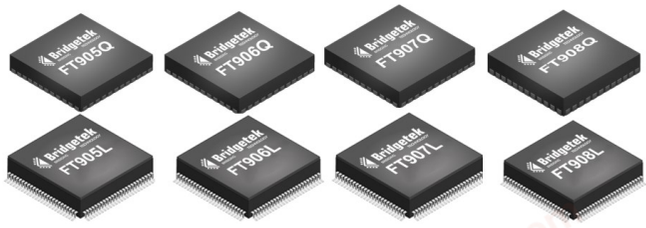
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FT905/6/7/8
(Datasheet)



The FT905/6/7/8 series includes the FT905, FT906, FT907 and FT908 which are complete System-On-Chip 32-bit RISC microcontrollers for embedded applications featuring a high level of integration and low power consumption. They have the following features:

- High performance, low power 32-bit FT32core processor, running at a frequency of 100MHz.
- 256kB on-chip Flash memory.
- 256kB on-chip shadow program memory.
- True Zero Wait States (0WS) up to 3.1 DMIPS per MHz performance.
- 64kB on-chip data memory.
- Flash OTP memory for security configuration.
- Integrated Phase-Locked Loop (PLL) supports external 12MHz crystal and direct external clock source input.
- 32.768 kHz Real Time Clock (RTC) support.
- One USB 2.0 EHCI compatible host controller supports high-speed (480Mbit/s), full-speed (12Mbit/s), and low-speed (1.5Mbit/s).
- One USB 2.0 device controller supports high-speed (480Mbit/s) and full-speed (12Mbit/s).
- USB 2.0 host and device controllers support the Isochronous, Interrupt, Control, and Bulk transfers.
- Supports USB Battery Charging Specification Rev 1.2. Downstream port can be configured as SDP, CDP or DCP. Upstream port can perform BCD mode detection.
- 10/100Mbps Ethernet that is compliant with the IEEE 802.3/802.3u standards. (FT905 and FT906 only).
- Supports One-Wire debugger for downloading firmware to Flash memory or shadow program memory and supports a software debugger.
- Two CAN controllers support CAN protocol2.0 parts A&B, data rate is up to 1Mbit/s. (FT905 and FT907 only).
- One SPI master supports single / dual / quad modes of data transfer. Clock rate is up to 25 MHz.
- One SPI slave supports single data transfer with a 25MHz clock.
- One I^2C interface which can be configured as a master or a slave. It supports standard / fast / fast-plus / high speed mode data transfers of up to 3.4 Mbit/s. Clock stretching is supported.
- UART interface can be configured as one full programmable UART0 or two simple UART0 and UART1 with CTS / RTS control function only.
- Four user timers with pre-scaling and a watchdog function.
- Supports 7 independent PWM channels. Channel 0 and 1 can be configured as PCM 8-bit/16-bit stereo audio output.
- Supports two 10-bit DACs 0/1 channels output, sample rate at ~1 MS/s.
- Supports four 8-bit/10-bit ADC 1/4 channels input, sample rate is up to ~960 KS/s.
- Single 3.3 volt power supply and built-in 1.2 V regulators.
- 3.3 volt I/O power supply.
- Supports VBUS power switching and overcurrent control.
- Provides a Power-On Reset (POR) signal to indicate stable power regulator.
- -40°C to 85°C extended operating temperature range.
- Available in compact Pb-free -76-pin (QFN) and 80-pin (LQFP) packages (all RoHS compliant).

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1 Typical Applications

- Home security system
- Home Automation
- Embedded audio application
- Motor drive and application control
- E-meter
- CCTV monitor
- Industrial automation
- Medical appliances
- Instrumentation
- DAQ System

1.1 Part Numbers

Part Number	Package
FT905Q-C-X	76 Pin QFN, pitch 0.4mm, body 9mm x 9mm x 0.9mm, support both CAN Bus and Ethernet features.
FT905L-C-X	80 Pin LQFP, pitch 0.4mm, body 10mm x 10mm x 1.40mm, support both CAN Bus and Ethernet features.
FT906Q-C-X	76 Pin QFN, pitch 0.4mm, body 9mm x 9mm x 0.9mm, support Ethernet, doesn't support CAN Bus.
FT906L-C-X	80 Pin LQFP, pitch 0.4mm, body 10mm x 10mm x 1.40mm, support Ethernet, doesn't support CAN Bus.
FT907Q-C-X	76 Pin QFN, pitch 0.4mm, body 9mm x 9mm x 0.9mm, support CAN Bus, doesn't support Ethernet.
FT907L-C-X	80 Pin LQFP, pitch 0.4mm, body 10mm x 10mm x 1.40mm, support CAN Bus, doesn't support Ethernet.
FT908Q-C-X	76 Pin QFN, pitch 0.4mm, body 9mm x 9mm x 0.9mm, doesn't support either CAN Bus or Ethernet features.
FT908L-C-X	80 Pin LQFP, pitch 0.4mm, body 10mm x 10mm x 1.40mm, doesn't support either CAN Bus or Ethernet features.

Table 1-1 - FT905/6/7/8 Series Part Numbers

Note: Packaging codes for x is:

-R: Taped and Reel (qty per reel for LQFP is 1000; qty per reel for QFN is 3000)

-T: Tray packing (qty per tray for LQFP is 160; qty per tray for QFN is 260)

1.2 USB 2.0 Compliant

The FT905/6/7/8 series contains a USB 2.0 host controller and device controller that are both compliant with USB 2.0 specification.

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2 FT905 Block Diagram

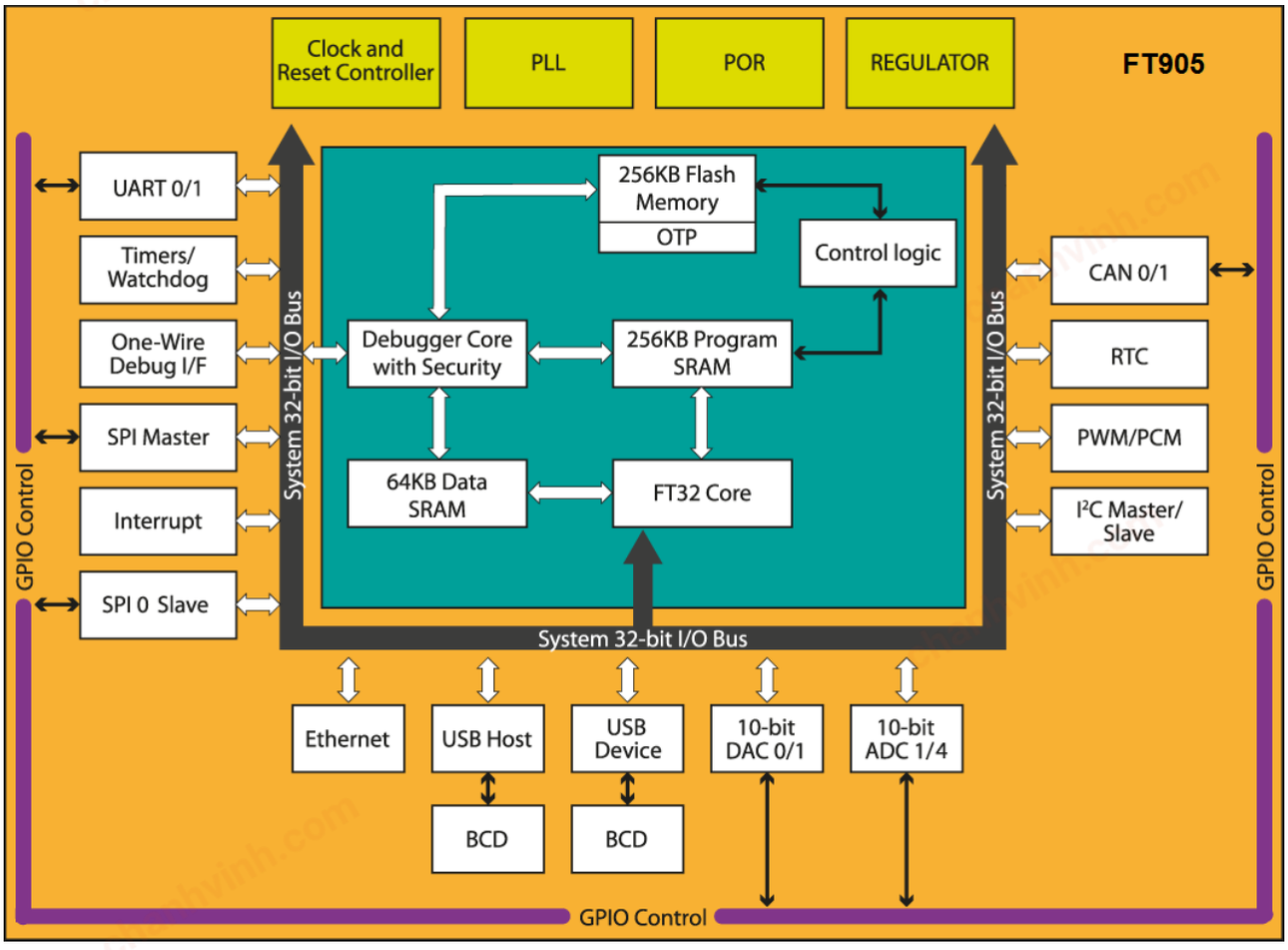


Figure 2-1 - FT905 Block Diagram

For a description of each function please refer to Chapter 4.

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3 Device Pin Out and Signal Description

3.1 Pin Out – FT905 QFN-76

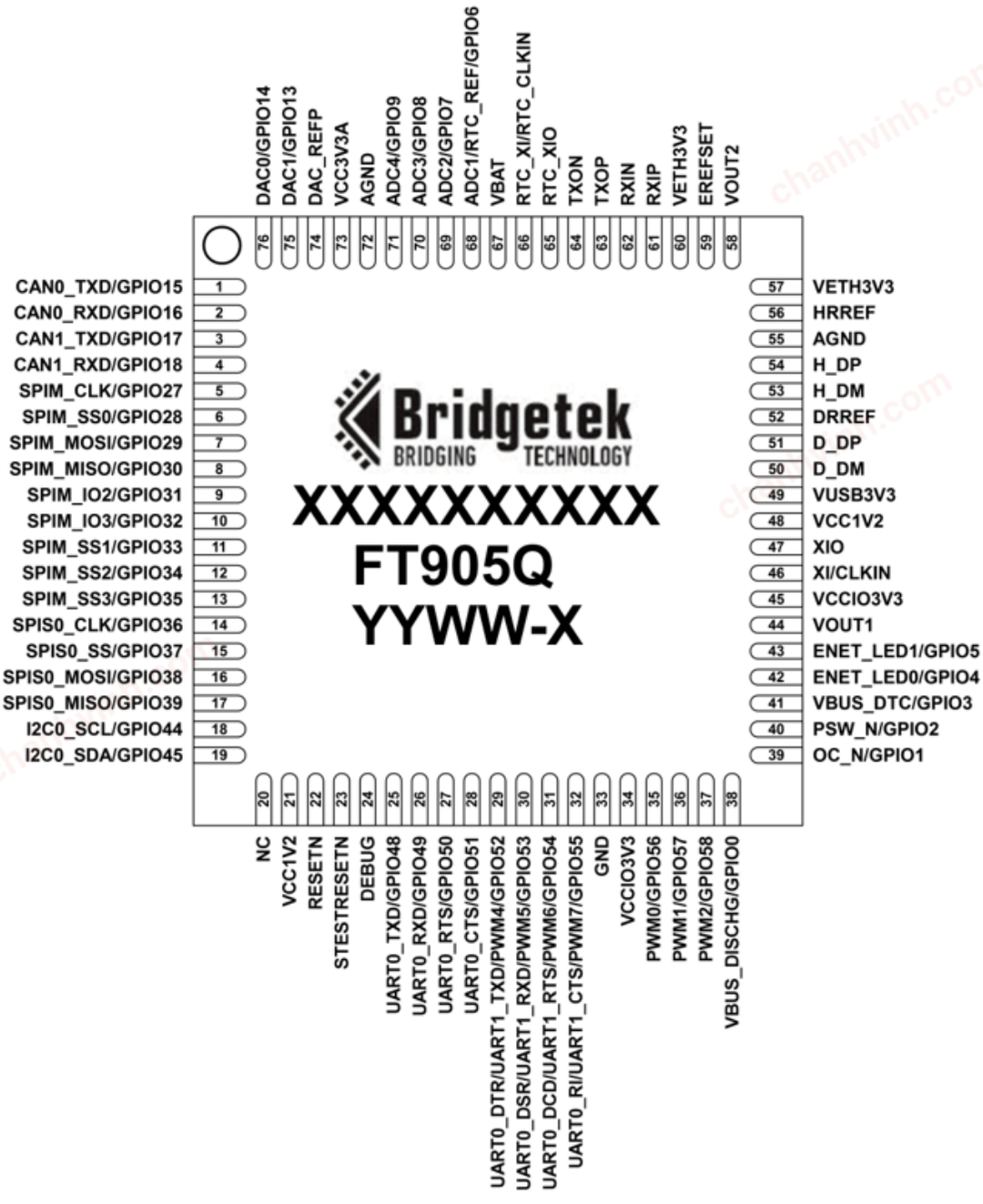


Figure 3-1 - Pin Configuration FT905Q (top-down view)

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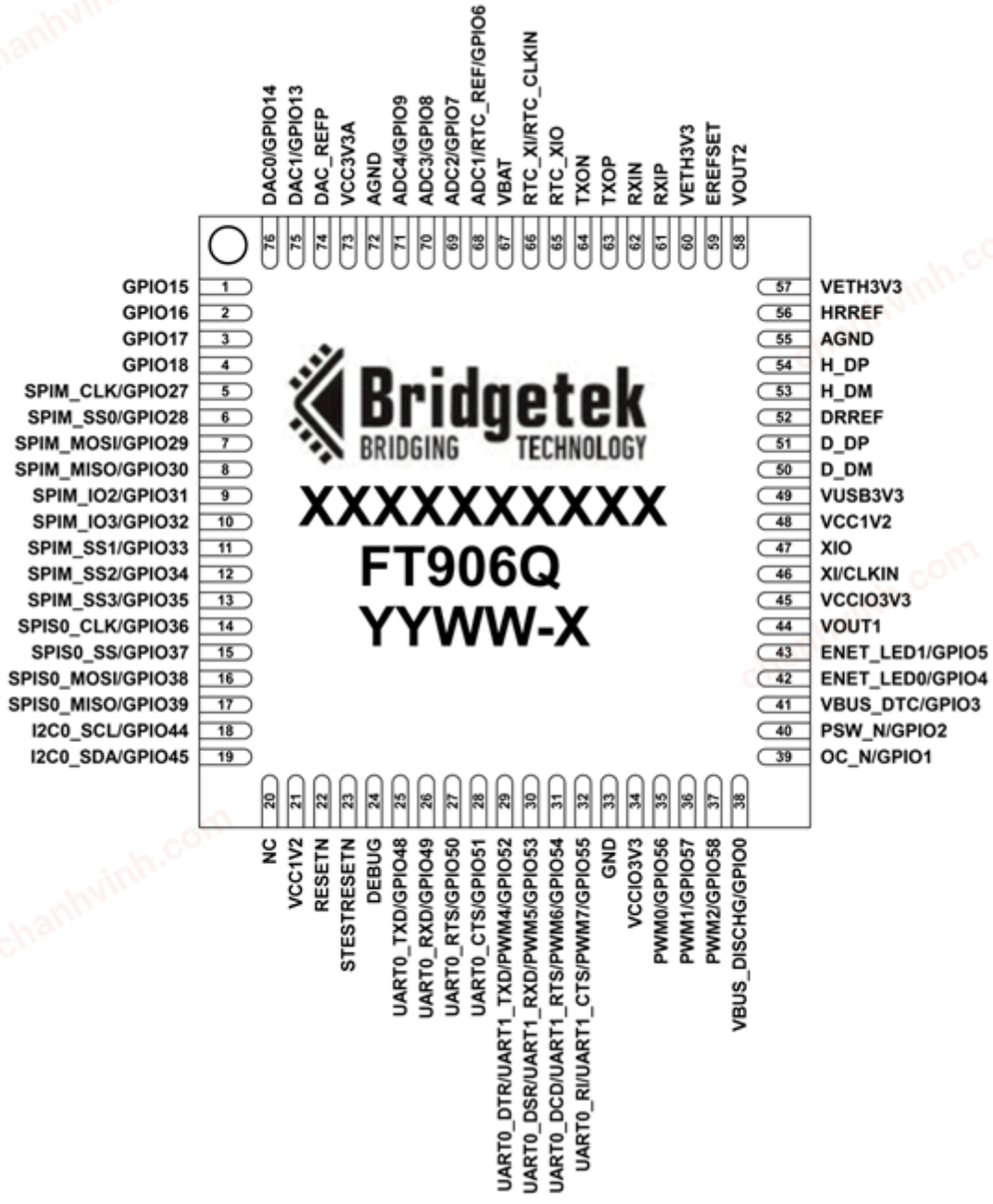


Figure 3-2 - Pin Configuration FT906Q (top-down view)

