A new approach for digital power control

Using SMED & STLUX

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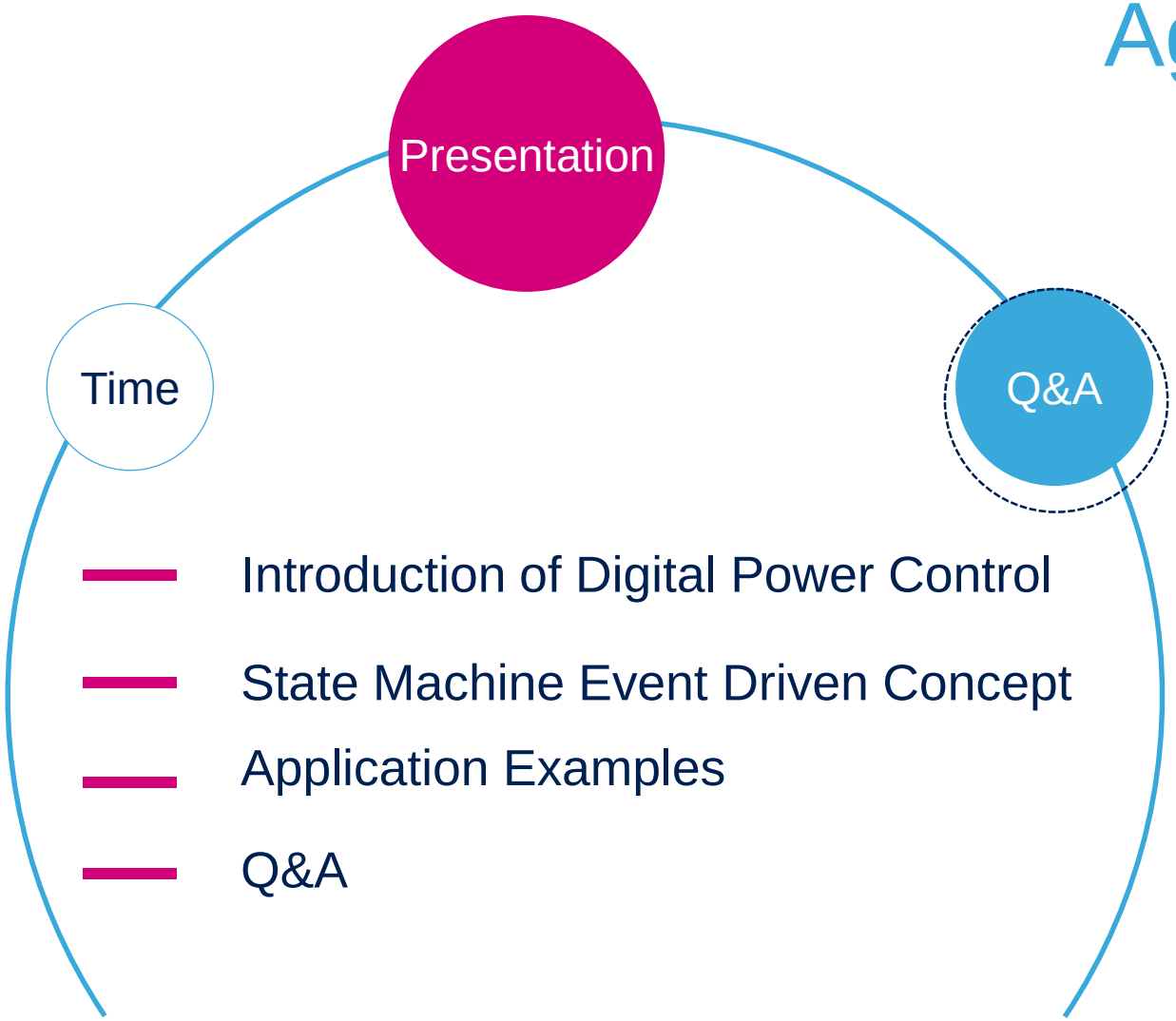
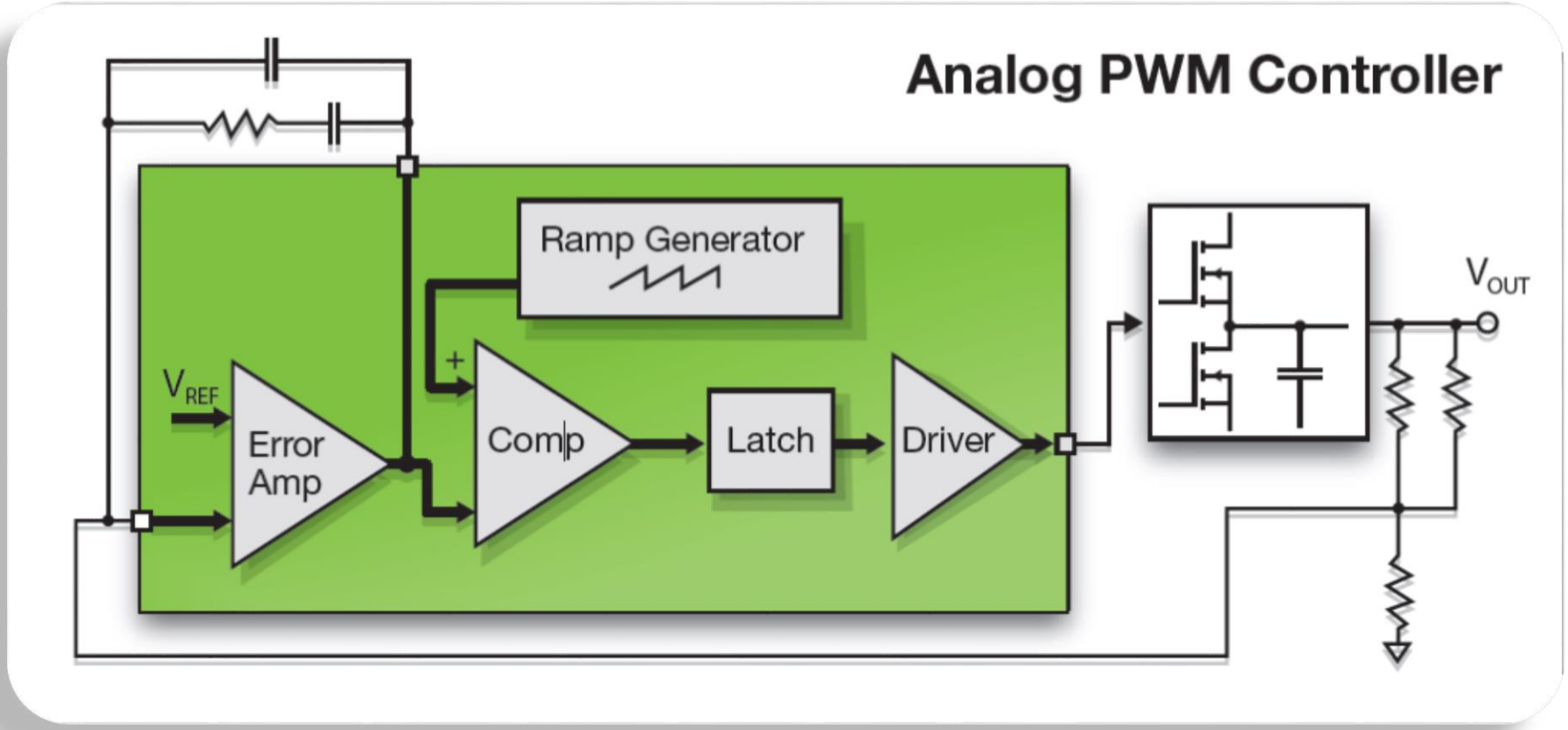
Agenda



