LEDTS
LED and Touch-Sense

XMC™ microcontrollers
September 2016

Agenda

1. Functions enabling via hardware
2. Configurable LED brightness
3. Pad scheme
4. Flexible measurement time on touch pads
5. Extended frames
6. Multiple kernels synchronization

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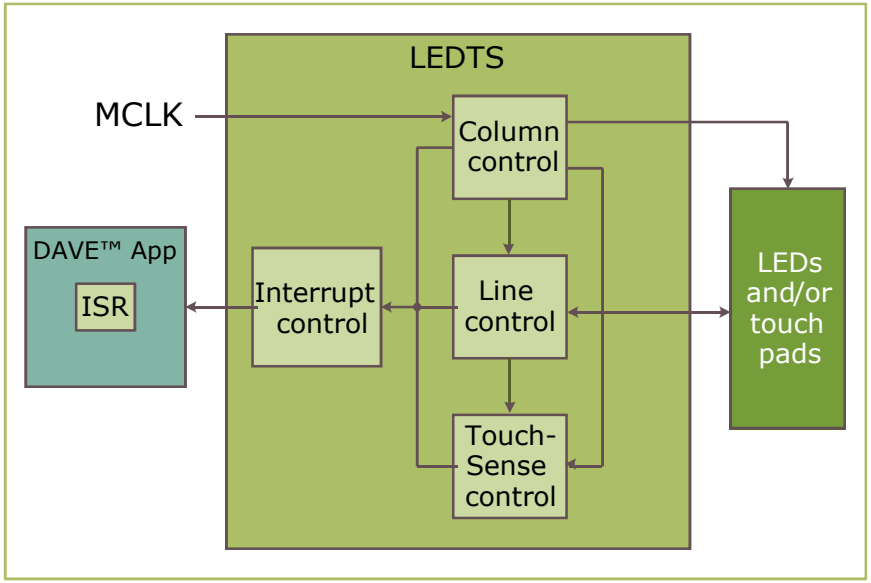
LEDTS
LED and Touch-Sense



Highlights

The LEDTS is especially designed to enable driving of LEDs (up to 64 LEDs in a LED matrix) and control capacitive touch pads (up to 8 pads per kernel) at the same time. The LEDTS controls the LEDs and touch pads in a time-multiplexed manner, thus allowing them to share pins.

Key feature

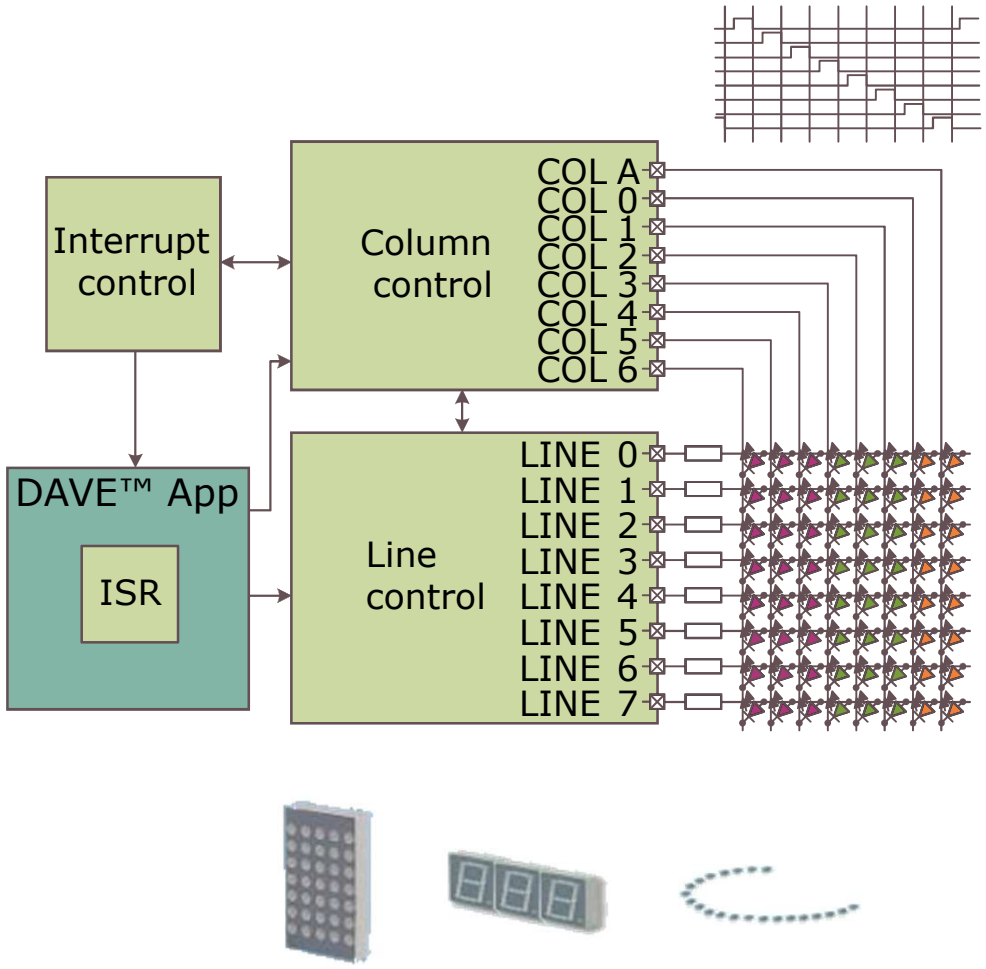
- LEDs are driven in a LED matrix
- Capacitive touch sensing via relaxation oscillator topology
- LEDs and touch pads can share pins

Customer benefits

- Drive more LEDs with limited pins
- No additional hardware needed to generate oscillations
- The number of pins needed for such applications is minimized

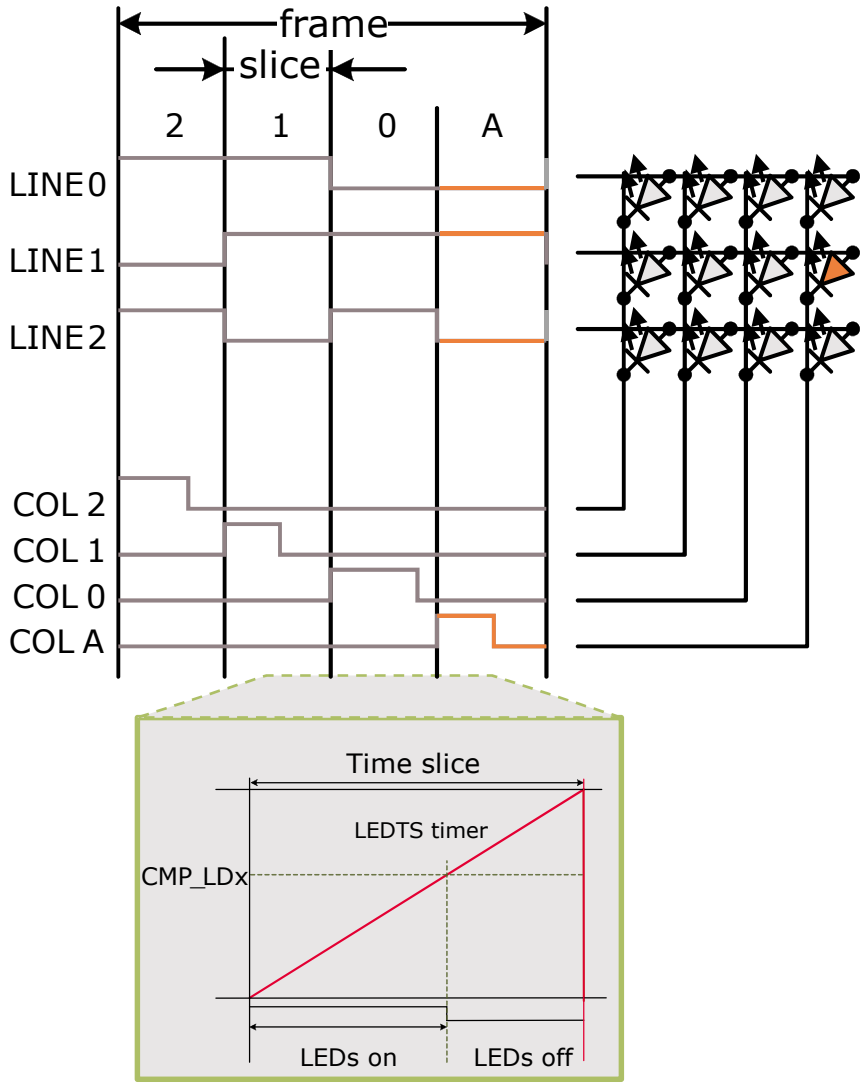
LEDTS
LEDs are driven in a LED matrix (1/2)