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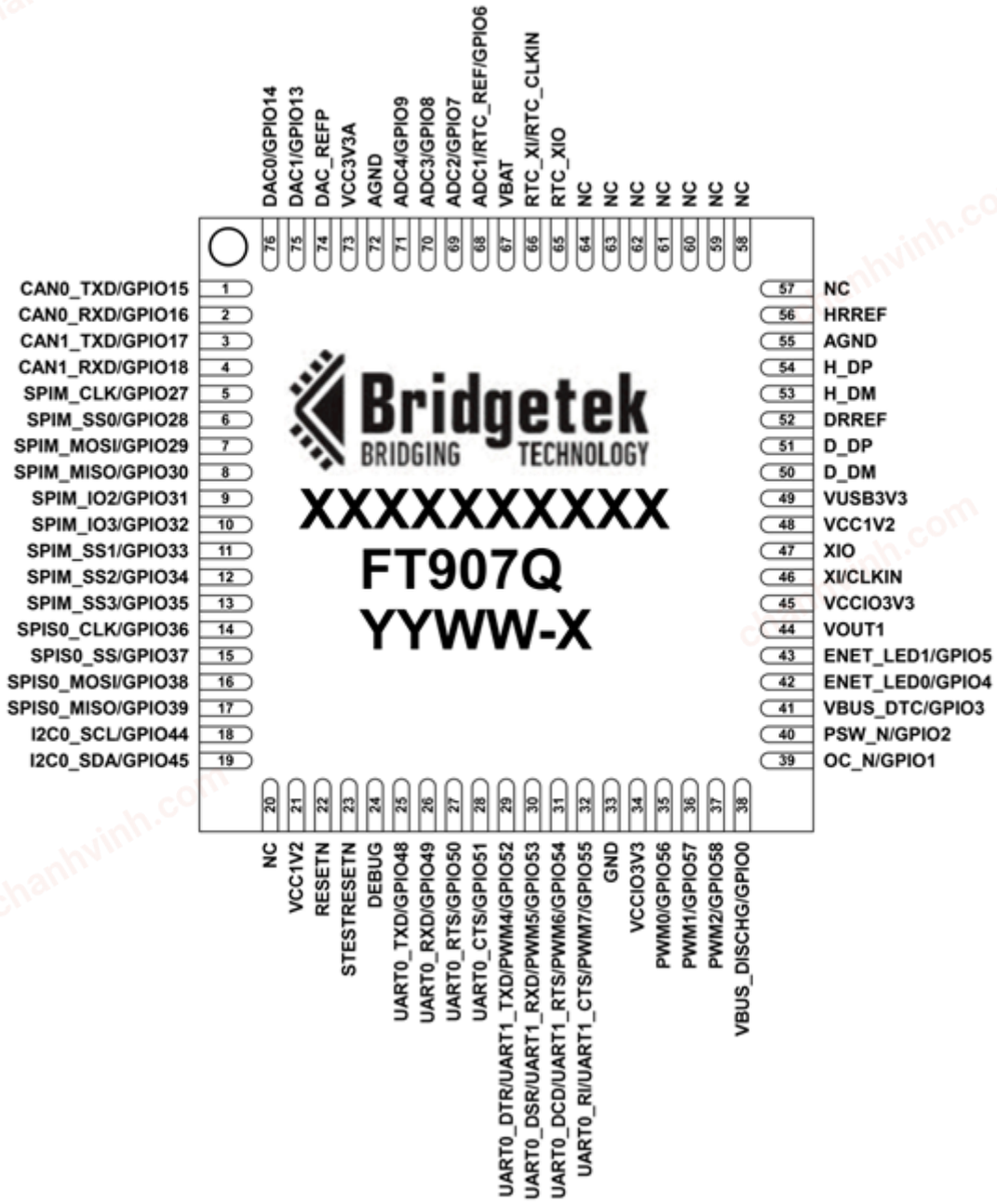


Figure 3-3 - Pin Configuration FT907Q (top-down view)

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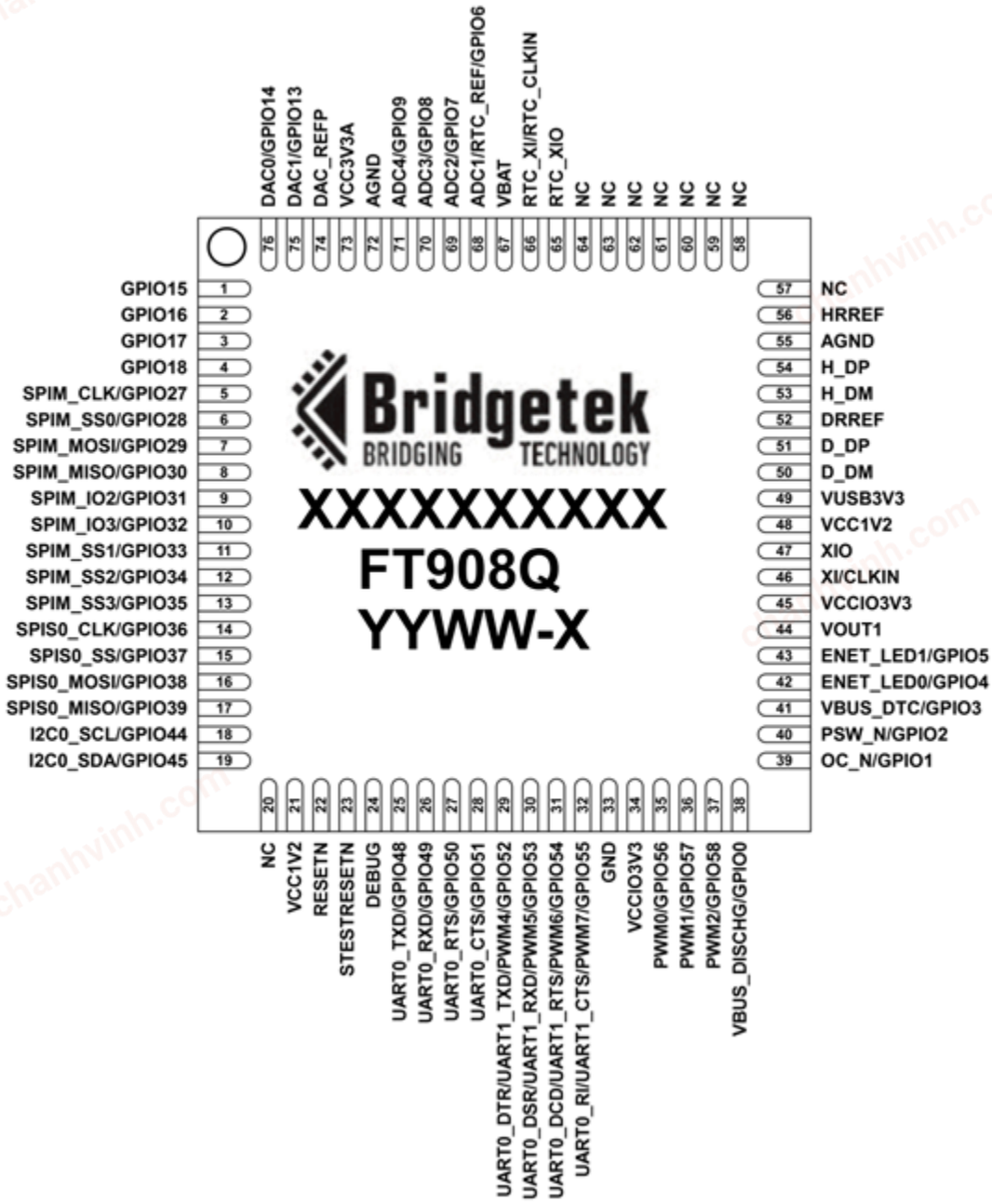


Figure 3-4 - Pin Configuration FT908Q (top-down view)

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3.2 Pin Out – FT905 LQFP-80

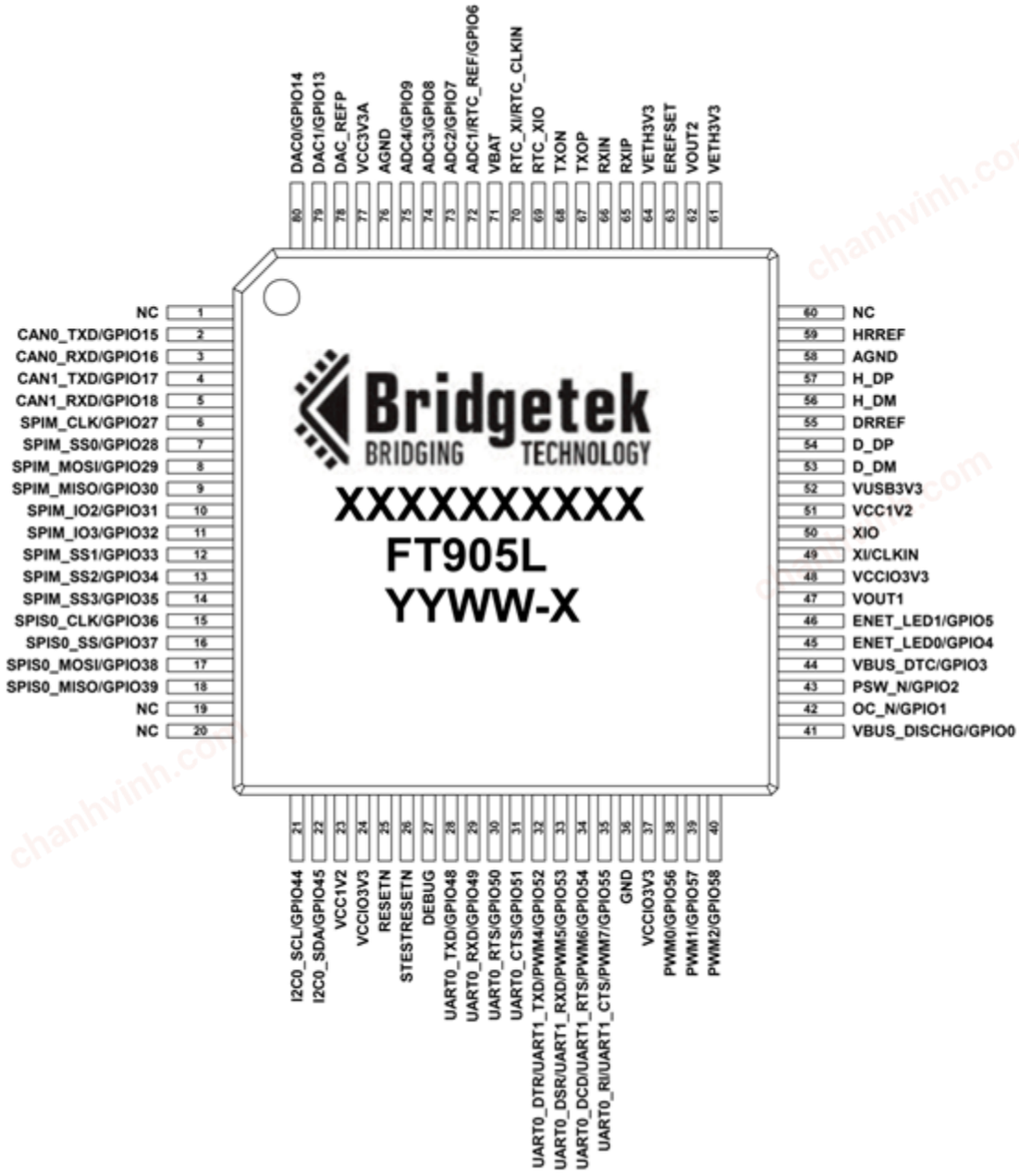


Figure 3-5 - Pin Configuration FT905L (top-down view)

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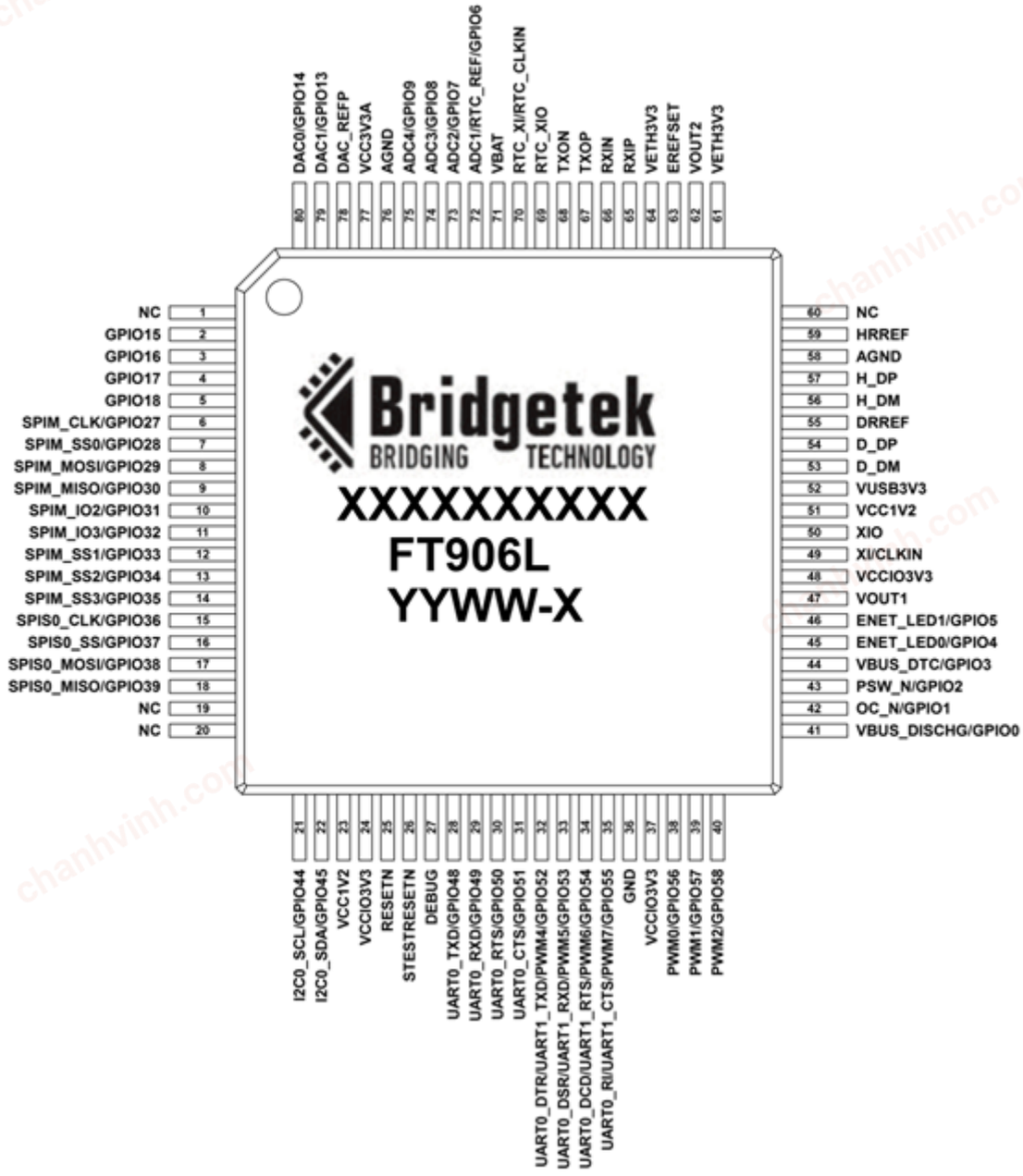


Figure 3-6 - Pin Configuration FT906L (top-down view)

