



NXP MCX N Series High Performance Microcontrollers User Guide

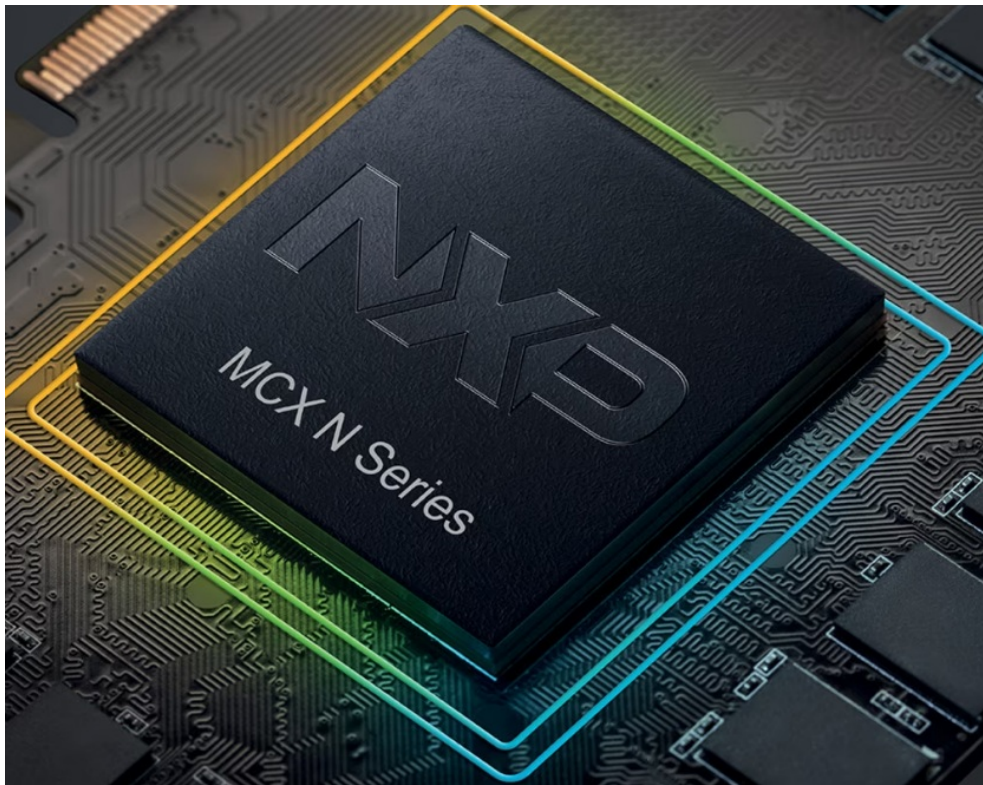
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NXP MCX N Series High Performance Microcontrollers



Product Information

- **Specifications:**

- **Model:** MCX Nx4x TSI
- **Touch Sensing Interface (TSI)** for capacitive touch sensors
- **MCU:** Dual Arm Cortex-M33 cores operating up to 150 MHz
- **Touch Sensing Methods:** Self-capacitance mode and Mutual-capacitance mode
- **Number of Touch Channels:** Up to 25 for self-cap mode, up to 136 for mutual-cap mode

Product Usage Instructions

- **Introduction:**

- The MCX Nx4x TSI is designed to provide touch-sensing capabilities on capacitive touch sensors using the TSI module.

- **MCX Nx4x TSI Overview:**

- The TSI module supports two touch sensing methods: self-capacitance and mutual capacitance.

- **MCX Nx4x TSI Block Diagram:**

- The TSI module has 25 touch channels, with 4 shield channels to enhance drive strength. It supports self-cap and mutual-cap modes on the same PCB.

- **Self-Capacitive Mode:**

- Developers can use up to 25 self-cap channels to design touch electrodes in self-cap mode.

- **Mutual-Capacitive Mode:**

- Mutual-cap mode allows for up to 136 touch electrodes, providing flexibility for touch key designs like touch keyboards and touchscreens.

- **Usage Recommendations:**

- Ensure proper connection of sensor electrodes to the TSI input channels via I/O pins.

- Utilize shield channels for enhanced liquid tolerance and driving ability.
- Consider design requirements when choosing between self-cap and mutual-cap modes.

FAQs

- **Q: How many touch channels does the MCX Nx4x TSI module have?**
 - **A:** The TSI module has 25 touch channels, with 4 shield channels for enhanced drive strength.
- **Q: What design options are available for touch electrodes in mutual-capacitive mode?**
 - **A:** Mutual-cap mode supports up to 136 touch electrodes, providing flexibility for various touch key designs such as touch keyboards and touchscreens.

Document Information

Information	Content
Keywords	MCX, MCX Nx4x, TSI, touch.
Abstract	The Touch Sensing Interface (TSI) of the MCX Nx4x series is the upgraded IP with new features to implement the baseline/threshold autotuning.

Introduction

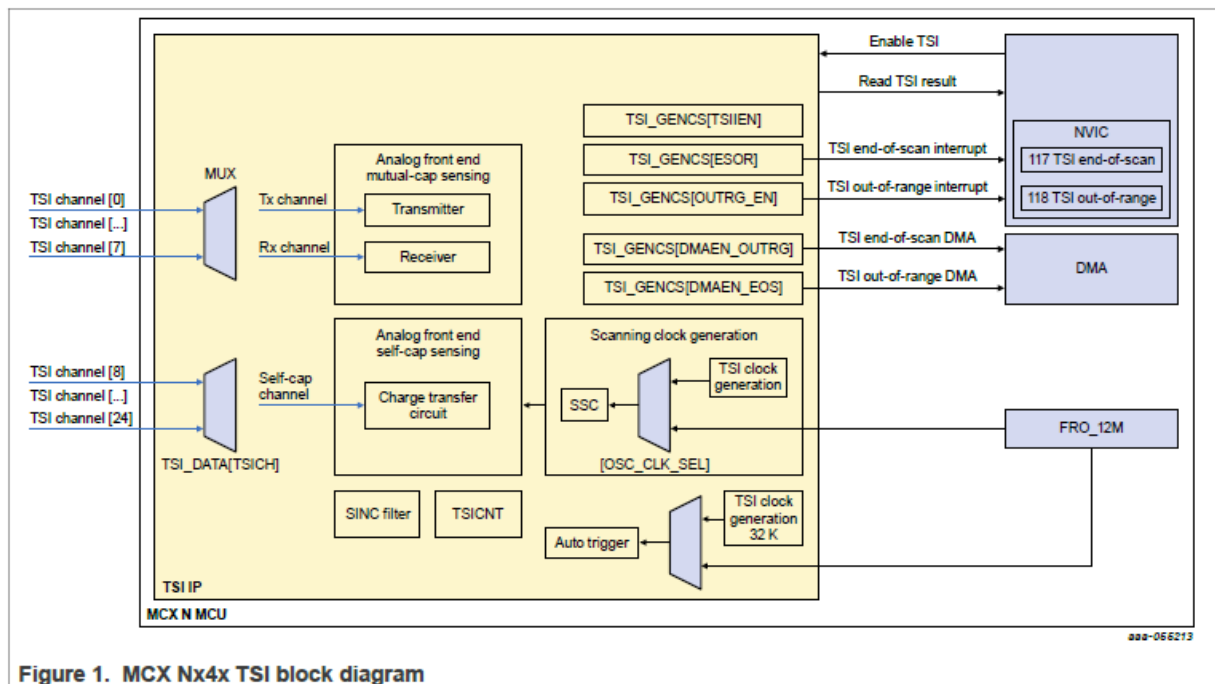
- The MCX N series of the Industrial and IoT (IIoT) MCU features dual Arm Cortex-M33 cores operates up to 150 MHz.
- The MCX N series are high-performance, low-power microcontrollers with intelligent peripherals and accelerators providing multitasking capabilities and performance efficiency.
- The Touch Sensing Interface (TSI) of the MCX Nx4x series is the upgraded IP with new features to implement the baseline/threshold autotuning.

