Application Note

AN_560

Migrating from FT2xxR to FT2xxRN

Version 1.2

Issue Date: 27-07-2023

This Application Note shows how to migrate from FT232R/FT245R to FT232RN/FT245RN and discusses all hardware and software aspects.

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1 Introduction

To improve our supply efficiency on the popular R-Series, FTDI has launched a new RN-Series which are designed / manufactured according to the current R-Series specification.

The RN-series are drop in pin-compatible replacements for the equivalent R-Series in nearly 100% of all design cases. This document details all hardware and software considerations when migrating to the latest version of the IC (FT232RN/FT245RN).

Please refer to TN_183 FT232RN / FT245RN Errata Technical Note which describes the differences.

In this Application Note, FT2xxR denotes the original FT232R/FT245R and FT2xxRN denotes the new FT232RN/FT245RN ICs.

The FT2xxR and FT2xxRN product pages and datasheet links can be found in the References section.

Table 1.1 shows the part number summary.

Original Part Number	New Part Number	Description
FT232RQ	FT232RNQ	USB to Serial UART Bridge in 32-pin QFN package
FT232RL	FT232RNL	USB to Serial UART Bridge in 28-pin SSOP package
FT245RQ	FT245RNQ	USB to FIFO Bridge in 32-pin QFN package
FT245RL	FT245RNL	USB to FIFO Bridge in 28-pin SSOP package

Table 1.1 Part Number Summary

Table 1.2 shows current silicon revisions.

Part Number	Revision
FT232RQ / FT232RL	C
FT245RQ / FT245RL	C
FT232RNQ / FT232RNL	B
FT245RNQ / FT245RNL	B

Table 1.2 Part Revisions

The original FT232R/FT245R ICs have a limitation with respect to using the internal oscillator as detailed in the datasheets:

- **The minimum operating voltage VCC must be +4.0V (could use VBUS=+5V) when using the internal clock generator. Operation at +3.3V is possible using an external crystal oscillator.**

This has now been improved with the new FT232RN/FT245RN ICs. If VCC is supplied with 3.3V, the internal oscillator can now be used, simplifying designs further.

The only difference that is not compatible with the FT2xxRN migration is when using an external oscillator. There are no issues when using internal oscillator or external crystal. This is detailed in this document.

1.1 Product Summary Comparison

Table 1.3 shows a side-by-side feature comparison of FT232R to FT232RN and Table 1.4 shows a side-by-side feature comparison of FT245R to FT245RN. This easily shows any differences between the ICs.

	FT232R	FT232RN
USB 2.0 Full Speed compatible. Compliant with the USB 2.0 specification	✓	✓
No USB specific firmware programming required	✓	✓
Fully integrated USB termination resistors (27ohm)	✓	✓
Fully integrated clock generation, fully operation w/o external clock.	✓	✓
Optional clock output selection enabling a glue-less interface to external MCU or FPGA (6, 12,24, 48MHz)	✓	✓
Can use External 12MHz Crystal	✓	✓
Can use External 1.8V Clock source	✓	✓
Can use External 3.3V Clock source	✓	✗
Data transfer rates from 300 to 3M baud (RS422, RS485, RS232) at TTL levels	✓	✓
True 5V/3.3V/2.8V/1.8V CMOS drive output and TTL input	✓	✓
128 bytes receive buffer, and 256 bytes transmit buffer	✓	✓
Synchronous and asynchronous bit bang interface options with RD# and WR# strobes	✓	✓
UART interface support for 7 or 8 data bits, 1 or 2 stop bits and odd / even / mark / space / no parity	✓	✓
FIFO receives and transmits buffers for high data throughput	✓	✓
Unique USB FTDIChip-ID™ feature	✓	✓
Device supplied pre-programmed with unique USB serial number	✓	✓
Fully integrated 1024-bit EEPROM storing device descriptors and CBUS I/O configuration, Able to re-write 10K cycles	✓	✓
Configurable CBUS I/O pins, Configurable I/O pin output drive strength 2~8mA	✓	✓
TXDEN -Enable transmit data for RS485	✓	✓
PWREN#-Output is low after the device has been configured by USB, then high during USB suspending mode	✓	✓
TXLED#-Transmit data LED drive: Data from USB Host to FT232R.	✓	✓
RXLED#-Receive data LED drive: Data from FT232R to USB Host.	✓	✓
TX&RXLED#-LED drive – pulses low when transmitting or receiving data via USB.	✓	✓
SLEEP#-Goes low during USB suspend mode	✓	✓
Clock output-CLK48, CLK24, CLK12, CLK6	✓	✓
CBitBangI/O-CBUS bit bang mode option	✓	✓
BitBangWRn-Synchronous and asynchronous bit bang mode WR# strobe output	✓	✓
BitBangRDn-Synchronous and asynchronous bit bang mode RD# strobe output	✓	✓