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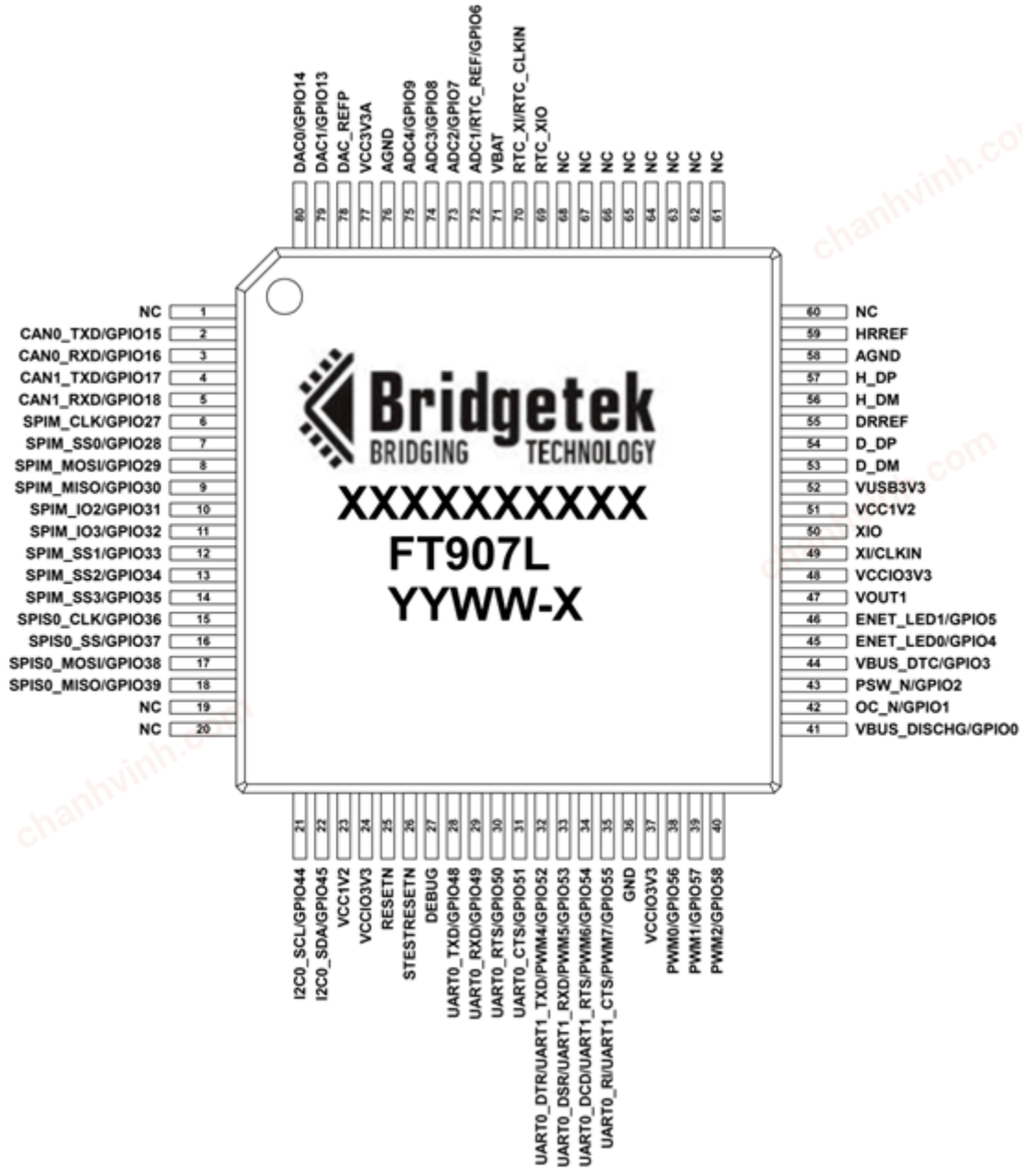


Figure 3-7 - Pin Configuration FT907L (top-down view)

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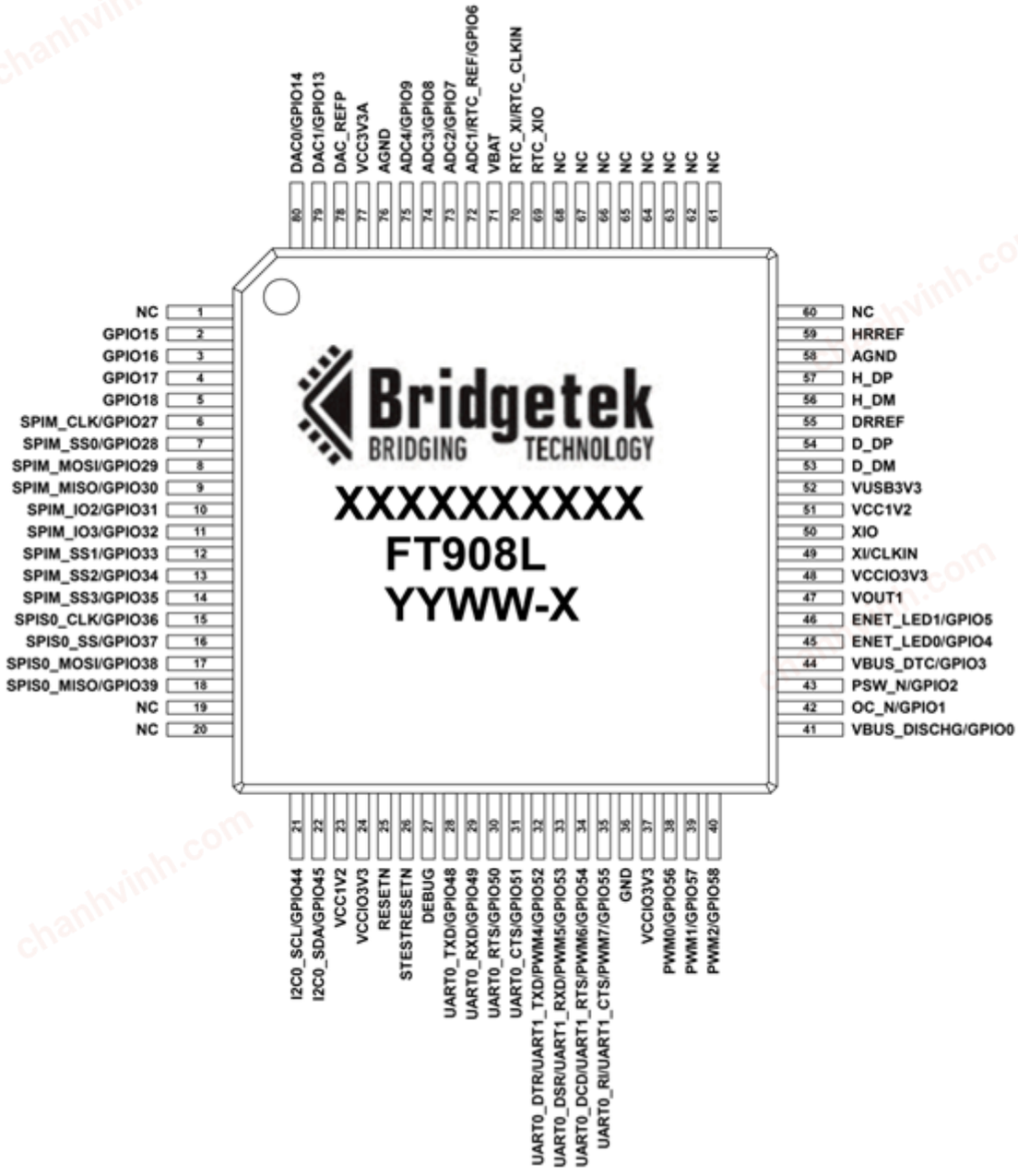


Figure 3-8 - Pin Configuration FT908L (top-down view)

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3.3 Pin Description

QFN Pin No.	LQFP Pin No.	Name	Type	Description
-	1	NC	-	Not connected.
1	2	CAN0_TXD/GPIO15	I/O	GPIO15 input/output. (By default, is GPIO input, internal pull-low) CAN0 transmitter output.[1]
2	3	CAN0_RXD/GPIO16	I/O	GPIO16 input/output. (By default, is GPIO input, internal pull-low) CAN0 receiver input.[1]
3	4	CAN1_TXD/GPIO17	I/O	GPIO17 input/output. (By default, is GPIO input, internal pull-low) CAN1 transmitter output.[1]
4	5	CAN1_RXD/GPIO18	I/O	GPIO18 input/output. (By default, is GPIO input, internal pull-low) CAN1 receiver input.[1]
5	6	SPIM_CLK/GPIO27	I/O	GPIO27 input/output. (By default, is GPIO input, internal pull-low) Serial clock output for SPI master.
6	7	SPIM_SS0/GPIO28	I/O	GPIO28 input/output. (By default, is GPIO input, internal pull-low) Slave select 0 output for SPI master.
7	8	SPIM_MOSI/GPIO29	I/O	GPIO29 input/output. (By default, is GPIO input, internal pull-low) Master out slave in for SPI master. Data line 0 input/output for SPI master dual & quad mode.
8	9	SPIM_MISO/GPIO30	I/O	GPIO30 input/output. (By default, is GPIO input, internal pull-low) Master in slave out for SPI master. Data line 1 input/output for SPI master dual & quad mode.
9	10	SPIM_IO2/GPIO31	I/O	GPIO31 input/output. (By default, is GPIO input, internal pull-low) Data line 2 input/output for SPI master quad mode.
10	11	SPIM_IO3/GPIO32	I/O	GPIO32 input/output. (By default, is GPIO input, internal pull-low) Data line 3 input/output for SPI master quad mode.
11	12	SPIM_SS1/GPIO33	I/O	GPIO33 input/output. (By default, is GPIO input, internal pull-low) Slave select 1 output for SPI master.
12	13	SPIM_SS2/GPIO34	I/O	GPIO34 input/output. (By default, is GPIO input, internal pull-low) Slave select 2 output for SPI master.
13	14	SPIM_SS3/GPIO35	I/O	GPIO35 input/output. (By default, is GPIO input, internal pull-low) Slave select 3 output for SPI master.
14	15	SPIS0_CLK/GPIO36	I/O	GPIO36 input/output. (By default, is GPIO input, internal pull-low) Serial clock input for SPI slave 0.
15	16	SPIS0_SS/GPIO37	I/O	GPIO37 input/output. (By default, is GPIO input, internal pull-low) Slave select input for SPI slave 0.
16	17	SPIS0_MOSI /GPIO38	I/O	GPIO38 input/output. (By default, is GPIO input, internal pull-low) Master out slave in for SPI slave 0.
17	18	SPIS0_MISO /GPIO39	I/O	GPIO39 input/output. (By default, is GPIO input, internal pull-low) Master in slave out for SPI slave 0.

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QFN Pin No.	LQFP Pin No.	Name	Type	Description
-	19	NC	-	Not connected.
-	20	NC	-	Not connected.
18	21	I2C0_SCL/GPIO44	I/O	GPIO44 input/output. (By default, is GPIO input, internal pull-low) I2C 0 serial clock input/output. (By default, is I2C 0 master)
19	22	I2C0_SDA/GPIO45	I/O	GPIO45 input/output. (By default, is GPIO input, internal pull-low) I2C 0 data line input/output. (By default, is I2C 0 master)
20	-	NC	-	Not connected.
21	23	VCC1V2	P	+1.2V supply voltage for PLL. Connect +1.2V output from the internal regulator to this pin. Specifically, this pin must be connected to pin 44 of QFN package or pin 47 of LQFP package. Connect a 0.1uF decoupling capacitor to GND.
-	24	VCCIO3V3	P	+3.3V supply voltage. This is the supply voltage for all the I/O ports. Connect a 0.1uF decoupling capacitor to GND. This pin must be connected to pin 37.
22	25	RESETN	I	Chip reset input for normal operation. Active low. Connect external 10kΩ pull-up to VCC3V3 for safe operation.
23	26	STESTRESETN	I	Chip reset input for test mode. Connect this pin to Ground via a 10kΩ resistor for normal operation.
24	27	DEBUG	I/O	One-wire debugger interface input/output.
25	28	UART0_TXD/GPIO48	I/O	GPIO48 input/output. (By default, is GPIO input, internal pull-low) Transmitter output for UART0.
26	29	UART0_RXD/GPIO49	I/O	GPIO49 input/output. (By default, is GPIO input, internal pull-low) Receiver input for UART0.
27	30	UART0_RTS/GPIO50	I/O	GPIO50 input/output. (By default, is GPIO input, internal pull-low) Request to send output for UART0.
28	31	UART0_CTS/GPIO51	I/O	GPIO51 input/output. (By default, is GPIO input, internal pull-low) Clear to send input for UART0.
29	32	UART0_DTR/UART1_TXD/PWM4/GPIO52	I/O	GPIO52 input/output. (By default, is GPIO input, internal pull-low) PWM channel 4, output. Transmitter output for UART1. Data terminal ready output for UART0.
30	33	UART0_DSR/UART1_RXD/PWM5/GPIO53	I/O	GPIO53 input/output. (By default, is GPIO input, internal pull-low) PWM channel 5, output. Receiver input for UART1. Data set ready input for UART0.
31	34	UART0_DCD/UART1_RTS/PWM6/GPIO54	I/O	GPIO54 input/output. (By default, is GPIO input, internal pull-low) PWM channel 6, output. Request to send output for UART1. Data carrier detection input for UART0.
32	35	UART0_RI/UART1_CTS/PWM7/GPIO55	I/O	GPIO55 input/output. (By default, is GPIO input, internal pull-low) PWM channel 7, output. Clear to send input for UART1. Ring indicator input for UART0.

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QFN Pin No.	LQFP Pin No.	Name	Type	Description
33	36	GND	P	Ground
34	37	VCCIO3V3	P	+3.3V supply voltage. This is the supply voltage for all the I/O ports. Connect 10uF and 0.1uF decoupling capacitors.
35	38	PWM0/GPIO56	I/O	GPIO56 input/output. (By default, is GPIO input, internal pull-low) PWM channel 0, output. A stereo 16/8-bit PCM audio data channel output.
36	39	PWM1/GPIO57	I/O	GPIO57 input/output. (By default, is GPIO input, internal pull-low) PWM channel 1, output. A stereo 16/8-bit PCM audio data channel output.
37	40	PWM2/GPIO58	I/O	GPIO58 input/output. (By default, is GPIO input, internal pull-low) PWM channel 2, output.
38	41	VBUS_DISCHG /GPIO0	I/O	GPIO0 input/output. (By default, is GPIO input, internal pull-high) USB host VBUS discharge.
39	42	OC_N/GPIO1	I/O	GPIO1 input/output. (By default, is GPIO input, internal pull-high) USB host port over current status output. Active low.
40	43	PSW_N/GPIO2	I/O	GPIO2 input/output. (By default, is GPIO input, internal pull-high) USB host port external VBUS power switcher. Active low.
41	44	VBUS_DTC/GPIO3	I/O	GPIO3 input/output. (By default, is GPIO input, internal pull-low) USB device VBUS detection.
42	45	ENET_LED0/GPIO4	I/O	GPIO4 input/output. (By default, is GPIO input, internal pull-low) Ethernet activity indicator LED 0.[2]
43	46	ENET_LED1/GPIO5	I/O	GPIO5 input/output. (By default, is GPIO input, internal pull-low) Ethernet activity indicator LED 1.[2]
44	47	VOUT1	P	+1.2V Regulator power supply. This is internal regulator output. Connect 4.7uF and 0.1uF decoupling capacitors.
45	48	VCCIO3V3	P	+3.3V supply voltage. This is the supply voltage for all the I/O ports. Connect a 0.1uF decoupling capacitor. This pin must be connected to pin 34 of QFN package or pin 37 LQFP package.
46	49	XI/CLKIN	AI	12MHz clock frequency input to the Oscillator circuit or to internal clock generator circuit.
47	50	XIO	AO	Output from the Oscillator amplifier.
48	51	VCC1V2	P	+1.2V Regulator power supply for USB. Provide +1.2V power to this pin. This pin must be connected to pin 44 of QFN package or pin 47 of LQFP package. Connect 0.1uF decoupling capacitor.
49	52	VUSB3V3	P	+3.3V supply voltage. This is the supply voltage for USB device and host I/O ports. Connect 10uF and 0.1uF decoupling capacitors. This pin could be connected to all +3.3V power supply pins without 10uF capacitor.
50	53	D_DM	AI/O	USB device bidirectional DM line.
51	54	D_DP	AI/O	USB device bidirectional DP line.
52	55	DRREF	AI	USB device reference voltage input. Connect 12Kohm +/- 1% resistor to GND.

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QFN Pin No.	LQFP Pin No.	Name	Type	Description
53	56	H_DM	AI/O	USB host bidirectional DM line.
54	57	H_DP	AI/O	USB host bidirectional DP line.
55	58	AGND	P	Analog Ground
56	59	HRREF	AI	USB host reference voltage input. Connect 12Kohm +/- 1% resistor to GND.
-	60	NC	-	Not connected.
57	61	VETH3V3	P	+3.3V supply voltage. This is the supply voltage for Ethernet I/O ports. Connect 10uF and 0.1uF decoupling capacitors. This pin could be connected to all +3.3V power supply pins without 10uF capacitor.
58	62	VOUT2	P	+1.2V Regulator power supply.[2] This is internal regulator output for Ethernet transceiver. Connect 0.1uF decoupling capacitor.
59	63	EREFSET	AI	Ethernet reference voltage input.[2] Connect 12.3Kohm +/- 1% resistor to GND.
60	64	VETH3V3	P	+3.3V supply voltage. This is the supply voltage for Ethernet I/O ports. Connect a 0.1uF decoupling capacitor. This pin must be connected to pin 57 of QFN package or pin 61 of LQFP package.
61	65	RXIP	I	Ethernet receive data positive input.[2] Differential receive signal pair.
62	66	RXIN	I	Ethernet receive data negative input.[2] Differential receive signal pair.
63	67	TXOP	O	Ethernet transmit data positive output.[2] Differential transmit signal pair.
64	68	TXON	O	Ethernet transmit data negative output.[2] Differential transmit signal pair.
65	69	RTC_XIO	AO	Output from the RTC Oscillator amplifier.
66	70	RTC_XI/RTC_CLKIN	AI	32.768KHz clock frequency input to the RTC Oscillator circuit or to internal RTC clock generator circuit.
67	71	VBAT	P	+1.5V RTC supply voltage.
68	72	ADC1/RTC_REF/GPIO6	I/O	GPIO6 input/output. (By default, is GPIO input, internal pull-low) Reference clock for RTC calibration. 10-bit A/D converter 1, input.
69	73	ADC2/GPIO7	I/O	GPIO7 input/output. (By default, is GPIO input, internal pull-low) 10-bit A/D converter 2, input.
70	74	ADC3/GPIO8	I/O	GPIO8 input/output. (By default, is GPIO input, internal pull-low) 10-bit A/D converter 3, input.
71	75	ADC4/GPIO9	I/O	GPIO9 input/output. (By default, is GPIO input, internal pull-low) 10-bit A/D converter 4, input.
72	76	AGND	P	Analog Ground
73	77	VCC3V3A	P	+3.3V supply voltage. This is the supply voltage for Analog I/O ports. Connect 10uF and 0.1uF decoupling capacitors. This pin could be connected to all +3.3V power supply pins without 10uF capacitor.
74	78	DAC_REFP	P	10-bit DAC positive reference voltage.
75	79	DAC1/GPIO13	I/O	GPIO13 input/output. (By default, is GPIO input, internal pull-low) 10-bit D/A converter 1, output.