MCX Nx4x TSI overview

- TSI provides touch-sensing detection on capacitive touch sensors. The external capacitive touch sensor is typically formed on PCB and the sensor electrodes are connected to the TSI input channels through the I/O pins in the device.

MCX Nx4x TSI block diagram

- MCX Nx4x has one TSI module and supports 2 kinds of touch sensing methods, the self-capacitance (also called self-cap) mode and the mutual-capacitance (also called mutual-cap) mode.
- The block diagram of MCX Nx4x TSI is shown in Figure 1:



- The TSI module of MCX Nx4x has 25 touch channels. 4 of these channels can be used as shield channels to enhance the drive strength of touch channels.
- The 4 shield channels are used to enhance the liquid tolerance and improve the driving ability. The enhanced driving ability also enables users to design a larger touchpad on the hardware board.
- The TSI module of MCX Nx4x has up to 25 touch channels for self-cap mode and 8 x 17 touch channels for mutual-cap mode. Both mentioned methods can be combined on a single PCB, but the TSI channel is more flexible for Mutual-cap mode.
- The TSI[0:7] are TSI Tx pins and the TSI[8:25] are TSI Rx pins in Mutual-cap mode.
- In self-capacitive mode, developers can use 25 self-cap channels to design 25 touch electrodes.
- In mutual-capacitive mode, design options expand to up to 136 (8 x 17) touch electrodes.
- Several use cases such as a multiburner induction cooker with touch controls, touch keyboards, and touchscreen, require a lot of touch key design. The MCX Nx4x TSI can support up to 136 touch electrodes when mutual-cap channels are used.
- The MCX Nx4x TSI can expand more touch electrodes to meet the requirements of multiple touch electrodes.
- Some new features have been added to make the IP easier to use in low-power mode. TSI has advanced EMC robustness, which makes it suitable for use in industrial, home appliance, and consumer electronics applications.

MCX Nx4x parts supported TSI

Table 1 shows the number of TSI channels corresponding to different parts of the MCX Nx4x series. All these parts support one TSI module that has 25 channels.

Table 1. MCX Nx4x parts supporting TSI module

Parts	Frequency [Max] (MHz)	Flash (MB)	SRAM (kB)	TSI [Number, channels]	GPIOs	Package type
MCXN546VDFT	150	1	352	1 x 25	124	VFBGA184
MCXN546VNLT	150	1	352	1 x 25	74	HLQFP100
MCXN547VDFT	150	2	512	1 x 25	124	VFBGA184
MCXN547VNLT	150	2	512	1 x 25	74	HLQFP100
MCXN946VDFT	150	1	352	1 x 25	124	VFBGA184
MCXN946VNLT	150	1	352	1 x 25	78	HLQFP100
MCXN947VDFT	150	2	512	1 x 25	124	VFBGA184
MCXN947VNLT	150	2	512	1 x 25	78	HLQFP100

MCX Nx4x TSI channel assignment on different packages

Table 2. TSI channel assignment for MCX Nx4x VFBGA and LQFP packages

184BGA ALL	184BGA AL L pin name	100HLQFP N94X	100HLQFP N94X pin name	100HLQFP N54X	100HLQFP N54X pin name	TSI channel
A1	P1_8	1	P1_8	1	P1_8	TSI0_CH17/ADC1_A8
B1	P1_9	2	P1_9	2	P1_9	TSI0_CH18/ADC1_A9
C3	P1_10	3	P1_10	3	P1_10	TSI0_CH19/ADC1_A10
D3	P1_11	4	P1_11	4	P1_11	TSI0_CH20/ADC1_A11
D2	P1_12	5	P1_12	5	P1_12	TSI0_CH21/ADC1_A12
D1	P1_13	6	P1_13	6	P1_13	TSI0_CH22/ADC1_A13
D4	P1_14	7	P1_14	7	P1_14	TSI0_CH23/ADC1_A14
E4	P1_15	8	P1_15	8	P1_15	TSI0_CH24/ADC1_A15
B14	P0_4	80	P0_4	80	P0_4	TSI0_CH8
A14	P0_5	81	P0_5	81	P0_5	TSI0_CH9
C14	P0_6	82	P0_6	82	P0_6	TSI0_CH10
B10	P0_16	84	P0_16	84	P0_16	TSI0_CH11/ADC0_A8

Table 2. TSI channel assignment for MCX Nx4x VFBGA and LQFP packages...continued

184BGA ALL	184BGA AL L pin name	100HLQF P N94X	100HLQF P N94X p in name	100HLQF P N54X	100HLQF P N54X pi n name	TSI channel
A10	P0_17	85	P0_17	85	P0_17	TSI0_CH12/ADC0_A9
C10	P0_18	86	P0_18	86	P0_18	TSI0_CH13/ADC0_A10
C9	P0_19	87	P0_19	87	P0_19	TSI0_CH14/ADC0_A11
C8	P0_20	88	P0_20	88	P0_20	TSI0_CH15/ADC0_A12
A8	P0_21	89	P0_21	89	P0_21	TSI0_CH16/ADC0_A13
C6	P1_0	92	P1_0	92	P1_0	TSI0_CH0/ADC0_A16/CMP0_IN 0
C5	P1_1	93	P1_1	93	P1_1	TSI0_CH1/ADC0_A17/CMP1_IN 0
C4	P1_2	94	P1_2	94	P1_2	TSI0_CH2/ADC0_A18/CMP2_IN 0
B4	P1_3	95	P1_3	95	P1_3	TSI0_CH3/ADC0_A19/CMP0_IN 1
A4	P1_4	97	P1_4	97	P1_4	TSI0_CH4/ADC0_A20/CMP0_IN 2
B3	P1_5	98	P1_5	98	P1_5	TSI0_CH5/ADC0_A21/CMP0_IN 3
B2	P1_6	99	P1_6	99	P1_6	TSI0_CH6/ADC0_A22
A2	P1_7	100	P1_7	100	P1_7	TSI0_CH7/ADC0_A23

Figure 2 and Figure 3 show the assignment of dual TSI channels on the two packages of MCX Nx4x. In the two packages, the pins marked in green are the location of the TSI channel distribution. To make a reasonable pin assignment for hardware touch board design, refer to pin location.