Product Page
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	FT232R	FT232RN
+3.3V to +5.25V Single Supply Operation (using external oscillator)	✓	✓
+3.3V to +3.99V Single Supply Operation (using internal oscillator)	✗	✓
+4.0V to +5.25V Single Supply Operation (using internal oscillator)	✓	✓
Low operating and USB suspend current(50~100uA)	✓	✓
Integrated power-on-reset circuit	✓	✓
+3.3V LDO regulator, with a maximum current of 50mA	✓	✓*
VCCIO can connect +1.8V to +5.25V DC and supply to the UART Interface and CBUS group pins	✓	✓
Available in compact Pb-free 28 Pin SSOP and QFN-32 packages (both RoHS compliant).	✓	✓
-40°C to 85°C extended operating temperature range	✓	✓

Table 1.3 FT232R/FT232RN Part Comparison

	FT245R	FT245RN
USB 2.0 Full Speed compatible. Compliant with the USB 2.0 specification	✓	✓
No USB specific firmware programming required	✓	✓
Fully integrated USB termination resistors (27ohm)	✓	✓
Fully integrated clock generation, fully operation w/o external clock.	✓	✓
Optional clock output selection enabling a glue-less interface to external MCU or FPGA (6, 12,24, 48MHz)	✓	✓
Can use External 12MHz Crystal	✓	✓
Can use External 1.8V Clock source	✓	✓
Can use External 3.3V Clock source	✓	✗
Data transfer rate to 1 Megabyte / second (D2XX Driver). Data transfer rate to 300 kilobyte / second (VCP Driver).	✓	✓
True 5V/3.3V/2.8V/1.8V CMOS drive output and TTL input	✓	✓
128 bytes receive buffer, and 256 bytes transmit buffer	✓	✓
Synchronous and asynchronous bit bang interface options with RD# and WR# strobes	✓	✓
Simple interface to MCU / PLD / FPGA logic with simple 4-wire handshake interface	✓	✓
FIFO receives and transmits buffers for high data throughput	✓	✓
Unique USB FTDIChip-ID™ feature	✓	✓
Device supplied pre-programmed with unique USB serial number	✓	✓
Fully integrated 1024-bit EEPROM storing device descriptors and CBUS I/O configuration, Able to re-write 10K cycles	✓	✓
Configurable CBUS I/O pins, Configurable I/O pin output drive strength 2~8mA	✓	✓