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QFN Pin No.	LQFP Pin No.	Name	Type	Description
76	80	DAC0/GPIO14	I/O	GPIO14 input/output. (By default, is GPIO input, internal pull-low) 10-bit D/A converter 0, output.

Table 3-1 - FT905 pin description

[1] CAN Bus 0/1 only are featured on both FT905 and FT907 packages.
[2] Ethernet pins are available on FT905 and FT906 only. For FT907 and FT908, shall leave all Ethernet pins as NC pin floating except for ENET_LED0/GPIO4 and ENET_LED1/GPIO5 as GPIO by default.

Notes:

P : Power or ground
I : Input
O : Output
OD : Open drain output
I/O : Bi-direction Input and Output
AI : Analog Input
AO : Analog Output
AI/O : Analog Input / Output

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4 Function Description

4.1 Architectural Overview

The FT905/6/7/8 series embedded microcontrollers include a high performance 32-bit FT32 RISC core processor and 256kB hi-speed Flash memory for software program downloading with a One-Wire debugger interface. The core processor uses a 32-bit I/O system bus to connect to all of the peripherals.

- 32-bit MCU Processor Core
- 256kB Flash Memory
- 256kB Shadow Program Memory
- 64kB Data Memory
- USB2.0 host controller with battery charging capability
- USB2.0 device controller with battery charging detection capability
- 10/100Mbps Ethernet controller *(FT905 and FT906 only)*
- Two CAN bus interfaces *(FT905 and FT907 only)*
- Real Time Clock
- One-Wire debugger interface
- One SPI master interface and one SPI slave interface
- One I^2C bus interface, which can be configured as a master or a slave
- Programmable 8 Mb/s UART interface, which can be configured as one fully-functional UART or two simple UARTs with CTS/RTS flow control function only
- Four 16-bit timers and one 32-bit watchdog timer
- 8-Channel PWM with optional 2-Channel Audio PCM
- 10-bit DAC0/1 channel
- Configurable 8-bit/10-bit four channel 480/960 kS/s ADC
- General purpose I/O interface

The functions for each controller / interface are briefly described in the following subsections.

4.2 FT32 Core Processor

The FT32 core processor is running at frequencies of up to 100MHz. The processor contains the CPU itself with control logic and its 256kB program memory and 64kB data memory. The outside connections for the core processor are the memory-mapped I/O interface, the interrupt interface, asynchronous reset, and the system clock.

4.3 256kB Flash Memory

The internal 256kB Flash memory is used to store a boot loader or user application of the FT905/6/7/8 series. It is a high performance and low power consumption memory that supports up to 80MHz serial clock. The system will perform memory copy from Flash memory to CPU program memory automatically after system power on.

4.4 Boot Sequence

After the initial memory copy completes, the CPU jumps to program memory location zero. This may be the start of the user application which is stored in advance in Flash memory, or a boot loader only which allows program memory to perform modifications via (e.g.) UART or USB.

The option of a boot loader is a special purpose routine in the FT905/6/7/8 series embedded microcontrollers. It is small routine stored in the Flash memory. Typically, the boot loader is 1-4kbytes in size and is loaded at the top of the available memory.

4.5 Interrupt

The FT905/6/7/8 series interrupt controller handles 32 interrupt inputs. When an interrupt occurs, the Interrupt Service Route (ISR) will process this event via the CPU. The ISR vector range is from 0 to 31, which corresponds to interrupts 0 to 31. See Table 4-1 for more information.

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Each interrupt shall be assigned the interrupt vector number and priority before use. By default, the highest priority interrupt is interrupt 0, and the lowest is interrupt 31. However, the interrupt priority can be rearranged by register settings and also allows multiple interrupts at the same priority.

To prevent the loss and delay of high priority interrupts, the FT905/6/7/8 series uses nested interrupts if enabled. Nested interrupts allow interrupt requests of a high priority to pre-empt interrupt requests of a low priority. The FT905/6/7/8 series supports up to 16-levels deep, nested interrupts.

The interrupt controller has a global interrupt mask bit to temporarily block all interrupts. If this bit is set to "1", then with the exception of an interrupt assigned priority as "0", which is a non-maskable interrupt (NMI) input, all interrupts are masked.

See Table 4-1 for FT905/6/7/8 series default interrupt priority.

Peripherals of Interrupt	Interrupt Vector Index	Default Priority
Power Management	0	0 (NMI)
USB2.0 Host Controller	1	1
USB2.0 Device Controller	2	2
Ethernet Controller	3	3
UNUSED	**4**	**4**
CAN Bus 0	5	5
CAN Bus 1	6	6
UNUSED	**7**	**7**
SPI Master	8	8
SPI Slave 0	9	9
UNUSED	**10**	**10**
I^2C Master	11	11
I^2C Slave	12	12
UART 0	13	13
UART 1	14	14
UNUSED	**15**	**15**
PWM	16	16
Timers	17	17
GPIO	18	18
RTC	19	19
ADC	20	20
DAC	21	21
Slow Clock Timer	22	22
UNUSED	**23-31**	**23-31**

Table 4-1 - Default interrupt priority in FT905/6/7/8 series

4.6 Memory Mapping

A list of the I/O memory mapping for registers and memory in the FT905/6/7/8 series is given below in table 4-2. Refer to the FT9xx User Manual for a detailed description of registers.

Function	Address Memory Range		Comment
General setup registers	0x10000	0x100BF	DW/W/B
Interrupt controller registers	0x100C0	0x100FF	DW/W/B
USB2.0 host controller registers	0x10100	0x1017F	DW/W/B
USB2.0 host controller RAM memory	0x11000	0x12FFF	DW/W/B
USB2.0 device controller registers	0x10180	0x1021F	DW/W/B
USB2.0 device registers for high-bandwidth isochronous	0x10A1C	0x10A33	DW/W/B
Ethernet controller registers	0x10220	0x1023F	Registers: DW/W/B FIFO: DW
CAN BUS 0 registers	0x10240	0x1025F	B
CAN BUS 1 registers	0x10260	0x1027F	B
RTC registers	0x10900	0x1093F	DW
SPI master registers	0x102A0	0x102BF	DW

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Function	Address Memory Range		Comment
SPI master registers (extended)	0x10940	0x1095F	DW
SPI slave 0 registers	0x102C0	0x102DF	DW
SPI slave 0 registers (extended)	0x10960	0x1097F	DW
I^2C master registers	0x10300	0x1030F	B
I^2C slave registers	0x10310	0x1031F	B
UART 0 register	0x10320	0x1032F	B
UART 1 registers	0x10330	0x1033F	B
Timers & Watchdog registers	0x10340	0x1034F	B
PWM registers	0x103C0	0x103FF	Registers: B FIFO: W
Flash controller registers	0x10800	0x108BF	B

Table 4-2 - I/O memory mapping in FT905/6/7/8 series

Notes: DW / W / B are length of register operation

DW: Double Word (32-bit) W: Word (16-bit) B: Byte (8-bit)

4.7 USB 2.0 Host Controller

The Hi-Speed USB 2.0 single-port host controller is compliant with the USB 2.0 specification and the Enhanced Host Controller Interface (EHCI) specification. There is an option to enable a downstream port with a Battery Charging (BC) feature, which can be configured as a Standard Downstream Port (SDP), or Charging Downstream Port (CDP), or Dedicated Charging Port (DCP).The battery charging feature is compatible with the Battery Charging Specification Revision 1.2 (BC 1.2) by USB-IF.

Features

- Compliant with the USB specification revision 2.0.
- Compliant with EHCI specification revision 1.0.
- The USB1.1 host is integrated into the USB2.0 EHCI compatible host controller.
- Supports data transfer at high speed (480 Mb/s), full-speed (12 Mb/s) and low speed (1.5 Mb/s).
- Supports the split transaction for hi-speed hubs and the preamble transaction of full-speed hubs.
- Supports the Isochronous/Interrupt/Control/Bulk data transfers.
- 8 kB high speed RAM memory integrated.
- Supports Battery Charging specification revision 1.2.
- Supports VBUS power switching and over current control.

4.8 USB2.0 Device Controller

The USB 2.0 device controller is fully compliant with the USB2.0 specification. There is also an option to enable a battery charger detection (BCD) feature on an upstream port, which can identify whether the connected downstream port supports SDP, CDP or DCP charging function. Battery charge detection allows the USB device to determine if higher currents may be available from the USB connection for rapid battery charging.

Features

- Supports data transfer at high speed (480 Mb/s) and full speed (12 Mb/s).
- Software configurable EP0 control endpoint size 8-64 bytes.
- Software configurable 7 IN/OUT endpoints.
- EP1-EP7 has double buffering which contains 2kB IN and 2kB OUT buffers.
- Supports the Isochronous/Interrupt/Control/Bulk data transfers.
- Supports high-bandwidth isochronous IN transaction.
- Max endpoint packet sizes upon 1024 bytes.
- Supports VBUS detection.
- Supports suspend and resume power management functions.
- Supports remote wakeup feature.
- Supports Battery Charging specification revision 1.2.

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4.9 Ethernet Controller

The Ethernet controller contains an on-chip 10/100BASE-TX Ethernet transceiver and Media Access Control (MAC) designed to provide high performance of frame transmission and reception. The Ethernet transceiver is compliant with 10/100BASE-TX Ethernet standards, such as IEEE802.3/802.3u and ANSI X3.263-1995, and the MAC protocol refers to IEEE standard 802.3-2000.

Features

- 10/100Mbps data transfer.
- Conforms to IEEE 802.3-2002 specification.
- Supports full-duplex and half-duplex modes.
  - Supports CSMA/CD protocol for half-duplex operation.
  - Supports IEEE802.3x flow control for full-duplex operation.
- Programmable MAC address.
- CRC-32 algorithm calculates the FCS a nibble at a time, with automatic FCS generation and checking, able to capture frames with CRC errors if required.
- Promiscuous mode support.
- Station Management (STA) entity included.
- Supports double buffering for 2kB TX and 4kB RX memory.
- Two LED indicators used by Ethernet multi-function.

4.10 CAN Bus Controller

The FT905/6/7/8 series contains two controllers, CAN0 and CAN1. Controller Area Network (CAN) is a high-performance communication protocol for serial data communication. It is widely used in automotive and industrial applications; however, this is expanding due to its reliability and feasibility. CAN bus use a multi-master bus scheme with one logic bus line and equal nodes. The number of nodes is not limited by the protocol. Nodes do not have specific addresses. Instead, message identifiers are used, indicating the message content and priority of the message. The FT905/6/7/8 CAN controller supports multicasting and broadcasting with an external CAN transceiver.

Features

- Conforms to protocol version 2.0 parts A and B.
- Supports bit rates of up to 1 Mb/s.
- Supports standard (11-bit identifier) and extended (29-bit identifier) frames.
- Support hardware message filtering with dual/single filters.
- 64 Bytes receiver and 16 Bytes transmitter FIFO.
- No overload frames are generated.
- Supports normal and listen-only modes.
- Supports single shot transmission.
- Supports a transmission feature.
- Readable error counters and last error code capture supported.

4.11 Real Time Clock

The Real Time Clock (RTC) runs off a dedicated 32.768 kHz oscillator with its own power rail which can be connected to a separate battery via the VBAT pin.

Features

- Built-in Clock Stabilizer for the 32.768 kHz input.
- Records systems sleep time.
- Supports Date and Time format in BCD.
- Counts Second, Minute, Hour, Day, Date of the Month, Month and Year with Leap-Year Compensation Valid up to 2199.
- Supports two configurable Time-of-Day Alarms.
- Supports interrupt for two configurable alarm events.
- Supports On-Chip Digital Trimming with Auto Calibration.

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4.12 One-Wire Debugger Interface

The Debugger interface provides the capability, over a One-Wire half duplex serial link, to access memory mapped address space, such as the Flash memory, program memory, data memory and I/O memory. However, there is no transfer capability from any of the internal memory to the debugger interface.

Features

- Single wire half duplex link that has one Start, eight Data and one Stop bits at a 1M bit/s rate.
- Supports debugger command read / write operation with variable data transfer.
- Supports CHIP ID read out.
- Supports checksum checking by Flash memory operation.
- Supports CPU software debugging to execute Run, Stop, Step, Halt, Set software breakpoint, etc. operations.
- Use semaphore flag to control resource allocated by CPU or Debugger.

4.13 SPI Interface

The FT905/6/7/8 series contains one SPI master and one SPI slave controller. SPI is a full duplex serial interface designed to handle multiple masters and slaves connected to a given bus.

Features

- Maximum SPI data bit rate is 50 MHz in master and 25 MHz in slave mode.
- Full duplex synchronous serial data transfer.
- Compliant with SPI specification, support four transfer formats.
- The SPI master controller supports Single, Dual and Quad SPI transfer.
- The SPI slave controller supports Single transfer only.
- Supports SPI mode and FIFO mode operations.
- Multi-master system supported.
- Supports bus error detection.
- The SPI master controller can address up to 4 SPI slave devices.
- Support 16 / 64 Bytes receiver and 16 / 64 Bytes transmitter FIFO, respectively.

4.14 I^2C Interface

The FT905/6/7/8 series supports an I^2C bus controller which is a bidirectional, two wires (Serial Clock line (SCL) and a Serial Data line (SDA)) interface. The interface can be programed to operate with arbitration and clock synchronization allowing it to operate in multi-master systems. It supports transmission speed up to 3.4 Mb/s.

Features

- Conforms to v2.1 and v3.0 of the I^2C specification.
  - UM10204 I^2C-bus specification and user manual Rev. 6 – 4 April 2014
- Supports flexible transmission speed modes.
  - Standard (up to 100 kb/s)
  - Fast (up to 400 kb/s)
  - Fast-plus (up to 1 Mb/s)
  - High-speed (up to 3.4 Mb/s)
- Can be configured as Master mode or Slave mode.
- Perform arbitration and clock synchronization.
- Multi-master systems supported.
- Supports both 7-bit and 10-bit addressing modes on the I^2C bus.
- Supports clock stretching.

4.15 UART Interface

The FT905/6/7/8 series contains two UART controllers, namely UART0 and UART1, with standard transmit and receive data lines.

UART0 provides a full modem control handshake interface and support for 9-bit data, allowing automatic address detection while 9-bit data mode is enabled.

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UART1 is a simplified programmable serial interface with CTS and RTS flow control logic. The signals are multiplexed with UART0 and can only be used if UART0 is used in simple mode (CTS/RTS only).

Features

- Maximum UART data bit rate of 8Mbit/s.
- Supports UART mode and FIFO mode operation.
- 16 / 128 bytes FIFO for TX and RX in FIFO mode to reduce the interrupt frequency.
- Software compatible with 16450, 16550, 16750 and 16950 industry standard.
- Modem control function (CTS, RTS, DSR, DTR, RI, and DCD) support for UART0.
- Programmable automatic out-of- band flow control logic through Auto-RTS and Auto-CTS.
- Programmable automatic flow control logic using DTR and DSR.
- Programmable automatic in-band flow control logic using XON/XOFF characters.
- Supports external RS-485 buffer enable.
- Fully programmable serial interface characteristics:
  - 5-, 6-, 7-, 8-, or 9-bit characters
  - Even, Odd, or No-parity bit generation and detection
  - 1-, 1.5- (for 5 data bits only) or 2- (for 6/7/8 data bits) stop bit generation
  - Baud rate generation
  - Detection of bad data in Receive FIFO
- Supports Transmitter and Receiver disable capability.

4.16 Timers and Watchdog Timer

The FT905/6/7/8 series has four 16-bit user timers with individual pre-scaler and a 32-bit watchdog feature.

The watchdog timer is controlled from the main clock. The watchdog can be initialized with a 5-bit register. The value of this register points to a bit of the 32-bit counter which will be set by the application firmware. As the timer decrements, an interrupt occurs when the timer rolls over. Once started and initialized the watchdog can't be stopped. It can only be cleared by writing into a register.

The four user timers can be controlled from the main clock, each timer has its own 16-bit pre-scaler. These timers can be started, stopped and cleared / initialized. The pre-scalers can be cleared or initialised the same way.

The current value of all timers/pre-scalers can be read from a common register one-at-a-time (multiplexed access).

All timers can count up/down and signal an interrupt when the timer rolls over. The timers can also be configured to be one-shot or in continuous mode. They are initialised from a common register one-at-a-time (multiplexed access).