- A LED matrix consists of many LEDs arranged in lines and columns
- The columns are activated one after another
- The line signals are automatically synchronized to the column activation
- Saves cost:
  - Maximizes the number of LEDs that can be driven with limited number of pins
  - Up to 64 LEDs without touch pads, 56 LEDs with touch pads
- Flexible:
  - the LEDs can be arranged in various layouts



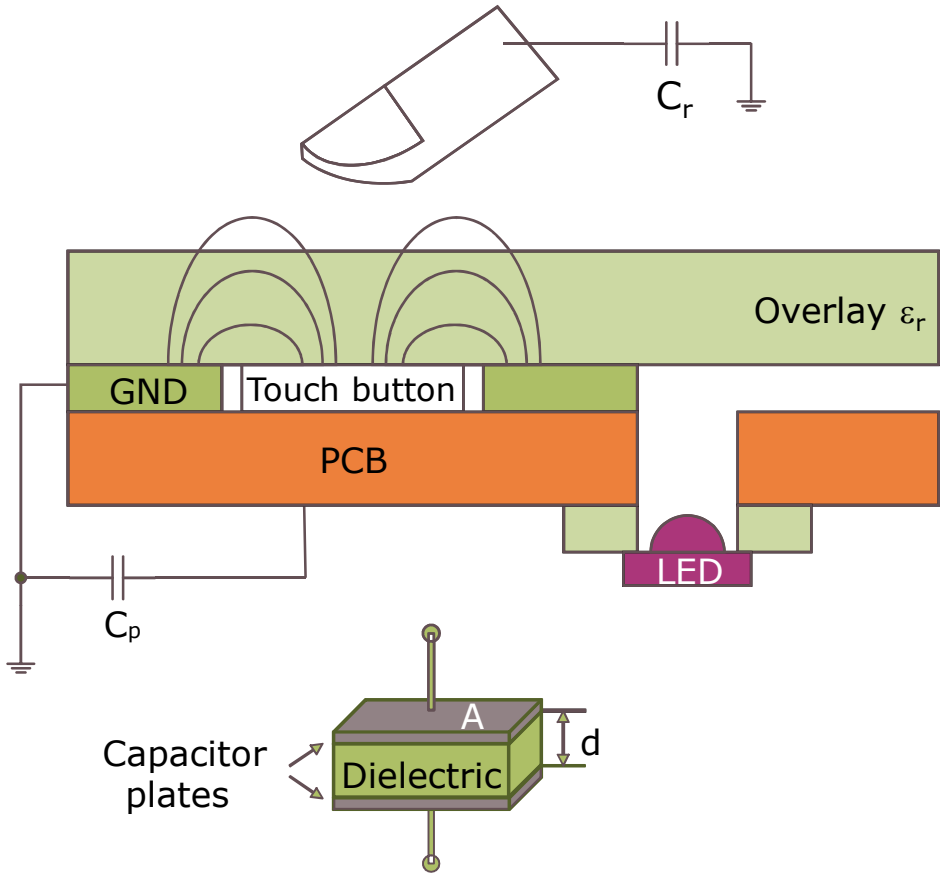
LEDTS
LEDs are driven in an LED matrix (2/2)

- Time slice
  - Smallest time period used in LEDTS
  - Only one LED column can be active in a time slice
- COMPARE value (CMP_LDx bit field)
  - Column active time within a time slice
  - Determines brightness level
  - 0xFF – brightest, 0x00 - off
- Time frame
  - Time taken for all columns to have been activated in a round
  - = Time slice * no. of LED columns (with no touch pads)



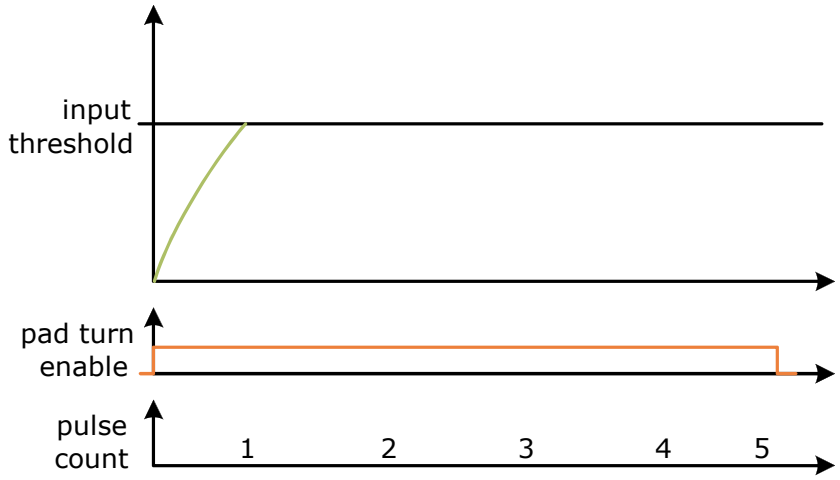
LEDTS
Capacitive touch via relaxation oscillator (1/2)

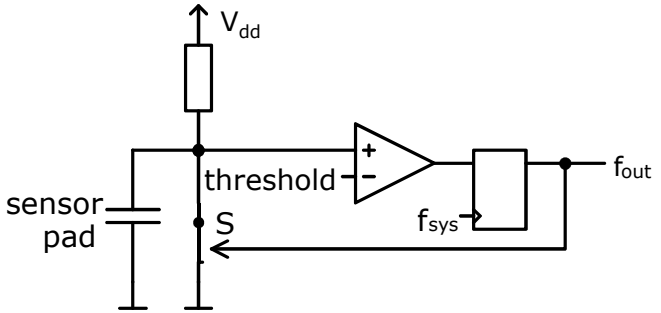
- What is capacitive touch sensing?
  - Touch pad controller regularly measures the capacitance of touch pads
  - When the pads are touched, their capacitance increases
  - Touch by a finger forms a parallel capacitance (increase in overall capacitance)
  - Parallel-plate capacitor model of the extra capacitance: $C = \varepsilon_0\varepsilon_r * (A/d)$
- Benefits:
  - Flexible design
  - Can have protective overlay
  - No wear and tear



ε_0 = permittivity of free space
ε_r = relative permittivity of dielectric material
A = area of the plates (~ finger touch area)
d = distance between plates (~ cover thickness)

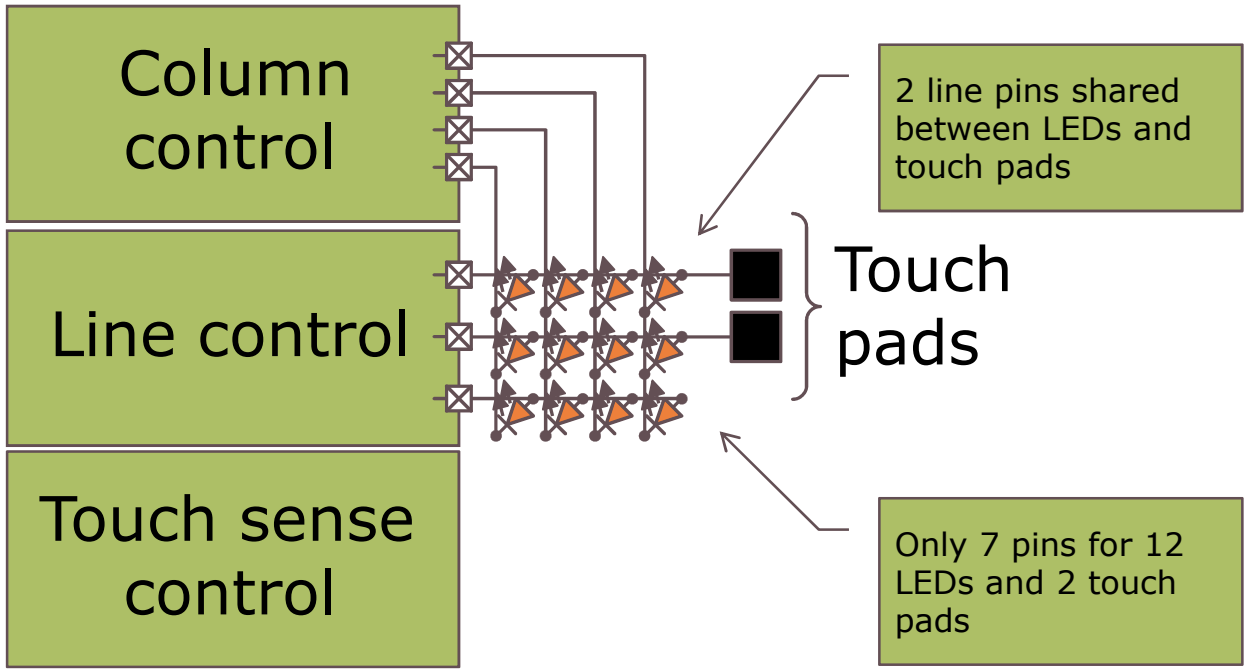
LEDTS
Capacitive touch via relaxation oscillator (2/2)





