

Touch Sensing Controller (TSC)

Application - Microcontroller Division

MMS Group



TSC Features (1/2)

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- Proven and robust surface charge transfer acquisition principle available on **STM32F0, STM32F3, STM32L0 and STM32L4 series**
- Supports up to **24** capacitive sensing channels split over **8** analog I/O groups
 - Number of channels and analog I/O groups depend on the device used
- **Up to 8 capacitive sensing channels can be acquired in parallel** offering a very good response time
 - 1 counter per analog I/O group to store the current acquisition result
- **One sampling capacitor for up to 3 capacitive sensing channels** to reduce the system components
- Full hardware management of the charge transfer acquisition sequence
 - No CPU load during acquisition
- **Spread spectrum** to improve system robustness in noisy environment



TSC Features (2/2)

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- Programmable charge transfer frequency
- **Programmable sampling capacitor I/O pin and channel I/O pin**
 - Any GPIO of an analog IO group can be used for the sampling capacitor
 - Any GPIO of an analog IO group can be used for the channel
- **SYNC input pin** to synchronize the acquisition with an external signal
- **Programmable max count value** to avoid long acquisition when a channel is faulty
- Dedicated **end of acquisition and max count error flags with interrupt capability**
- Compatible with **proximity, touchkey, linear and rotary touch sensors**
- Designed to operate with **STMTouch touch sensing middleware** available in corresponding STM32Cube package



STM32F051x TSC Overview

- Supports up to **18** capacitive sensing channels split over **6** analog I/O groups
- **6.8 MHz** maximum charge transfer frequency

Analog I/O group	Number of capacitive sensing channels		
	STM32F051Rx	STM32F051Cx	STM32F051Kx
G1	3	3	3
G2	3	3	3
G3	3	2	2
G4	3	3	3
G5	3	3	3
G6	3	3	0
Number of capacitive sensing channels	18	17	14

STM32F302/303 TSC Overview

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- Supports up to **24** capacitive sensing channels split over **8** analog I/O groups
- **10.2 MHz** maximum charge transfer frequency

Analog I/O group	Number of capacitive sensing channels		
	STM32F30xVx	STM32F30xRx	STM32F30xCx
G1	3	3	3
G2	3	3	3
G3	3	3	2
G4	3	3	3
G5	3	3	3
G6	3	3	3
G7	3	0	0
G8	3	0	0
Number of capacitive sensing channels	24	18	17



STM32F372/373 TSC Overview

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- Supports up to **24** capacitive sensing channels split over **8** analog I/O groups
- **10.2 MHz** maximum charge transfer frequency

Analog I/O group	Number of capacitive sensing channels		
	STM32F37xVx	STM32F37xRx	STM32F37xCx
G1	3	3	3
G2	3	3	2
G3	3	3	1
G4	3	3	3
G5	3	3	3
G6	3	2	2
G7	3	0	0
G8	3	0	0
Number of capacitive sensing channels	24	17	14



