SPI: Micron N25Q256A13EF840E / XiP Mode - Internal Flash: ART enable - Compiler: IAR v7.30.1.7746

  - Power consumption of the STM32L4 during this benchmark (External Flash memory excluded)

Conditions	External QSPI	Internal Flash	Internal SRAM
CPU @ 80 MHz – QSPI SDR 4 lanes @ 40 MHz	21 mA	12.74 mA	14.11 mA
CPU @ 48 MHz - QSPI DDR 4 lanes @ 48 MHz	14.6 mA	8.79 mA	8.64 mA

External Quad-SPI: Micron N25Q256A13EF840E / XiP Mode - Internal Flash: ART enable - Compiler: IAR v7.30.1.7746
The external Flash consumption depends on the Quad-SPI Flash device.
We measured ~4.7 mA @ 80 MHz/SDR and ~6.1 mA @48 MHz/DDR on data read benchmark for the selected part.

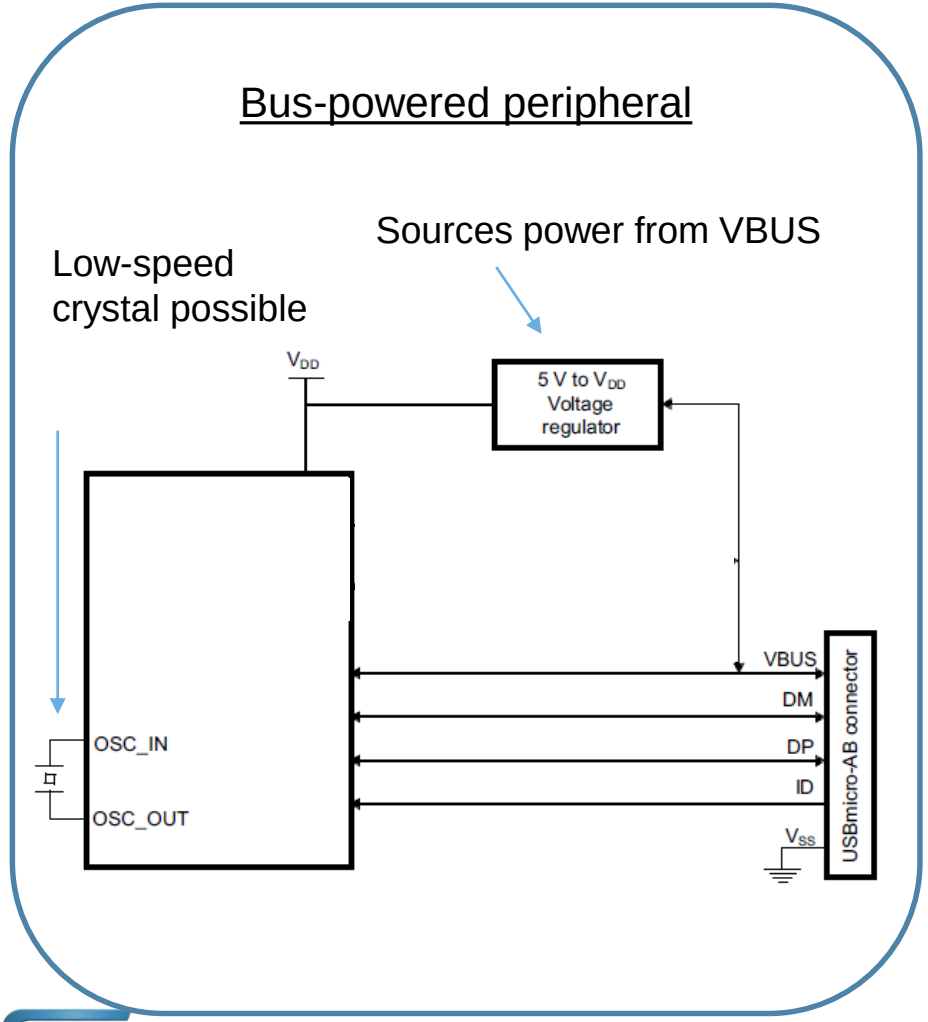
STM32L4 – USB

Extended functionality

life.augmented

STM32 L4

Overview



- Provides USB 2.0 Full Speed interface
  - Supports OTG specification (OTG 2.0)
  - Includes battery charger detection (BC1.2)
  - ADP (Attach Detect Protocol)
  - Soft disconnection feature

Application benefits

- Separated power supply pin (V_{USB})
- VBAT charging feature w/ built-in serial resistor controllable by software
- Can work using internal 48MHz MSI oscillator
- On-The-Go (OTG) functionality
- Charging feature thanks to battery charger (BC) detection (up to 1.5A)

STM32L4 - DFSDM

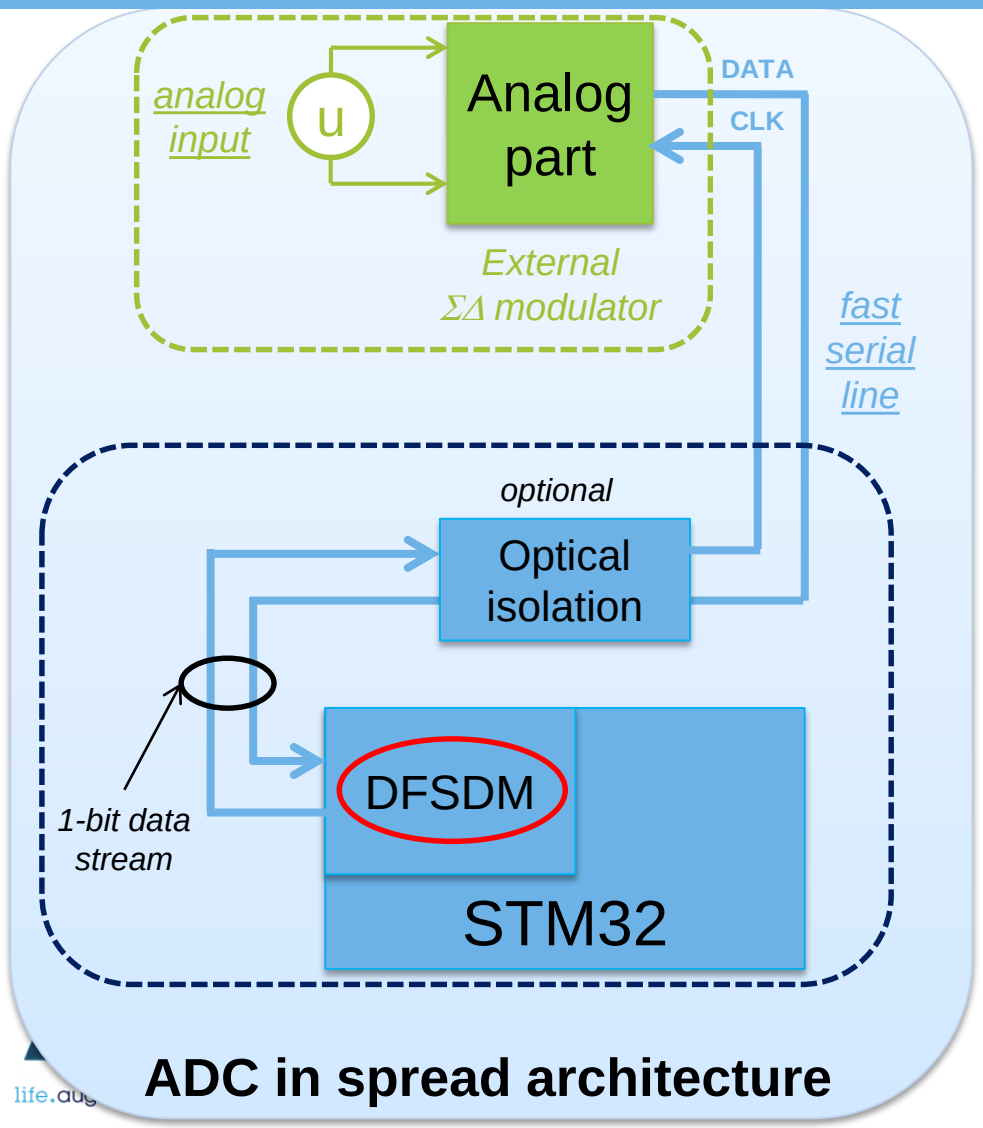
Digital filter for Sigma-Delta modulators interface

life.augmented

STM32 L4

DFSDM: introduction and typical usage

Behavior like ADC with scalable speed/resolution and external analog front end



ADC in spread architecture

- Split of analog and digital part:
  - Benefit from external analog selection
  - Benefit from internal digital features (DFSDM)

Application benefits

- External analog part: selection according needs: precision, less noise, extra fast, galvanic isolation, linearity, cheap, high voltage-side operation
- Digital part: serial line interface (1 or 2 wires), scalable speed vs. resolution (up to 24 bits), full features like ADC
- Examples: electricity meter, motor control, medical applications, MEMS microphone audio,