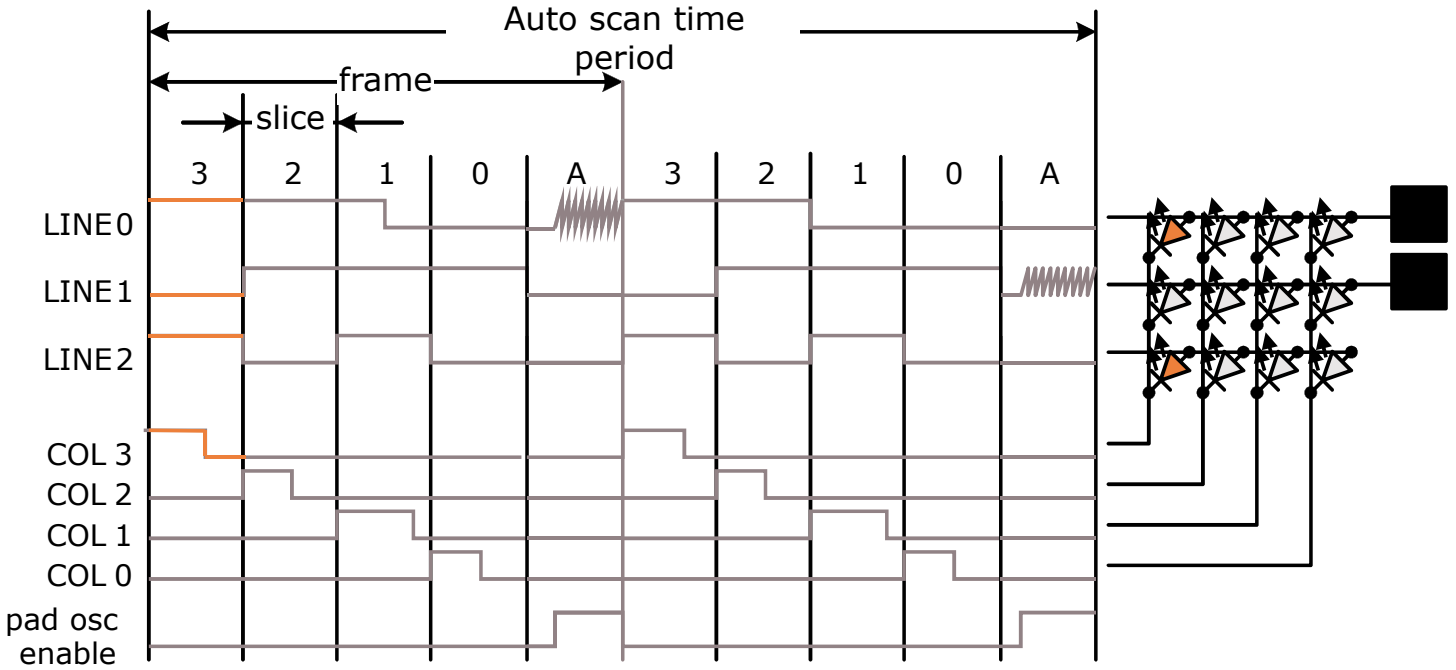
- What is the relaxation oscillator topology?
  - A simple circuit generates oscillations on the sensor pad
  - The number of oscillations is monitored in an adjustable time window (called the oscillation window)
  - The output frequency depends on the pad capacitance
  - The higher the capacitance the lower the frequency and the lower the number of pulses -> if the pad is touched, the number of pulses becomes lower
- Benefits:
  - HW needed for charging and discharging is already available in the pad
  - No need for extra HW to be designed

LEDTS
LEDs and touch pads can share pins (1/2)



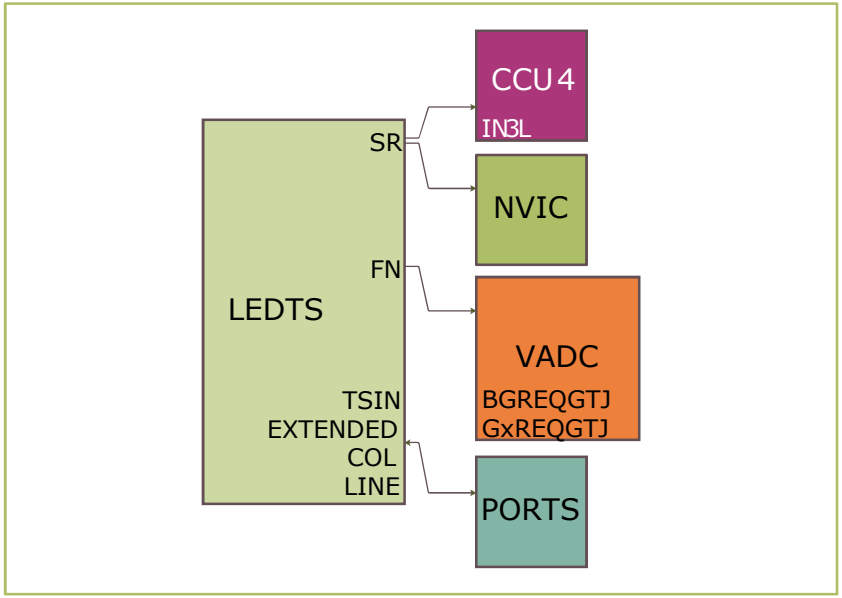
- LEDs and touch pads can co-exist and share pins
- The LEDTS drives LEDs and controls touch pads in a time-multiplexed manner
- Benefit:
  - The number of pins needed to drive multiple LEDs and touch pads can be minimized = cost saved

LEDTS
LEDs and touch pads can share pins (2/2)



- Time-multiplexing
  - At any one time, only 1 LED column or the touch-sense function is active
  - Touch pads are active during a touch-sense time block
  - Only 1 touch pad is active in any touch-sense time block
  - Touch pads are activated and serviced in a round-robin manner
- Auto scan time period
  - When all touch pads have been serviced
  - = time frame * no. of touch pads

LEDTS
System integration



- Target applications
  - Human machine interface
  - Touch sense

LEDTS is interconnected with several modules in the MCU system.

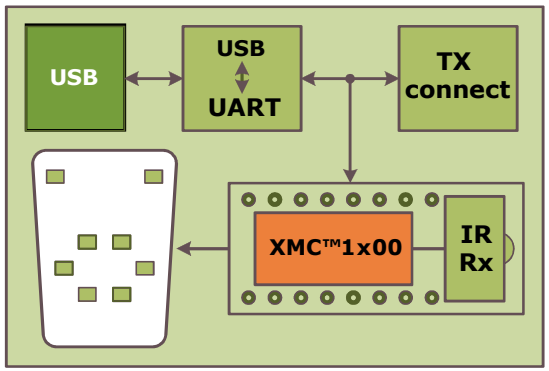
CCU4 – Input signal to CCU4 module **(Not on XMC™4x00).**

NVIC – To generate interrupt.

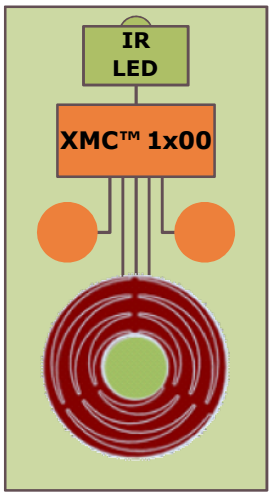
VADC – Input signal to VADC module.

PORTS - Pin oscillation control unit is integrated with the standard PORTS pad. Eliminates the need for additional hardware circuitry to generate oscillations.

Application example
IR remote control



IR receiver with USB docking station



IR transceiver with touch control

In brief

The IR remote control features a combination of capacitive touch control and IR communication. It comprises of two parts – the IR receiver and transceiver. User input is captured and processed by the LEDTS. Infrared transmission and reception is realized via the standard RC-5 protocol.