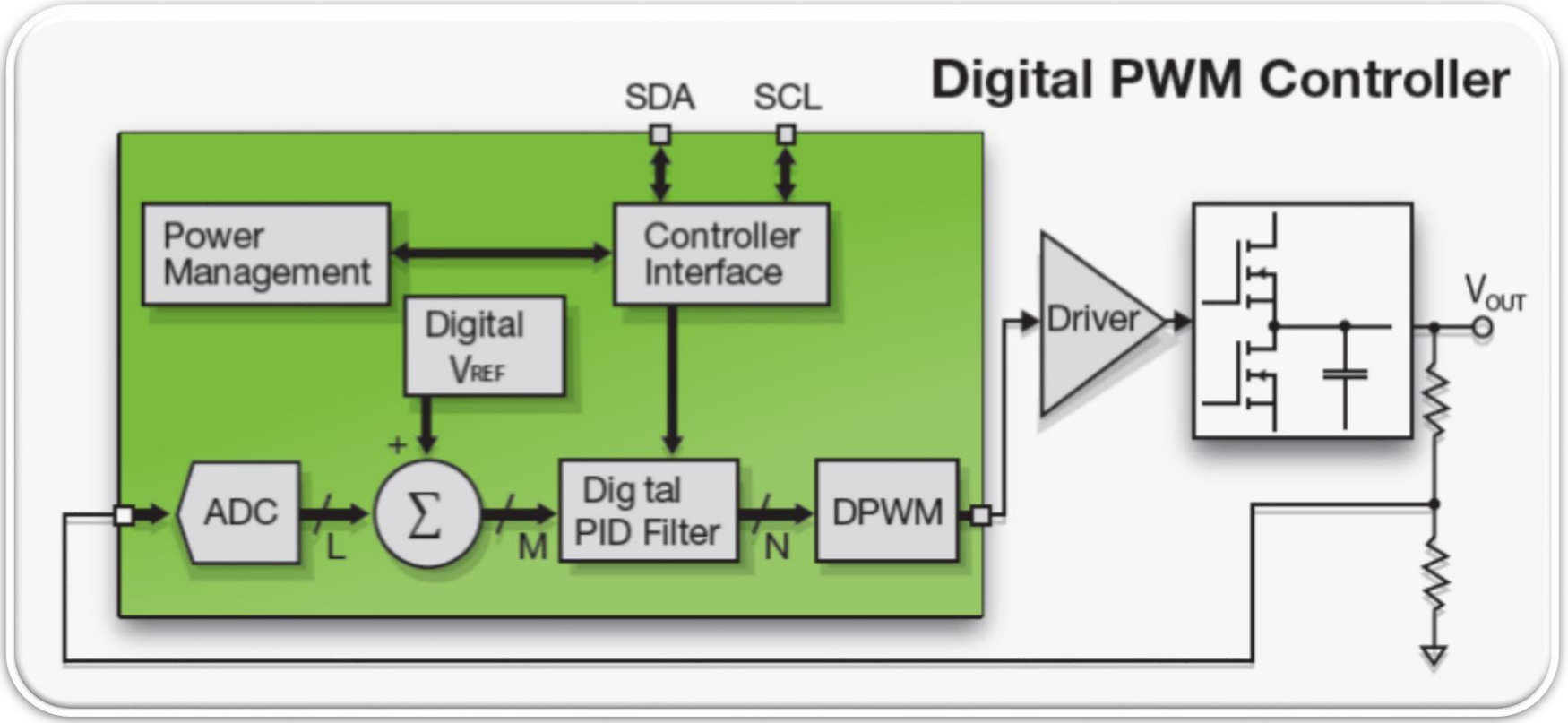
- Introduction of Digital Power Control
- State Machine Event Driven Concept
- Application Examples
- Q&A

Classic Analog Controller



Picture from Ericsson Digital Power Report

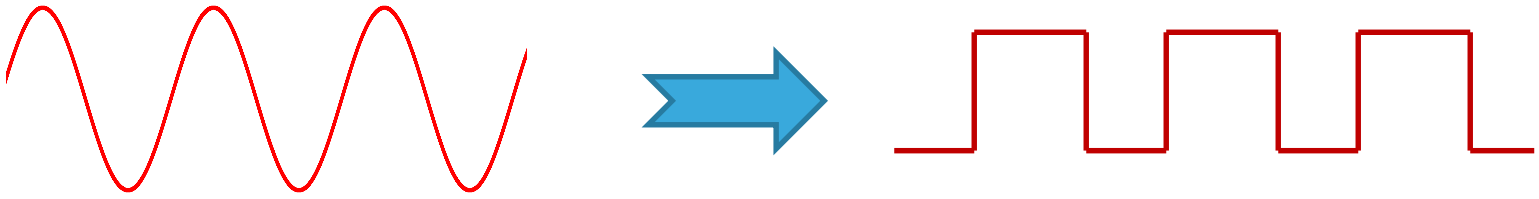
Classic Digital Controller



Picture from Ericsson Digital Power Report

Re-thinking Digitizing

Classic digital control: Digitizing the analog process

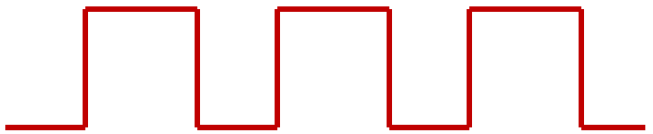


Analog Domain

Time Domain

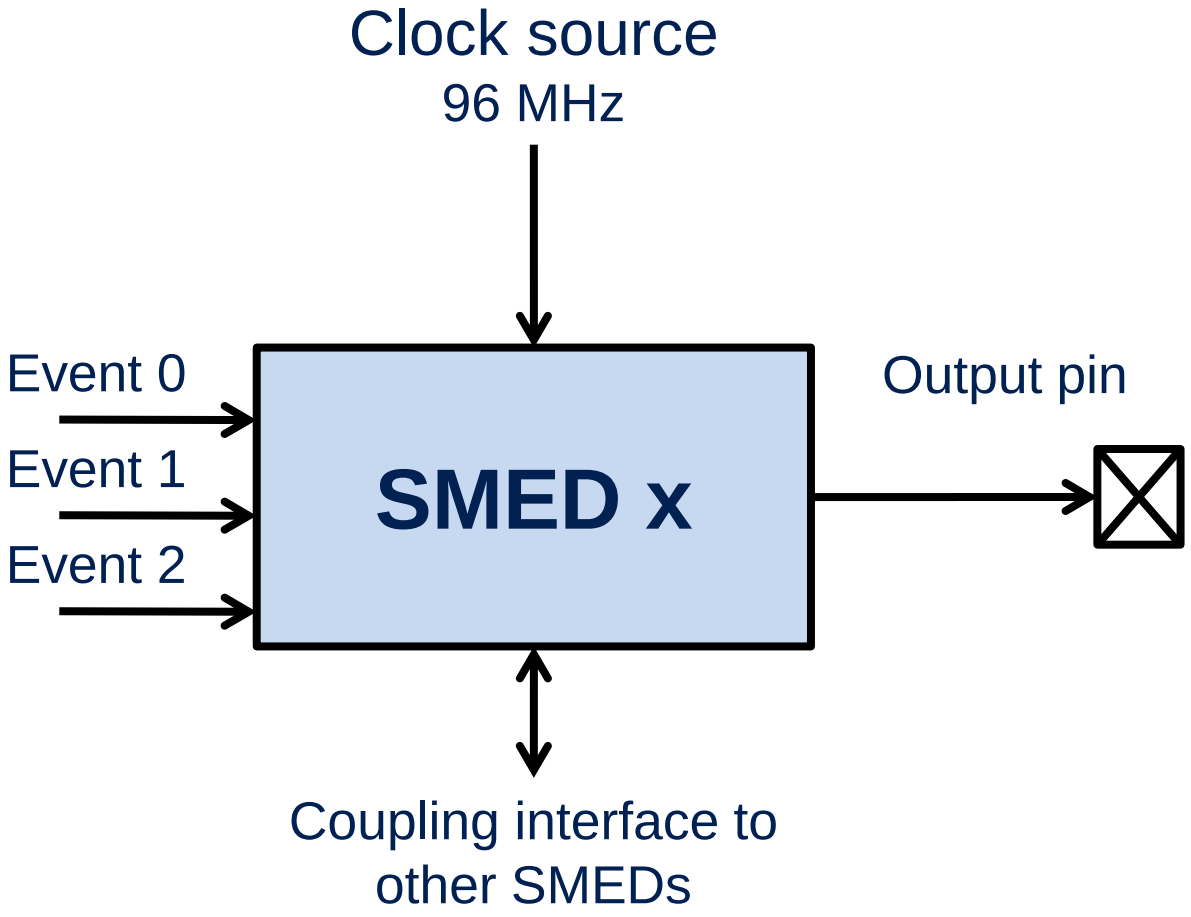
Different approach: State machine

Is it over current?
Is it over voltage?
Does it reach the timer?