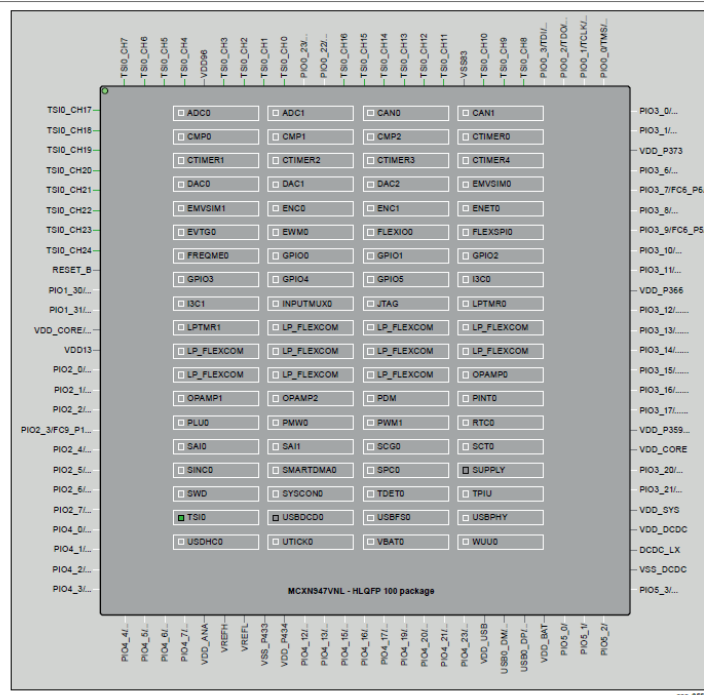


Figure 2. TSI channel assignment of MCX Nx4x 100LQFP and 164VFBGA

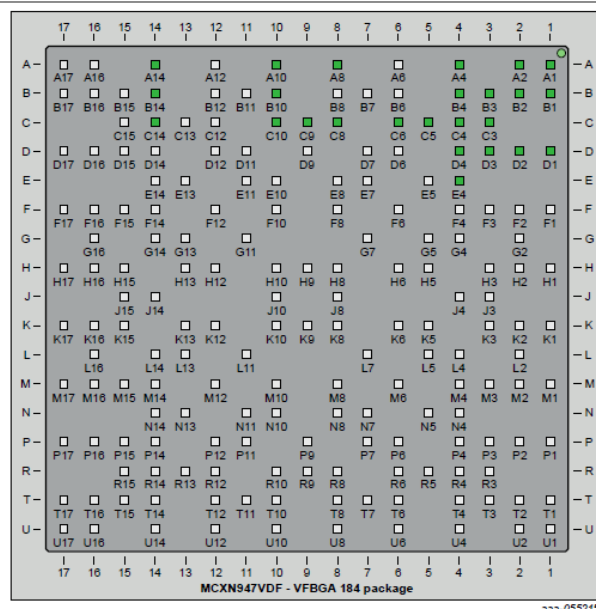


Figure 3. TSI channel assignment of MCX Nx4x 100LQFP and 164VFBGA

MCX Nx4x TSI features

- This section gives the details of MCX Nx4x TSI features.

TSI comparison between MCX Nx4x TSI and Kinetis TSI

- MCX Nx4x of TSI and TSI on the NXP Kinetis E series TSI are designed on different technology platforms.
- Therefore, from the basic features of TSI to the registers of TSI, there are differences between MCX Nx4x TSI and TSI of the Kinetis E series. Only the differences are listed in this document. To check the TSI registers, use the reference manual.
- This chapter describes the features of MCX Nx4x TSI by comparing it to the TSI of the Kinetis E series.
- As shown in Table 3, MCX Nx4x TSI is not affected by the VDD noise. It has more function clock choices.
- If the function clock is configured from the chip system clock, the TSI power consumption can be decreased.

- Even though the MCX Nx4x TSI has only one TSI module, it supports designing more hardware touch keys on a hardware board when using mutual-cap mode.

Table 3. The difference between MCX Nx4x TSI and Kinetis E TSI (KE17Z256)

	MCX Nx4x series	Kinetis E series
Operating voltage	1.71 V – 3.6 V	2.7 V – 5.5 V
VDD noise impact	No	Yes
Function clock source	<ul style="list-style-type: none"> • TSI IP internally generated • Chip system clock 	TSI IP internally generated
Function clock range	30 KHz – 10 MHz	37 KHz – 10 MHz
TSI channels	Up to 25 channels (TSI0)	Up to 50 channels (TSI0, TSI1)
Shield channels	4 shield channels: CH0, CH6, CH12, CH18	3 shield channels for each TSI: CH 4, CH12, CH21
Touch mode	Self-cap mode: TSI[0:24]	Self-cap mode: TSI[0:24]

	MCX Nx4x series	Kinetis E series
	Mutual-cap mode: Tx[0:7], Rx[8:24]	Mutual-cap mode: Tx[0:5], Rx[6:12]
Touch electrodes	self-cap electrodes: up to 25 mutual-cap electrodes: up to 136 (8×17)	self-cap electrodes: up to 50 (25+25) mutual-cap electrodes: up to 72 (6×6 +6×6)
Products	MCX N9x and MCX N5x	KE17Z256

The features supported both by MCX Nx4x TSI and Kinetis TSI are shown in Table 4.

Table 4. The features supported both by MCX Nx4x TSI and Kinetis TSI

	MCX Nx4x series	Kinetis E series
Two kinds of Sensing mode	Self-cap mode: Basic self-cap mode Sensitivity boost mode Noise cancellation mode Mutual-cap mode: Basic mutual-cap mode Sensitivity boost enable	
Interrupt support	End of scan interrupt Out of range interrupt	
Trigger source support	1. Software trigger by writing the GENCS[SWTS] bit 2. Hardware trigger through INPUTMUX 3. Automatic trigger by AUTO_TRIG[TRIG_EN]	1. Software trigger by writing the GENCS[SWTS] bit 2. Hardware trigger through INPUTMUX
Low-power support	Deep Sleep: fully functions when GENCS[STPE] is set to 1 Power Down: If the WAKE domain is active, TSI can operate as in “Deep Sleep” mode. Deep Power Down, VBAT: not available	STOP mode, VLPS mode: fully functioning when GENCS[STPE] is set to 1.
Low-power wakeup	Each TSI channel can wake up the MCU from low-power mode.	
DMA support	The out-of-range event or end-of-scan event can trigger the DMA transfer.	
Hardware noise filter	SSC reduces the frequency noise and promotes the signal-to-noise ratio (PRBS mode, up-down counter mode).	

MCX Nx4x TSI new features

Some new features are added to MCX Nx4x TSI. The most significant are listed in the table below. MCX Nx4x TSI provides a richer range of features for users. Like the functions of Baseline auto trace, Threshold auto trace, and Debounce, these features can realize some hardware calculations. It saves software development resources.

Table 5. MCX Nx4x TSI new features

	MCX Nx4x series
1	Proximity channels merge function
2	Baseline auto-trace function
3	Threshold auto-trace function
4	Debounce function
5	Automatic trigger function
6	Clock from the chip system clock
7	Test finger function

MCX Nx4x TSI function description

Here is the description of these newly added features:

1. The proximity channels merge function

- The proximity function is used to merge multiple TSI channels for scanning. Configure TSI0_GENCS[S_PROX_EN] to 1 to enable the proximity mode, the value in TSI0_CONFIG[TSICH] is invalid, it is not used to select a channel in proximity mode.
- The 25-bit register TSI0_CHMERGE[CHANNEL_ENABLE] is configured to select multiple channels, the 25-bit controls the selection of 25 TSI channels. It can select up to 25 channels, by configuring the 25 bits to 1 (1_1111_1111_1111_1111_1111b). When a trigger occurs, the multiple channels selected by TSI0_CHMERGE[CHANNEL_ENABLE] are scanned together and generate one set of the TSI scan values. The scan value can be read from register TSI0_DATA[TSICNT]. The proximity merge function theoretically integrates the capacitance of the multiple channels and then starts scanning, which is only valid in self-cap mode. The more touch channels merged can get a shorter scanning time, the smaller the scanning value, and the poorer the sensitivity. Therefore, when touch detects, more touch capacitance is needed to get the higher sensitivity. This function is suitable for large-area touch detection and large-area proximity detection.