Overview

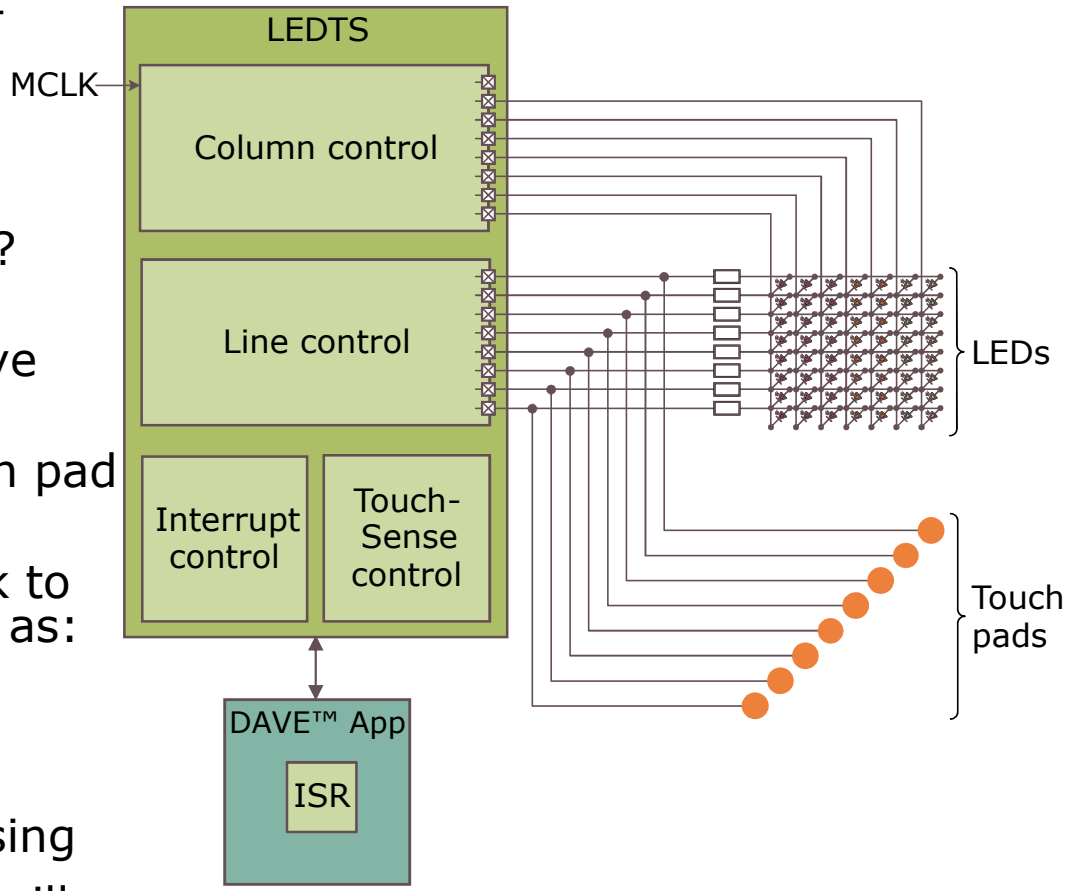
In Human-Machine Interface (HMI) applications such as the IR remote control, the LEDTS gives flexibility and a high-level of customization to the design. The LEDTS too, with the use of capacitive touch technology, enables the detection of user input through enclosure materials. The behavior of the touch inputs can be simply adjusted through software parameters, independent of mechanical constraints.

On the IR transceiver, the LEDTS controls and processes the touch signals for two buttons and a touch wheel, using only 5 pins of the XMC™xx00. These touch inputs are designed on a flexible PCB which is glued directly onto the underside of the upper part of the remote control housing.

On the IR receiver, the LEDTS drives the LEDs that serve as indicators for the corresponding touches on the IR transceiver.

LEDTS
Functions enabling via hardware

- The LEDTS drives LEDs and controls touch pads in a time-multiplexed manner
- Taken care by hardware:
  - Column enabling – which column is to be active now?
  - Function enabling – LED or touch-sensing is to be active now?
  - Touch pad enabling – which pad to service now?
- Minimizes the amount of work to be handled by software, such as:
  - LED line pattern
  - LED brightness level
  - Touch-sense signal processing
- Even all these software work will be taken care by the DAVE™ App



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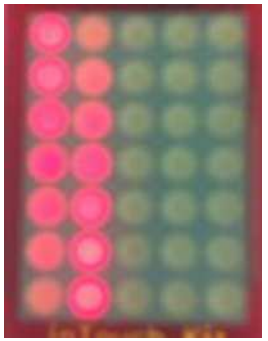
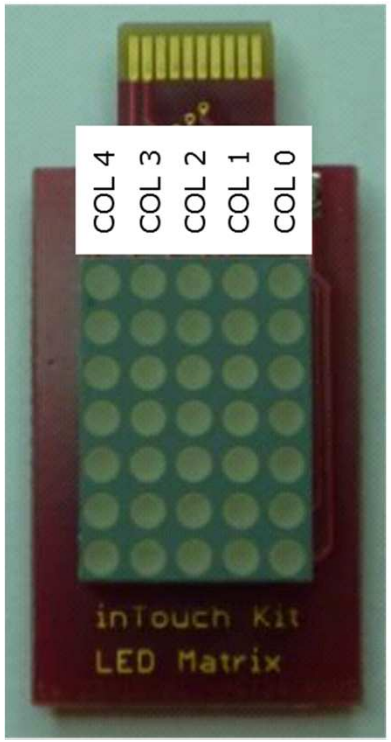
5. Extended frames
6. Multiple kernels synchronization

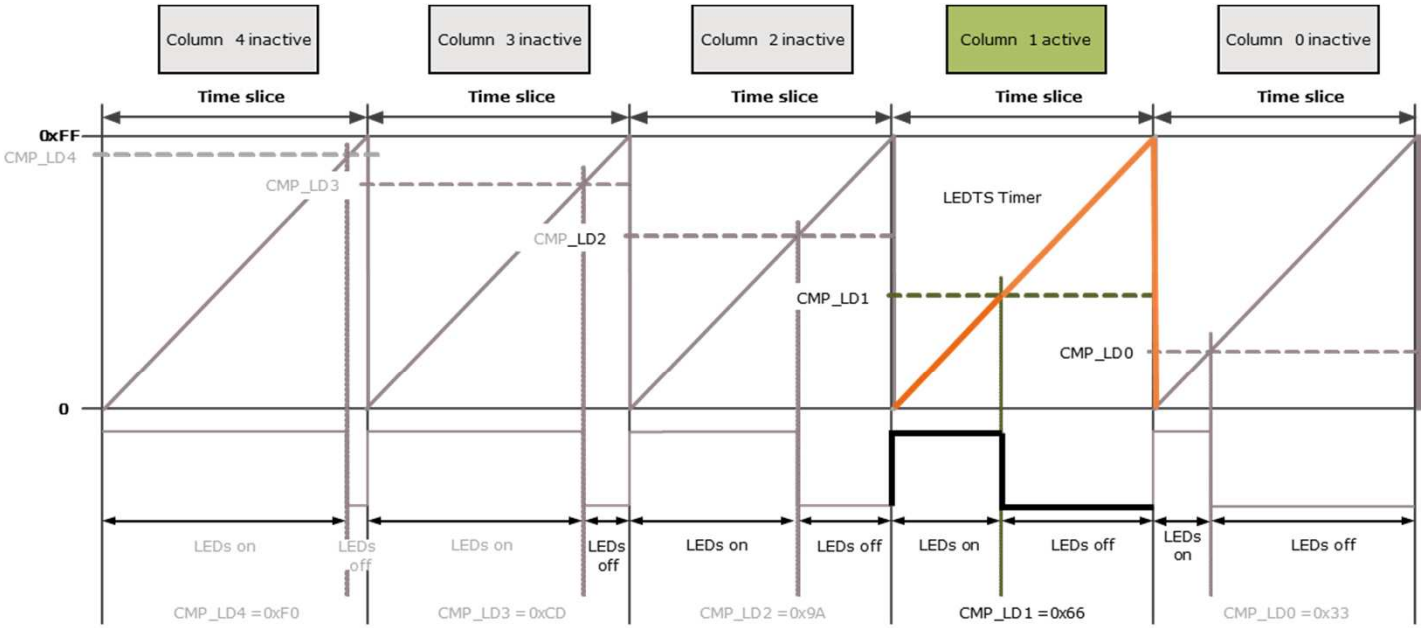
LEDTS
Configurable LED brightness (1/3)