Move real time signal into SMED

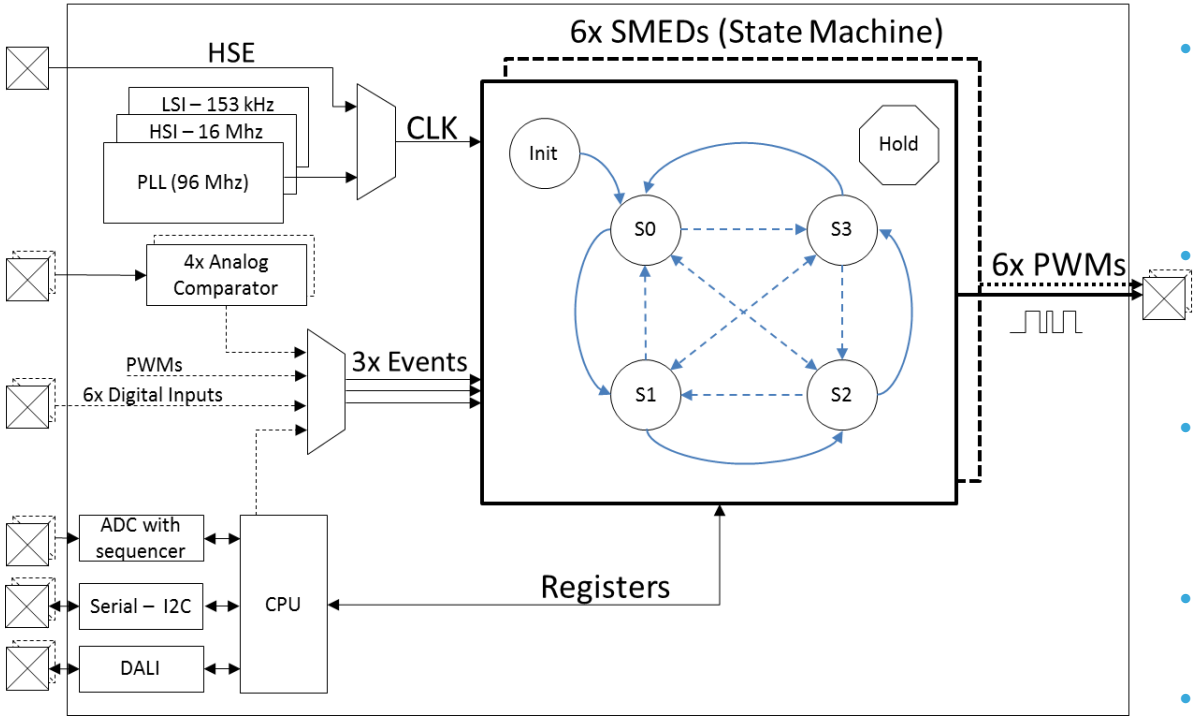
State Machine Event Driven(SMED)



Thinking with SMED

- Use time instead of the analog signals (when is possible)
- Divide the circuit functions that you need in three categories:
  - CCE = Cycle by Cycle Event: ZCD, top current, protection (current or voltage), …
  - HFE = High Frequency Control Loop Event: the control loop regulation time
  - LFE = Low Frequency Control Loop Event: low signal variation
- Map the CC event directly into SMED using:
  → the input events and the SMED states
- Map the HF event using an HIGH priority interrupt
- Map the LF event on the main code, when core is free
- Use wfi() instruction when core wait an event to improve current consumption and decrease the interrupt service time

STLUX385A meets Power Conv. requirements



- **SIX** configurable PWM **S**tate **M**achine **E**vent **D**riven (SMED) 1.3ns resolution (with automatic dithering) – 10.4 native.
- 4 Analog Comparators and 6 fast digital inputs synchronized with 96MHz clock
- 8 channels 10 bit ADC with programmable op amp GAIN resolution), 2.4 µs conversion time,
- -40 ºC to 105 ºC temperature range
- TSSOP38

STLUX digital power converters are the right solution for digital power conversion applications.

ST programmable SMED peripherals + Switch matrix and 8 bits ST core provide flexible and complete power management functionalities in a single IC.

By providing high–speed PWMs (96MHz), dedicated 8ch ADCs with selectable gain, STLUX exploits system performance and reliability

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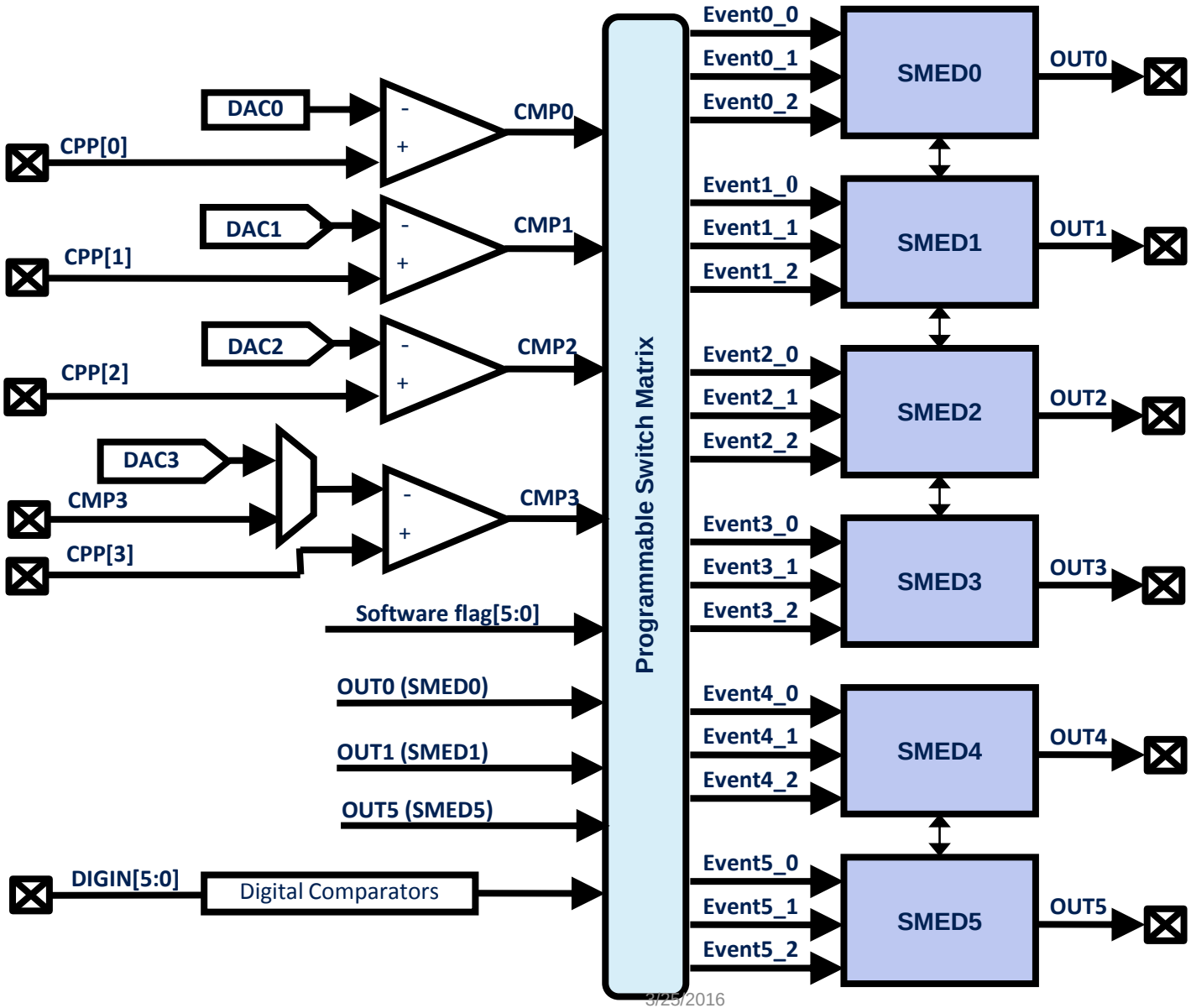
Connection Switch Matrix – Input Events