2. Baseline auto-trace function

- The TSI of MCX Nx4x provides the register to set the baseline of TSI and the baseline trace function. After the TSI channel software calibration is complete, fill in an initialized baseline value in the TSI0_BASELINE[BASELINE] register. The initial baseline of the touch channel in the TSI0_BASELINE[BASELINE] register is written in the software by the user. The setting of the baseline is valid only for one channel. The baseline trace function can adjust the baseline in the TSI0_BASELINE[BASELINE] register to make it close to the TSI current sample value. The baseline trace enable function is enabled by the TSI0_BASELINE[BASE_TRACE_EN] bit, and the auto trace ratio is set in the register TSI0_BASELINE[BASE_TRACE_DEBOUNCE]. The baseline value is increased or decreased automatically, the change value for each increase/decrease is $\text{BASELINE} * \text{BASE_TRACE_DEBOUNCE}$. The baseline trace function is only enabled in low-power mode and the setting is valid only for one channel. When the touch channel is changed, the baseline-related registers must be reconfigured.

3. Threshold auto-trace function

- The threshold can be calculated by the IP internal hardware if the threshold trace is enabled by configuring the TSI0_BASELINE[THRESHOLD_TRACE_EN] bit to 1. The calculated threshold value is loaded to threshold register TSI0_TSHD. To get the desired threshold value, select the threshold ratio in TSI0_BASELINE[THRESHOLD_RATIO]. The threshold of the touch channel is calculated according to the below formula in the IP internal. Threshold_H: $\text{TSI0_TSHD}[\text{THRESH}] = [\text{BASELINE} + \text{BASELINE} \gg (\text{THRESHOLD_RATIO}+1)]$ Threshold_L: $\text{TSI0_TSHD}[\text{THRESL}] = [\text{BASELINE} - \text{BASELINE} \gg (\text{THRESHOLD_RATIO}+1)]$ BASELINE is the value in TSI0_BASELINE[BASELINE].

4. Debounce function

- MCX Nx4x TSI provides the hardware debounce function, the TSI_GENCS[DEBOUNCE] can be used to configure the number of out-of-range events that can generate an interrupt. Only the out-of-range interrupt event mode supports the debounce function and the end-of-scan interrupt event does not support it.

5. Automatic trigger function.

- There are three trigger sources of TSI, including the software trigger by writing the TSI0_GENCS[SWTS]

bit, the hardware trigger through INPUTMUX, and the automatic trigger by TSI0_AUTO_TRIG[TRIG_EN]. Figure 4 shows the automatically trigger-generated progress.

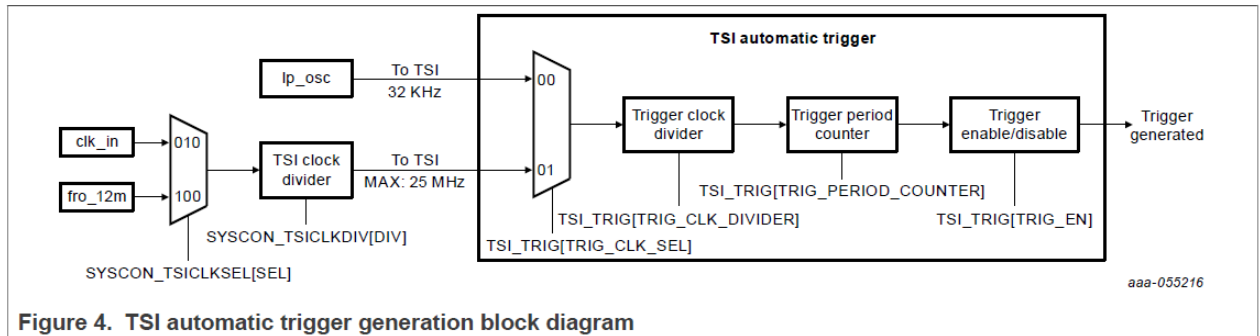


Figure 4. TSI automatic trigger generation block diagram

- The automatic trigger function is a new feature in MCX Nx4x TSI. This feature is enabled by setting TSI0_AUTO_TRIG[TRIG_EN] to 1. Once the automatic trigger is enabled, the software trigger and hardware trigger configuration in TSI0_GENCS[SWTS] is invalid. The period between each trigger can be calculated by the below formula:
- Timer period between each trigger = trigger clock/trigger clock divider * trigger clock counter.
- Trigger clock: configure TSI0_AUTO_TRIG[TRIG_CLK_SEL] to select the automatic trigger clock source.
- Trigger clock divider: configure TSI0_AUTO_TRIG[TRIG_CLK_DIVIDER] to select the trigger clock divider.
- Trigger clock counter: configure TSI0_AUTO_TRIG[TRIG_PERIOD_COUNTER] to configure the trigger clock counter value.
- For the clock of the automatic trigger clock source, one is the Ip_osc 32k clock, another is the FRO_12Mhz clock or the clk_in clock can be selected by TSICKSEL[SEL], and divided by TSICKDIV[DIV].

6. Clock from chip system clock

- Usually, Kinetis E series TSI provides an internal reference clock to generate the TSI functional clock.
- For the TSI of MCX Nx4x, the operating clock cannot only be from the IP internal, but it can be from the chip system clock. MCX Nx4x TSI has two function clock source choices (by configuring TSICKSEL[SEL]).
- As shown in Figure 5, one from the chip system clock can decrease the TSI operating power consumption, another is generated from the TSI internal oscillator. It can decrease the jitter of the TSI operating clock.

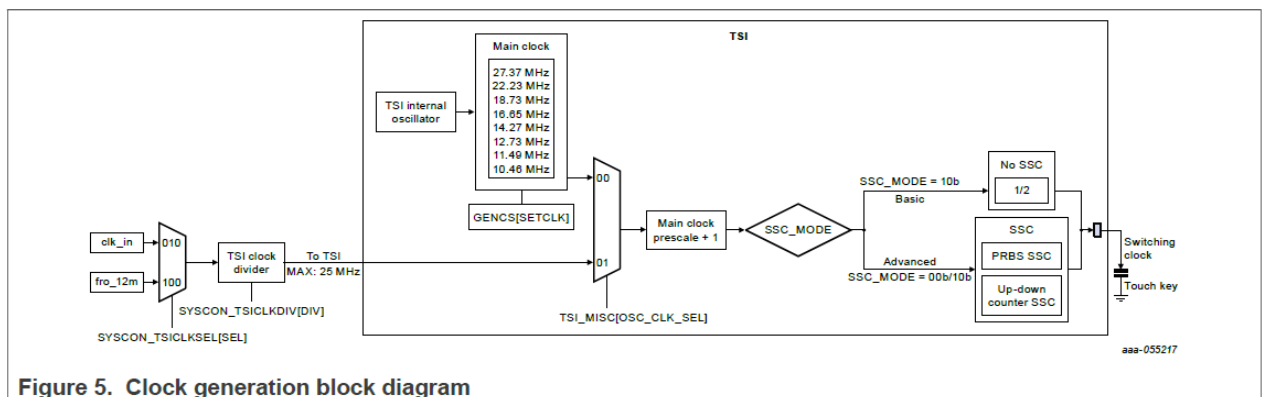


Figure 5. Clock generation block diagram

- FRO_12 MHz clock or the clk_in clock is the TSI function clock source, it can be selected by TSICKSEL[SEL] and divided by TSICKDIV[DIV].