- Application may require different brightness level for LEDs connected to same microcontroller
- LEDTS allows customized brightness level
  - On a column level
    - LEDs on same column have same brightness
  - On an individual LED level
    - Using some software tricks



LEDTS
Configurable LED brightness (2/3) – column

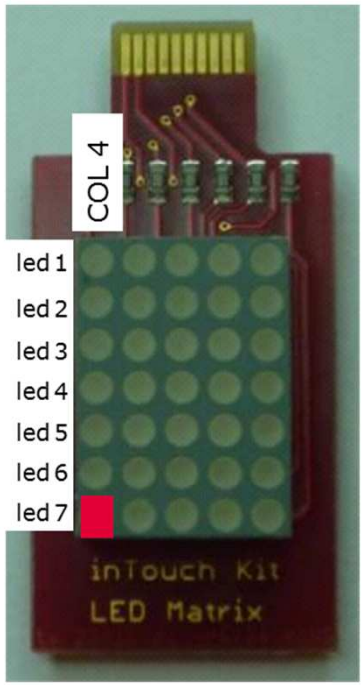


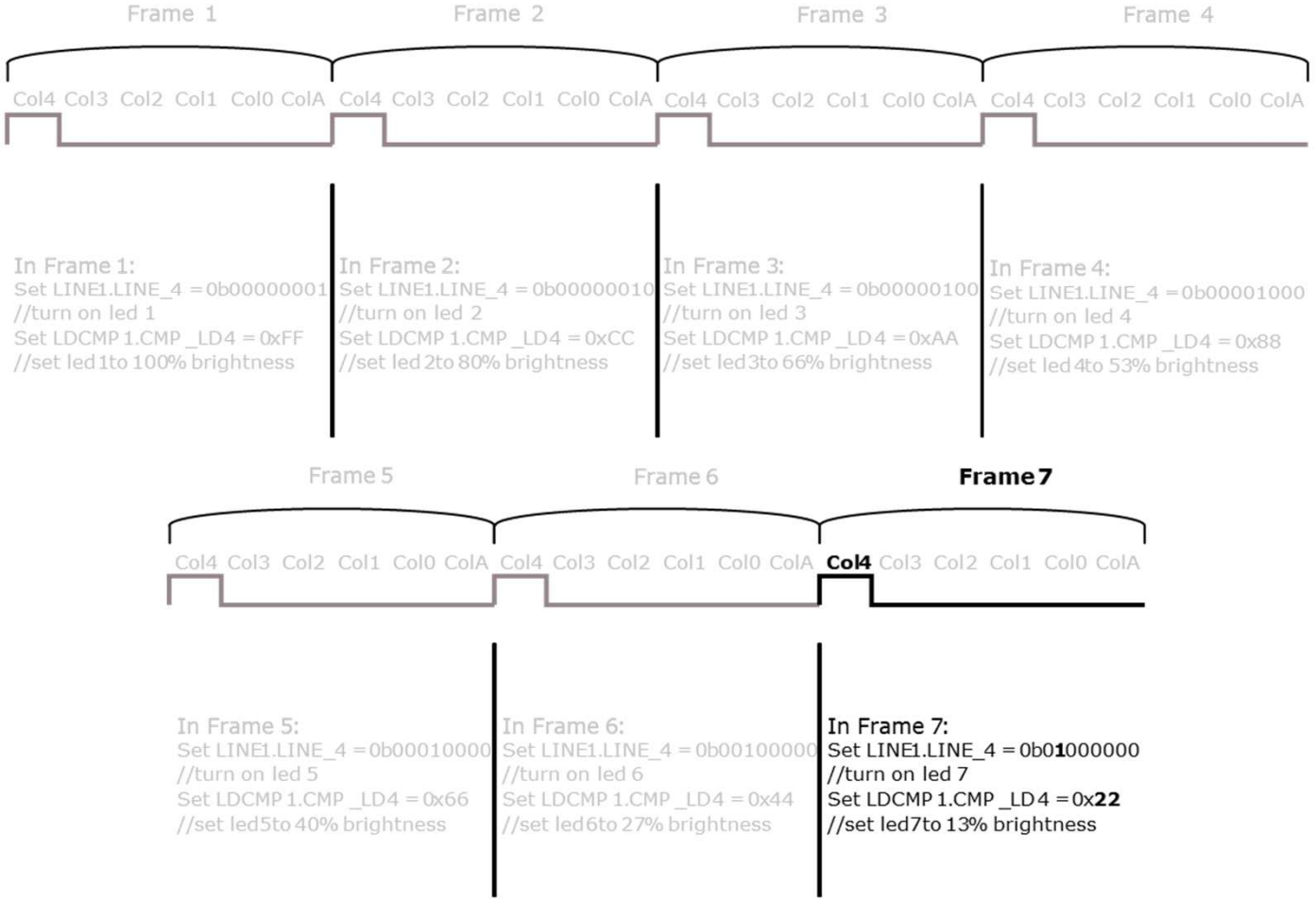


- The brightness level of the LEDs in a particular column depends on the time period within the column time slice, during which the LEDs are turned ON
- This “LED ON” time period can be adjusted via the respective CMP_LDx register bit fields

LEDTS
Configurable LED brightness (3/3) - individual

- LEDs connected to the same column pin can have different brightness levels as well
- How? In every time slice, only 1 LED is switched on with its desired brightness level





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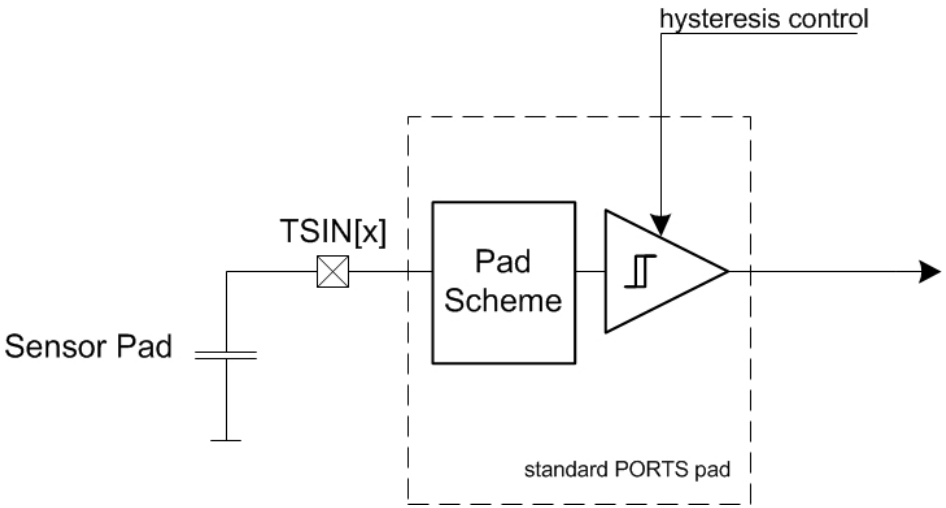
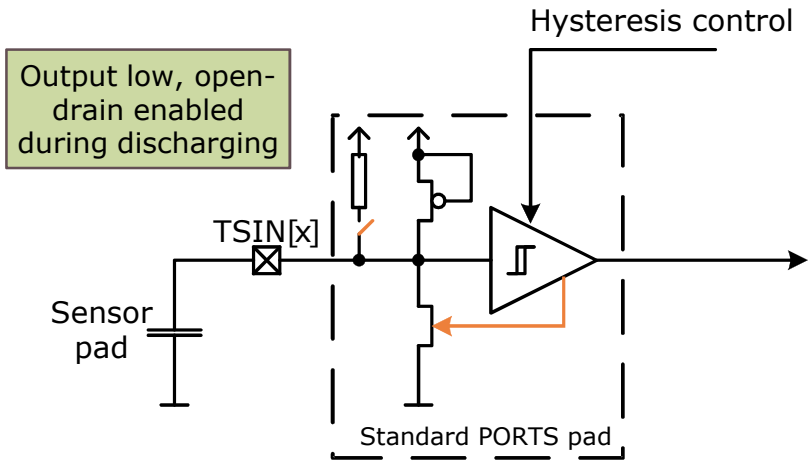
LEDTS
Pad scheme (1/4)