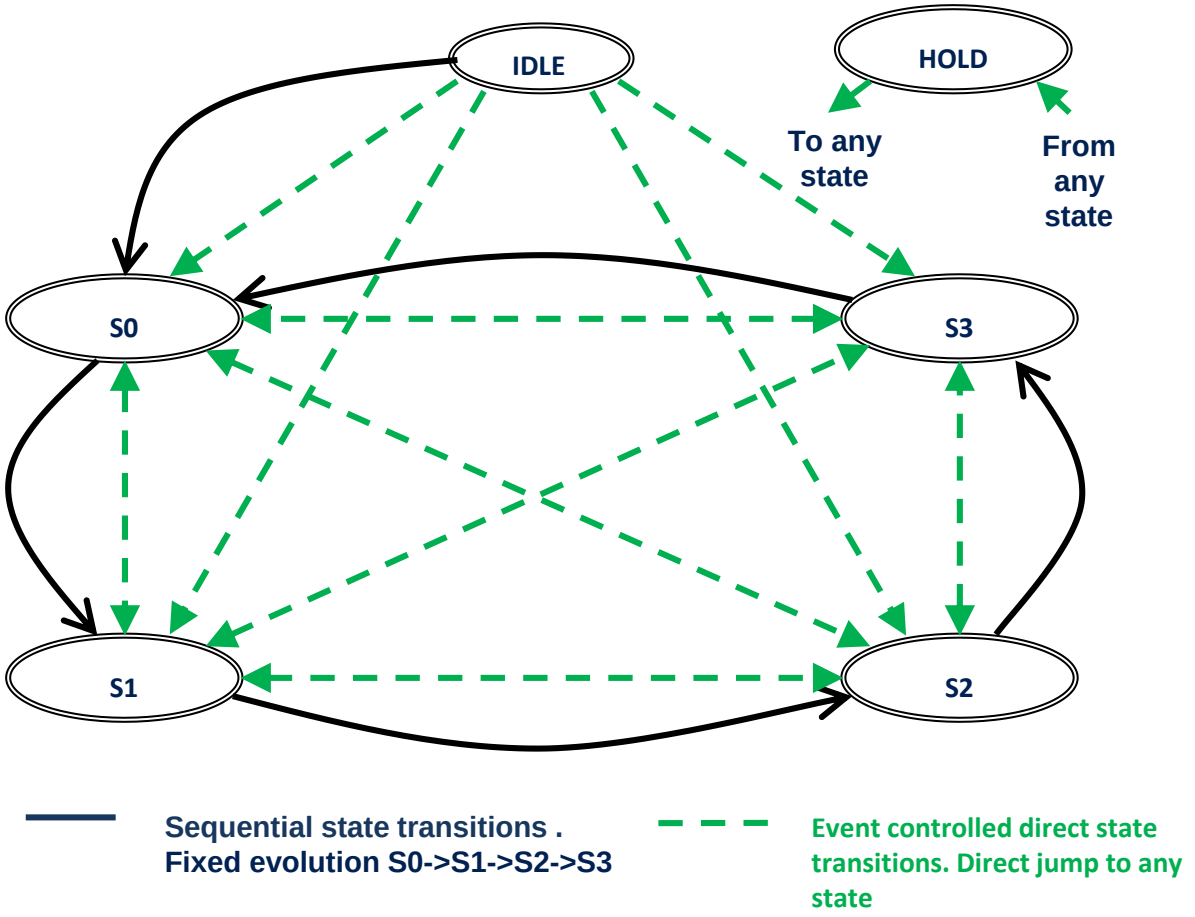


CONNECTION MATRIX configuration

Con-box Interconnection Matrix					
SMED	Event input	Matrix selection			
		00	01	10	11
0	0	CP0	DIG0	DIG2	DIG5
	1	CP1	DIG0	DIG3	CP3
	2	CP2	DIG1	DIG4	SW0
1	0	CP1	DIG1	DIG3	DIG0
	1	CP2	DIG1	DIG4	CP3
	2	CP0	DIG2	DIG5	SW1
2	0	CP2	DIG2	DIG4	DIG1
	1	CP0	DIG2	DIG5	PWM0
	2	CP1	DIG3	DIG0	SW2
3	0	CP0	DIG3	DIG5	DIG2
	1	CP1	DIG3	DIG0	PWM1
	2	CP2	DIG4	DIG1	SW3
4	0	CP1	DIG4	DIG0	DIG3
	1	CP2	DIG4	DIG1	PWM5
	2	CP0	DIG5	DIG2	SW4
5	0	CP2	DIG5	DIG1	DIG4
	1	CP0	DIG5	DIG2	CP3
	2	CP1	DIG0	DIG3	SW5

- MSC_CBOXSn register in SMEDn defines the EVx connection (field Conb_sx)
- Each SMED can be connected to all CPs and DIGINs
- Each SMED can be triggered by 1 SW event
- Some SMEDs can be connected to other smeds.

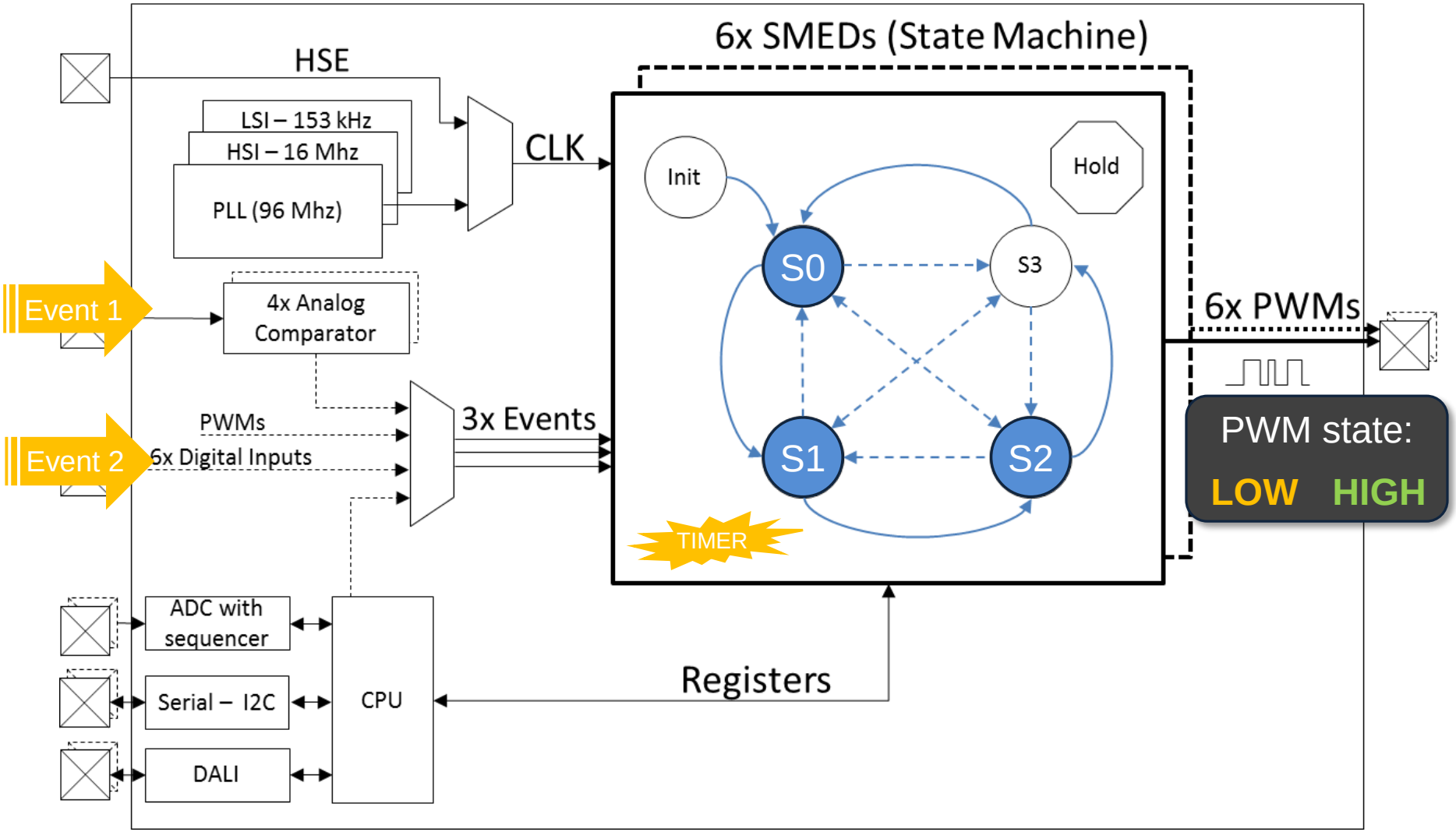
State Machine - Complete



Each state has 3 configuration registers to program

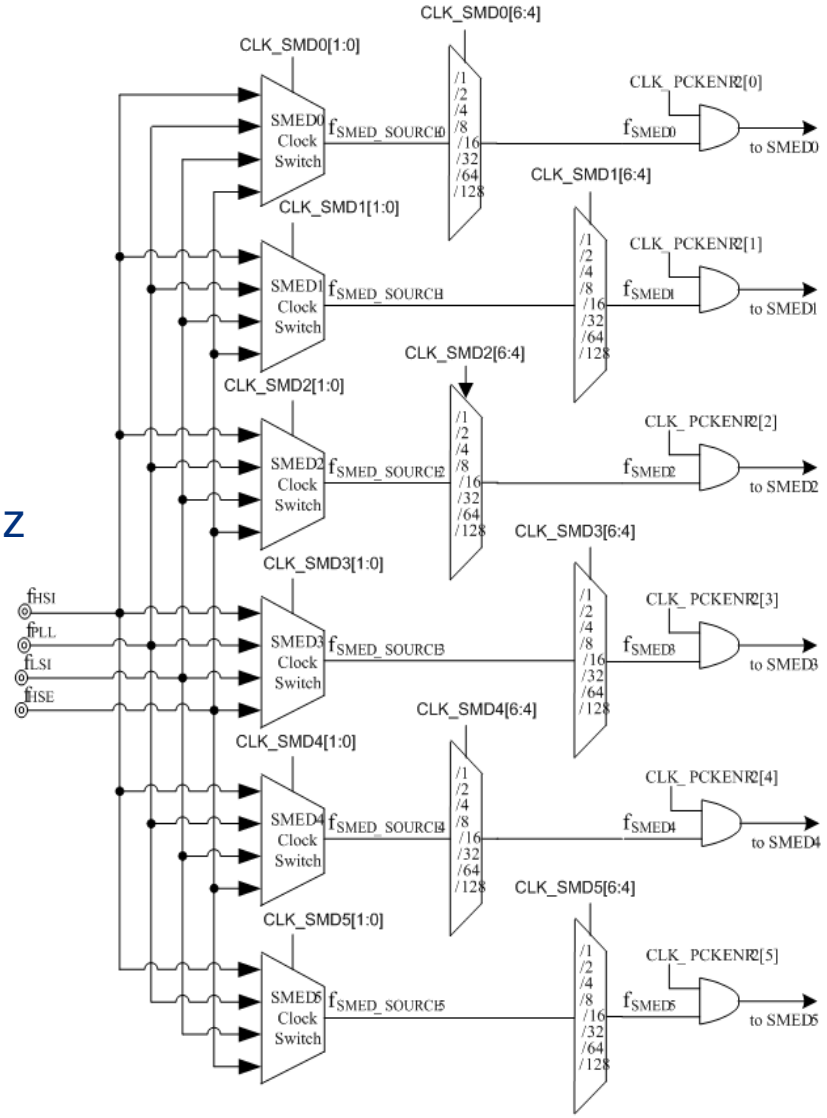
- Conditions when the machine leaves the current state and what is the next state
- Actions to be done when leaving the state – (counter reset and/or output pin level)