	FT245R	FT245RN
TXDEN -Enable transmit data for RS485	✓	✓
PWREN#-Output is low after the device has been configured by USB, then high during USB suspending mode	✓	✓
TXLED#-Transmit data LED drive: Data from USB Host to FT232R.	✓	✓
RXLED#-Receive data LED drive: Data from FT232R to USB Host.	✓	✓
TX&RXLED#-LED drive – pulses low when transmitting or receiving data via USB.	✓	✓
SLEEP#-Goes low during USB suspend mode	✓	✓
Clock output-CLK48, CLK24, CLK12, CLK6	✓	✓
CBitBangI/O-CBUS bit bang mode option	✓	✓
BitBangWRn-Synchronous and asynchronous bit bang mode WR# strobe output	✓	✓
BitBangRDn-Synchronous and asynchronous bit bang mode RD# strobe output	✓	✓
+3.3V to +5.25V Single Supply Operation (using external oscillator)	✓	✓
+3.3V to +3.99V Single Supply Operation (using internal oscillator)	✘	✓
+4.0V to +5.25V Single Supply Operation (using internal oscillator)	✓	✓
Low operating and USB suspend current(50~100uA)	✓	✓
Integrated power-on-reset circuit	✓	✓
+3.3V LDO regulator, with a maximum current of 50mA	✓	✓*
VCCIO can connect +1.8V to +5.25V DC and supply to the UART Interface and CBUS group pins	✓	✓
Available in compact Pb-free 28 Pin SSOP and QFN-32 packages (both RoHS compliant).	✓	✓
-40°C to 85°C extended operating temperature range	✓	✓

Table 1.4 FT245R/FT245RN Part Comparison

* See section 2.4 Using 3V3OUT to Power External Circuitry

The FT2xxR and FT2xxRN are fully compliant with the USB 2.0 specification and have been given the USB-IF Test-IDs (TID) according to Table 1.5 below.

	FT232R	FT232RN	FT245R	FT245RN
USB-IF Test-ID (TID)	40770018	6654	40770019	6689

Table 1.5 USB-IF Test-IDs (TID)

2 Hardware

This section discusses the hardware aspects of the migration.

2.1 VCC Supply Improvement

VCC supply for the device core is specified from +3.3V to +5.25V.

FT2xxRN has made a significant improvement with respect to VCC and clock source which would help to simplify some designs further by removing the need for an external crystal or oscillator.

FT2xxR specifies a hardware limitation in the datasheet:

- **The minimum operating voltage VCC must be +4.0V (could use VBUS=+5V) when using the internal clock generator. Operation at +3.3V is possible using an external crystal oscillator.**

Designs which are configured to power the IC with 3.3V to VCC meant that an external clock must be used, adding more external hardware with more expense.

Now FT2xxRN has improved this aspect of the design. Any designs with VCC supply from +3.3V to +5.25V can use the internal clock source! This can simplify existing designs that were affected by the original FT2xxR limitation.

2.2 Pin Compatibility

As mentioned in the introduction, the ICs are drop in pin compatible. This means that most hardware designs require no changes.