If the user timer has already started using its pre-scaler, it cannot be cleared and the command is ignored. Each of the pre-scalers automatically stops after it is cleared individually. It also starts automatically when the corresponding user timer starts using it.

Features

- Four user timers with individual pre-scaler.
- Supports 16-bit pre-scaler with system clock reference.
- Supports individual timer interrupt.
- Supports one-shot and continuous count for timer.
- Supports 32-bit counter watchdog.
- Supports watchdog interrupt.

4.17 PWM

The FT905/6/7/8 series supports 7 separate independent PWM output channels. All channels share an 8-bit pre-scaler to scale the system clock frequency to the desired channels.

Each channel has its own 16-bit comparator value. This is the value that would be matched to a preset 16-bit counter. When a channel's 16-bit comparator value matches that of the 16-bit counter, the

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corresponding PWM channel output will toggle. This 16-bit comparator value will continue to count until it reaches its preset value, and the counter will just roll over.

A special feature allows the 7 channels each to also toggle their own output based on the comparison results of other channels. Hence each channel potentially can have up to 8 toggle edges. The PWM signal generated can be output as a single-shot or continuous output.

The PWM counter also supports an external trigger. There are 6 GPIOs selectable for an external trigger. PWM channel 0 and channel 1 can double as a stereo 11.025 kHz or 22.050 kHz PCM audio channel. Once this feature is setup, the 16-bit or 8-bit PCM audio data can be downloaded to the PWM local FIFO which can hold up to 64 bytes stereo or 128 bytes mono audio data. The data is played back based on the pre-scaler and 16-bit counter and is automatically scaled to fit in the playback period if necessary.

PWM FIFO can generate a number of interrupts to support PCM playback. They are FIFO empty, full, half-full, overflow, and underflow. Each of these interrupts can be individually masked if required.

Features

- Supports 7 PWM output channels.
- Supports single-shot or continuous PWM data output.
- Supports external GPIO trigger.
- Supports 16-bit / 8-bit stereo PCM audio data output.
- Controls PCM FIFO full, empty, half-empty, and over-flow / under-flow buffer management.
- Supports PCM volume control for audio playback.

4.18 Analog to Digital Converter (ADC)

The FT905/6/7/8 series has a low-power, high-speed, successive approximation Analog-to-Digital Converter (ADC) that supports a configurable 8-bit/10-bit resolution and superior maximum sampling frequencies of up to approximately 960 Kilo Samples Per-second (kS/s). This ADC accepts analog inputs ranging from ground supplies to power supplies. This ADC can be used in various low-power and medium-resolution applications.

Features

- Configurable 8-bit/10-bit successive approximation ADC.
- Supports 7 channel input.
- Individual channels can be selected for conversion.
- Power-down mode support.
- Max conversion rate up to approximately 960 kS/s.
- Measurement range 0 to VCC3V3A, by default the range voltage is 10% off of VCC3V3A. See Table 5-7.
- INL: +/-2 LSB (max).
- DNL: +/-1 LSB (max).

4.19 Digital to Analog Converter (DAC)

The FT905/6/7/8 series has two 10-bit, 1 Mega Samples Per-second (MS/S) Digital-Analog converter (DAC). It includes digital logic for registering the DAC value and a unity-gain buffer capable of driving off-chip. The module can also be switched to a power-down state where it consumes a minimum amount of current. The maximum output value of the DAC is decided by the reference voltage at pin DAC_REFP.

Features

- Two 10-bit DACs.
- 10-bit R-2R DAC ladder structure.
- Buffered output.
- Power-down mode support.
- Programmable conversion rate, the maximum rate is 1MHz.
- Selectable output drive.
- INL: +/-2 LSB (max).
- DNL: +/-1 LSB (max).

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4.20 General Purpose Input Output

The FT905/6/7/8 provides up to 42 configurable Input / Output pins controlled by GPIO registers. All pins have multiple functions with special peripheral connection. Separate registers allow setting or clearing any number of outputs simultaneously. All GPIO pins default to inputs with pull-down resistors enabled on reset except GPIO0/1/2 inputs with pull-up resistors enabled.

All GPIOs can function as an interrupt. The polarity can be either positive edge or negative edge if its interrupt capability is enabled. In the meantime, the GPIO pin must be configured as a GPIO input.

Features

- All GPIOs default to inputs after reset (except GPIO0/1/2).
- Multi-function selection on GPIO pins.
- Pull-up/Pull-down resistor configuration and open-drain configuration can be programmed through the pin connect block for each GPIO pin.
- Direction control of individual bits.
- Supports GPIO input Schmitt trigger.
- Supports GPIO interrupt, where each enabled GPIO interrupt can be used to wake-up the system from power-down mode.

4.21 System Clocks

4.21.1 12MHz Oscillator

The oscillator generates a 12MHz reference frequency output to the clock multiplier PLL. The oscillator clock source comes from either an external 12MHz crystal or a 12MHz square wave clock. The external crystal is connected across XI/CLKIN and XIO in the configuration shown in Session 6.1. The optional external clock input is connected to XI/CLKIN only.

4.21.2 Phase Locked Loop

The internal PLL takes a 12 MHz clock input from a crystal oscillator. The PLL outputs 100 MHz system clock frequency to the CPU processor and other peripheral circuits. Each peripheral has an individual enable control signal to gate the clock source.

4.21.3 32.768 KHz RTC Oscillator

The RTC oscillator provides a clock to the RTC time counter. Either an external 32.768 KHz crystal or a 32.768 KHz square wave clock can be used as clock source. The external crystal is connected across RTC_XI/RTC_CLKIN and RTC_XIO in the configuration shown in Session 6.2. The optional external clock input is connected to the RTC_XI/RTC_CLKIN pin directly.

4.21.4 Internal Slow Clock Oscillator

The FT905/6/7/8 internal slow clock oscillator provides at least 5ms slow clock source to generate an interrupt for the USB 2.0 device remote wake-up feature. A USB 2.0 device with remote wake-up capability may not generate resume signalling unless the bus has been continuously in the idle state for 5ms. For a detailed description of USB 2.0 suspend/resume, please refer to USB 2.0 specification chapter 7.1.7.7.

4.22 Power Management

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4.22.1 Power Supply

The FT905/6/7/8 series may be operated with a single supply of +3.3V applied to VCCIO3V3, VUSB3V3, VETH3V3 and VCC3V3A pins. The +1.2V internal regulator VOUT1 provides the power to the core circuit after VCCIO3V3 power on and the system will generate a Power on Reset (POR) pulse when the output voltage rises above the POR threshold.

The second +1.2V internal regulator VOUT2 will provide the power to the Ethernet transceiver when VETH3V3 gets the power supply.

4.22.2 Power down mode

Power down mode applies to the entire system. In the power down mode, the system 12MHz oscillator and PLL both switch off and the system clock to the core and all peripherals stop except for the RTC oscillator and internal regulator. The internal regulator retains the power for the core and RTC running.
An interrupt from GPIO or wake-up events from the USB 2.0 device controller and host controller can wake-up the system from power down mode independently.

If the USB 2.0 host controller was used and the respective interrupt bit enabled before the system entered into power down mode, then the following events can wake-up the system.

- Remote wake-up interrupt to USB 2.0 host controller.
- USB device connected interrupt to USB 2.0 host controller.
- USB device disconnected interrupt to USB 2.0 host controller.
- USB 2.0 host controller detected the over-current (OC) protection event.

If the USB 2.0 device controller was used and the respective interrupt bit also enabled before the system entered into power down mode, the following events can wake-up the system.

- USB 2.0 device controllers detect connect interrupt.
- USB 2.0 device controllers detect disconnect interrupt.
- USB host issue reset signal to USB 2.0 device controller.
- USB host issue resume signal to USB 2.0 device controller.

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5 Devices Characteristics and Ratings

5.1 Absolute Maximum Ratings

The absolute maximum ratings for the FT905/6/7/8 series devices are as follows. These are in accordance with the Absolute Maximum Rating System (IEC 60134). Exceeding these may cause permanent damage to the device.

Parameter	Value	Unit
Storage Temperature	-65 to +150	°C
Floor Life (Out of Bag) At Factory Ambient (30°C / 60% Relative Humidity)	168 Hours (IPC/JEDEC J-STD-033A MSL Level 3 Compliant)*	Hours
Ambient Temperature (Power Applied)	-40 to +85	°C
VCC3V3 Supply Voltage	-0.5 to +4.6	V
DC Input Voltage – USB Host H_DP and H_DM	-0.5 to +5	V
DC Input Voltage – USB Device D_DP and D_DM	-0.5 to +5	V
DC Input Voltage – Ethernet TXON, TXOP, RXIN and RXIP	-0.5 to +5.6	V
DC Input Voltage – 5V tolerance I/O cells (GPIOs that are not shared with ADC/DAC)	-0.5 to +5.8	V
Others – 3V I/O cells (GPIOs that are shared with ADC/DAC)	-0.5 to VCC3V3+0.5	V

Table 5-1 - Absolute Maximum Ratings

* If devices are stored out of the packaging beyond this time limit the devices should be baked before use. The devices should be ramped up to a temperature of +125°C and baked for up to 17 hours.

5.2 DC Characteristics

Electrical Characteristics (Ambient Temperature = -40°C to +85°C)

The typical values are obtained at room temperature (T_j = 25°C), VCC3V3 = 3.3V, and VCC1V2 = 1.2V.

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
VCCIO3V3	I/O operating supply voltage	2.97	3.3	3.63	V	Normal Operation
I_{cc1}	Power down current	-	700	-	uA	Power Down Mode
I_{cc2}	Idle current	-	42	-	mA	Idle
I_{cc3}	System operating current*	-	75	-	mA	USB 2.0 Host controller high speed data transfer
		-	75	-	mA	USB 2.0 Device controller high speed data transfer
		-	100	-	mA	10/100 Mbit/s Ethernet transfer data
		-	50	-	mA	ADC / DAC Operation
VOUT1	Internal LDO voltage	-	1.2	-	V	Normal Operation

Table 5-2 - Operating Voltage and Current

Note: The typical system operating current measured, based on each function, implements normal operation with the FT32 core active, and other peripherals kept idle.

DC characteristics of I/O cells

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
V_{oh}	Output Voltage High	2.4	-	-	V	$\|I_{oh}\|$=2mA~16mA
V_{ol}	Output Voltage Low	-	-	0.4	V	$\|I_{ol}\|$=2mA~16mA
V_{opu}*	Output pull-up Voltage for 5V tolerance I/Os	VCCIO3V3 -0.9	-	-	V	$\|I_{pu}\|$ = 1uA
V_{ih}	Input High Voltage	2.0	-	-	V	LVTTL
V_{il}	Input Low Voltage	-	-	0.8	V	LVTTL
V_{th}	Schmitt trigger positive	-	1.6	2.0	V	LVTTL

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	threshold Voltage					
V_{tl}	Schmitt-trigger negative threshold Voltage	0.8	1.1	-	V	LVTTL
R_{pu}	Input pull-up resistance equivalent	40	75	190	KΩ	V_{in} = 0V
R_{pd}	Input pull-down resistance equivalent	40	75	190	KΩ	V_{in} = VCCIO3V3
I_{in}	Input leakage current	-	±1	-	uA	V_{in} = VCCIO3V3 or 0
		-	±1	-	uA	V_{in} = 5V or 0
C_{in}*	Input Capacitance	-	2.8	-	pF	VCCIO3V3 with 5V tolerance I/O

Table 5-3 - Digital I/O Pin Characteristics (VCCIO3V3 = +3.3V, Standard Drive Level)

Note: This parameter indicates that the pull-up resistor for the 5V tolerance I/O cells cannot reach VCCIO3V3 DC level even without DC loading current.

C_{in} includes the cell layout capacitance and pad capacitance.

DC characteristics of USB I/O cells

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
General characteristics						
VUSB3V3	USB power supply voltage	2.97	3.3	3.63	V	Normal operation
VCC1V2*	USB core supply voltage	1.08	1.2	1.32	V	Normal operation
Input level for high speed						
V_{hscm}	Voltage of high speed data signal in the common mode	-50	-	500	mV	-
V_{hssq}	High speed squelch detection threshold	-	-	100	mV	Squelch is detected
		150	-	-	mV	Squelch is not detected
V_{hsdsc}	High speed disconnection detection threshold	625	-	-	mV	Disconnection is detected
		-	-	525	mV	Disconnection is not detected
Output level for high speed						
V_{hsoi}	High speed idle output voltage (Differential)	-10	-	10	mV	-
V_{hsol}	High speed low level output voltage (Differential)	-10	-	10	mV	-
V_{hsoh}	High speed high level output voltage (Differential)	-360	-	400	mV	-
V_{chirpj}	Chirp-J output voltage (Differential)	700	-	1100	mV	-
V_{chirpk}	Chirp-K output voltage (Differential)	-900	-	-500	mV	-
Input level for full speed and low speed						
V_{di}	Differential input voltage sensitivity	0.2	-	-	V	$\|V_{dp}-V_{dm}\|$
V_{cm}	Differential common mode voltage	0.8	-	2.5	V	-
V_{se}	Single ended receiver threshold	0.8	-	2.0	V	-
Output level for full speed and low speed						
V_{ol}	Low level output voltage	0	-	0.3	V	-
V_{oh}	High level output voltage	2.8	-	3.6	V	-
Resistance						
R_{drv}	Driver output impedance	40.5	45	49.5	ohm	Equivalent resistance used as an internal chip

Table 5-4 - USB I/O Pin (D_DP/D_DM, H_DP/H_DM) Characteristics

Note: The VCC1V2 is the USB Host or Peripheral transceiver core power supply input which needs connected to an external +1.2V voltage power while the USB Host or Peripheral controller is active.

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DC characteristics of Ethernet I/O cells

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
General characteristics						
VETH3V3	Ethernet power supply voltage	2.97	3.3	3.63	V	Normal operation
VOUT2*	Ethernet LDO voltage	-	1.2	-	V	Normal operation
Total dissipative power	10Base-TX mode (Including TX current)	-	-	510	mW	10Base-TX mode
	10Base-TX mode (Excluding TX current)	-	-	147	mW	10Base-TX mode
	100Base-TX mode (Including TX current)	-	-	310	mW	100Base-TX mode
	100Base-TX mode (Excluding TX current)	-	-	165	mW	100Base-TX mode
	Auto-negotiation mode (Including TX current)	-	-	550	mW	100Base-TX mode
	Auto-negotiation mode (Excluding TX current)	-	-	187	mW	100Base-TX mode
	Power down mode	-	-	10	mW	Ethernet power down

Table 5-5 – Ethernet I/O pin (TXON/TXOP, RXIN/RXIP) characteristics

Note: The VOUT2 is the internal Regulator +1.2V voltage output which provide a power supply for the Ethernet transceiver.