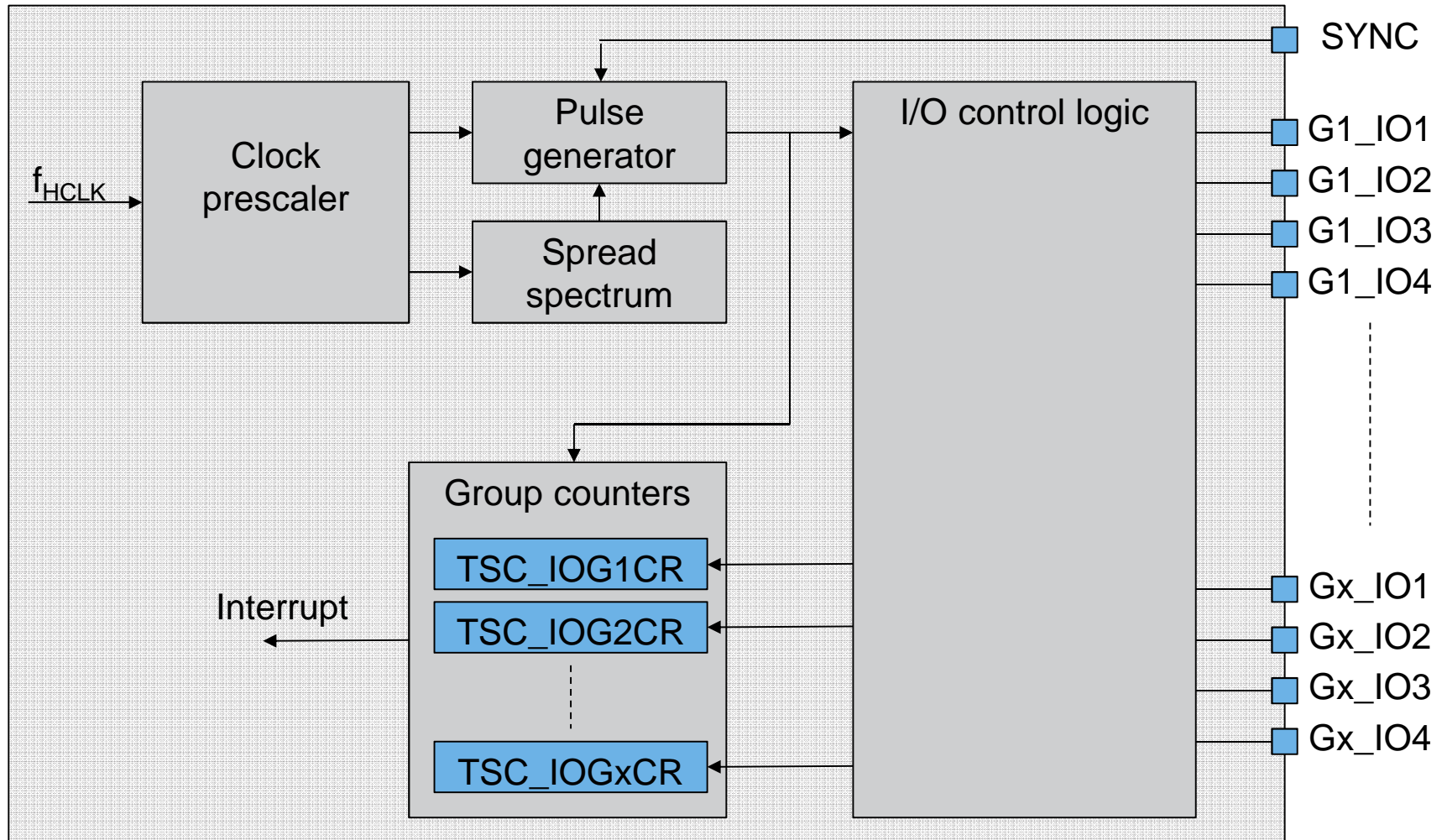
STM32L4 TSC Overview

- Supports up to **24** capacitive sensing channels split over **8** analog I/O groups
- **16 MHz** maximum charge transfer frequency

Analog I/O group	Number of capacitive sensing channels		
	STM32L486Zx STM32L486Qx STM32L476Zx STM32L476Qx STM32L471Zx STM32L471Qx	STM32L486Vx STM32L476Vx STM32L471Vx	STM32L486Jx STM32L486Rx STM32L476Jx STM32L476Rx STM32L471Jx STM32L471Rx
G1	3	3	3
G2	3	3	3
G3	3	3	0
G4	3	3	3
G5	3	3	0
G6	3	3	0
G7	3	3	3
G8	3	0	0
Number of capacitive sensing channels	24	21	12