Key features

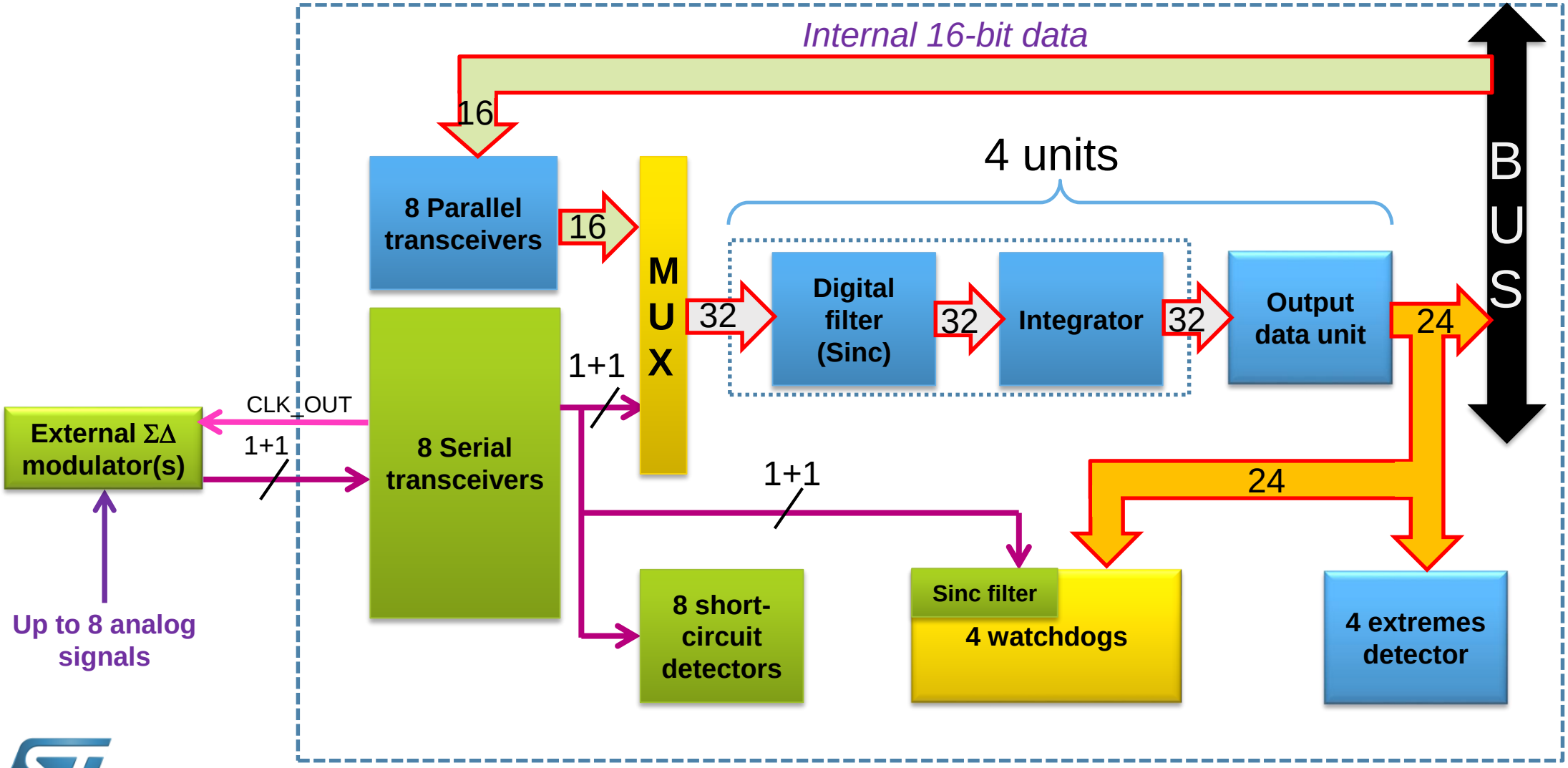
Decreased CPU burden and low-latency HW safety features

- Transceivers
  - Fast serial input (20 MHz):
    - SPI or Manchester-coded mode (with clock absence detection)
    - Clock generation
  - Internal parallel data input
    - 16-bit register data input (write by CPU/DMA)
- Filters
  - Sinc1, Sinc2, Sinc3, Sinc4, Sinc5 and FastSinc filters with oversampling ratio up to 1024
  - Integrator with oversampling ratio up to 1024

Application Benefits

- Support for various ΣΔ modulators suppliers (ST, TI, Analog Devices,…)
- Speed vs. resolution selection by filter configuration
- Internal data post-processing (SAR ADC results, ...)
- Additional functions: watchdog, short-circuit detector, extremes detector, offset correction

Block diagram

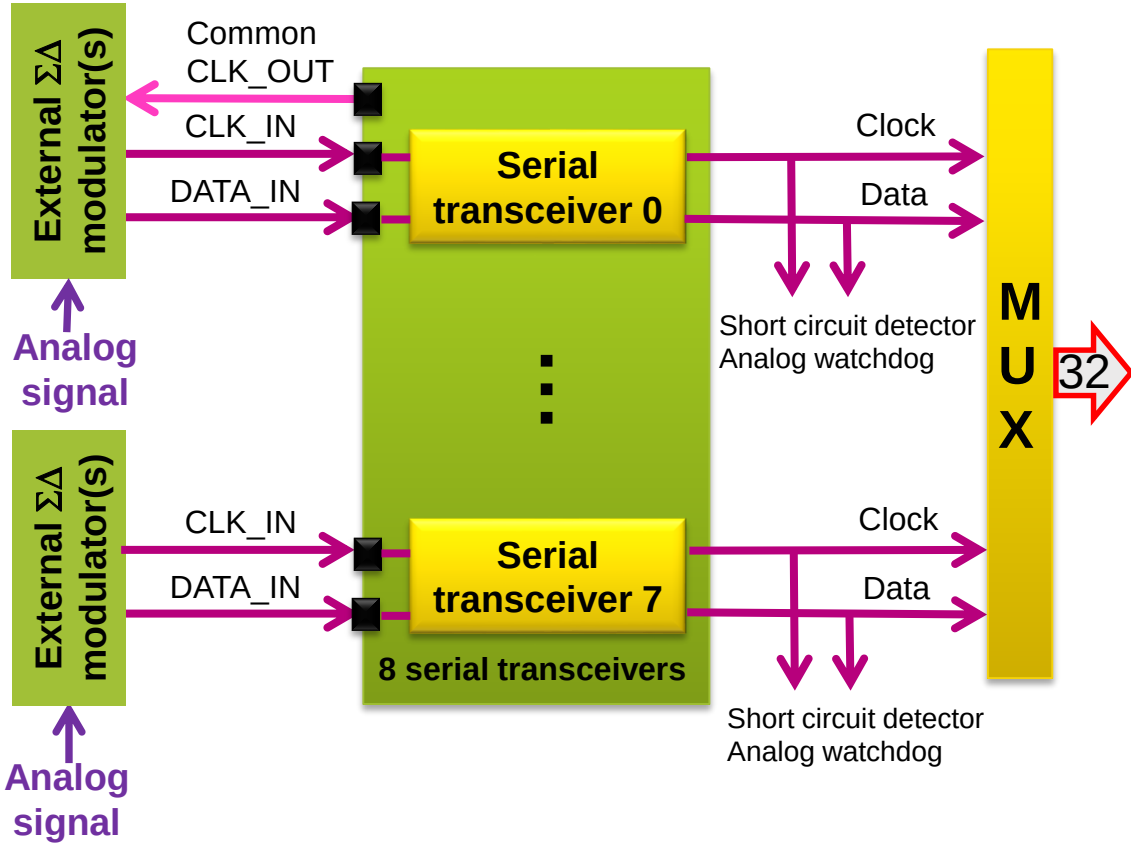


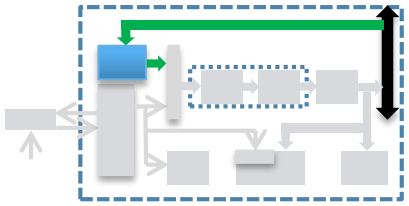
life.augmented

Serial transceivers

Compatible with any ΣΔ modulator output protocol

- To receive raw 1 bit serial stream from ΣΔ modulator and provide data & clock to the filter stage (up to 8 input serial channels)
- Any ΣΔ modulator output protocol support:
  - SPI mode (clock and data wire): falling/rising sampling edge, data rate measurement, clock presence detection
  - 1-wire Manchester-coded mode: lowest system cost (single isolator per input channel)
- Output clock generation on external pin:
  - Derived from system clock or audio PLL clock (divider)