7. Test finger function

- MCX Nx4x TSI provides the test finger function that can simulate a finger touch without a real finger touch on the hardware board by configuring the related register.

- This function is useful during the code debug and hardware board test.
- The strength of the TSI test finger can be configured by TSI0_MISC[TEST_FINGER], the user can change the touch strength through it.
- There are 8 options for the finger capacitance: 148pF, 296pF, 444pF, 592pF, 740pF, 888pF, 1036pF, 1184pF. The test finger function is enabled by configuring TSI0_MISC[TEST_FINGER_EN] to 1.
- The user can use this function to calculate the hardware touchpad capacitance, the TSI parameter debug, and do the software safety /failure tests (FMEA). In the software code, configure the finger capacitance first and then enable the test finger function.

Example use case of MCX Nx4x TSI new function

MCX Nx4x TSI has a feature for the low-power use case:

- Use the chip system clock to save the IP power consumption.
- Use the automatic trigger function, proximity channels merge function, baseline auto trace function, threshold auto trace function, and debounce function to do an easy low-power wake-up use case.

MCX Nx4x TSI hardware and software support

- NXP has four kinds of hardware boards to support the MCX Nx4x TSI evaluation.
- The X-MCX-N9XX-TSI board is the internal evaluation board, contract FAE/Marketing to request it.
- The other three boards are NXP official release boards and can be found on the [NXP](#) web where the user can download the officially supported software SDK and touch library.

MCX Nx4x series TSI evaluation board

- NXP provides evaluation boards to help users to evaluate the TSI function. The following is the detailed board information.

X-MCX-N9XX-TSI board

- The X-MCX-N9XX-TSI board is a touch sensing reference design including multiple touch patterns based on the NXP high-performance MCX Nx4x MCU that has one TSI module and supports up to 25 touch channels demonstrated on the board.
- The board can be used to evaluate the TSI function for the MCX N9x and N5x series MCU. This product has passed the IEC61000-4-6 3V certification.

NXP Semiconductors

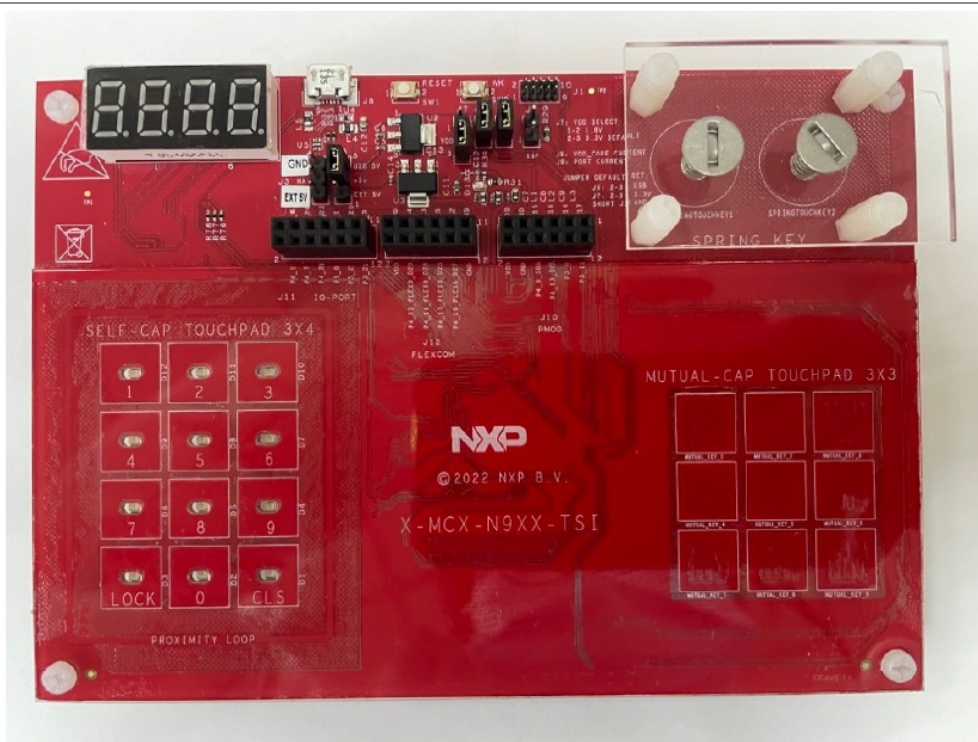


Figure 6. X-MCX-N9XX-TSI, MCX N5/N9 dedicated TSI evaluation board

MCX-N5XX-EVK

[MCX-N5XX-EVK](#) provides the touch slider on the board, and it is compatible with the FRDM-TOUCH board. NXP provides a touch library to realize the functions of keys, slider, and rotary touches.

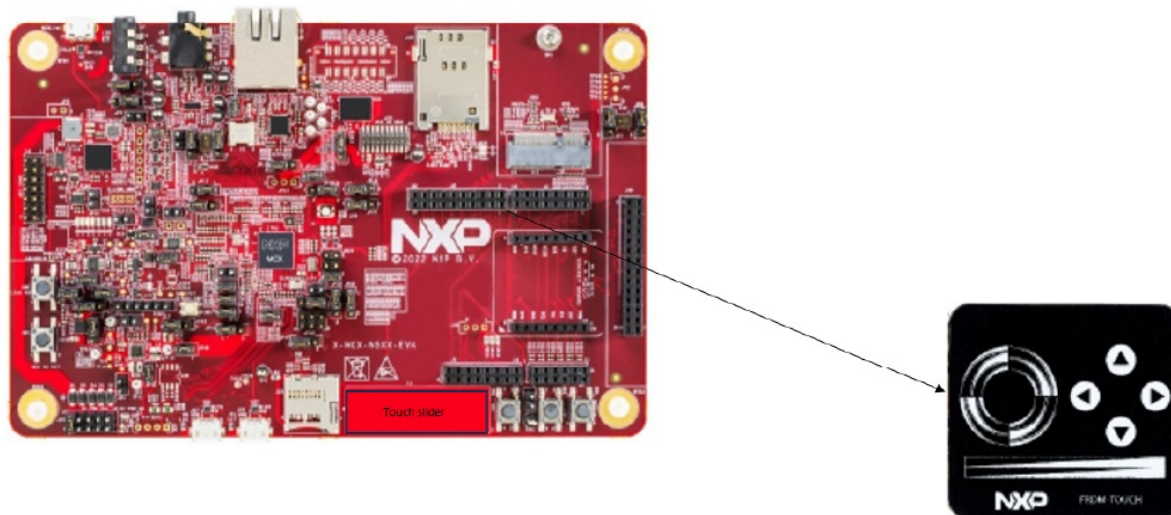


Figure 7. MCX-N5XX-EVK with touch

MCX-N9XX-EVK

[MCX-N9XX-EVK](#) provides the touch slider on the board, and it is compatible with the FRDM-TOUCH board. NXP provides a touch library to realize the functions of keys, slider, and rotary touches.