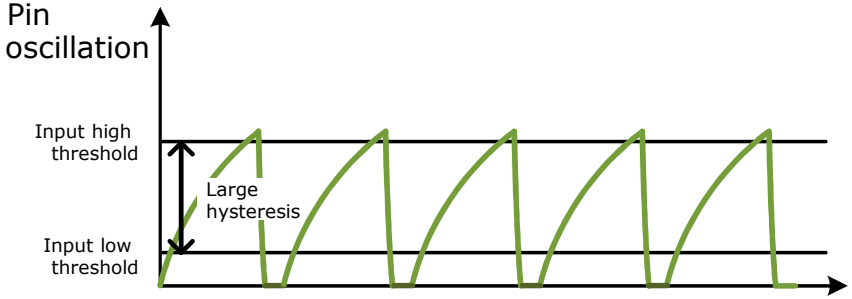
- Pad scheme: Pad configuration during charging and discharging of pad oscillators
- 2 schemes:
  - Scheme A: Slow charge – fast discharge (more in later slide) – on XMC™4x00, XMC™1200
  - Scheme B: Slow charge – slow discharge (more in later slide) – only on XMC™1200
- Offer a variation for pad oscillation behavior
- Coupled with pad hysteresis configuration
- More options to find better match for user application

LEDTS: Pad Scheme A (2/4) (available on XMC™4x00, XMC™1200)

- Scheme A
  - Pn_HWSEL = 01_B
  - Standard hysteresis: Pn_PHx=$0XX_B$



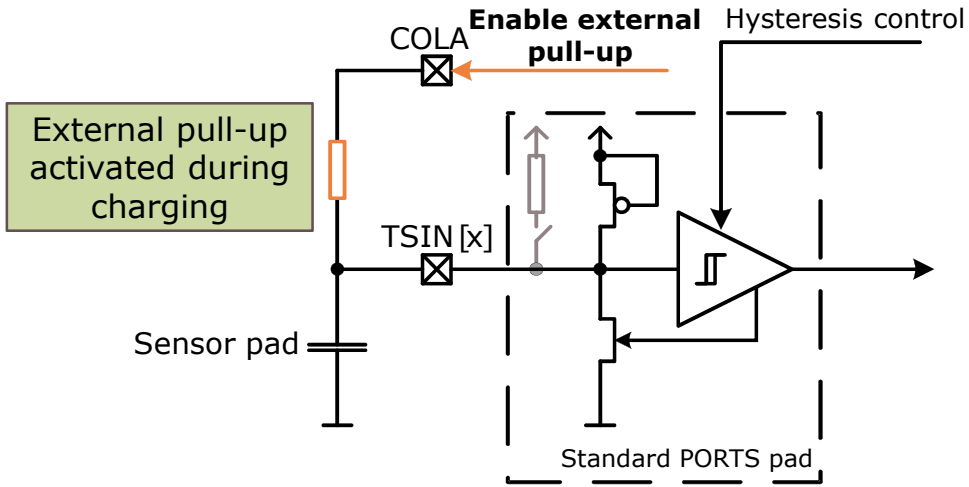
- Options available:
  - Large hysteresis: Pn_PHx=$1XX_B$

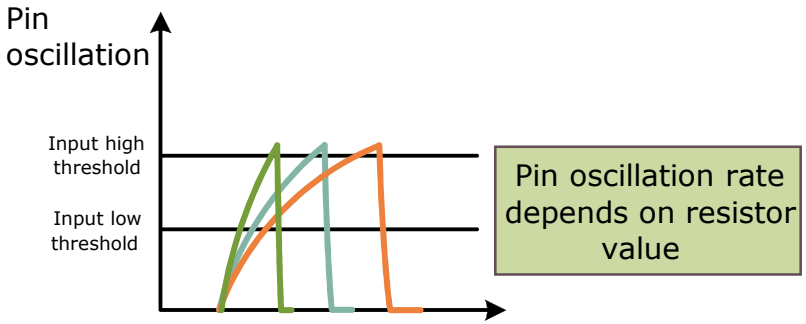


  - External pull-up (see next slide)
  - Pin-low-level active extension (see next slide)

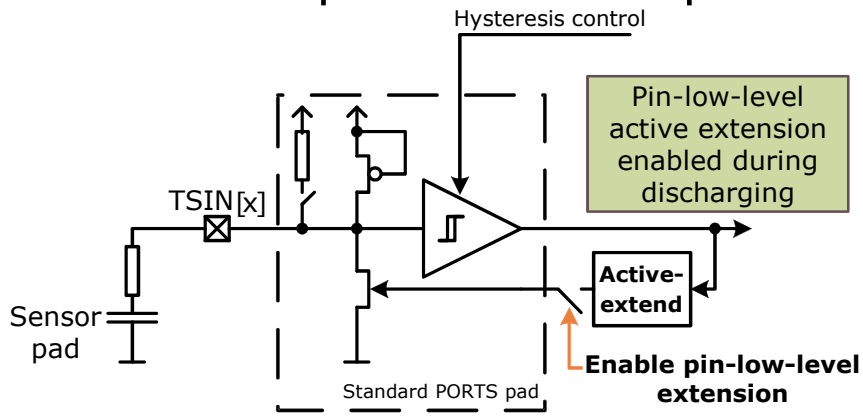
LEDTS: Pad scheme A options (3/4) (available on XMC™4x00, XMC™1200)

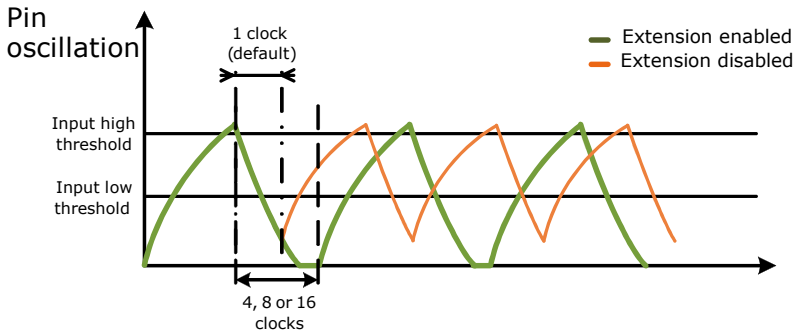
- External pull-up
  - Flexibility to adjust pin oscillation rate





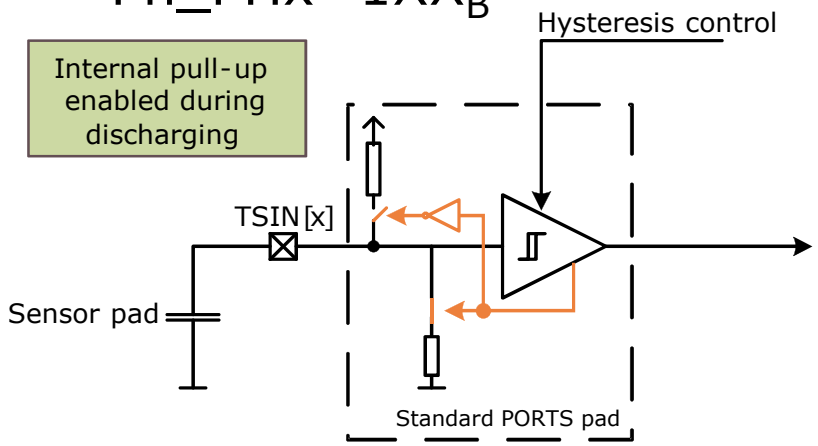
- Pin-low-level active extension
  - Option to delay the start of charging due to slower discharge e.g. series resistor between pin and touch pad

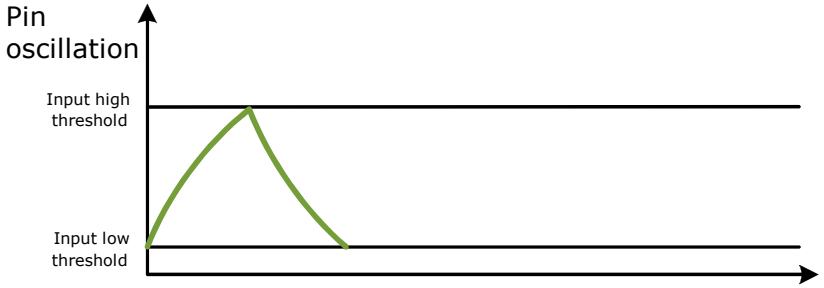




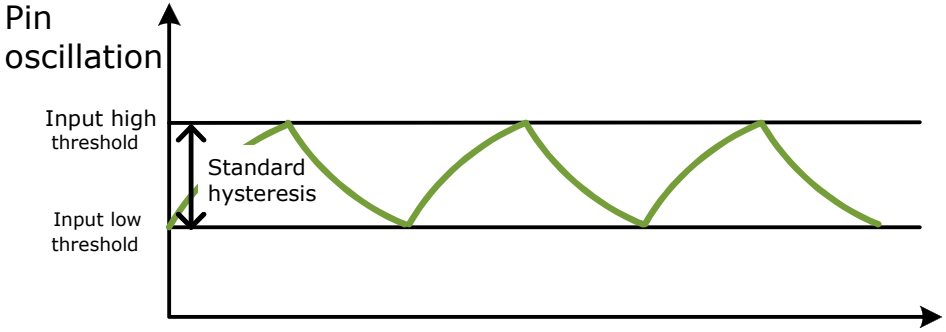
LEDTS: Pad scheme B (4/4) (available only on XMC™1200)