TSC Block Diagram

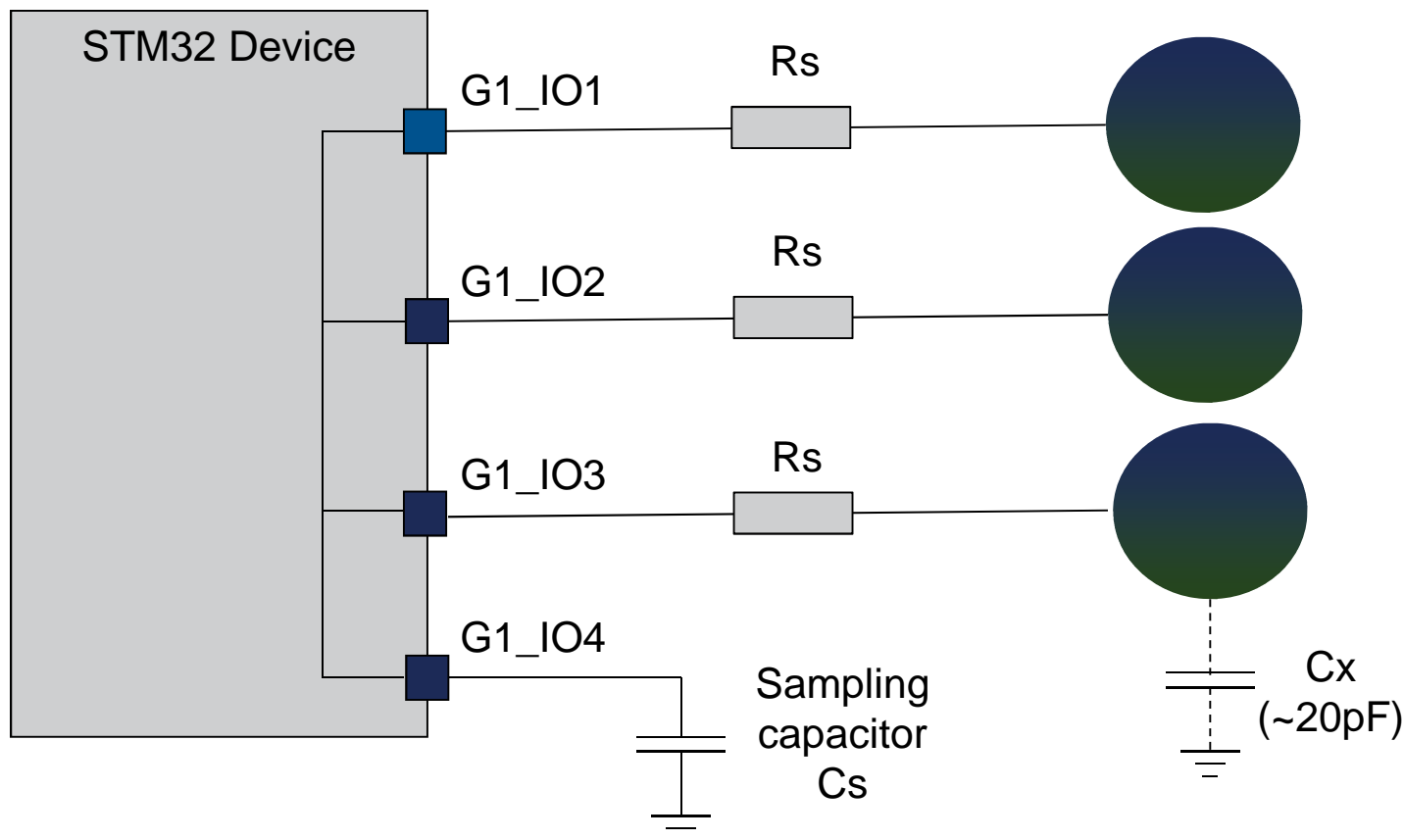
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Charge Transfer Measuring Circuit

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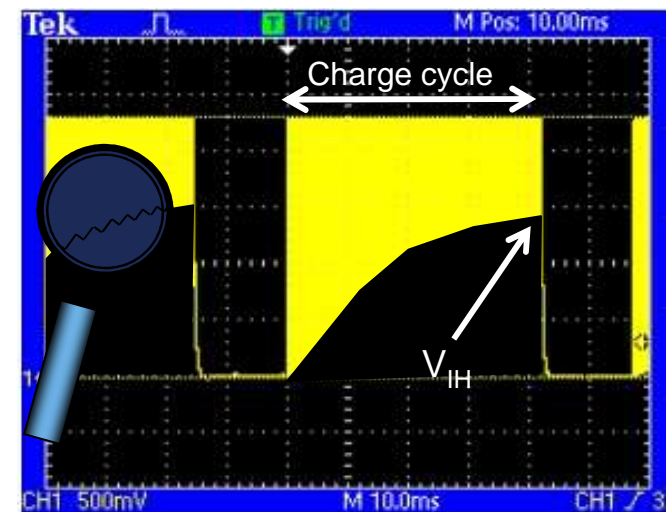
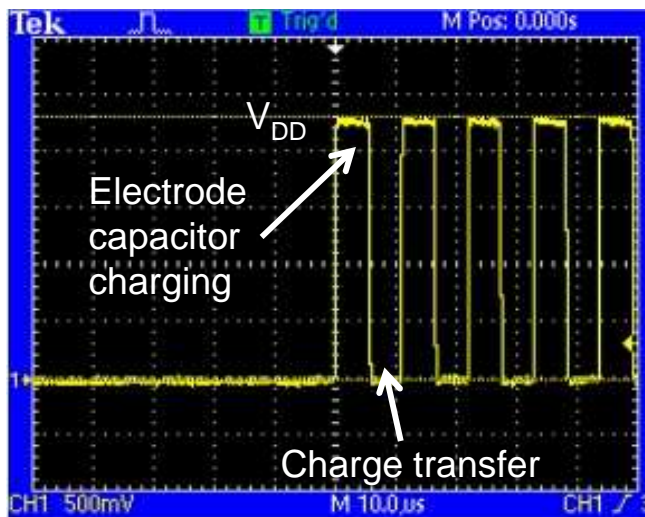
- R_s is used to improve ESD robustness (typically 1K)
- C_s sampling capacitor value depends on the required channels sensitivity
 - Higher C_s value is, higher the sensitivity but longer the acquisition time is