Figure 8. MCX-N9XX-EVK with touch

FRDM-MCXN947

[FRDM-MCXN947](#) provides a one-touch key on the board and it is compatible with the FRDM-TOUCH board. NXP provides a touch library to realize the functions of keys, slider, and rotary touches.

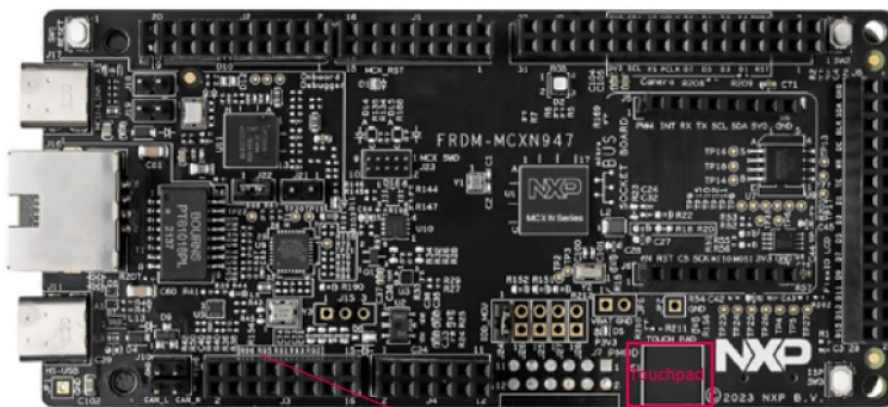


Figure 9. FRDM-MCXN947 with touch

NXP touch library support for MCX Nx4x TSI

- NXP offers a touch software library free of charge. It provides all the software required to detect touches and to implement more advanced controllers like sliders or keypads.
- TSI background algorithms are available for touch keypads and analog decoders, sensitivity auto-calibration, low-power, proximity, and water tolerance.
- The SW is distributed in source code form in "object C language code structure". A touch tuner tool based on FreeMASTER is provided for TSI configuration and tune.

SDK build and touch library download

- The user can build an SDK of MCX hardware boards from <https://mcuxpresso.nxp.com/en/welcome>, add the touch library to the SDK, and download the package.
- The process is shown in Figure 10, Figure 11, and Figure 12.