- Scheme B
  - Pn_HWSEL = 10_B
  - Large hysteresis: Pn_PHx=$1XX_B$





- Options available:
  - Standard hysteresis: Pn_PHx=$0XX_B$



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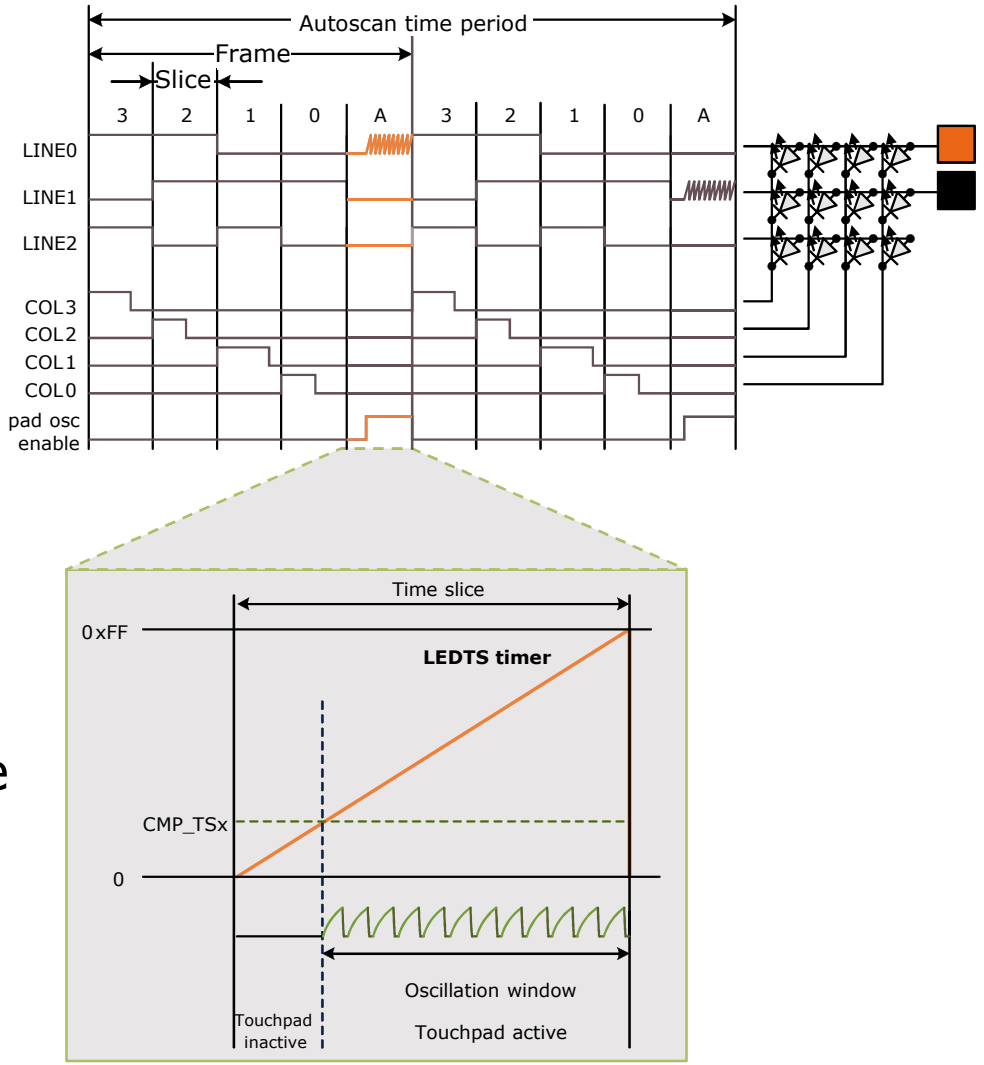
LEDTS
Flexible measurement time on touch pads

- Touch inputs used in applications may have different sensitivity due to design factors e.g. trace length, parasitic capacitance etc.
- As such, LEDTS enables measurement time to be customized for individual pads
  - Oscillation window size – touch pad active period and measurement is made
  - Customization via respective CMP_TSx bit fields
- Achieve consistent performance across all touch inputs



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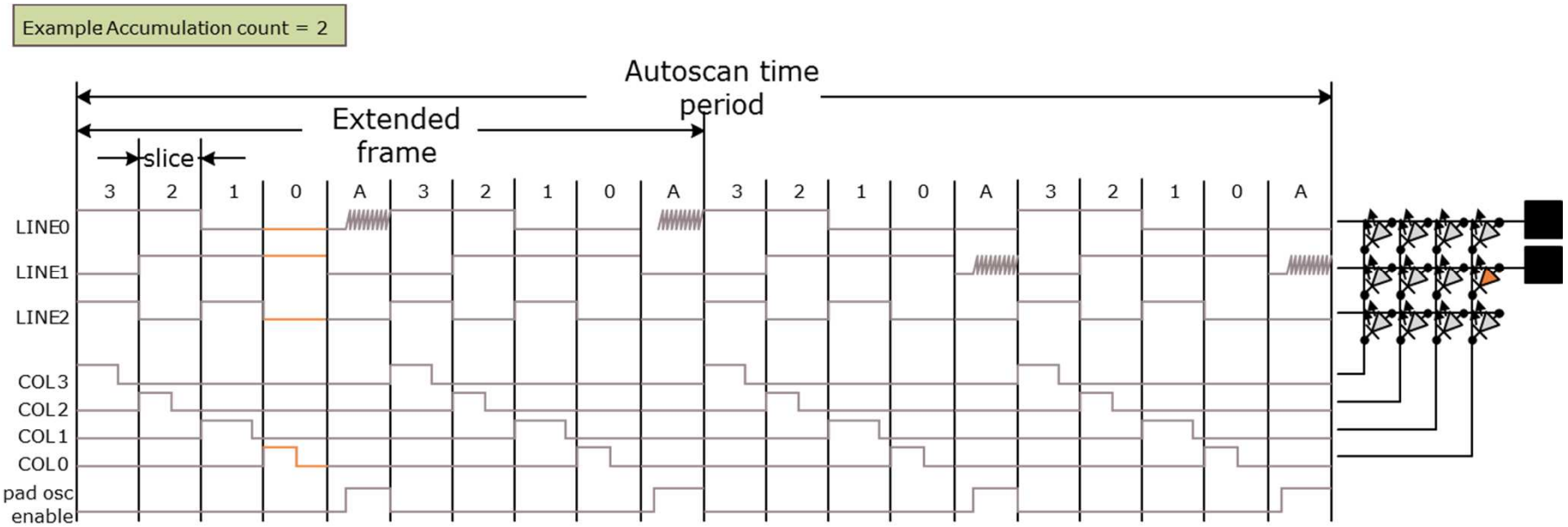
LEDTS
Extended frames

- Application problem: Low resolution for no. of oscillation counts
  - Hard to distinguish a touch
  - More susceptible to noise
- Solution: Accumulate the no. of oscillation counts over a few time frames
  - A touch pad is serviced for a no. of consecutive time frames (defined by ACCCNT bit field)
- Advantage: can be done by hardware, eases software