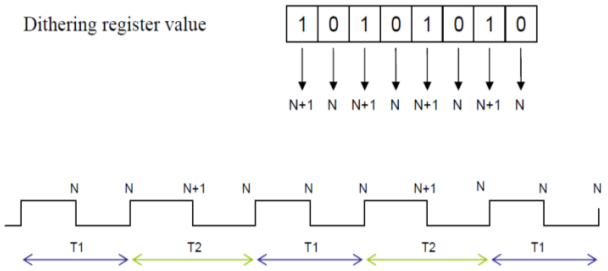
STLUX platform



SMED Clock Sources

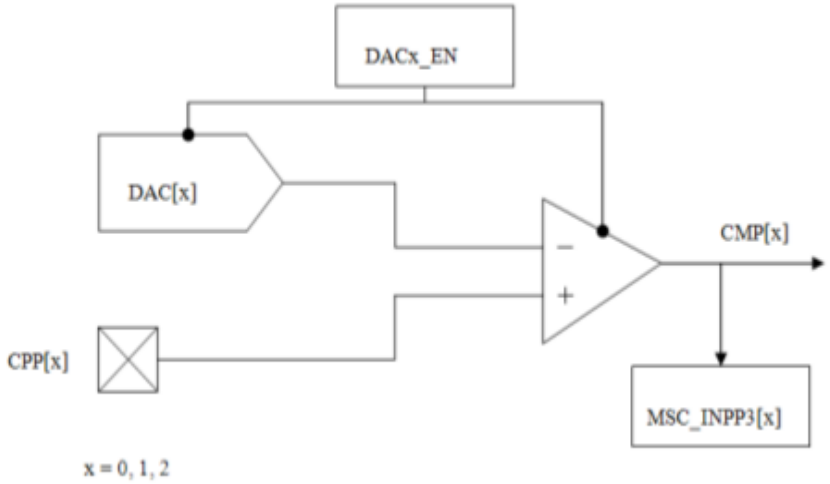
- Each SMED with independent clock
- 96MHz PLL+ programmable Dithering
  - 1.3ns average resolution
  - 13Hz average frequency step @ 100kHz

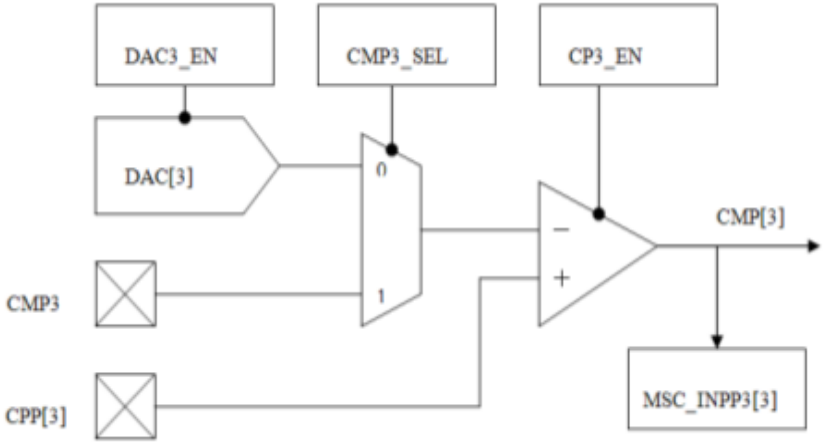




Analog Comparators

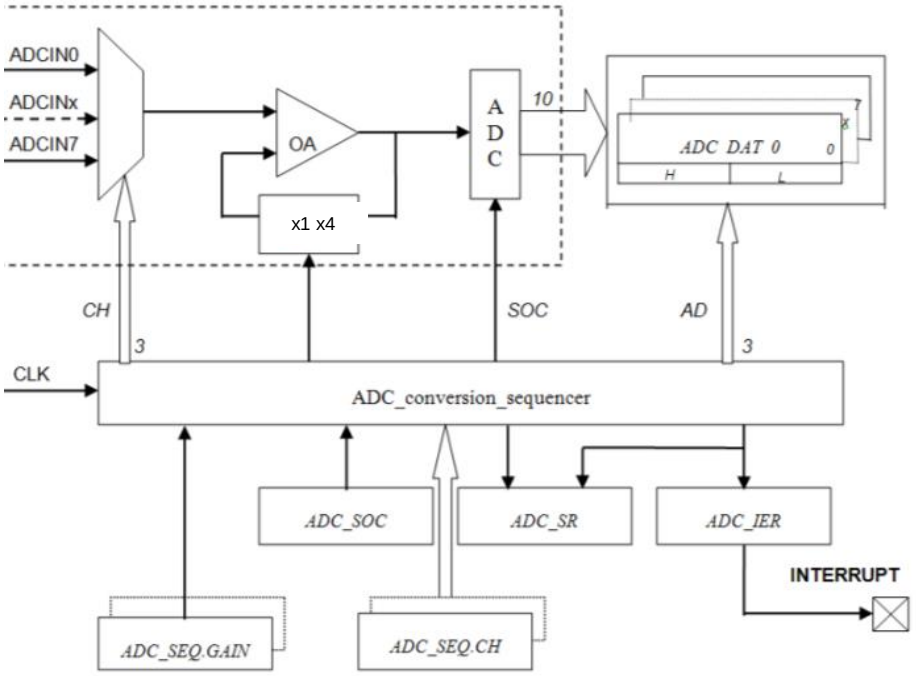
- Up to 4 independent comparators
- Very fast propagation delay (50 ns max)
- Internal 4 bit DAC reference: 16 values selectable from 0 to 1.23 V (bandgap reference)
- One comparator available with external reference





Analog to Digital Converter

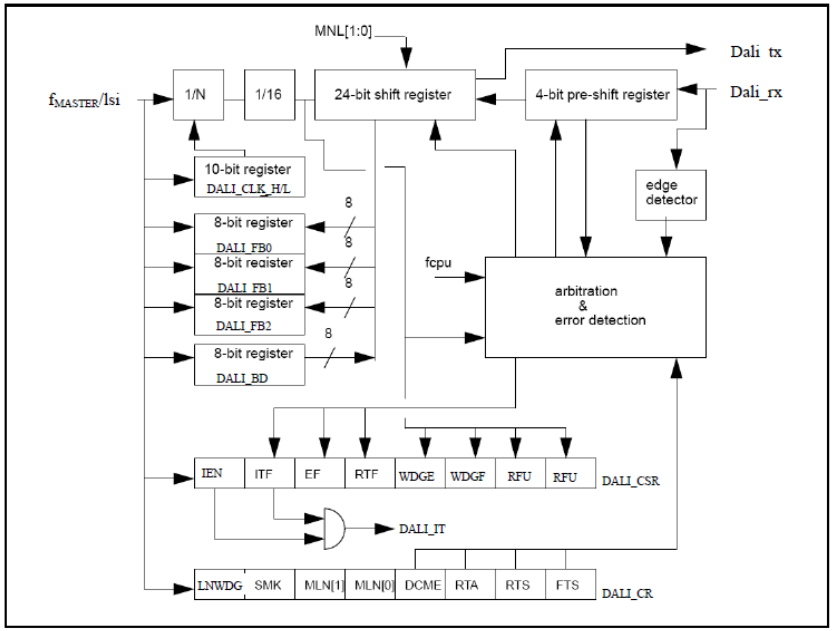
- 8 channels
- 10 bit resolution with gain (x1 or x4)
- 300 µV resolution (G = x4)
- Conversion time: 2.4 µs (single mode), 3 µs (circular mode)
- Input resistance: more then 10MΩ
- Reference internally generated from the band-gap => independent on supply voltage => no need for very accurate voltage supply



Hardware DALI

Main features:

- Bi-phase Manchester asynchronous serial data format (6-9V)
- Programmable 1.2kHz, 2.4kHz and 4.8 kHz transmission rate (±10%)
- Bi-directional communications in four 8-bit forward/backward data registers
- Variable 16-18bit and 24 bit forward message length are supported
- 153.6Khz internal RC can be used in low power (standby) mode for Dali peripheral
- 500ms (±10%) interface failure detection to monitor receiver line timeout
- Maskable interrupt
- Dali_rx, Dali_tx polarity insensitive signal lines
- Configurable Noise Rejection Fitler
  - remove any RX bounce, glitch or spurious pulse



Standard references – IEC 62386 – xxx:

- **101 – general requirements of systems**
- **102 – general requirements of control gears**
- 201 – fluorescent lamps
- 202 – emergency lighting
- 203 – discharge lamp (not Fluorescent)
- **204 – LV Halogen**
- 205 – supply voltage for incandescent lamps
- 206 – Conversion from digital to DC voltage
- **207 – LED modules**
- 208 – Switching function (on/off devices ndr)
- **209 – Color LED**
- 210 – Sequencer

*** available**

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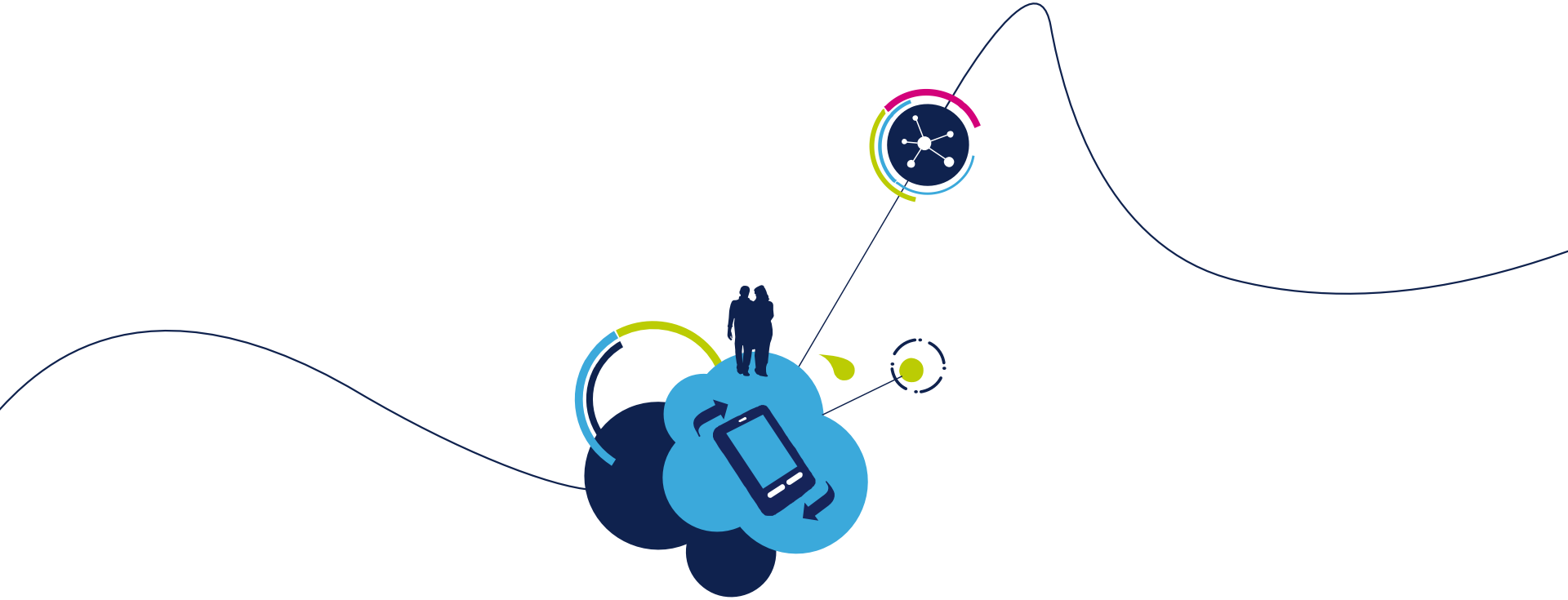
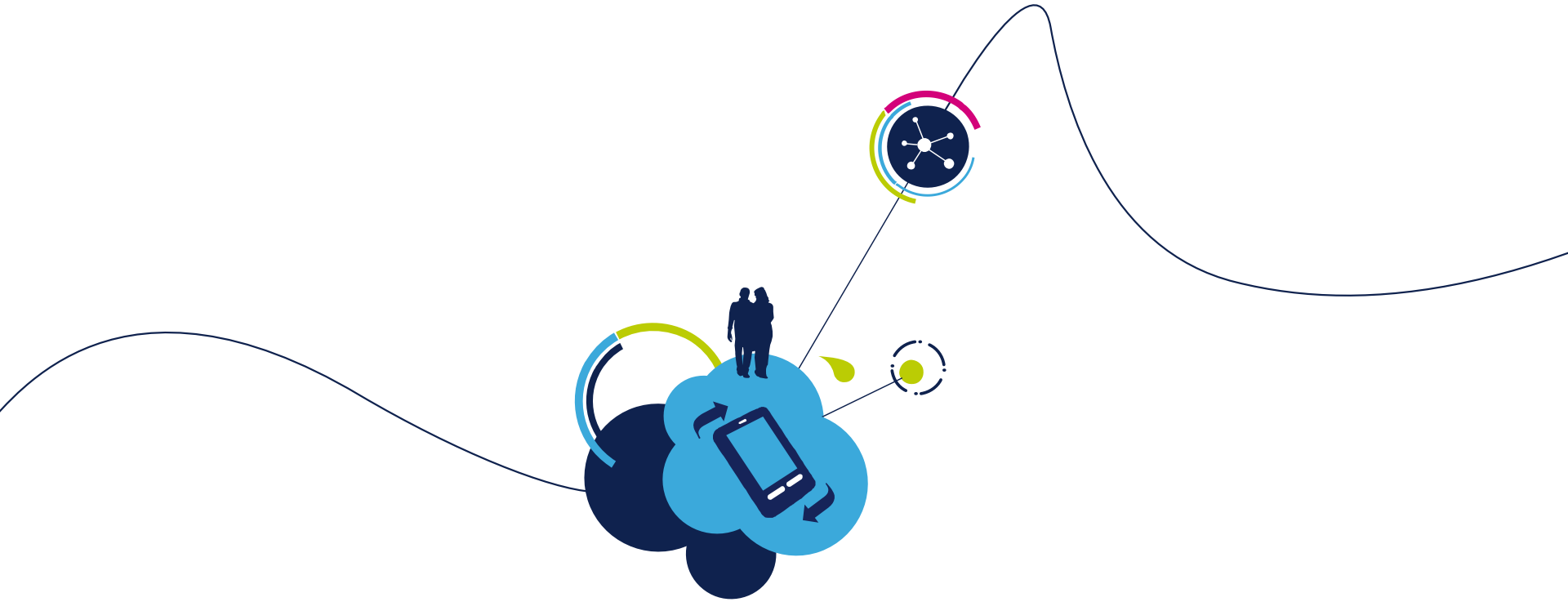
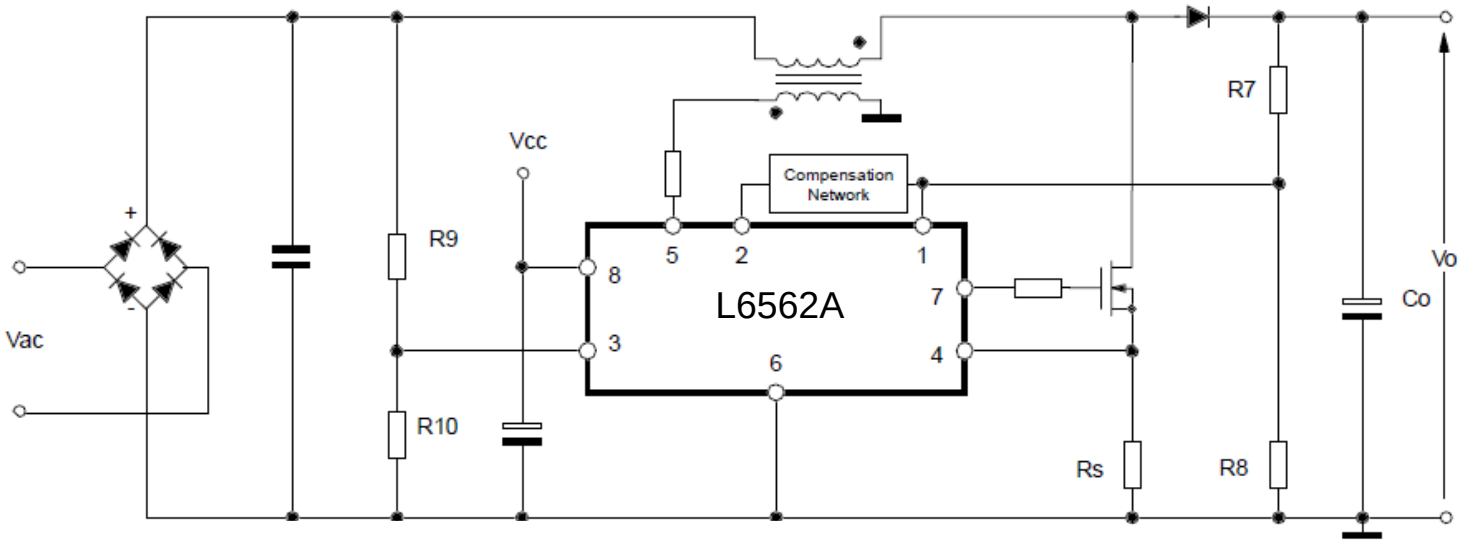