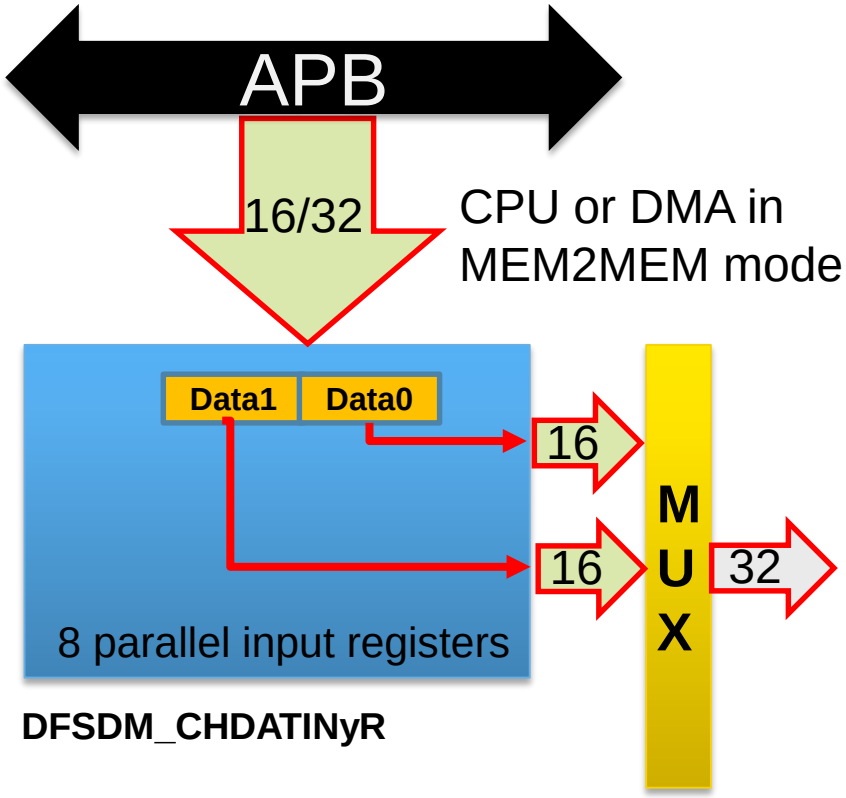




Parallel transceivers

Fast hardware filtering of internal data

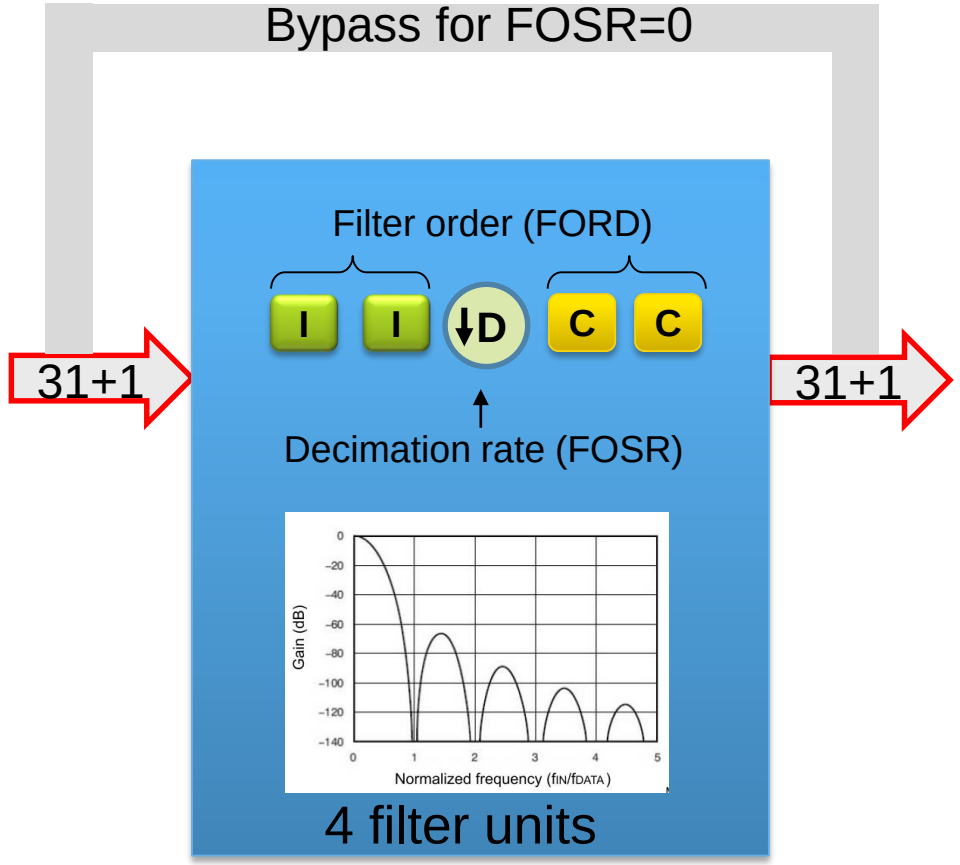
- To receive 16-bit parallel data stream from internal sources to the filter stage (up to 8 parallel channels/registers)
- RAM data post-processing
  - Data processing from internal ADCs
  - Data post-processing from collected data
- DMA or CPU can provide data to input registers



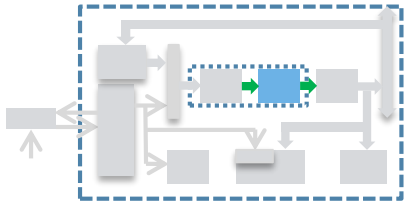
Sincx/x digital filter

CPU free digital filtering

- Digital filter stage performs digital filtering of input data stream
  - Mean value of input data stream from ΣΔ modulator is the final ADC value (averaging)
  - Sinc filter performs moving average over given number of samples (oversampling ratio)
- Configuration options:
  - Filter type: Sinc1, Sinc2, Sinc3, Sinc4, Sinc5 and FastSinc
  - Oversampling ratio (FOSR): 1-1024 (can be bypassed)
  - Speed vs. resolution balance selection
  - Filter data resolution is 31-bit max



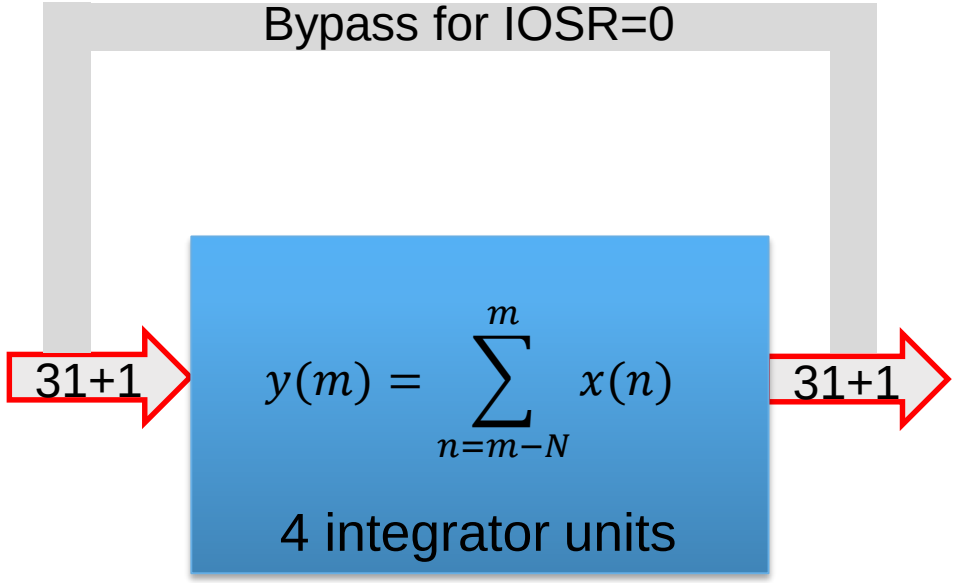
life.augmented

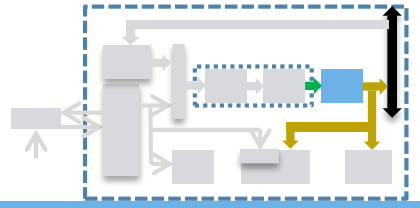


Integrator unit

Additional increase of resolution

- Integrator stage performs additional signal processing – averaging of data from digital filter (summing N samples)
- Configuration:
  - 1 to 256 samples (N) to sum
  - Can be bypassed (if IOSR=0)
- Final result is sent to the output data unit