Figure 2.1 to Figure 2.4 shows that there are no differences on a side-by-side comparison.
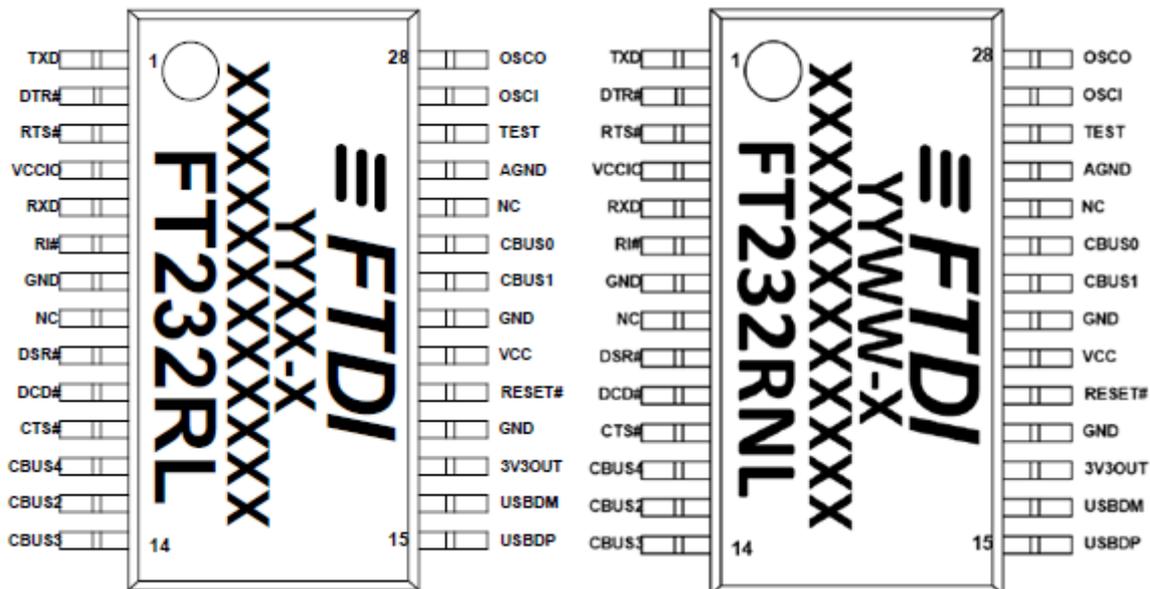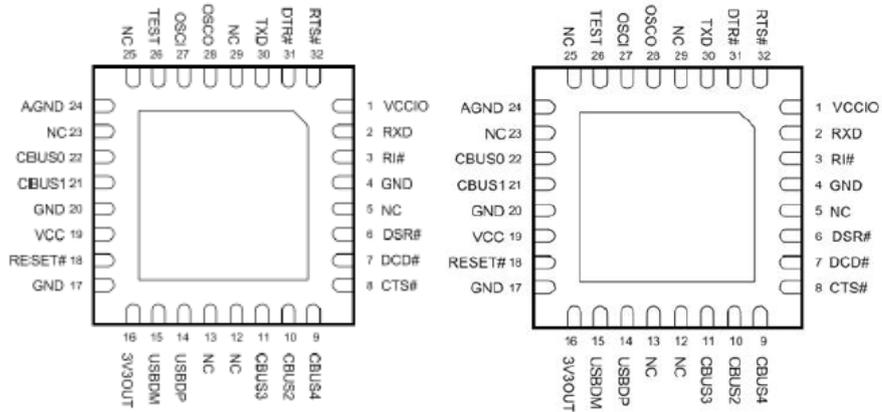

Figure 2.1 FT232RL and FT232RNL Pin Out
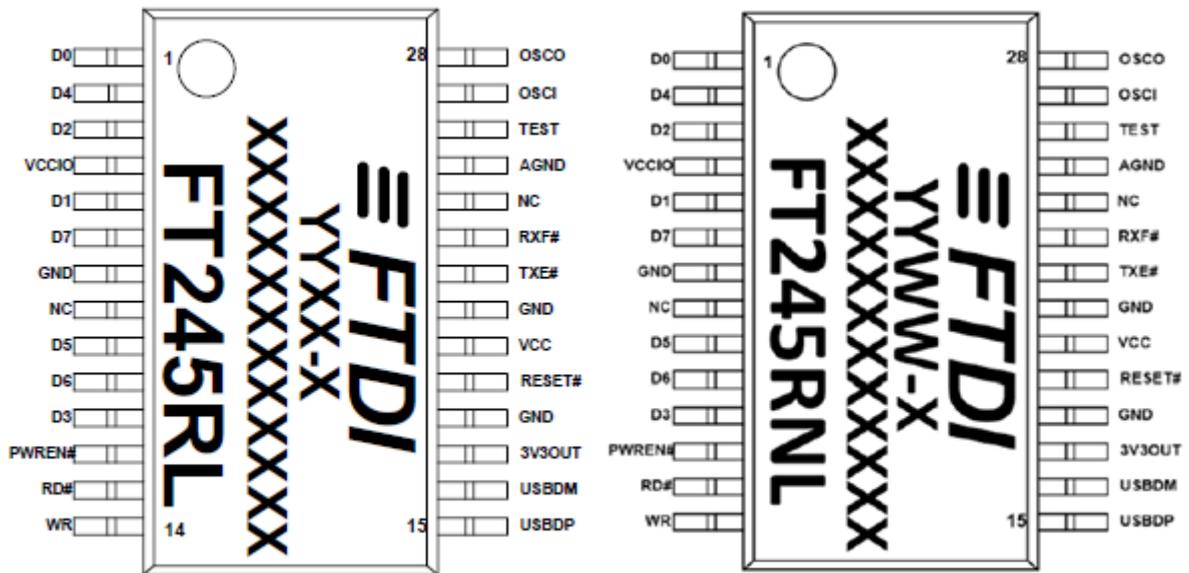
Figure 2.2 FT232RQ and FT232RNQ Pin Out