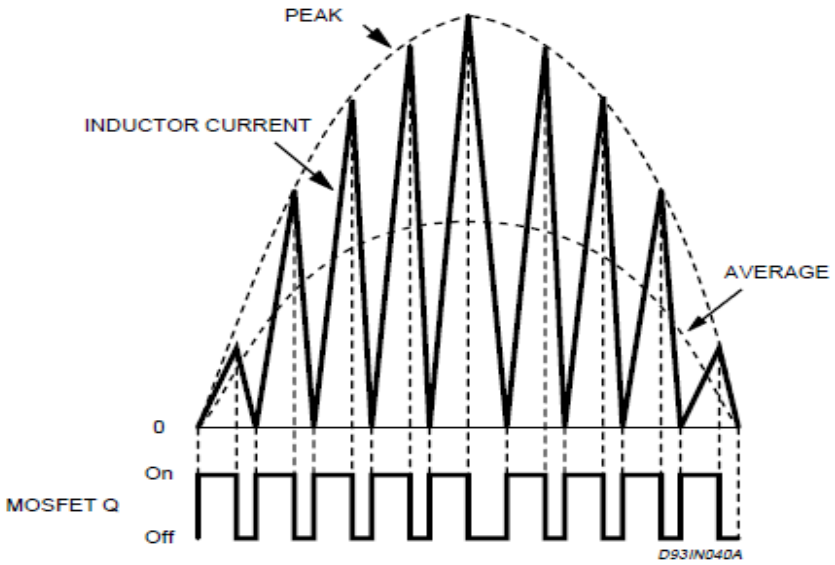
Application Examples



A Simple Power Factor Correction Implementation

Analog Transition Mode PFC





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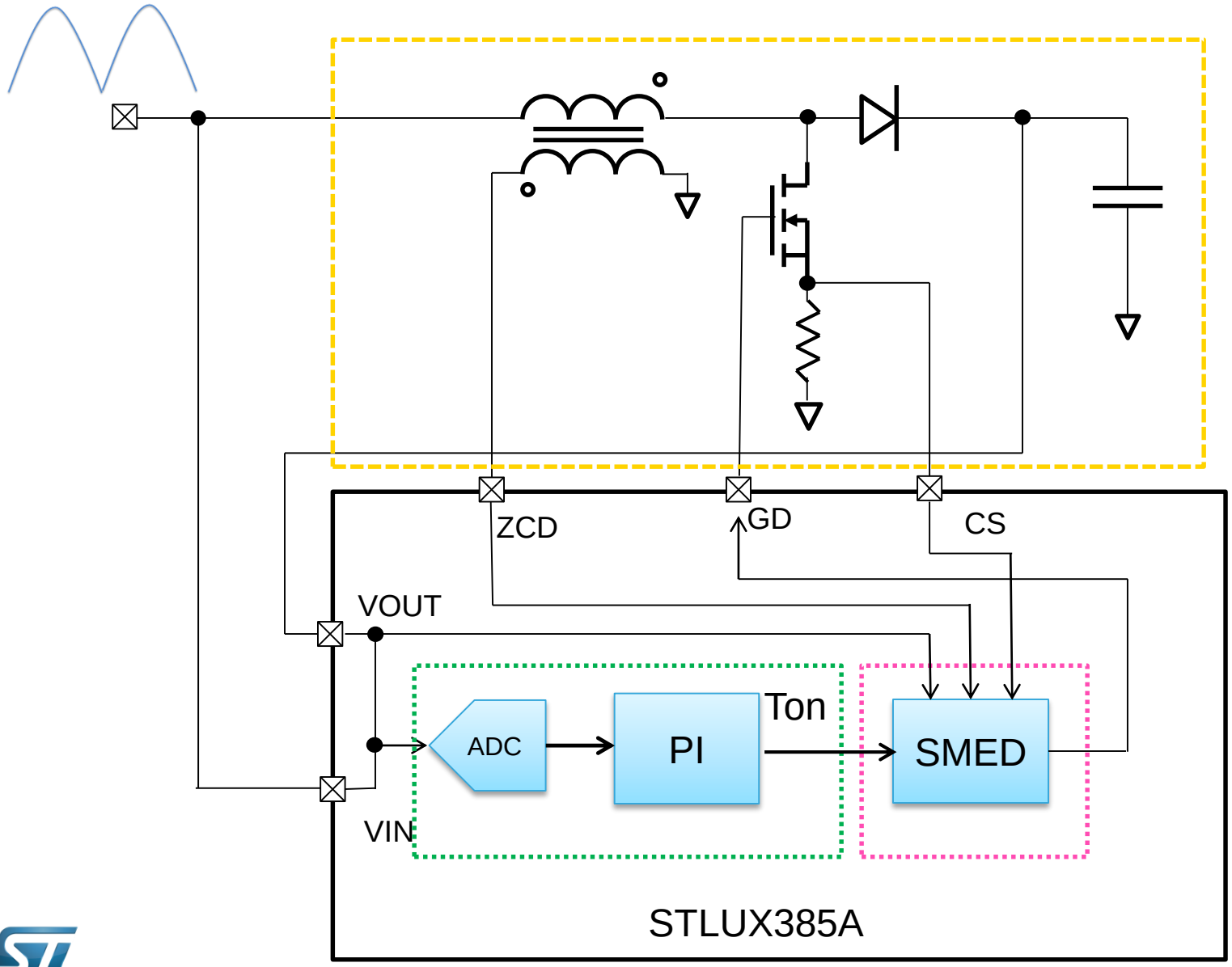
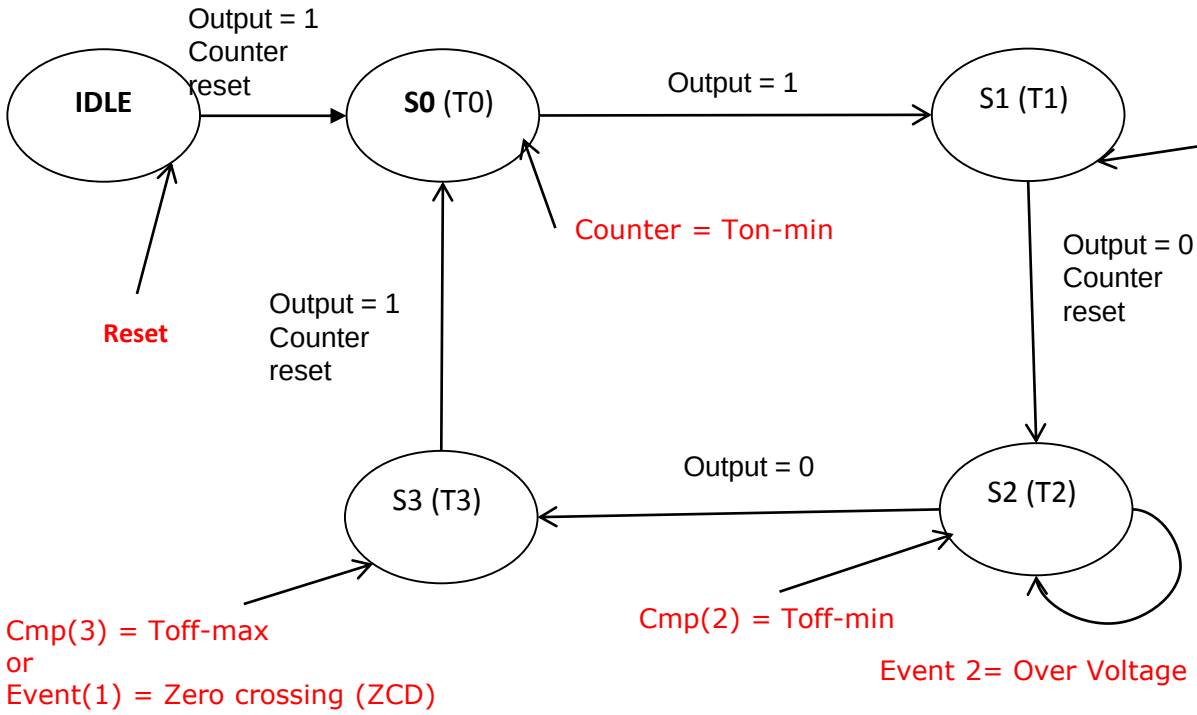
Digital PFC control