DC characteristics of DAC I/O cells

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
VCC3V3A	DAC power supply voltage	2.97	3.3	3.63	V	Normal Operation
VREFP	Reference voltage	0	-	VCC3V3A	V	DCAP_REFP positive reference
RES	Resolution	10	-	-	Bits	-
INL	Integral nonlinearity error	-2	-	2	LSB	VREFP = VCC3V3A
DNL	Differential nonlinearity error	-1	-	1	LSB	VREFP = VCC3V3A
-	Conversion latency	-	-	1	Clock cycle	-
-	DAC reference impedance	150	-	200	KΩ	-
C_{LOAD}	Output load: rated capacitance	-	-	10	pF	-
R_{LOAD}	Output load: rated resistance	6.7	-	-	KΩ	-

Table 5-6 – DAC I/O pin (DAC_REFP, DAC0/1) characteristics

DC characteristics of ADC I/O cells

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
VCC3V3A	Analog power supply voltage	2.97	3.3	3.63	V	Normal operation
XAIN	Analog input range	0	-	VCC3V3A	V	-
RES	Resolution	-	10	-	Bit	-
INL	Integral nonlinearity error	-3	0.56/-1.05	2	LSB	10%-90% of VCC3V3A Reference
		-4	0.56/-1.05	2	LSB	Rail-to-Rail VCC3V3A reference
DNL	Differential nonlinearity error	-1	0.66/-0.58	1	LSB	-
Xsampleclk	Sample rate	-	-	960	KSPS	-

Table 5-7 - ADC I/O Pin Characteristics

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5.3 AC Characteristics

AC Characteristics (Ambient Temperature = -40°C to +85°C)

System clock dynamic characteristics

Parameter	Value			Unit
	Minimum	Typical	Maximum	
Crystal oscillator				
Clock frequency	-	12.00	-	MHz
Clock accuracy	-	-	50	ppm
Period jitter	-	-	120	ps
Cycle-to-cycle jitter	-	-	150	ps
Long-term jitter	-	-	200	ps
External clock input				
external clock jitter	-	-	500	Ps
clock duty cycle	45	50	55	%
Input voltage on pin XI/CLKIN	-	3.3	-	V

Table 5-8 - System clock characteristics

RTC clock dynamic characteristics

Parameter	Value			Unit
	Minimum	Typical	Maximum	
Crystal oscillator				
Clock frequency	-	32768	-	Hz
External clock input				
external clock jitter	-	-	500	Ps
clock duty cycle	45	50	55	%
Startup time	-	0.5	5	S
Input voltage on pin RTC_XI/RTC_CLKIN	-	1.2	-	V

Table 5-9 - RTC clock characteristics

Analog USB I/O pins dynamic characteristics

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
Driver characteristic for high speed						
T_{hsr}	High speed differential rise time	500	-	-	ps	-
T_{hsf}	High speed differential fall time	500	-	-	ps	-
Driver characteristic for full speed						
T_{fr}	Rise time of DP/DM	4	-	20	ns	Cl=50pF 10%~90% of |Voh–Vol|
T_{ff}	Fall time of DP/DM	4	-	20	ns	Cl=50pF 10%~90% of |Voh–Vol|
T_{frma}	Differential rise/fall time matching	90	-	110	%	The first transition exclude from the idle mode
Driver characteristic for low speed						
T_{lr}	Rise time of DP/DM	75	-	300	ns	Cl=200pF~600pF 10%~90% of |Voh–Vol|
T_{lf}	Fall time of DP/DM	75	-	300	ns	Cl=200pF~600pF 10%~90% of |Voh–Vol|
T_{lrma}	Differential rise/fall time matching	80	-	125	%	The first transition exclude from the idle mode

Table 5-10 - Analog I/O pins (D_DP/D_DM, H_DP/H_DM) characteristics

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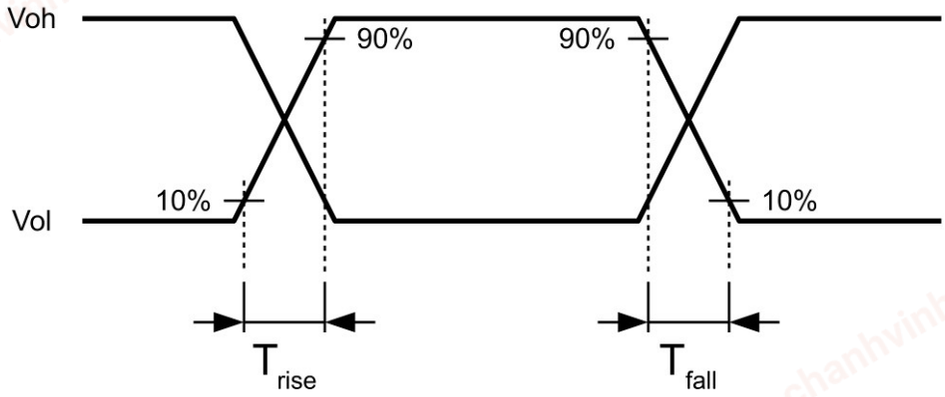


Figure 5-1 - USB Rise and Fall Times for DP/DM

Analog Ethernet I/O pins dynamic characteristics

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
Transmitter characteristics						
2 x V_{txa}	Peak-to-peak differential output voltage	1.9	2.0	2.1	V	100Base-TX mode
T_r / T_f	Signal rise/fall time	3.0	4.0	5.0	ns	100Base-TX mode
-	Output jitter	-	-	1.4	ns	100Base-TX mode, scrambled idle signal
V_{txov}	Overshoot	-	-	5.0	%	100Base-TX mode
Receiver characteristics						
-	Common-mode input voltage	2.97	3.3	3.63	V	-
-	Error-free cable length	100	-	-	meter	-

Table 5-11 - Analog I/O pins (TXON/TXOP, RXIN/RXIP) characteristics

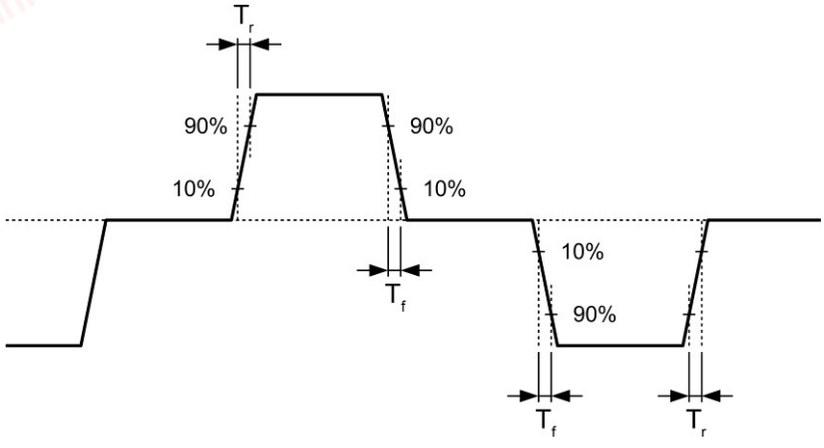


Figure 5-2 - 100Base-TX $T_{r/f}$ Timing

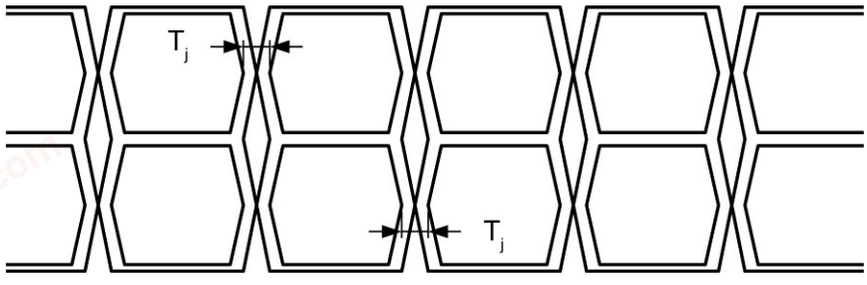


Figure 5-3 - 100Base-TX Jitter Timing

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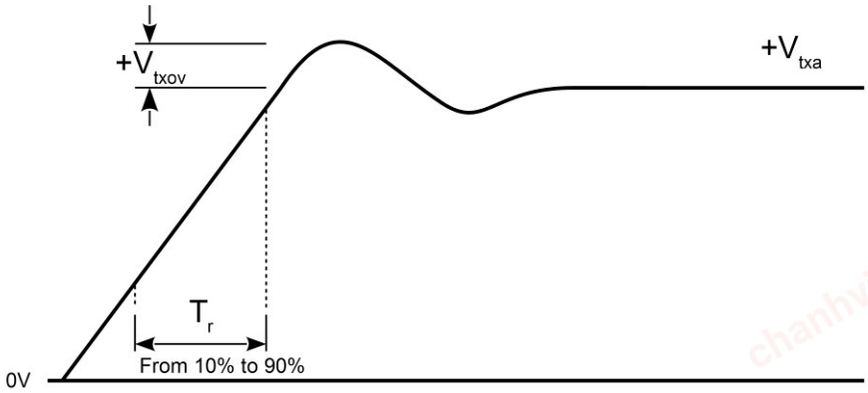


Figure 5-4 - 100Base-TX Transmission Waveform

I²C Bus I/O pins dynamic characteristics (V_{cc} (I/O) = 3.3V)

Parameter	Description	Standard mode (SM)		Fast mode (FM)		Fast mode Plus (FM+)		High Speed mode (HS)		Unit
		Min	Max	Min	Max	Min	Max	Min	Max	
F_{SCL}	SCL clock frequency	0	100	0	400	0	1000	0	3400	kHz
T_{SCLL}	SCL clock low period	4.7	-	1.3	-	0.5	-	0.320	-	µs
T_{SCLH}	SCL clock high period	4.0	-	0.6	-	0.26	-	0.120	-	µs
T_{SU}	data setup time	250	-	100	-	50	-	10	-	ns
T_{HD}	data hold time	0	-	0	-	0	-	0	150	ns
T_r	rise time	-	1000	-	300	-	120	20	160	ns
T_{rCL1}	rise time 1st clock after S_r (HS)							20	160	ns
T_{rCL}	rise time clock (HS)							20	80	ns
T_f	fall time	-	300	-	300	-	300	20	80 (SCL) 160 (SDA)	ns

Table 5-12 - I2C I/O pins (I2C0_SCL/SDA, I2C1_SCL/SDA) characteristics

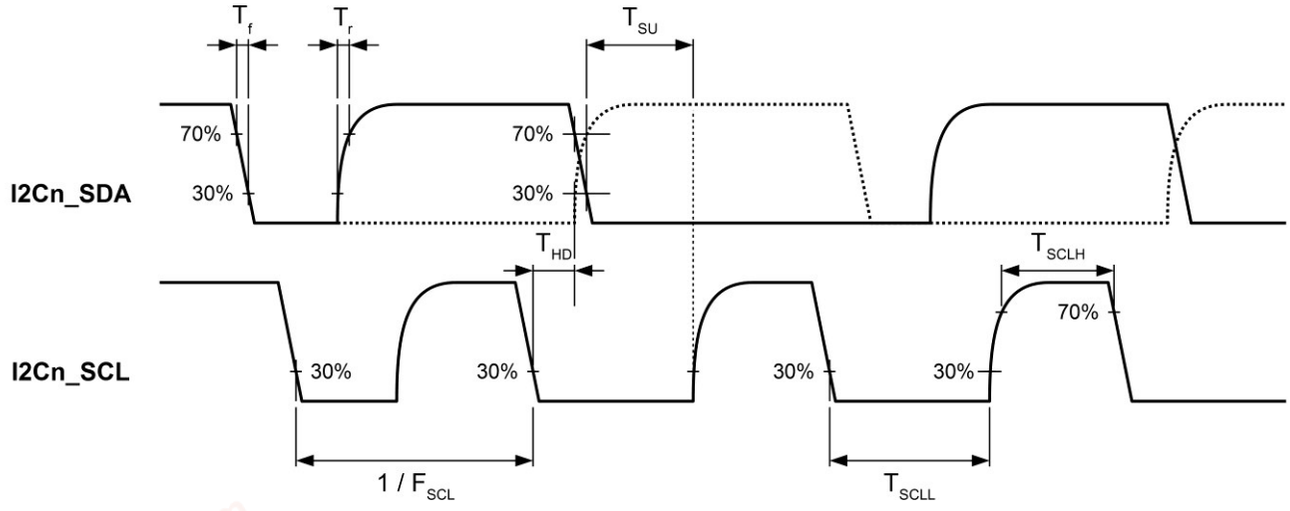


Figure 5-5 - Definition of I²C Timing F/S mode

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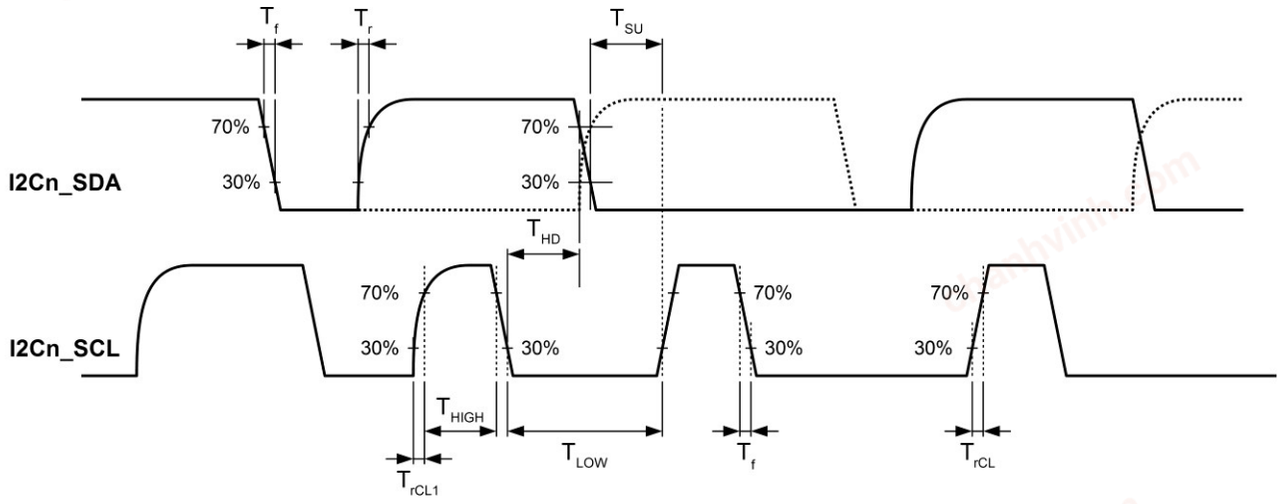


Figure 5-6 - Definition of I²C Timing HS mode

SPI Master I/O pins dynamic characteristics (V_{cc} (I/O) = 3.3V)

Parameter	Description	Min	Typ	Max	Unit
T_{SCLK}	SPI clock period	20			ns
T_{SCLKL}	SPI clock low duration	19			ns
T_{SCLKH}	SPI clock high duration	19			ns
T_{OD}	output data delay	19		20	ns

Table 5-13 - SPI I/O pins (SPIM_CLK/MOSI/MISO/SS0/SS1/SS2/SS3) characteristics

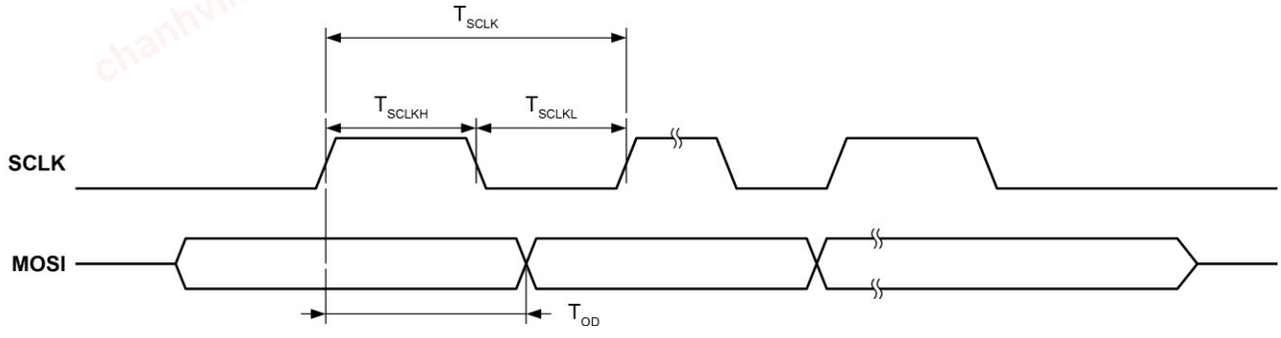


Figure 5-7 - Definition of SPI Master Timing Mode 0

SPI Slave I/O pins dynamic characteristics (V_{cc} (I/O) = 3.3V)

Parameter	Description	Min	Typ	Max	Unit
T_{SCLK}	SPI clock period	40			ns
T_{SCLKL}	SPI clock low duration	16			ns
T_{SCLKH}	SPI clock high duration	16			ns
T_{SAC}	SPI access time	20			ns
T_{OD}	output data delay	7		27	ns
T_{ZO}	output enable delay	10			ns
T_{OZ}	output disable delay	10			ns
T_{CSH}	CS hold time	0			ns

Table 5-14 - SPI I/O pins (SPIS0_CLK/MOSI/MISO/SS, SPIS1_CLK/MOSI/MISO/SS) characteristics

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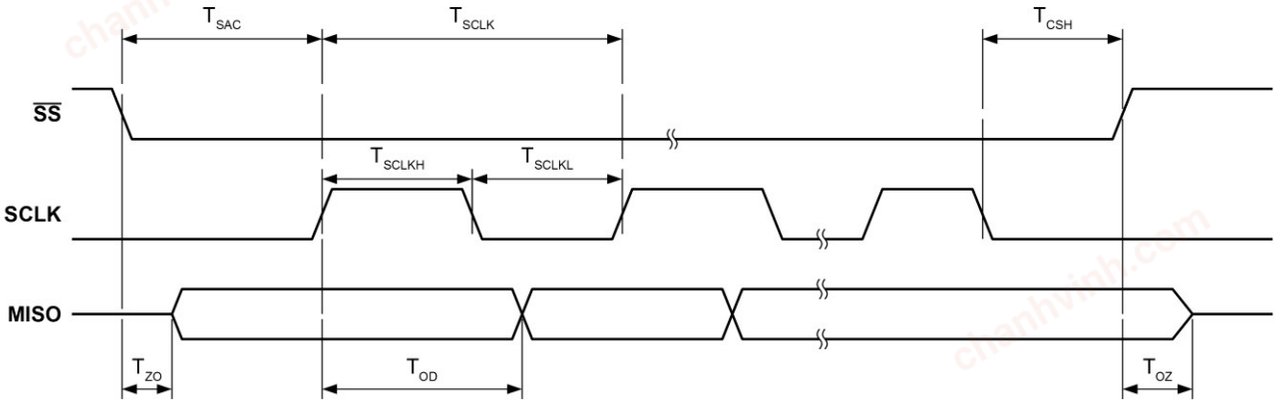


Figure 5-8 - Definition of SPI Slave Timing Mode 0

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6 Application Information

6.1 Crystal Oscillator

The crystal oscillator operates at a frequency of 12MHz. The oscillator can operate in one of two following configurations.

6.1.1 Crystal Oscillator Application Circuit

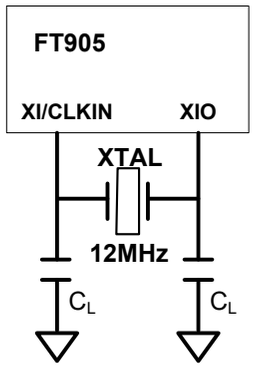


Figure 6-1 - Crystal oscillator connection

Feedback resistance is integrated on chip; only a crystal and capacitors C_L need to be connected externally. With the proper selection of crystal, the oscillator circuit can generate better quality signals for the FT905/6/7/8. Parameter C_L is typically 27pF but should be checked with the crystal manufacturer.