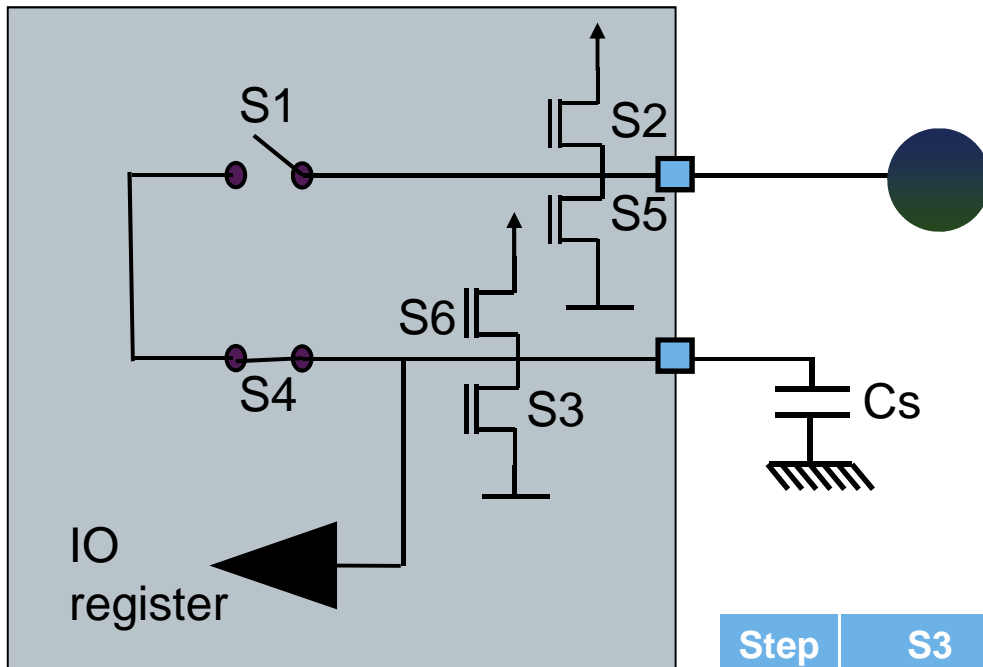
Charge Transfer Acquisition Overview

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- Charge transfer uses the electrical properties of the capacitor charge Q
- It uses a **sampling capacitor (C_S)** in which the **electrode (C_X)** charges are transferred to
- Charge Transfer is performed through analog switches directly embedded into the GPIO
- The charge transfer cycle is repeated N times until the voltage on the sampling capacitor reaches the **V_{IH} threshold** of the GPIO it is connected to
- The number N of transfer cycles required to reach the threshold represents the size of C_X
 - The number of transfer decreases when the electrode is touched.



Charge Transfer Acquisition Sequence



S4 closed for the whole acquisition
 S5 & S6 opened for the whole acquisition

Step	S3	S2	S1	Description
1	Closed	Opened	Closed	Cs discharge
2	Opened	Opened	Opened	Deadtime
3	Opened	Closed	Opened	Charge cycle (Cx charge)
4	Opened	Opened	Opened	Deadtime
5	Opened	Opened	Closed	Transfer cycle (charge transferred to Cs)
6	Opened	Opened	Opened	Deadtime
7	Closed	Opened	Closed	Cx discharge

Repeat until Vcs is read as a logical '1'