State Transition for PFC

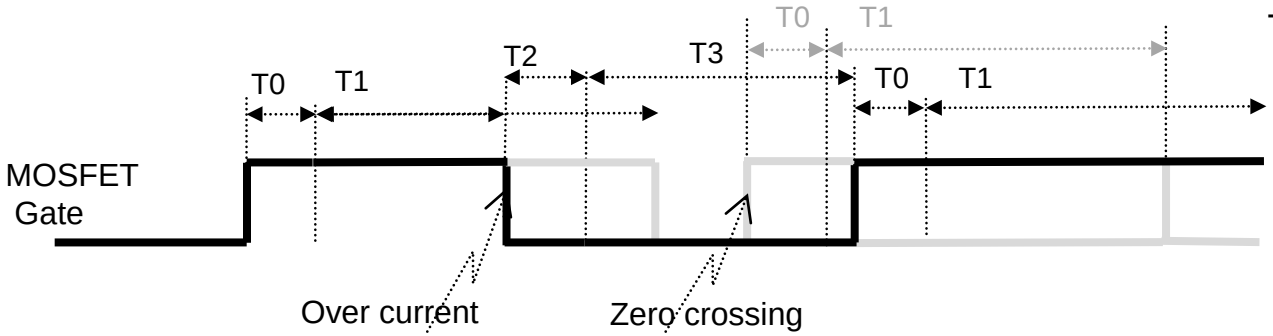


Event 0 = Current through the mosfet, Analog comparator

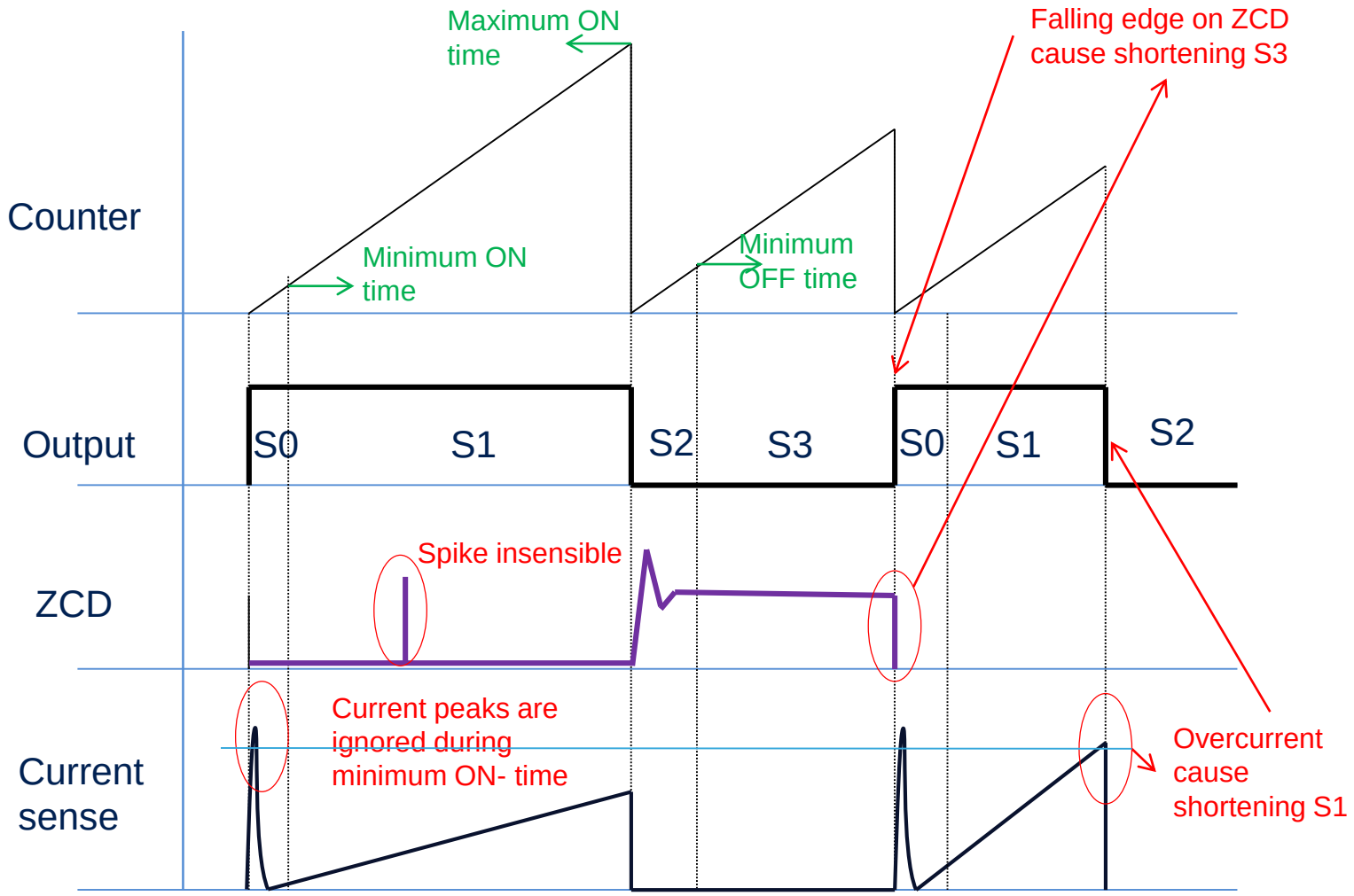
Event 1 = Zero current crossing (ZCD), Digital comparator

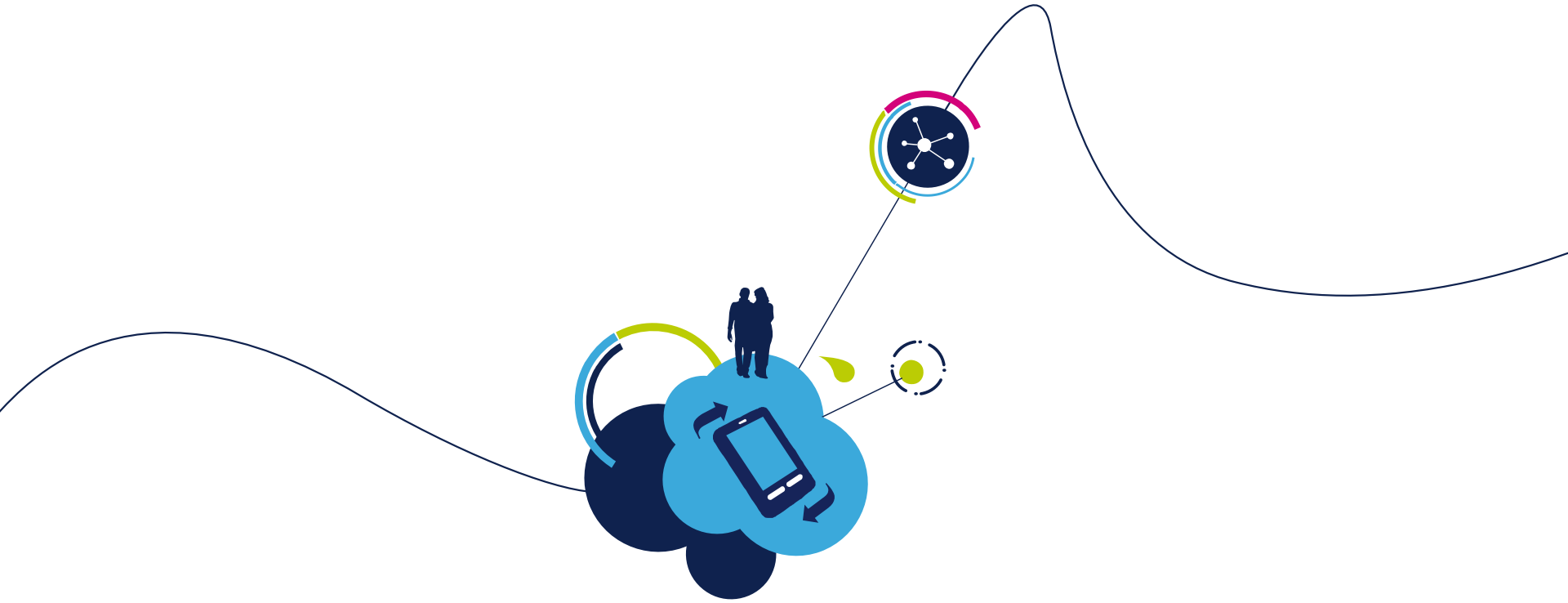
Event 2 = Vout protection, Analog comparator

T0 – minimum on time
T1 – maximum on time
T2 – minimum off time
T3 – maximum off time



Example Waveforms for States





Thank you for your attention