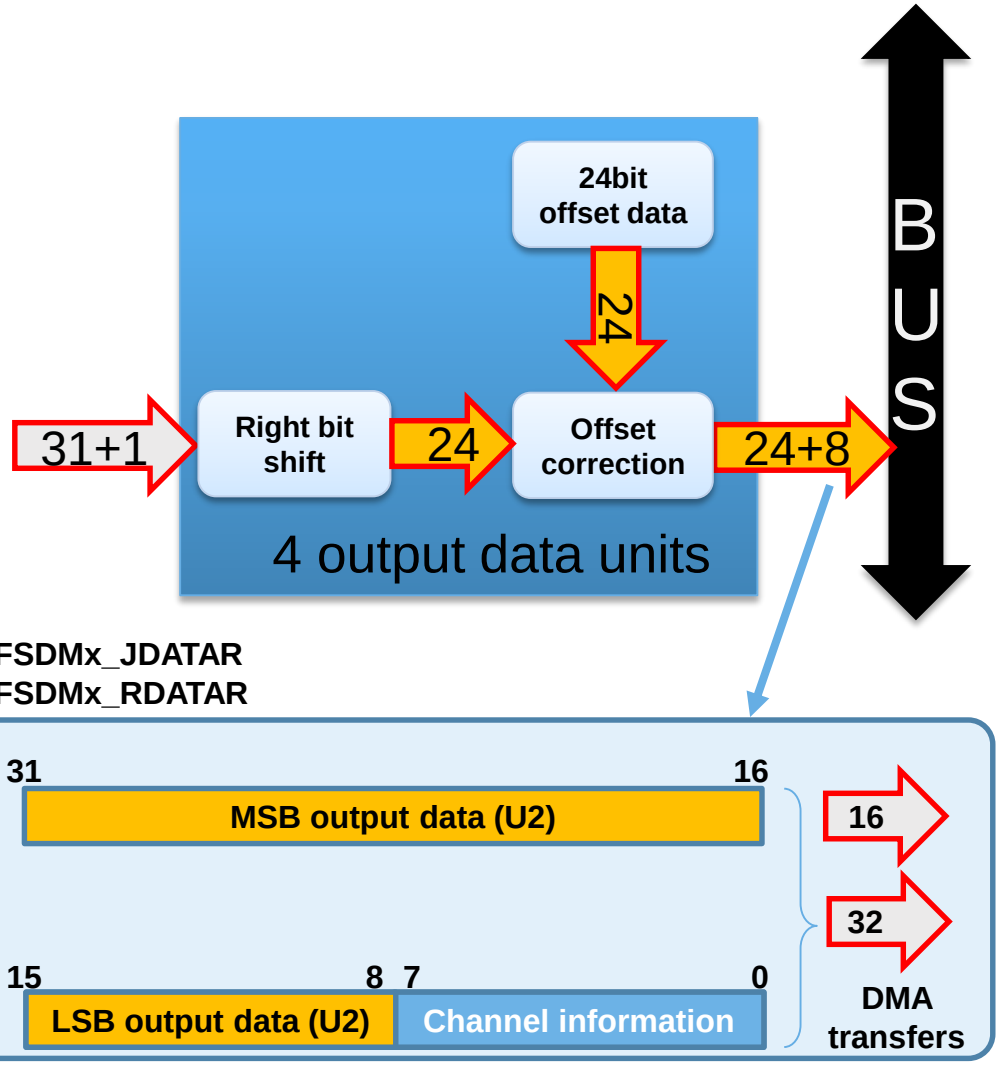


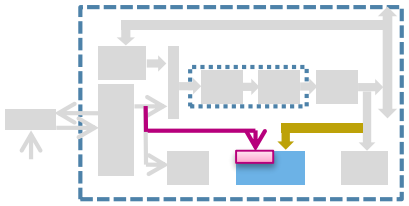


Output data unit

CPU-free external offset removal and data formatting

- Performs final post-processing functions on final data:
  - Offset compensation/subtraction
  - Programmable right-bit-shifting
- Offset correction feature:
  - Offset is stored in register by user (from user calibration procedure) - for each input channel
- 24-bit final data register width:
  - Configurable right bit shift to convert internal 31-bit resolution into final data register resolution

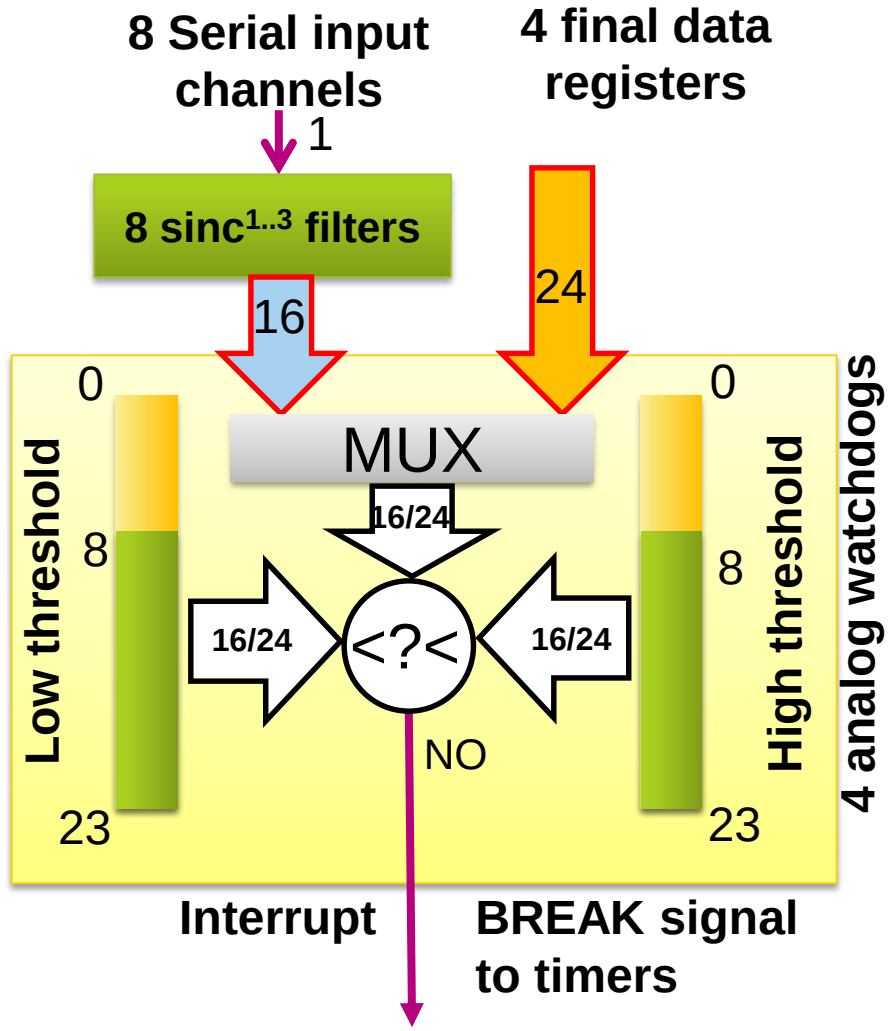




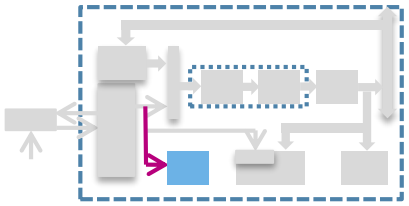
Analog watchdog

Safety and emergency functions such as monitoring of critical motor control values

- Monitoring if value is outside selected boundary
  - Final data result monitoring
  - Or independent input channels data monitoring
- Support for safety/emergency functions
  - Break or Interrupt signal generation
  - Separate flags for high and low boundaries
- Input channels monitoring has configurable filters:
  - Sinc1, Sinc2 and Sinc3 filter with an oversampling range 1 to 32
  - Watchdog data filters are available for user



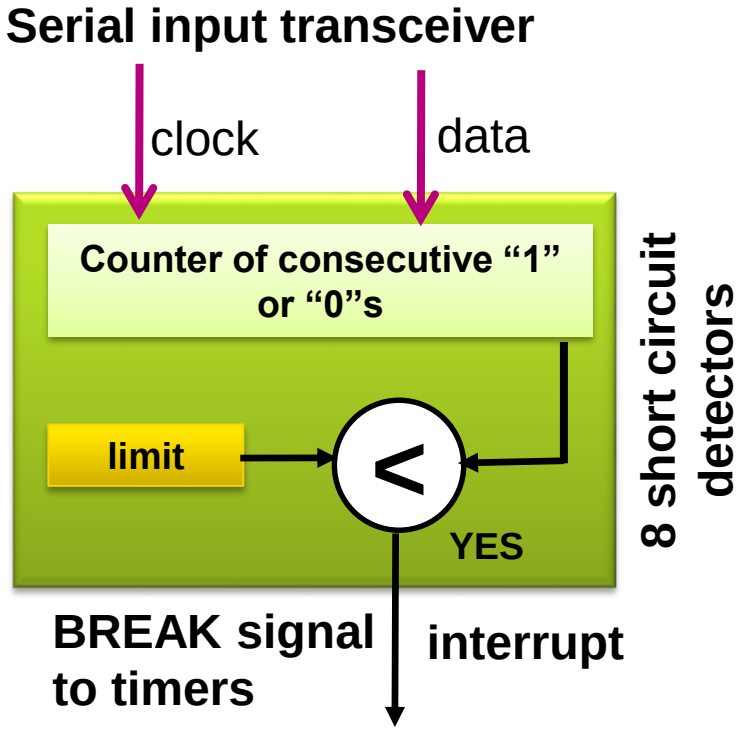
life.augmented

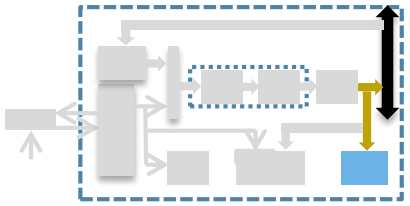


Short circuit detector

Very fast safety and emergency functions such as motor control short-circuit monitoring