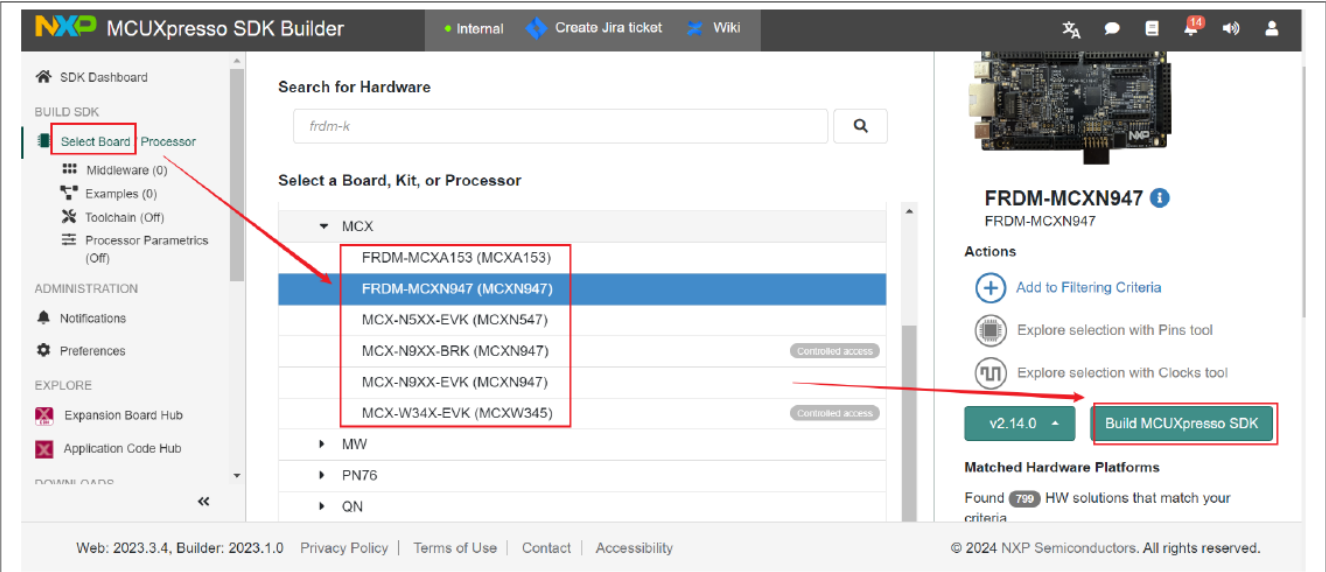


Figure 10. Build MCUXpresso SDK for selected board

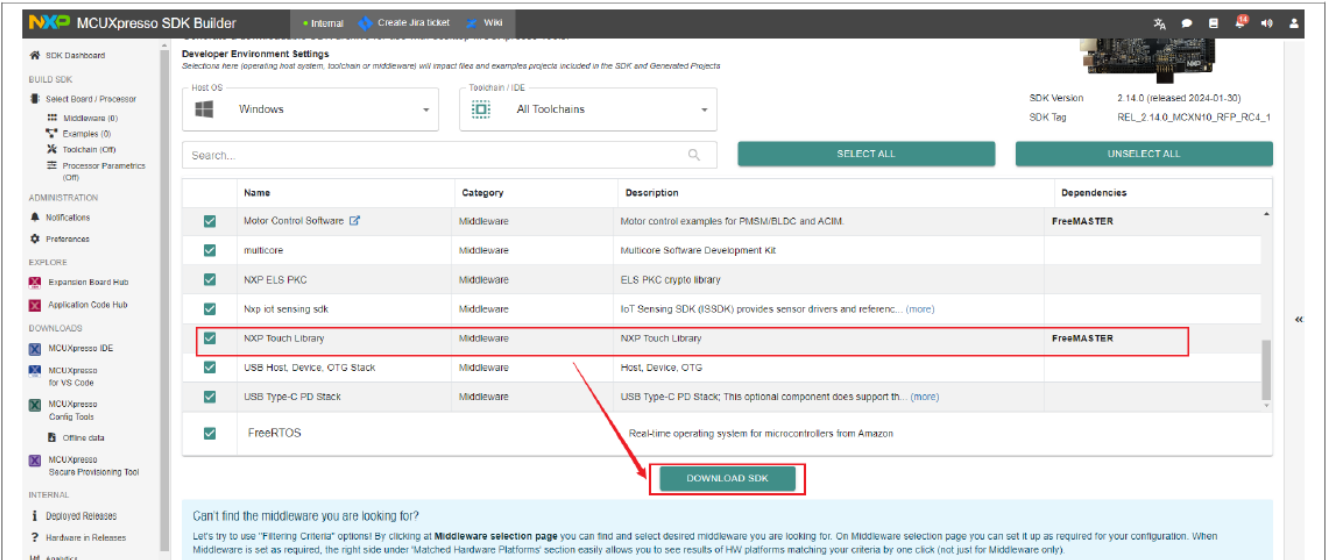


Figure 11. Add the touch library to SDK

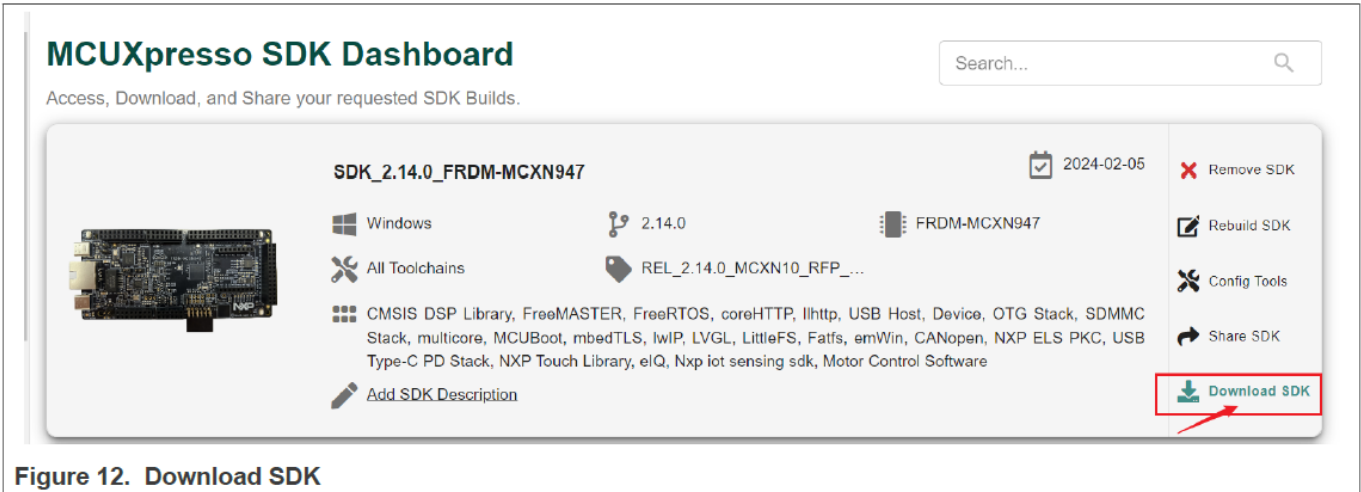
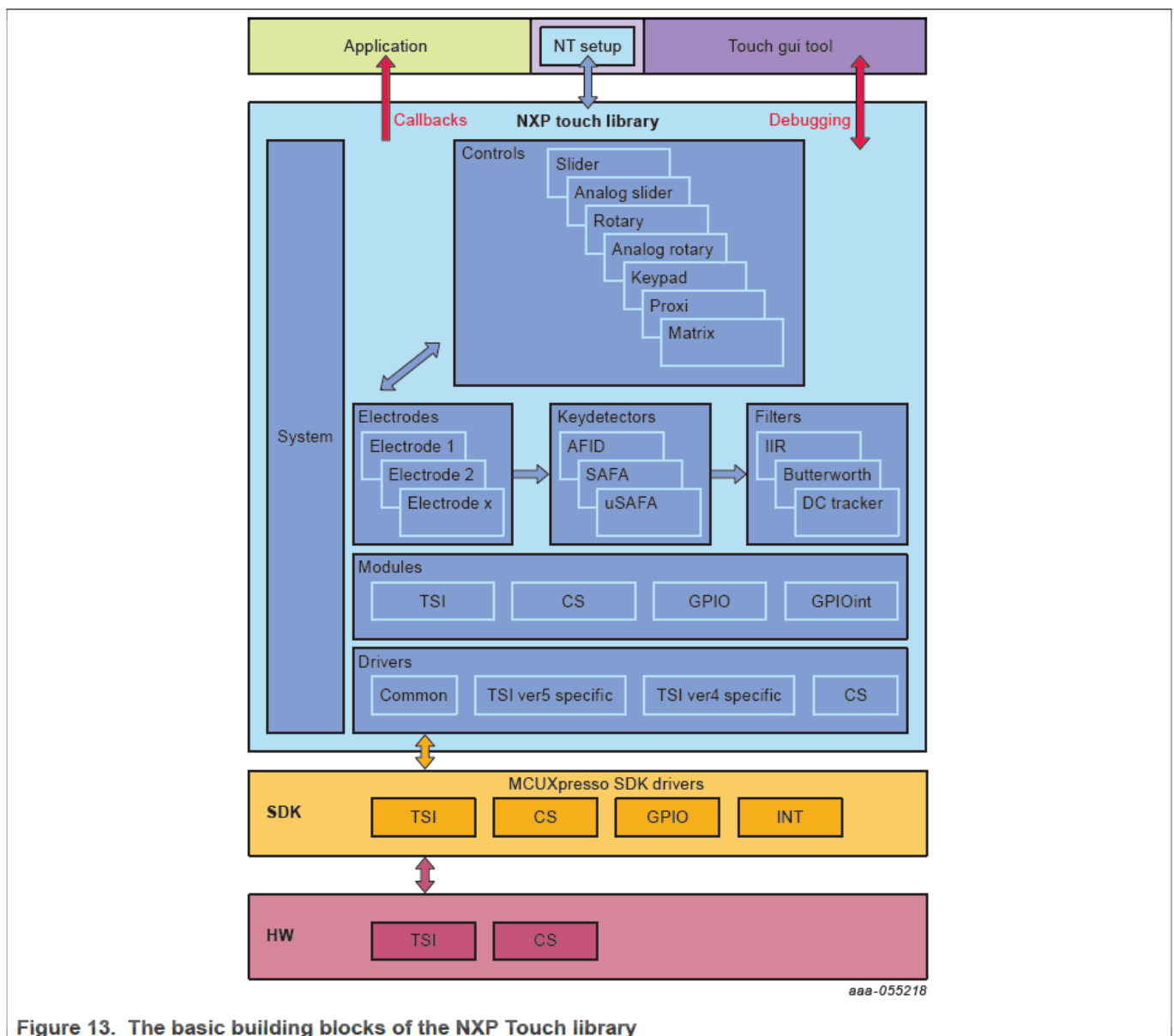


Figure 12. Download SDK

NXP touch library

- The touch sensing code in the downloaded SDK folder ...boards\frdm-mcxn947\demo_apps\touch_sensing is developed using the NXP touch library.
- The NXP Touch Library Reference Manual can be found in the folder .../middleware/touch/freemaster/html/index.html, it describes the NXP Touch software library for implementing touch-sensing applications on NXP MCU platforms. The NXP Touch software library provides touch-sensing algorithms to detect finger touch, movement, or gestures.
- The FreeMASTER tool for TSI configure and tune is included in the NXP touch library. For more information, see the NXP Touch Library Reference Manual (document [NT20RM](#)) or NXP Touch Development Guide (document [AN12709](#)).
- The basic building blocks of the NXP Touch library are shown in Figure 13:



MCX Nx4x TSI performance

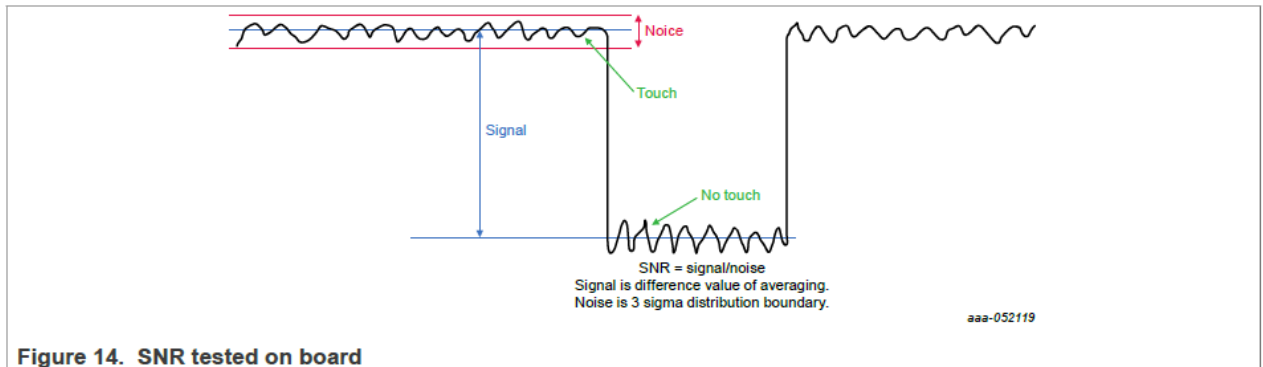
For MCX Nx4x TSI, the following parameters have been tested on the X-MCX-N9XX-TSI board. Here is the performance summary.

Table 6. Performance Summary

	MCX Nx4x series	
1	SNR	Up to 200:1 for self-cap mode and mutual-cap mode
2	Overlay thickness	Up to 20 mm
3	Shield drive strength	Up to 600pF at 1MHz, Up to 200pF at 2MHz
4	Sensor capacitance range	5pF – 200pF

1. SNR test

- The SNR is calculated according to the raw data of the TSI counter value.
- In the case when no algorithm is used to process the sampled values, SNR values of 200:1 can be achieved in self-cap mode and mutualcap mode.
- As shown in Figure 14, the SNR test has been performed on the TSI board on EVB.

**Figure 14.** SNR tested on board

2. Shield drive strength test

- The strong shield strength of TSI can improve the waterproof performance of the touchpad and can support a larger touchpad design on the hardware board.
- When the 4 TSI shield channels are all enabled, the maximum driver capability of the shield channels is tested at 1 MHz and 2 MHz TSI working clocks in self-cap mode.
- The higher the TSI operating clock, the lower the drive strength of the shielded channel. If the TSI operating clock is lower than 1MHz, the maximum drive strength of the TSI is larger than 600 pF.
- To do the hardware design, refer to the test results shown in Table 7.
- **Table 7.** Shield driver strength test result

Shield channel on	Clock	Max shield drive strength
CH0, CH6, CH12, CH18	1 MHz	600 pF
	2 MHz	200 pF

3. Overlay thickness test

- To protect the touch electrode from the interference of the external environment, the overlay material must be closely attached to the surface of the touch electrode. There should be no air gap between the touch electrode and the overlay. An overlay with a high dielectric constant or an overlay with a small thickness improves the sensitivity of the touch electrode. The maximum overlay thickness of the acrylic overlay material was tested on the X-MCX-N9XX-TSI board as shown in Figure 15 and Figure 16. The touch action can be detected on the 20 mm acrylic overlay.

- Here are the conditions to be fulfilled:

- SNR>5:1
- Self-cap mode
- 4 shield channels on
- The sensitivity boost

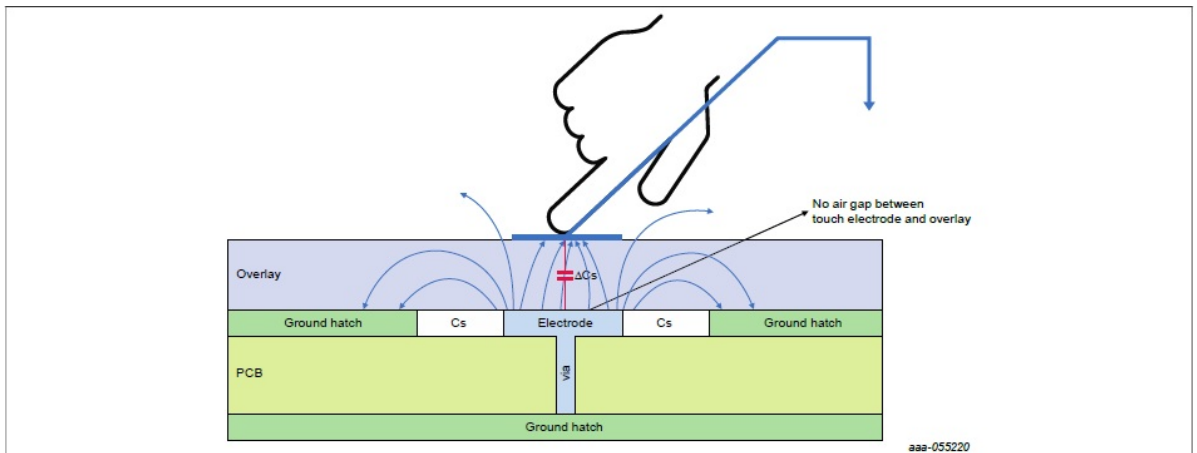


Figure 15. Overlay thickness test base on the acrylic

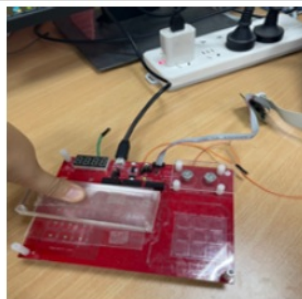


Figure 16. Overlay thickness test base on the acrylic

4. Sensor capacitance range test

- The recommended intrinsic capacitance of a touch sensor on a hardware board is in the range of 5 pF to 50 pF.
- The area of the touch sensor, the material of the PCB, and the routing trace on the board affect the size of the intrinsic capacitance. These must be considered during the hardware design of the board.
- After testing on the X-MCX-N9XX-TSI board, MCX Nx4x TSI can detect a touch action when the intrinsic capacitance is as high as 200 pF, the SNR is larger than 5:1. Therefore, the requirements for touch board design are more flexible.

Conclusion

This document introduces the basic functions of TSI on MCX Nx4x chips. For details on the MCX Nx4x TSI principle, refer to the TSI chapter of the MCX Nx4x Reference Manual (document [MCXNx4xRM](#)). For suggestions on the hardware board design and touchpad design, refer to the KE17Z Dual TSI User Guide (document [KE17ZDTSIUG](#)).

References

The following references are available on the NXP website:

1. MCX Nx4x Reference Manual (document [MCXNx4xRM](#))
2. KE17Z Dual TSI User Guide (document [KE17ZDTSIUG](#))

- 3. NXP Touch development guide (document [AN12709](#))
- 4. NXP Touch Library Reference Manual (document [NT20RM](#))

Revision history

Table 8. Revision history

Document ID	Release date	Description
UG10111 v.1	7 May 2024	Initial version

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- **Rev. 1** — 7 May 2024

Documents / Resources

	<p>NXP MCX N Series High Performance Microcontrollers [pdf] User Guide MCX N Series, MCX N Series High Performance Microcontrollers, High Performance Microcontrollers, Microcontrollers</p>
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References

- [🌐 Welcome | MCUXpresso SDK Builder](#)
- [User Manual](#)

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