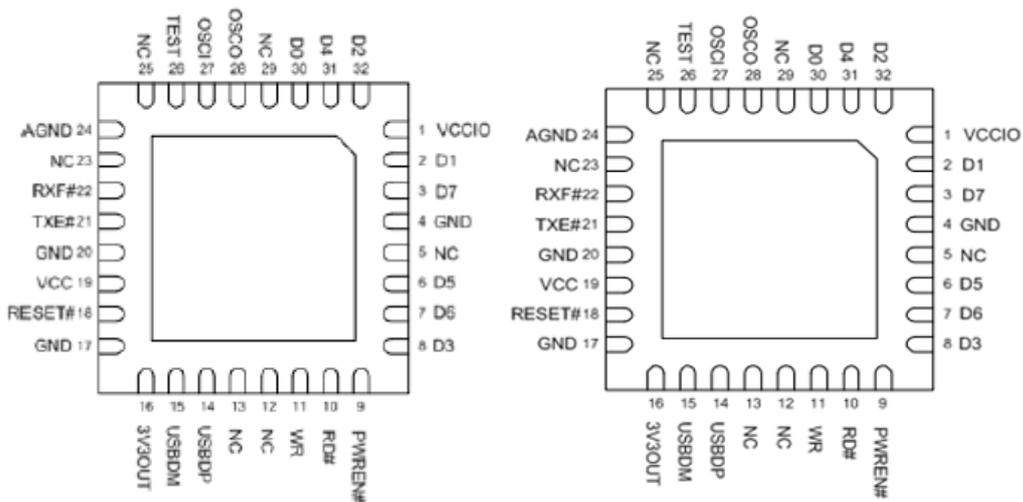**Figure 2.3 FT245RL and FT245RNL Pin Out**

Figure 2.4 FT245RQ and FT245RNQ Pin Out

2.3 Clock Source

The FT2xxR and FT2xxRN have three clock configuration possibilities to provide 12Mhz to the device:

- Internal Oscillator (default)
- External Crystal
- External Oscillator

2.3.1 Internal Oscillator

There are **no differences** if existing FT2xxR designs are using the internal oscillator.

These designs can easily migrate to FT2xxRN with **no hardware changes required**.

This is the default EEPROM configuration on both FT2xxR and FT2xxRN ICs.

Figure 2.5 shows that there are no external connections on the OSCI and OSCO pins.
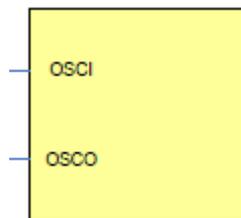
Figure 2.5 Internal Oscillator

2.3.2 External Crystal

There are **no differences** if existing FT2xxR designs are using an external crystal.

These designs can easily migrate to FT2xxRN with **no hardware changes required**.