- Very fast detection of critical state:
  - Saturation of input signal for longer time means overcurrent (short circuit) or overvoltage
- Detection if signal is saturated for given time
  - Configurable time: 1 to 256 consecutive 1s or 0s in the ΣΔ stream (all 1s or 0s)
- Independent monitoring on all input channels
  - Also if main conversion is stopped
  - Interrupt generation (for software intervention) or break signal (for example: to shutdown PWM generation with no latency)

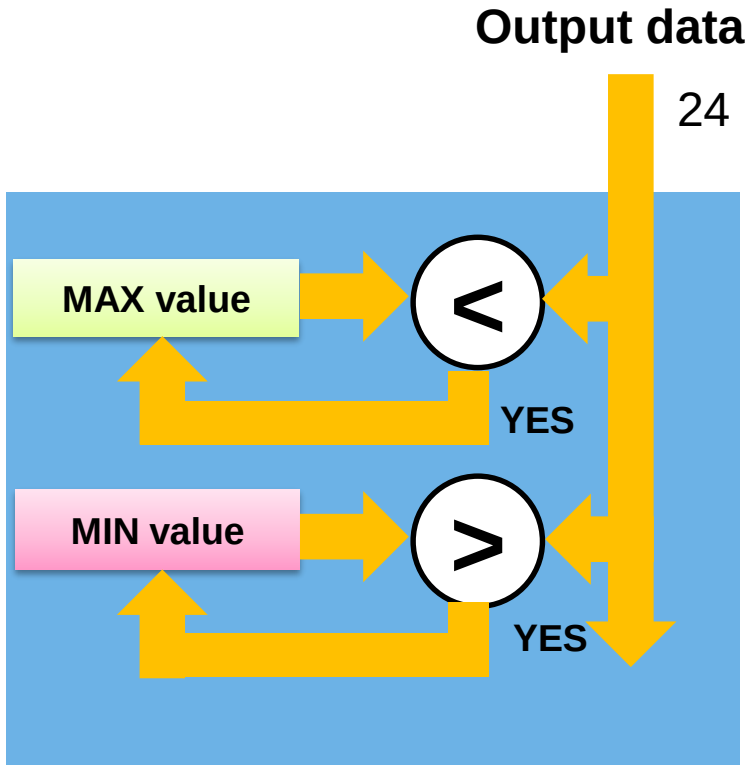




Extremes detector

Hardware detection of peak values
Example: audio data normalization

- Watching for minimum and maximum values in data output results
- Store the maximum and minimum values of the output data values into registers for selected channels
- Hardware monitoring of extreme values
- Extreme values are refreshed by software (by reading min/max registers)



4 extreme detectors

life.augmented

Conversion type selection

- **Regular conversions**
  - Only one channel selection (from 8 input channels)
  - Launched by software only (no HW trigger)
  - Continuous mode feature
  - Can be immediately interrupted by injected conversion (with flag signaling this interruption)

- **Injected conversions**
  - Can be set on more input channels (to add them into injected selection group)
  - Scan mode (by trigger event): all selected channels (whole group) are converted
  - Single mode (by trigger event): only one channel is converted and next is selected
  - Launched by SW or HW trigger: timers outputs or external pins
  - No continuous mode (can be emulated by timer triggered mode)

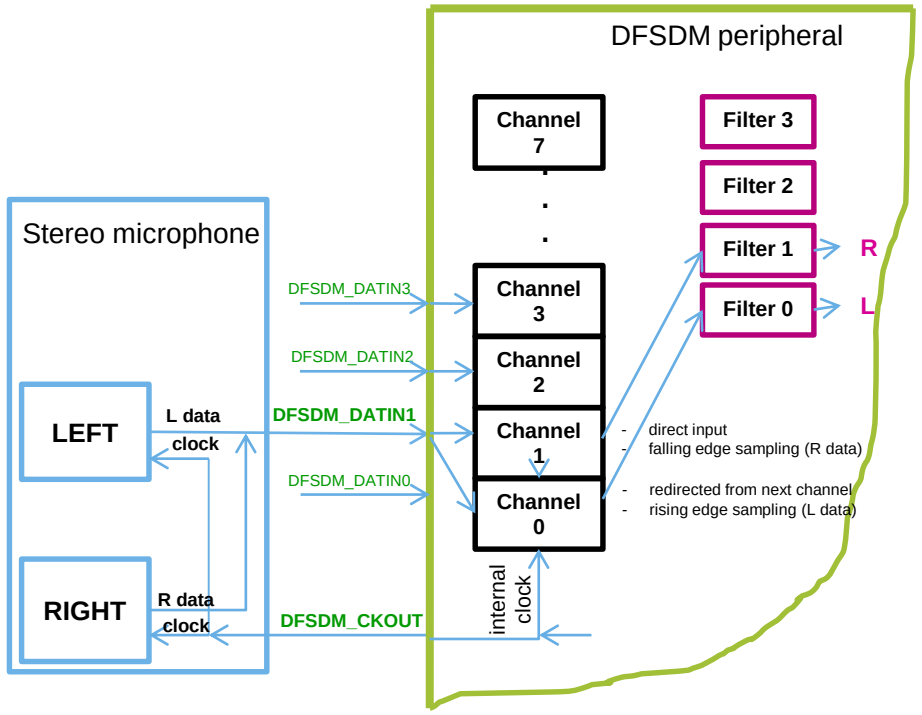
Very fast signal processing in hardware: consumption reduction.

All existing ΣΔ modulators speeds are supported.

- **Clock speeds**
  - Maximum DFSDM clock: same as system clock (max. 80 MHz)
  - Maximum input serial clock into channel (Input data rate)
    - SPI mode: DFSDM clock divided by 4 (max. 20 MHz)
    - Manchester mode: DFSDM clock divided by 6 (max. 10 MHz)
  - Maximum output frequency on clock output: DFSDM clock divided by 4 (max. 20 MHz)
- **Output data rate**
  - Depends on filter and integrator oversampling ratio (FOSR, IOSR):
    - Output data rate = Input data rate / (FOSR * IOSR) , where: FOSR = 1-1024, IOSR = 1-256