6.1.2 External Clock Input

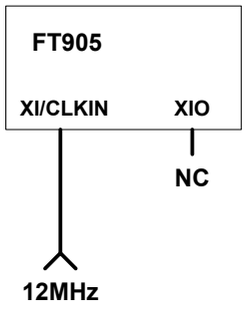


Figure 6-2 - External clock input

The 12MHz input clock signal connects XI/CLKIN to the internal oscillator directly. The XIO pin can be left unterminated.

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6.2 RTC Oscillator

In the RTC oscillator circuit Figure 6-3, only a 32.768 kHz crystal and capacitors C_{RTCL} need to be connected externally. The parameter C_{RTCL} should be checked with the crystal manufacturer.

An external input clock Figure 6-4 can be connected to RTC_XI/RTC_CLKIN if RTC_XIO is left open.

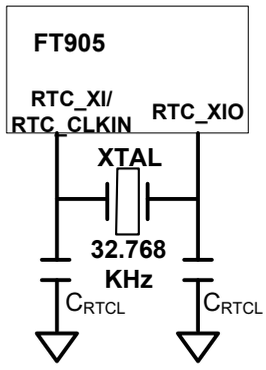


Figure 6-3 - RTC 32.768 KHz oscillator connection

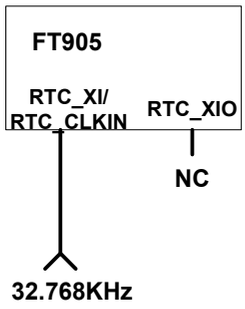


Figure 6-4 - External 32.768 KHz clock input

6.3 Standard I/O Pin Configuration

Figure 6-5 shows the possible pin modes for standard I/O pins with multiplex functions:

- Output driver enabled
- Output driver capability control
- Output slew rate control
- Open drain output
- Input with pull-up enabled
- Input with pull-down enabled
- Input with keeper enabled
- Input with Schmitt trigger

The default configuration for standard I/O pins is input with pull-down enabled except GPIO 0/1/2. All I/O pins have ESD protection.

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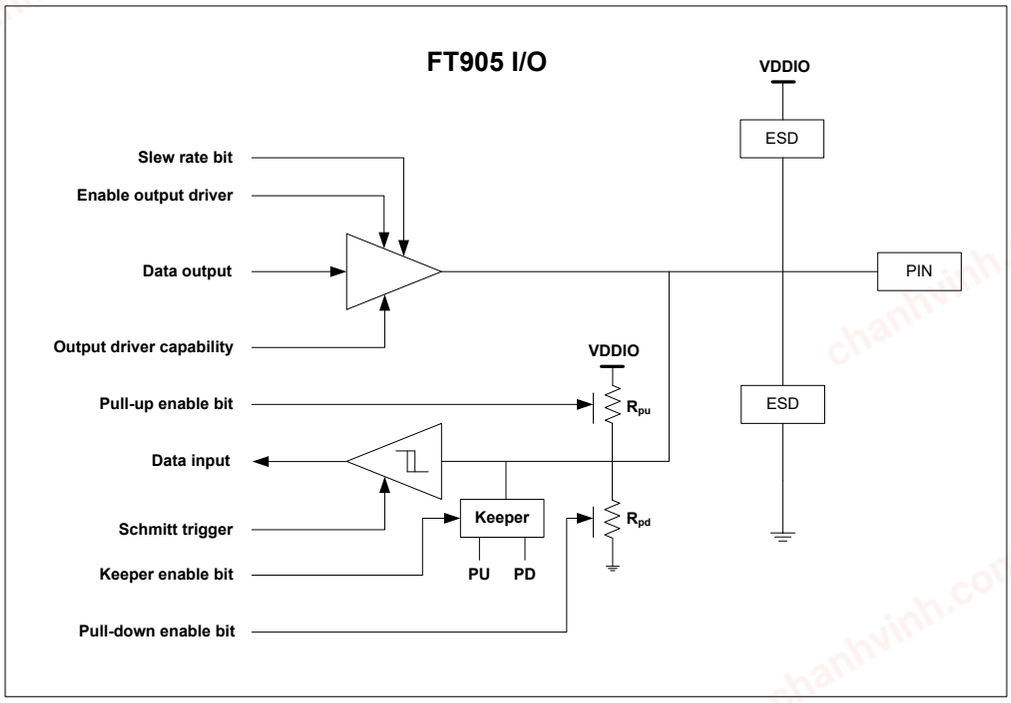


Figure 6-5 - Standard I/O pin configuration

6.4 USB 2.0 Device and Host Interface

The example diagram in Figure 6-6 shows the FT905/6/7/8 series supporting one USB 2.0 host port and one USB 2.0 device port, which makes the FT905/6/7/8 system data transfer possible via USB.

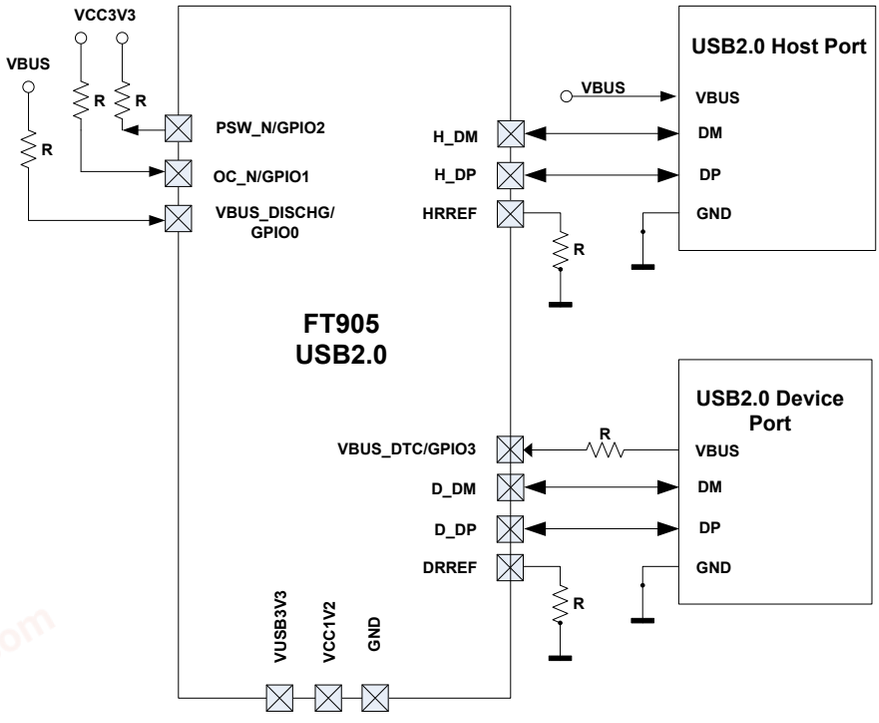


Figure 6-6 – USB 2.0 ports connection

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The FT905/6/7/8 System shall provide I/O power (+3.3V supply) on VUSB3V3 and core power (+1.2V supply) on VCC1V2 for the USB 2.0 device/host controller. The internal band-gap gets reference voltage from DRREF or HRREF with an external reference resistor R (12 KΩ ±1%) respective connected to GND.

The USB 2.0 host controller will provide +5V power voltage output for VBUS and go through PSW_N signal to control power switching on/off.

6.5 10/100 Mb/s Ethernet Interface

Figure 6-7 shows the 10/100 Mb/s Ethernet port configuration via the transmit (TXON & TXOP) and receive (RXIN & RXIP) differential pair pins.

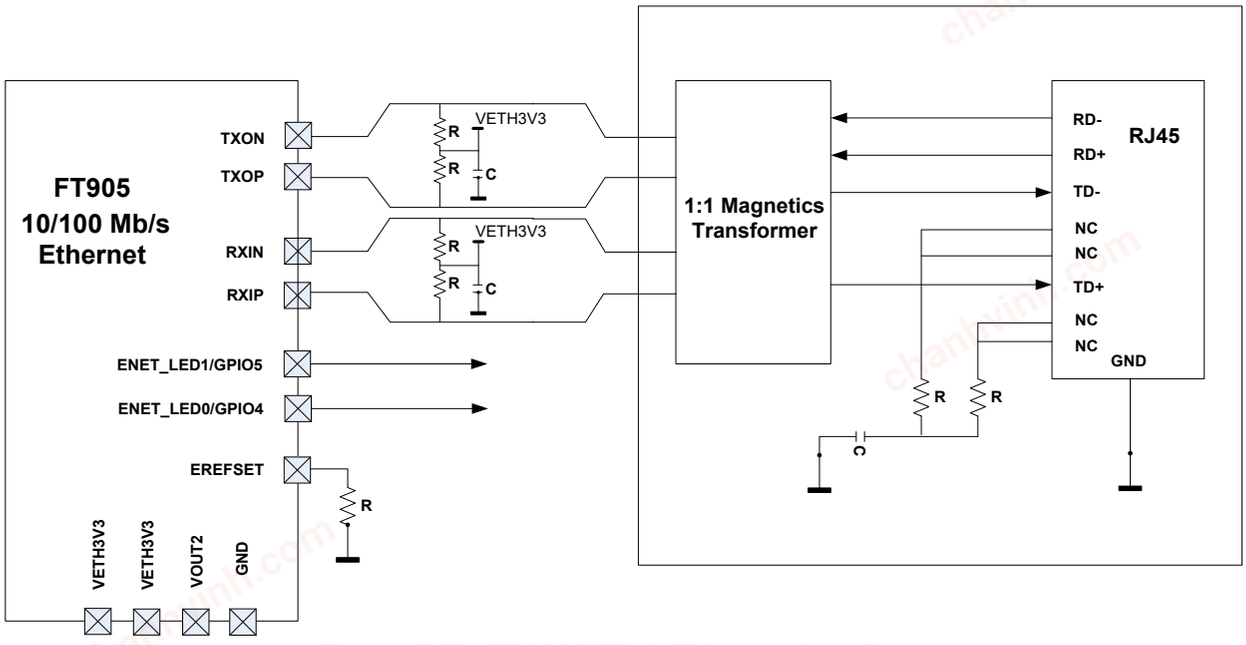


Figure 6-7 - 10/100 Mb/s Ethernet interface

The FT905/6/7/8 Ethernet connection to a termination network should go through a 1:1 magnetics transformer and an RJ-45. For space saving, the magnetics and RJ-45 may be a single integrated component. The system shall provide +3.3V power supply for VETH3V3. The internal Regulator will generate +1.2V output on VOUT2. The EREFSET connects an external resistor R (12.3 KΩ ±1%) to GND to provide a reference voltage for the Ethernet transceiver.

There are two Ethernet LEDs output for TX/RX transmission, Full-duplex/Half-duplex, Collision, Link or 10/100 Mb/s Speed indication. The required function should be set in the chip registers before using the LED indicator.

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6.6 Ethernet Connection when Unused (FT905 & FT906)

If the Ethernet peripheral is not used in the end application, connect VETH3V3 to ground, see Figure 6-8 and Figure 6-9.

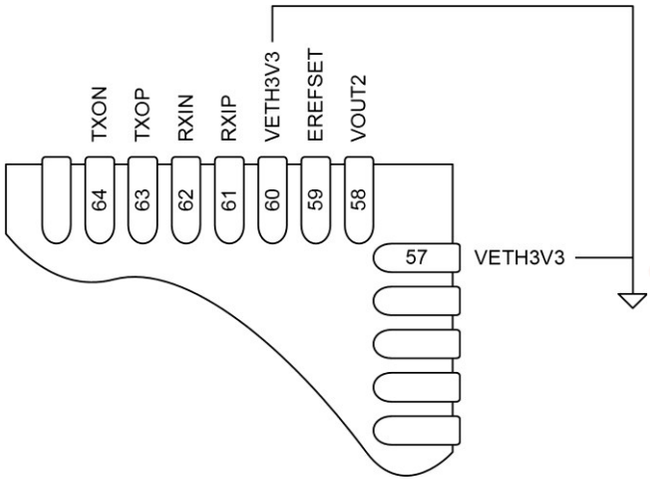


Figure 6-8 - Unused Ethernet Connection (QFN)

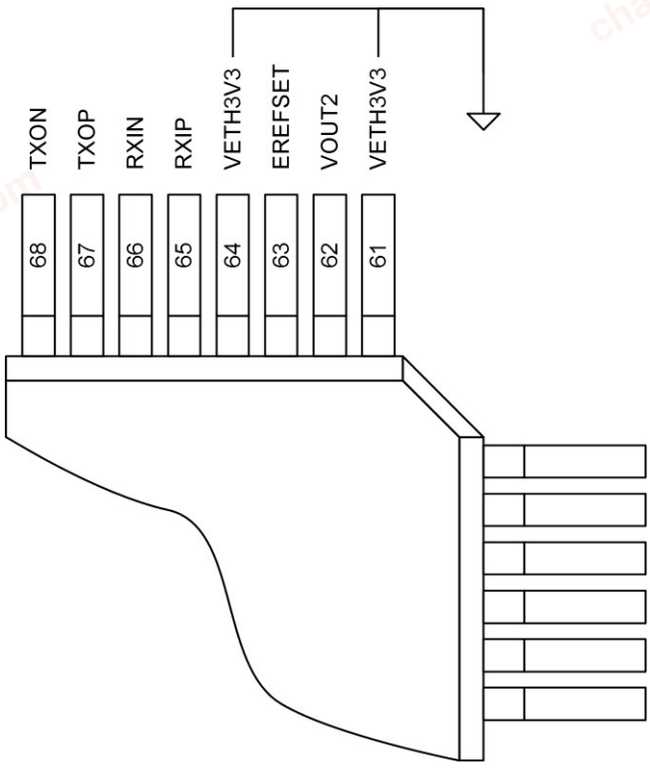


Figure 6-9 - Unused Ethernet Connection (LQFP)

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6.7 USB Connection when Unused (FT905/6/7/8)

If the USB peripheral (Host and Device) is not used in the end application, connect VUSB3V3, HRREF, and DRREF to ground, see Figure 6-10 and Figure 6-11.

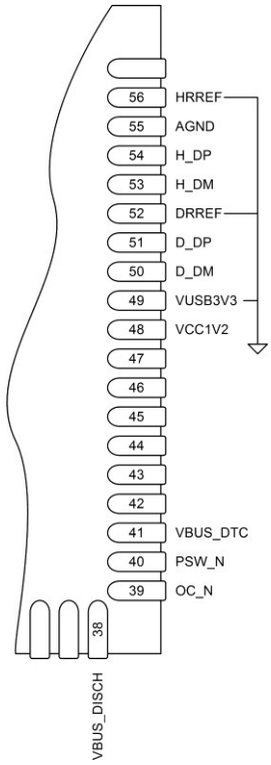


Figure 6-10 – Unused USB Connection (QFN)

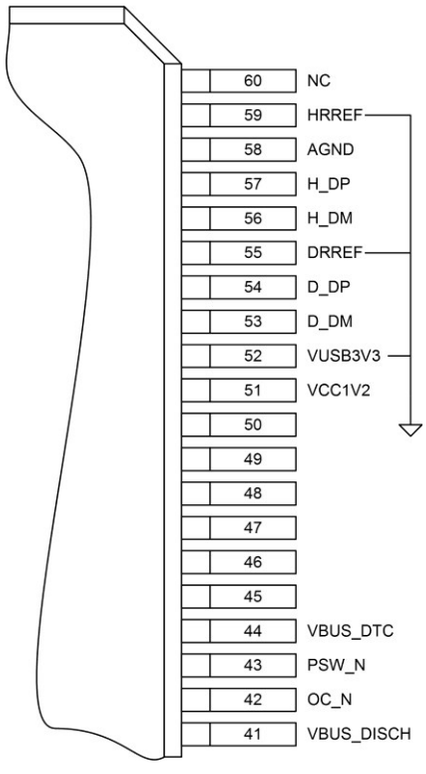


Figure 6-11 – Unused USB Connection (LQFP)

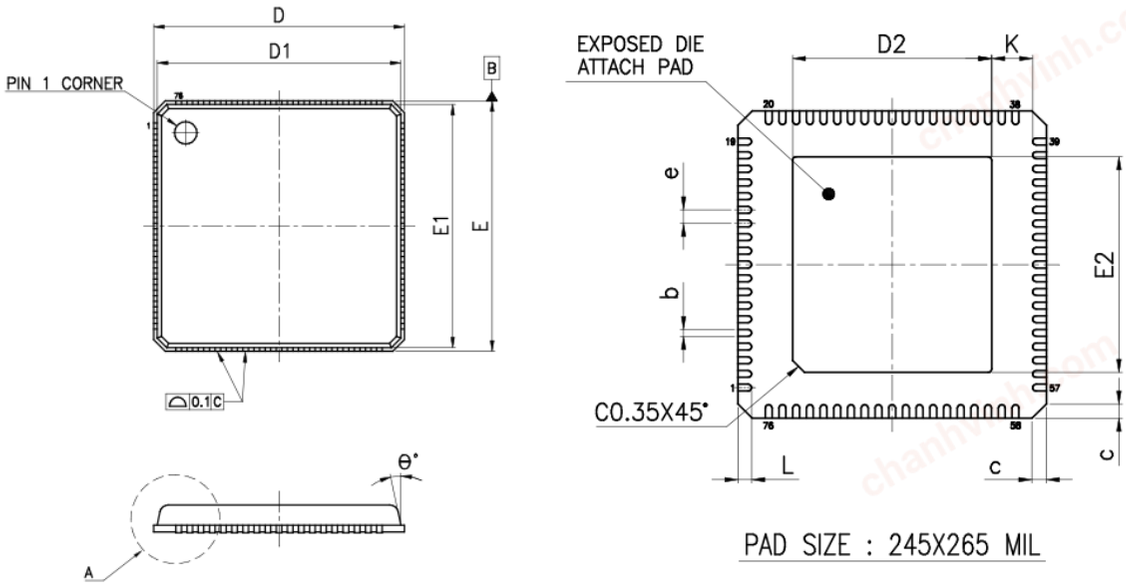
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7 Package Parameters

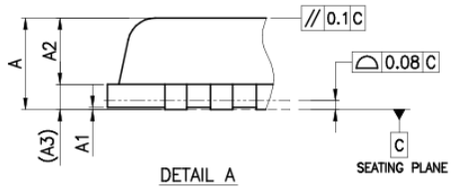
The FT905/6/7/8 series is available in two different packages. The FT905Q/FT906Q/FT907Q/FT908Q is the QFN-76 package and the FT905L/FT906L/FT907L/FT908L is LQFP-80 package. The dimensions, markings and solder reflow profile for all packages are described in the following sections.