Figure 2.6 shows an example of this configuration but note that it doesn't include all detail like the crystal load capacitors to keep this simple.
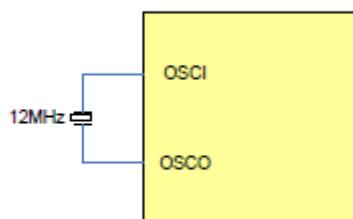

Figure 2.6 External Crystal

Note: The EEPROM configuration is updated to reflect this hardware configuration. FT PROG is used to change the EEPROM configuration. More details can be found in AN 100 Using the FT232R/FT245R with an External Crystal or Oscillator.

2.3.3 External Oscillator

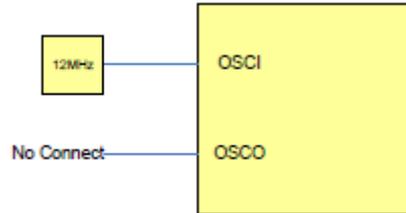Figure 2.7 shows an example of a hardware design which uses an external oscillator.

Figure 2.7 External Crystal Clock Source

TN_183 FT232RN / FT245RN Errata Technical Note details a hardware difference if the existing design is using an external oscillator.

Only with this configuration, a change would be required.

Table 2.1 shows the difference with the OSCI input voltage.

	FT2xxR	FT2xxRN
OSCI input voltage (max)	3.63V	1.98V

Table 2.1 OSCI input voltage comparison

If existing FT2xxR designs are using an external oscillator with a voltage above 1.98V then those designs would need to change. The change options are:

- Switch to the internal oscillator.
- Switch to using an external crystal.
- Adjust the external oscillator with an input level below 1.98V.

Note: The EEPROM configuration is updated to reflect this hardware configuration. FT PROG is used to change the EEPROM configuration. More details can be found in AN_100 Using the FT232R/FT245R with an External Crystal or Oscillator.

2.4 Using 3V3OUT to Power External Circuitry

The 3V3OUT pin can be used to power external circuitry with up to 50mA current.

A requirement of USB bus powered applications is when in USB suspend mode, the application draws a total current of less than 2.5mA. This requirement includes external logic.

To use this additional power, 3V3OUT must be gated with a Power Switching Configuration, for example using a MOSFET which is gated by PWREN# (output is low after the device has been configured by USB, then high during USB suspending mode). This is detailed in section 6 USB Power Configurations of all FT2xxR and FT2xxRN Datasheets and is shown in Figure 2.8.
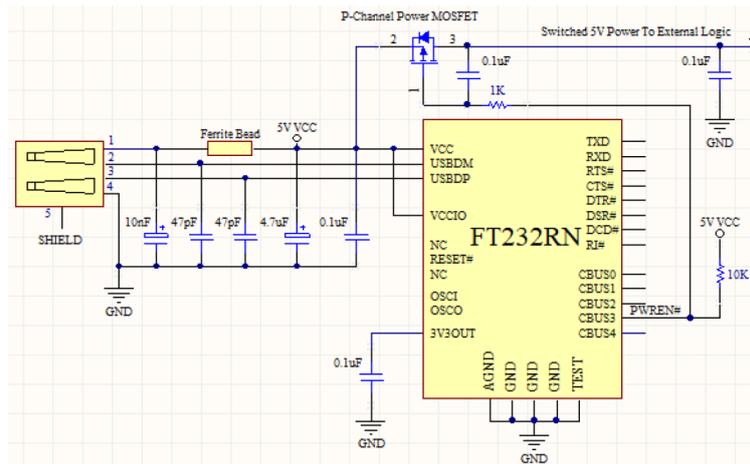
Figure 2.8 Power Switching Configuration

Note: This shows a power switch configuration from VBUS but the same principle applies to 3V3OUT as it's used to supply external circuitry.

When using FT2xxR and FT2xxRN with a power switching configuration, there are **no issues** with the migration. The same applies when 3V3OUT is not being used to supply external circuitry.

If a power switching configuration has not been implemented in your design to supply external circuitry, then it doesn't meet the specification and there can be issues with FT232RN due to low power mode regulator configuration.

FT2xxRN regulated 3.3V output power is limit to <25mA from power up. Once startup is complete, it's ok to power 50mA.