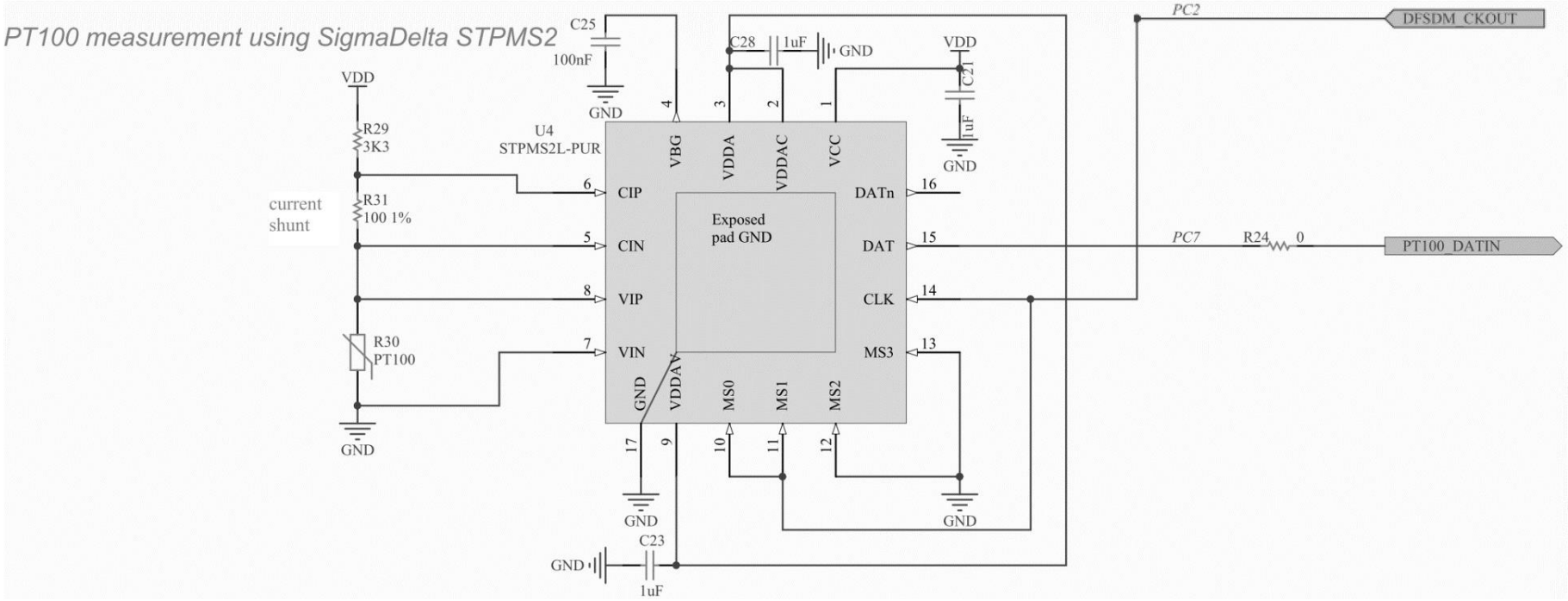
Application example 1

- **Stereo MEMS microphone (with PDM output) playback**
  - Only 2 wires are used to connect 2 microphones (stereo) – common clock and data wire with different sampling edges for left and right channel (and using DFSDM feature: redirection of data from given input channel pin to another channel data input).
  - Regular conversions are used for two DFSDM channels in continuous mode.
  - Low CPU load: one DMA transfers output audio data to RAM and second DMA transfers those data to I2S interface (which sends them to external audio codec and headphones).



Application example 2

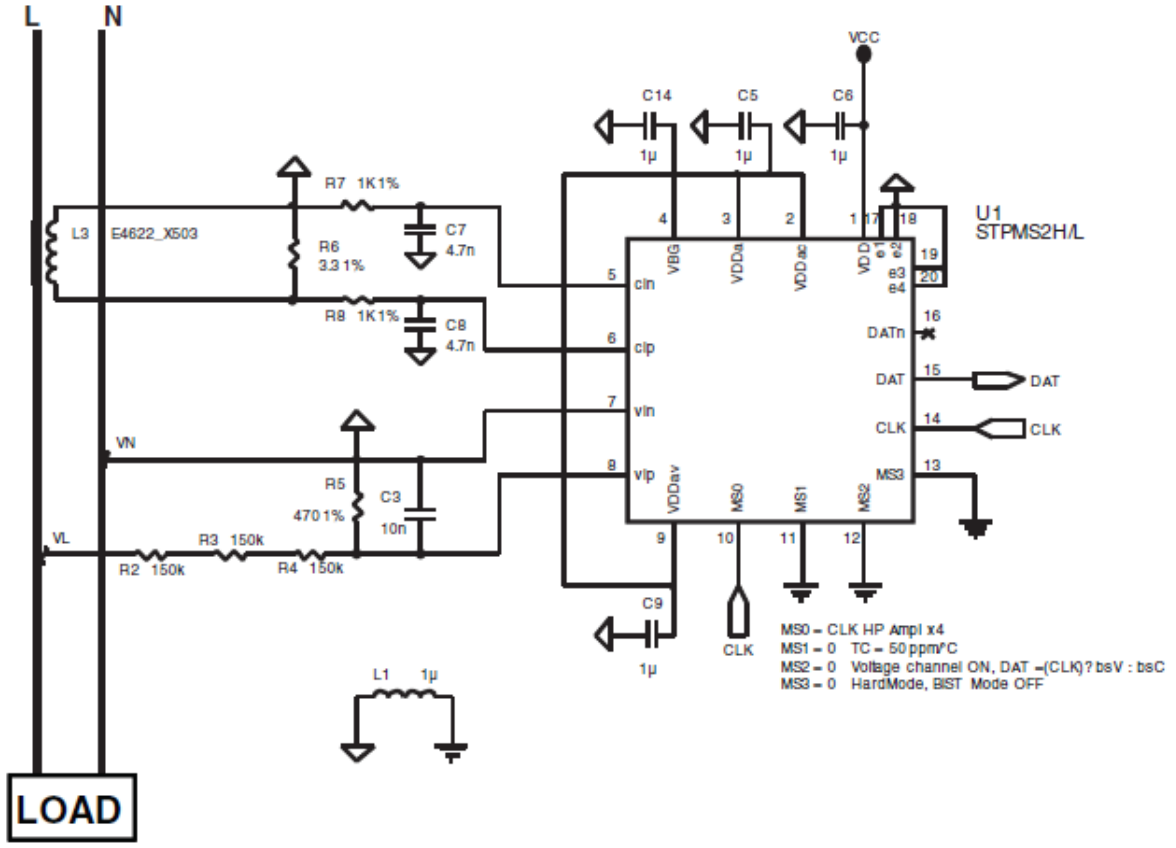
- **PT100 thermometer**
  - An external STPMS2 device (dual-channel, second-order sigma-delta modulator) is used to sense 2 input channels
  - One channel senses voltage on PT100 sensor, second channel senses current over PT100 sensor (on shunt). Ratio of channels data results is the PT100 sensor resistance.
  - Injected scan conversion is used for those 2 channels with 1-sec periodic timer trigger.



life.augmented

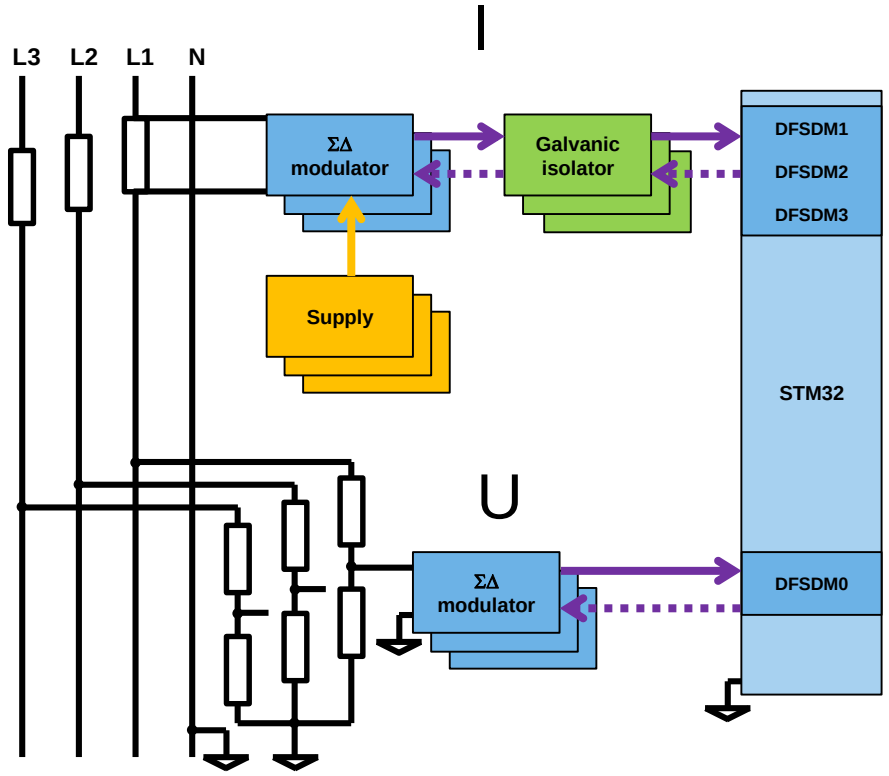
Application example 3

- **Electricity meter with STPMS2**
  - External STPMS2 device (dual ΣΔ modulator) is used to sense 2 input channels: voltage (voltage divider) and current (current transformer or shunt).
  - Voltage and current samples are sent to DFSDM by serial interface (clock and data wire only).
  - The DFSDM processes the voltage and current samples into wide resolution.
  - STM32 firmware calculates electric power and energy.



Application example 4

- **3-phase electricity meter** (using shunts, no transformers)
  - Voltages (U) are sensed by resistor dividers. One DFSDM filter with 3 multiplexed inputs is used to scan 3-phase voltages.
  - Currents (I) are sensed by shunt resistors with galvanic isolated ΣΔ modulators. One or two isolation lines per phase are necessary only for current data transfers to DFSDM channels (Manchester-coded mode requires only 1 line).
  - STM32 firmware calculates electric power and energy.



STM32L4 – other changes

life.augmented

STM32 L4

What else ?