7.1 QFN-76 Package Dimensions



SYMBOLS	MIN.	NOM.	MAX.
A	**0.80**	**0.90**	**1.00**
A1	0.00	0.02	0.05
A2		0.65 REF.	
A3		0.20 REF.	
b	0.15	0.20	0.25
c	0.24	0.42	0.60
D	8.90	9.00	9.10
D1	8.65	8.75	8.85
E	8.90	9.00	9.10
E1	8.65	8.75	8.85
e		0.40 BSC.	
K	0.20	—	—
θ°	0.00	—	12.00

UNIT : mm



	EXPOSED PAD						L		
	D2			E2					
DIE PAD	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
245X265 MIL	5.56	5.81	6.06	6.06	6.31	6.56	0.30	0.40	0.50

UNIT: MM

Figure 7-1 - QFN-76 Package Dimensions

Note: On the underside of the package, the exposed thermal pad should be connected to GND.

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7.2 QFN-76 Device Marking

FT90XQ Top Side

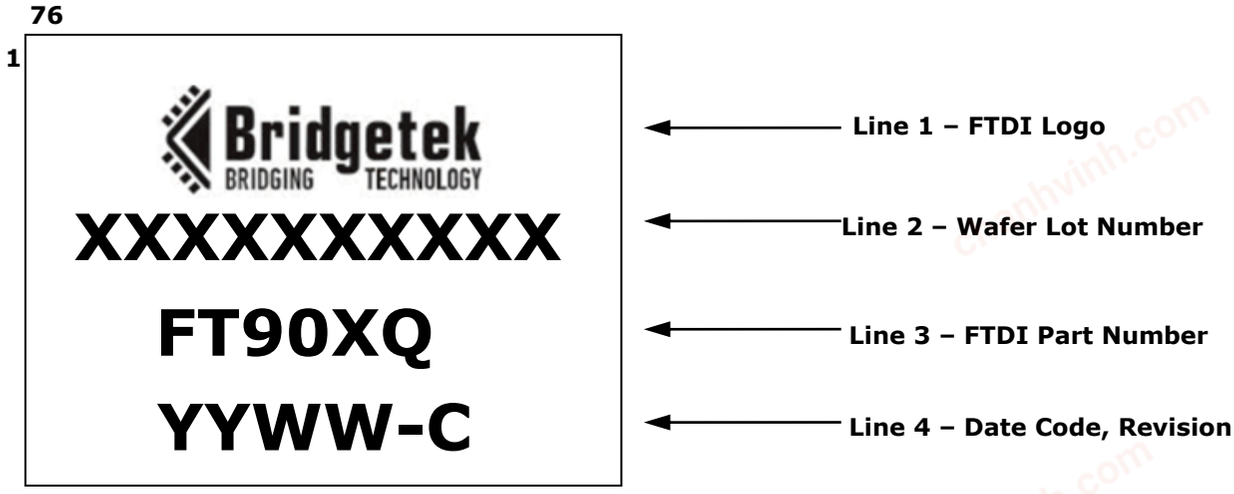


Figure 7-2 - FT90XQ Top side

Notes:

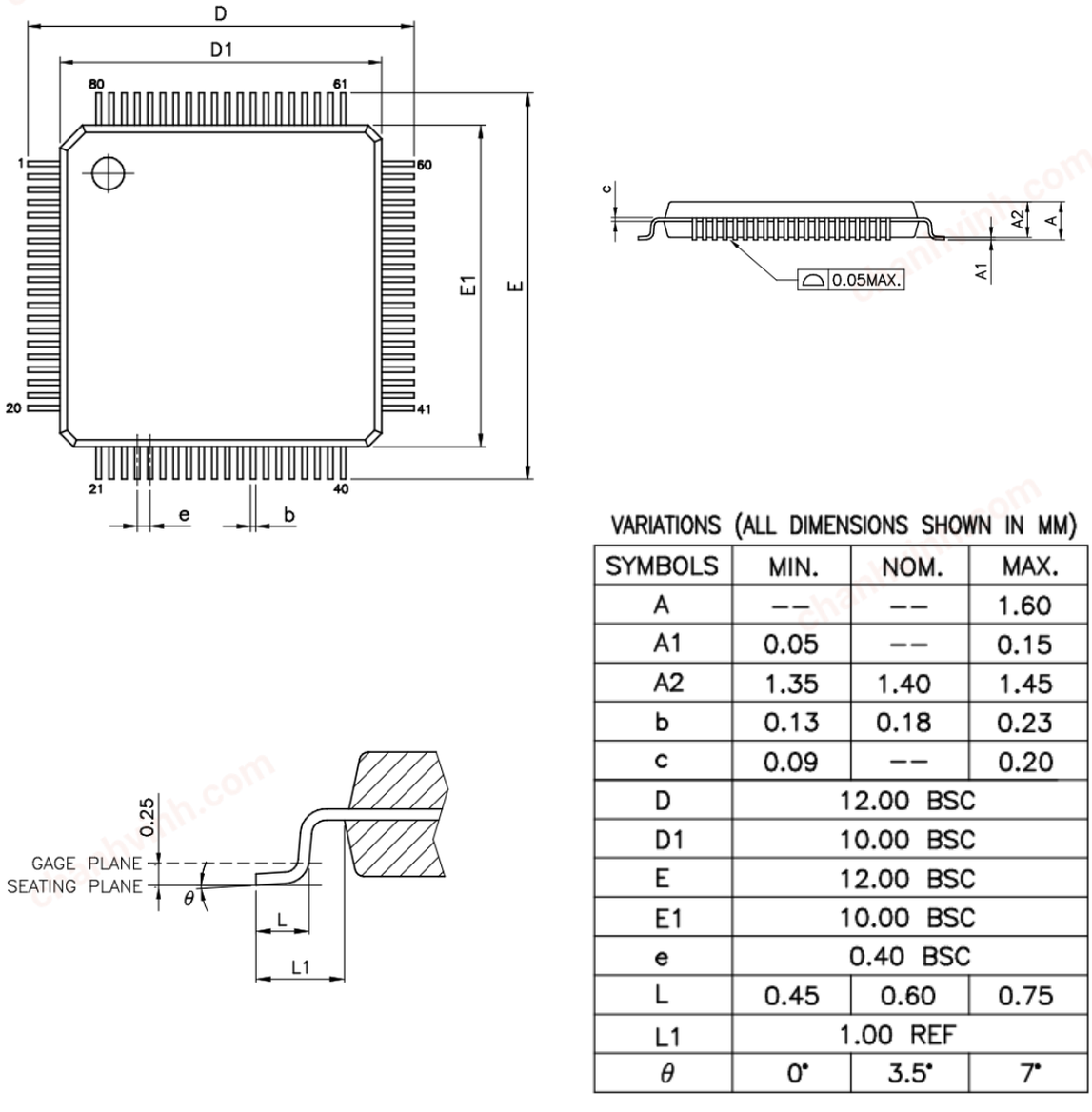
1. FT90XQ symbol stands for FT905Q, FT906Q, FT907Q and FT908Q.
2. YYWW = Date Code, where YY is year and WW is week number and following character B indicates the silicon revision B.
3. Marking alignment should be centre justified.
4. Laser marking should be used.

All marking dimensions should be marked proportionally. Marking font should be using standard font (Roman Simplex).

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7.3 LQFP-80 Package Dimensions



VARIATIONS (ALL DIMENSIONS SHOWN IN MM)

SYMBOLS	MIN.	NOM.	MAX.
A	--	--	1.60
A1	0.05	--	0.15
A2	1.35	1.40	1.45
b	0.13	0.18	0.23
c	0.09	--	0.20
D	12.00 BSC		
D1	10.00 BSC		
E	12.00 BSC		
E1	10.00 BSC		
e	0.40 BSC		
L	0.45	0.60	0.75
L1	1.00 REF		
θ	0°	3.5°	7°

Figure 7-3 - LQFP-80 Package Dimensions

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7.4 LQFP-80 Device Marking

FT90XL Top Side

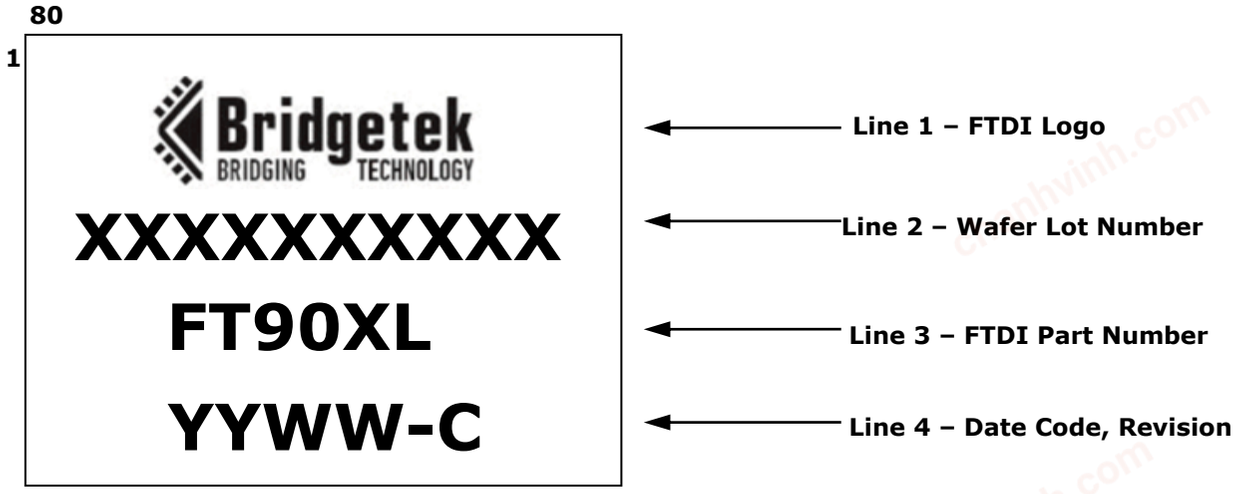


Figure 7-4 - FT90XL Top side

Notes:

1. FT90XL symbol stands for FT905L, FT906L, FT907L and FT908L.
2. YYWW = Date Code, where YY is year and WW is week number and following character B indicates the silicon revision B.
3. Marking alignment should be centre justified.
4. Laser marking should be used.
5. All marking dimensions should be marked proportionally. Marking font should be using standard font (Roman Simplex).

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7.5 Solder Reflow Profile

The FT905/6/7/8 series is supplied in Pb free QFN-76 package and LQFP-80 package. The recommended solder reflow profile for all packages options is shown in Figure 7-5.

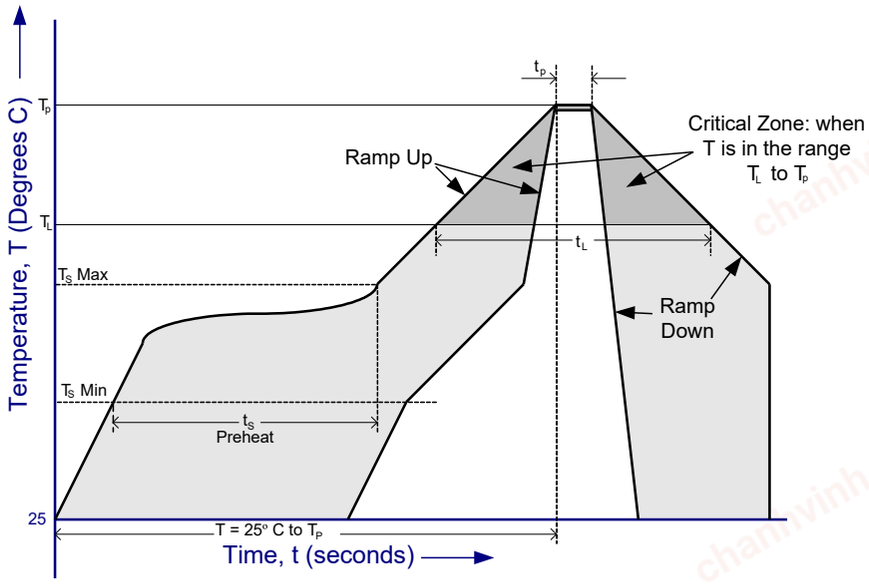


Figure 7-5 - FT905 Solder Reflow Profile

The recommended values for the solder reflow profile are detailed in Table 7-1. Values are shown for both a completely Pb free solder process (i.e. the FT905 is used with Pb free solder), and for a non-Pb free solder process (i.e. the FT905 is used with non-Pb free solder).

Profile Feature	Pb Free Solder Process	Non-Pb Free Solder Process
Average Ramp Up Rate (T_s to T_p)	3°C / second Max.	3°C / Second Max.
Preheat - Temperature Min (T_s Min.) - Temperature Max (T_s Max.) - Time (t_s Min to t_s Max)	150°C 200°C 60 to 120 seconds	100°C 150°C 60 to 120 seconds
Time Maintained Above Critical Temperature T_L: - Temperature (T_L) - Time (t_L)	217°C 60 to 150 seconds	183°C 60 to 150 seconds
Peak Temperature (T_p)	260°C	240°C
Time within 5°C of actual Peak Temperature (t_p)	20 to 40 seconds	20 to 40 seconds
Ramp Down Rate	6°C / second Max.	6°C / second Max.
Time for T= 25°C to Peak Temperature, T_p	8 minutes Max.	6 minutes Max.

Table 7-1 - Reflow Profile Parameter Values

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8 Contact Information

Refer to https://brtchip.com/contact-us/ for contact information.

Distributor and Sales Representatives

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

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Appendix A – References

Document References

FT90x Product Page

AN_324 FT9xx_User_Manual

BRT_AN_020_FT90x_Revison_C_User_Manual

BRT_AN_019_Migration_Guide_Moving_from_FT90x_Revision_B_to_FT90x_Revision_C

AN_341 FT32 Technical Manual (available under NDA. Contact Bridgetek for more information)

USB2.0 Specification

Battery Charging Specification Revision 1.2 (BC 1.2)

Acronyms and Abbreviations

Terms	Description
ADC	Analog-to-Digital Converter
BCD	Battery Charge Device
CAN	Controller Area Network
CDP	Charging Downstream Port
DAC	Digital-to-Analog Converter
DAQ	Data Acquisition
DCP	Dedicated Charging Port
DNL	Differential Nonlinearity
FCS	Ethernet Frame Check Sequence
FIFO	First In First Out
GPIO	General Purpose Input / Output
INL	Integral Nonlinearity
I/O	Input / Output
LQFP	Low profit Quad Flat Package
LSB	Least Significant Bit
MSPS	Mega Samples Per-Second

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Terms	Description
NMI	Non-Maskable Interrupt input
OTP	One-Time Programmable (memory)
POR	Power On Reset
PWM	Pulse Width Modulator
QFN	Quad Flat No-Lead
RTC	Real Time Clock
SDP	Standard Downstream Port
SPI	Serial Peripheral Interface
UART	Universal Asynchronous Receiver/Transmitter
USB	Universal Serial Bus
NDA	Non-Disclosure Agreement

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Appendix C - Revision History

Document Title: FT905/6/7/8 Revision C Embedded Microcontroller Datasheet
Document Reference No.: BRT_000173
Clearance No.: BRT#100
Product Page: http://brtchip.com/product/
Document Feedback: Send Feedback

Revision	Changes	Date
Version 1.0	Initial Release	01-11-2017
Version 1.1	Updated the following – IC Image on the cover page BRT Logo line of the package marking Company Address	03-02-2025

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