If your design is relying on <25mA externally from startup with no power switching configuration, there are **no issues** with FT2xxRN.

If your design is relying on >25mA externally from startup with no power switching configuration, there can be **USB enumeration issues** with FT2xxRN.

There are three possible workarounds:

1. Delay powering up external circuitry until FT2xxRN is powered-up for 200ms. This could possibly be done by adjusting RC delay of external reset to your external circuit.
2. Disable the low power mode regulator by using a custom version of FT_PROG. This would involve adding an additional step in your production to program the EEPROM if this is not already being done. Please contact your local FTDI support team if you require this custom version of FT_PROG. Also note that the external circuitry may need to be disabled to allow programming of the FT2xxRN EEPROM over USB.
3. Modify your design to add MOSFET power gating using PWREN# with 10Kohm external pullup, instead of directly connecting 3V3OUT to power external circuitry. This would involve a re-design of your hardware so is not a drop-in replacement option.

Option 3 is preferred by FTDI to ensure that your design meets the specification.

However, in cases where a redesign is not possible, you can consider options 1 and 2.

3 Software

No software changes are required when migrating from FT2xxR to FT2xxRN.

The same application software can be used.

The same drivers can be used. The latest driver versions can be found on the FTDI website: https://ftdichip.com/drivers/.

4 Conclusion

This document shows how to migrate from FT2xxR to FT2xxRN.

The main case when a hardware change is required is if the current FT2xxR design uses an external oscillator with a voltage above 1.98V.

No hardware changes are required if the current FT2xxR design uses the internal oscillator or external crystal.

An additional hardware change may be required as detailed in section 2.4 , although another alternative is offered to avoid hardware design changes.

Improvements to the FT2xxRN design has also removed the requirement for an external clock if VCC was below 4V so existing designs can simplify further.

No software or driver changes are required.

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Distributor and Sales Representatives

Please visit the Sales Network page of the FTDI Web site for the contact details of our
distributor(s) and sales representative(s) in your country.

Appendix A - References

Document References

TN_183 FT232RN / FT245RN Errata Technical Note
AN_100 Using the FT232R/FT245R with an External Crystal or Oscillator
FT_PROG
https://ftdichip.com/drivers/

New FT2xxRN Product Pages:

https://ftdichip.com/products/ft232rnq/
https://ftdichip.com/products/ft232rnl/
https://ftdichip.com/products/ft245rnq/
https://ftdichip.com/products/ft245rnl/

New FT2xxRN Datasheets:

FT232RN Datasheet
FT245RN Datasheet

Original FT2xxR Product Pages:

https://ftdichip.com/products/ft232rq/
https://ftdichip.com/products/ft232rl/
https://ftdichip.com/products/ft245rq/
https://ftdichip.com/products/ft245rl/

Original FT2xxRN Datasheets:

FT232R Datasheet
FT245R Datasheet

Acronyms and Abbreviations

Terms	Description
CMOS	Complementary Metal Oxide Semiconductor
EEPROM	Electrically Erasable Programmable Read Only Memory
FIFO	First In First Out
ICs	Integrated Circuits
LDO	Low-Dropout Regulator
TTL	Transistor-Transistor Logic
MOSFET	Metal Oxide Semiconductor Field Effect Transistor
UART	Universal Asynchronous Receiver Transmitter
USB	Universal Serial Bus

Appendix B – List of Tables & Figures

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Appendix C – Revision History

Document Title: AN_560 Migrating from FT2xxR to FT2xxRN

Document Reference No.:   FT_001543

Clearance No.:   FTDI#576

Product Page: https://ftdichip.com/product-category/products/ic/

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Revision	Changes	Date
1.0	Initial Release	18-10-2022
1.1	Updated Figure 2.1 label only	14-12-2022
1.2	Added section 2.4 Using 3V3OUT to Power External Circuitry	27-07-2023

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