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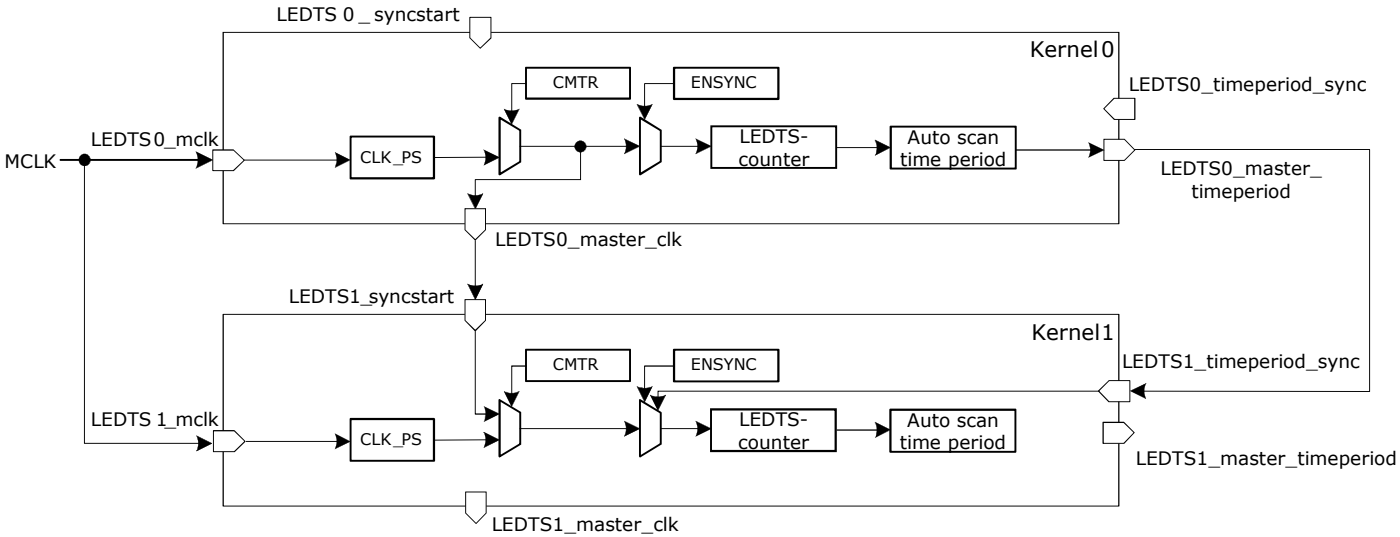
LEDTS: Multiple kernels synchronization (1/2) (only on XMC™1200)

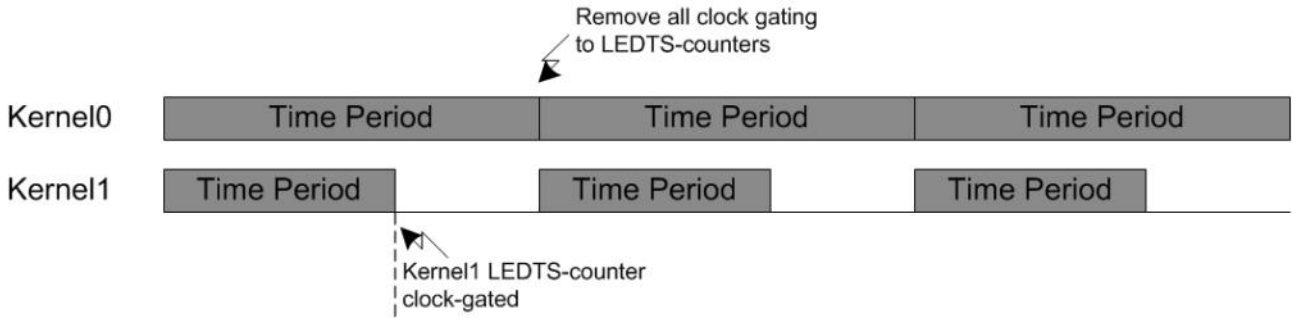
- 2 LEDTS kernels in XMC™1200
- Drive more LEDs and control more touch inputs
- Options for HW synchronization:
  - Start of LEDTS counters
    - Clock frequency determined by kernel 0's clock pre-scaler
    - Kernel 1 will take clock from kernel 0
  - Auto scan time period synchronization (next slide)



LEDTS: Multiple kernels synchronization (2/2) Auto scan (only on XMC™1200)

- Auto scan time period synchronization
  - When kernel 1 reaches its auto scan time period, its LEDTS-counter clock will be gated
  - When kernel 0 reaches its auto scan time period, gating on kernel 1's LEDTS-counter clock is removed

- Conditions:
  - Touch-sense function is enabled on all kernels
  - HW pad turn control on all kernels
  - Kernel 0 is enabled and has longest auto scan time period
  - Start of LEDTS counters synchronization is enabled



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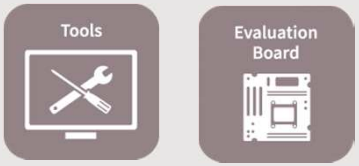
Technical Material 	– Application Notes – Technical Articles – Simulation Models – Datasheets, MCDS Files – PCB Design Data	– www.infineon.com/XMC – Kits and Boards – DAVE™ – Software and Tool Ecosystem
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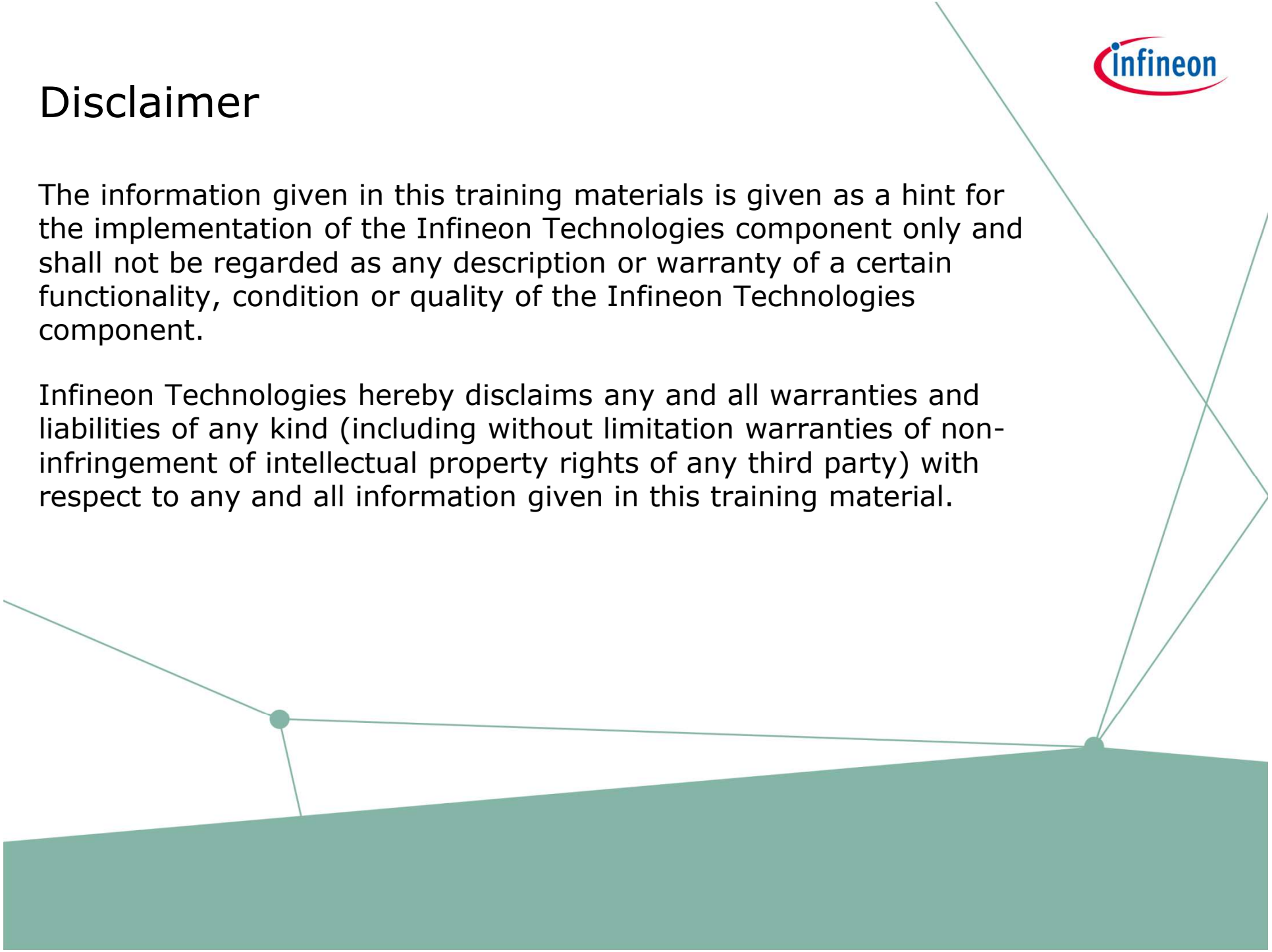

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