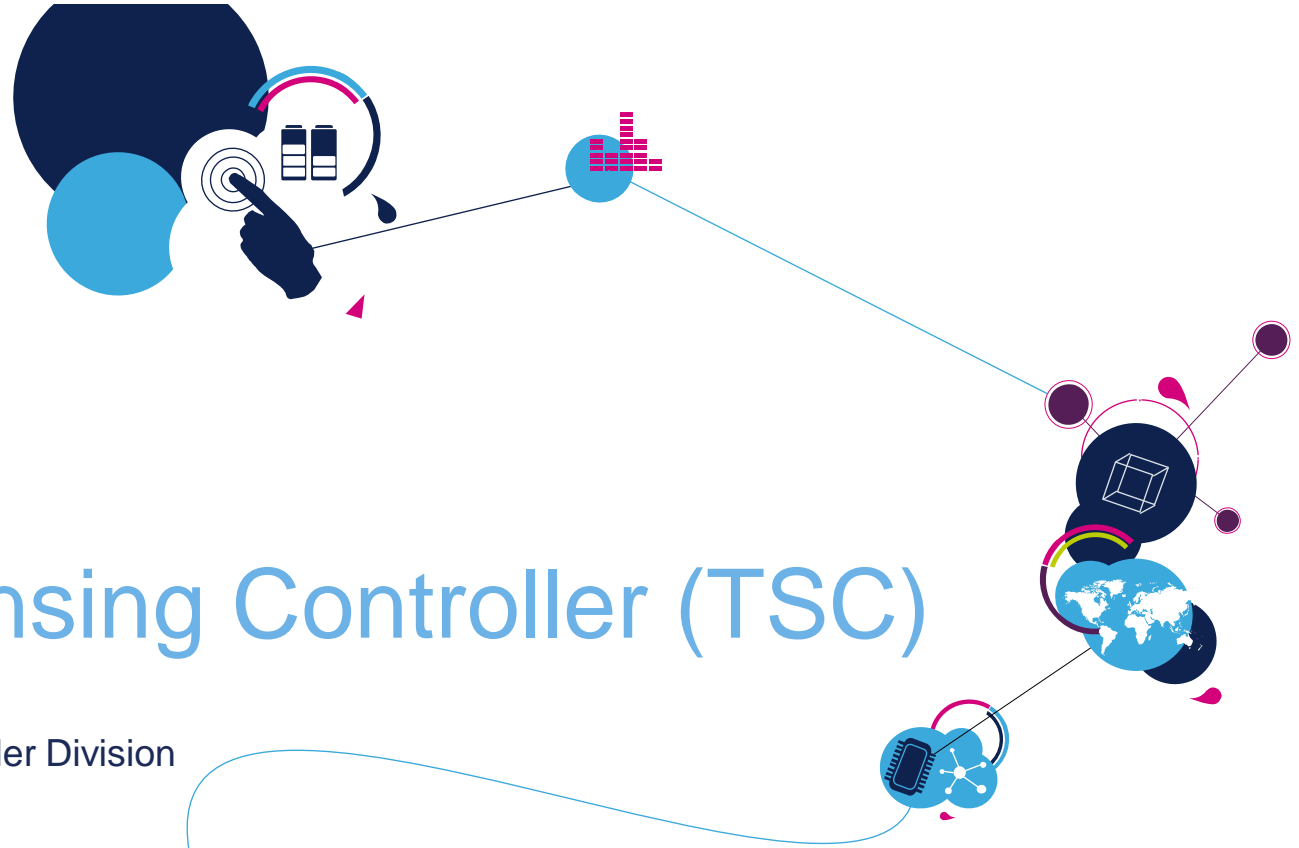
GPIO Analog Switch and Hysteresis Control

- In addition to the management of charge transfer acquisition, the touch sensing controller provides a manual control for both the embedded analog switch and hysteresis of the GPIOs belonging to the analog I/O groups.
- This could be useful to implement a different capacitive sensing acquisition principle of for others purpose (ie: analog multiplexor).

STM32 Touch Sensing Library

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- Complete **free C source code library** with firmware application examples
 - Available in corresponding STM32Cube packages
- Support of **proximity, touchkey, linear and rotary touch sensors**
- **Multifunction capability** to combine capacitive sensing functions with traditional MCU features
- **Enhanced processing features for optimized sensitivity and immunity**
 - Calibration, environment control system (ECS), debounce filtering , detection exclusion system (DxS), ...
- **Complete and simple API** for status reporting and application configuration
- **Compliant with MISRA**
- **Compliant with all STM32 C compilers**



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