ADC, DAC

Voltage reference buffer with output on the pin

FLASH

ECC feature with IRQ/NMI generation

GPIO

Default configuration of I/O lines is **analog input** for low power consumption

PWR

Programmable pull-up/pull-down resistors in Standby mode

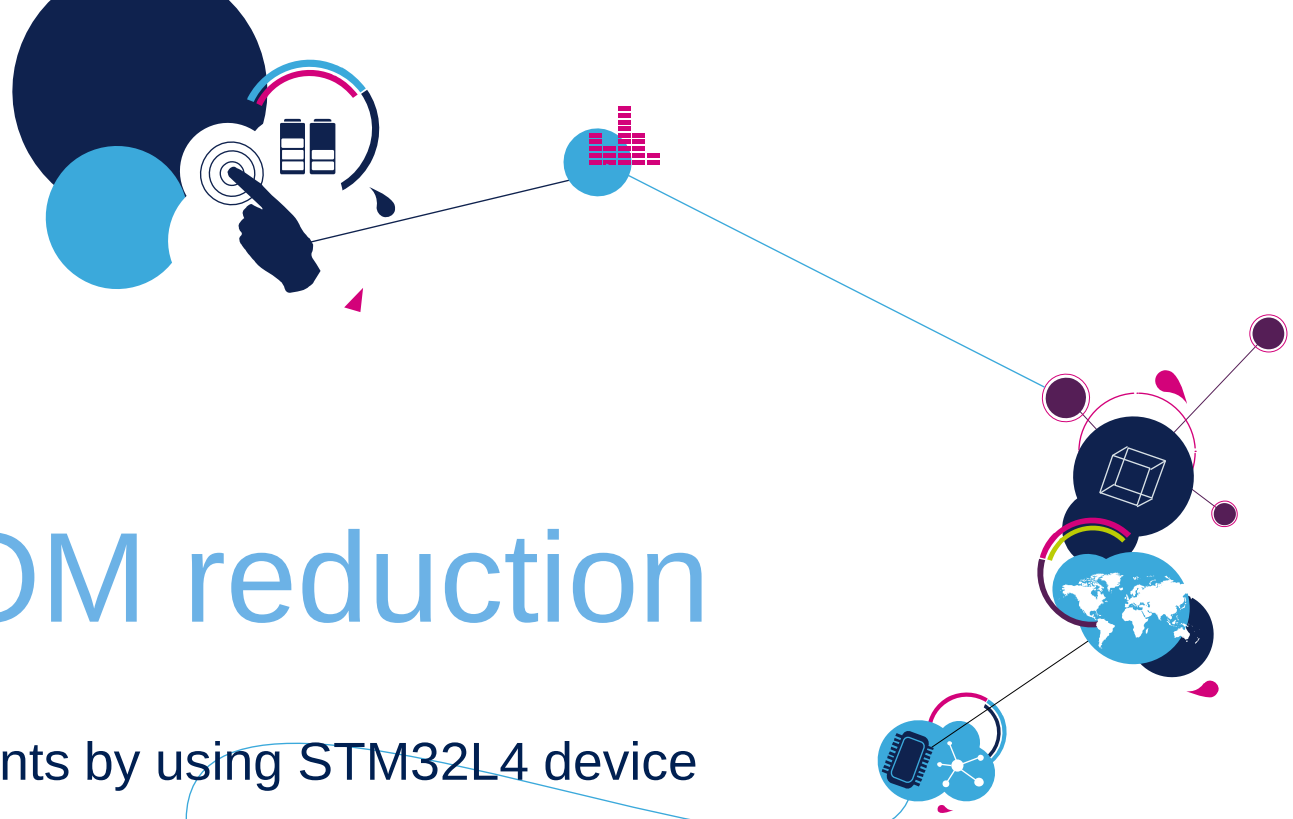
Peripherals Voltage Monitoring (PVM)

RCC

Low speed clock output pin (LSCO) to put LSE/LSI clock outside (even in STOP1/2 and STANDBY modes)

WWDG

Early wakeup function within Window Watchdog



STM32L4 – BOM reduction

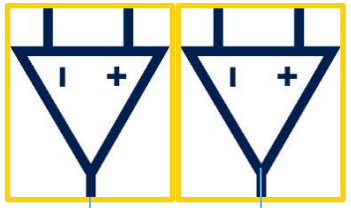
How we can reduce list of components by using STM32L4 device

life.augmented

STM32 L4

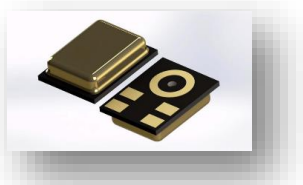
Nice to have, but…

Low cost, low power 2-channel ADC (Single Integration):
2 external comparators
2 external capacitors

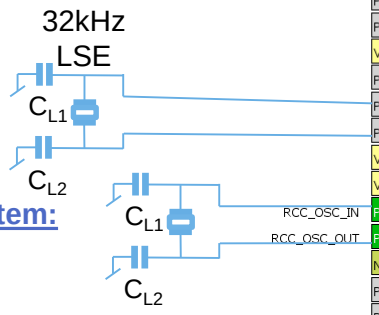


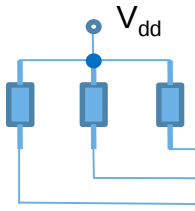
External ADC converter data processing:
High CPU load on data processing

Data collection from stereo MEMS microphone:
High CPU load on PDM decoding



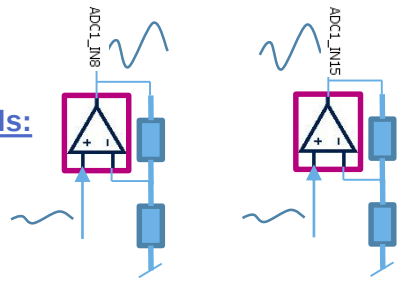
Precise clock for USB and system:
2 lines for the crystal
3 external components

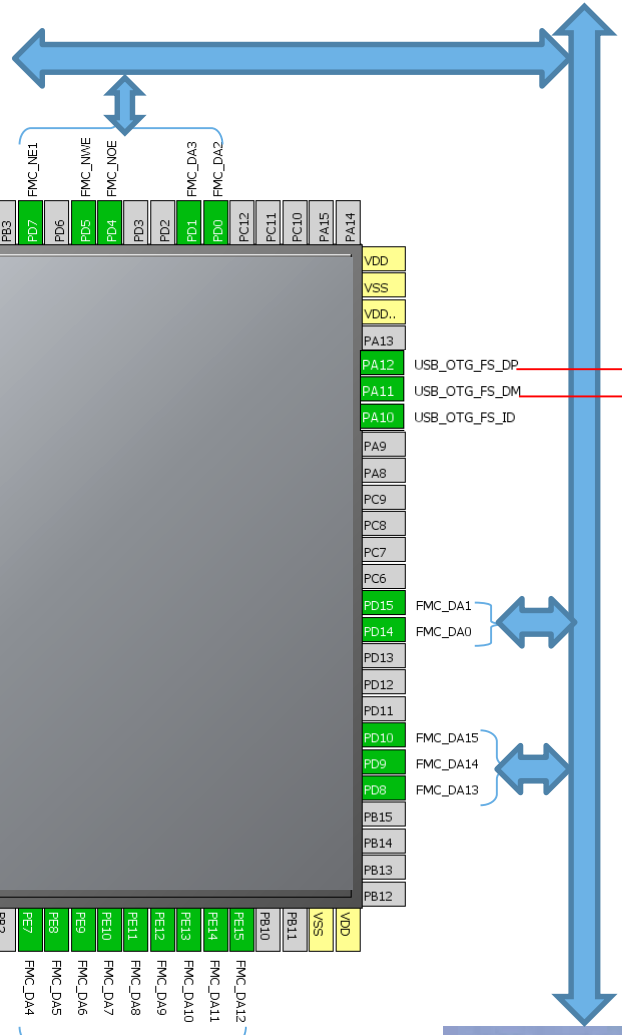


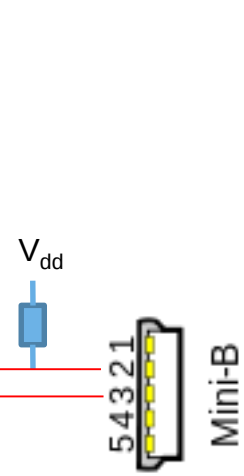


Configured state on N I/O lines in STANDBY mode:
N external pull-up/pull-down resistors

Measurement of low amplitude analog signals:
External OpAmps
2 external resistors per OpAmp







USB connector to the host:
Power supply >3.3V
External resistor
Additional hardware for USB reconnection

External Flash memory to store more data
NOR Flash over FSMC:
19 lines (16 data, 3 control)

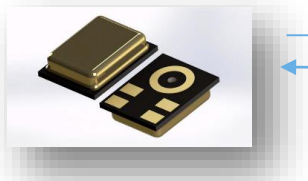
life.augmented

STM32L4 offer

Low cost, low power 2-channel ADC (Single Integration):
Built-in comparators

External ΣΔ ADC converter data processing:
Built-in Digital Filter for Sigma Delta Modulators

Data collection from stereo MEMS microphone:
Built-in Digital Filter for Sigma Delta Modulators
(HW processing of PDM signal)

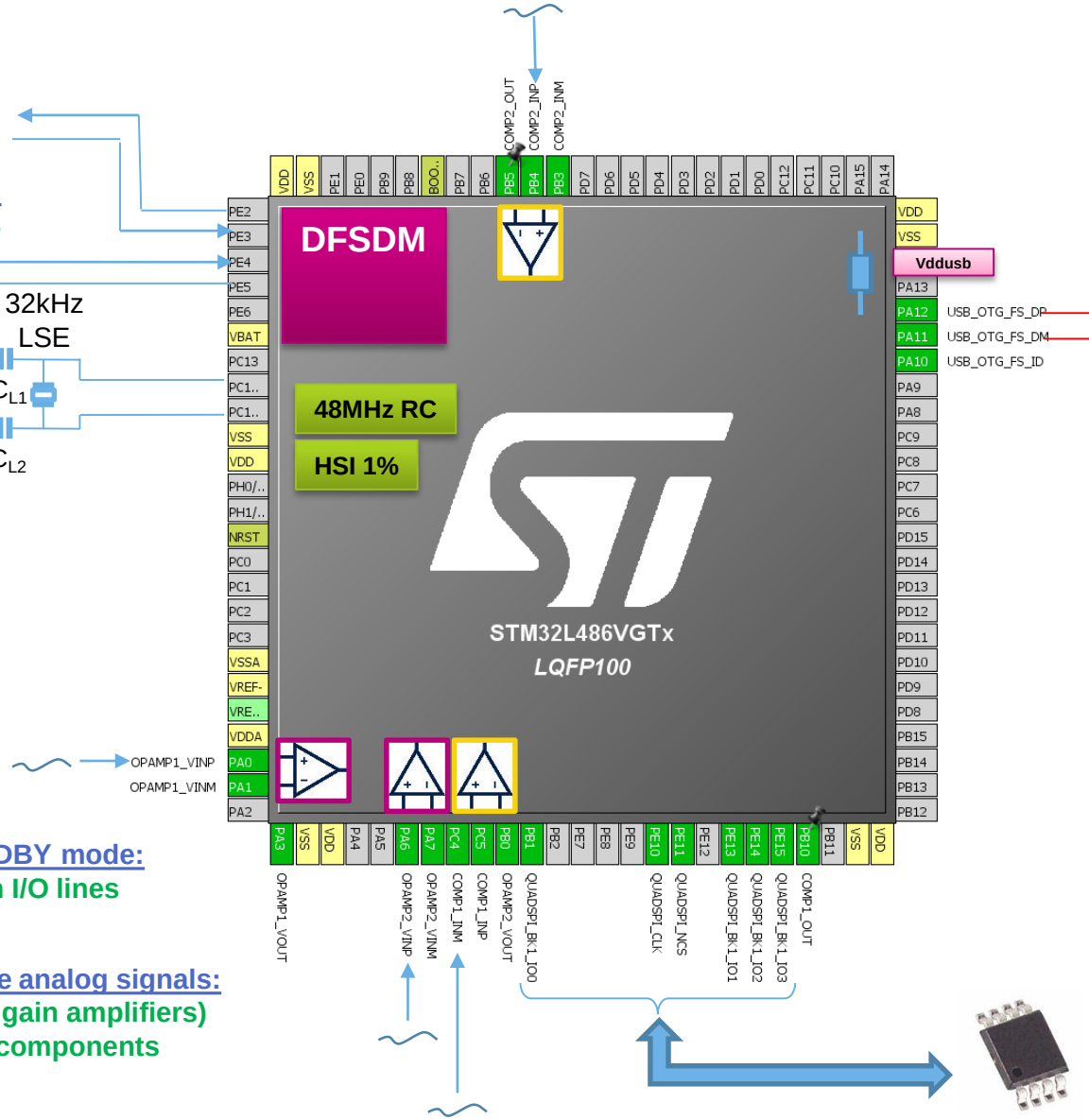


32kHz
LSE

C_{L1}

C_{L2}

Precise clock for USB and system:
Built-in precise RC oscillators:
MSI 48MHz – self-trimmable to LSE



USB connector to the host:
Separate USB power supply
Built-in pull-up resistor on DP line
Software reconnection

Configured state on N I/O lines in STANDBY mode:
Programmable pull-ups/pull-downs on I/O lines

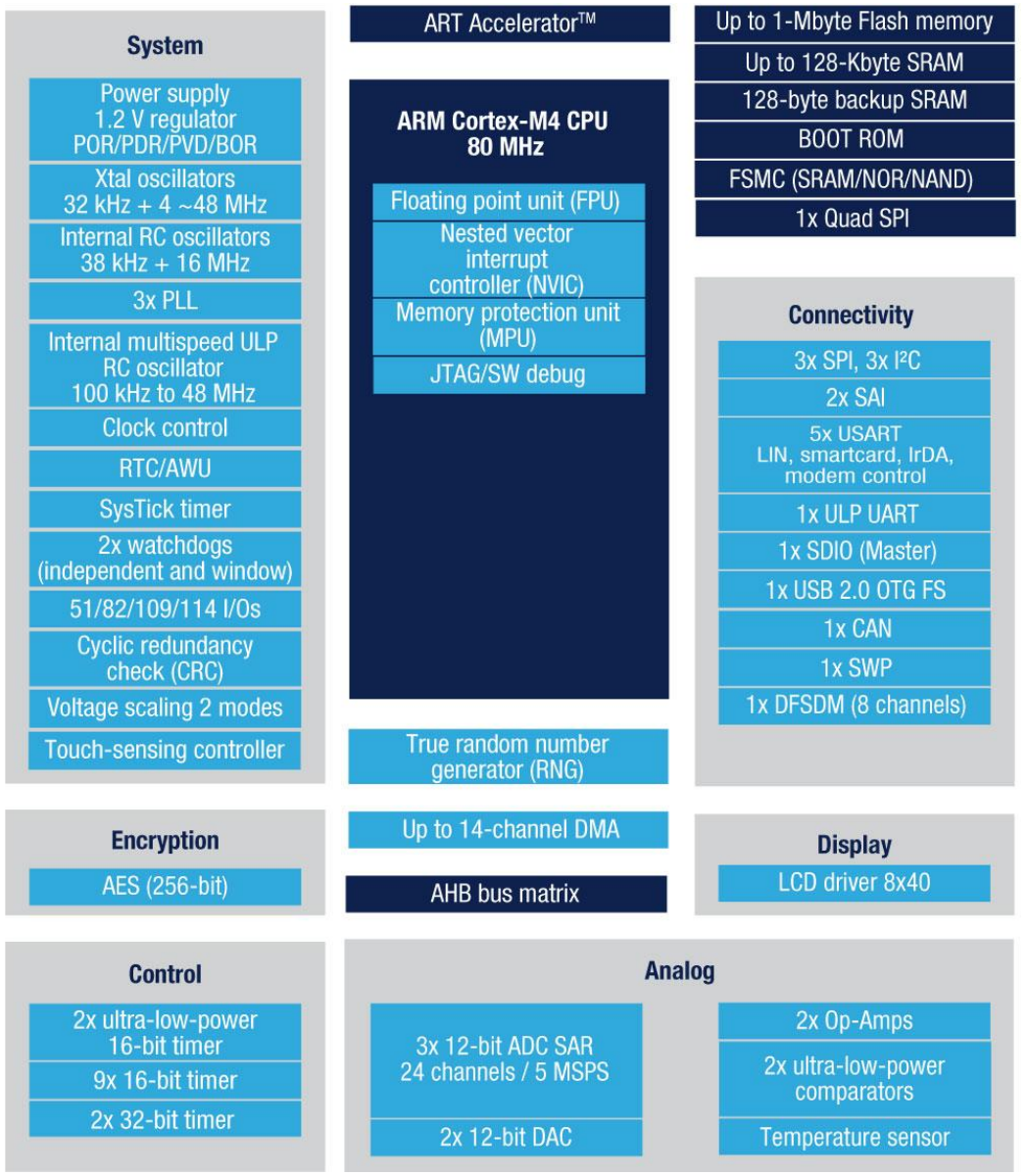
Measurement of low amplitude analog signals:
Built-in PGA (programmable gain amplifiers)
Possible to add external components

External Flash memory to store more data
QSPI Flash memory:
6 lines (4 data, 2 control)

life.augmented

…and even more

- Separate Vddio2 power supply for PG[2..15] I/O lines
  - connection of peripherals working with voltage down to 1.08V without level shifters
- Built-in voltage supervisors (working even in Standby mode)
  - No need for use of external ones
- Smaller current peaks due to more stable current consumption
  - Less complex PCB layout
- Lower power consumption in low power modes
  - Smaller battery needed
- Built-in interconnection matrix
  - No need for use of external connections between peripherals
- Built in reference voltage (also available on the pin)
  - No need for use of external reference voltage



life.augmented

Enjoy!

www.st.com/stm32l4

life.augmented