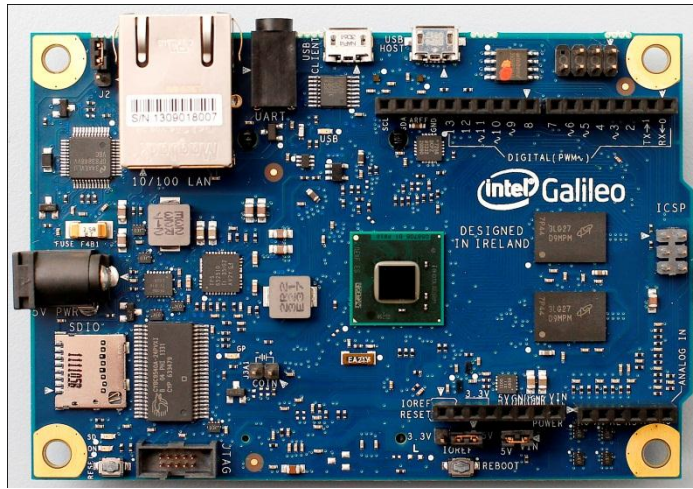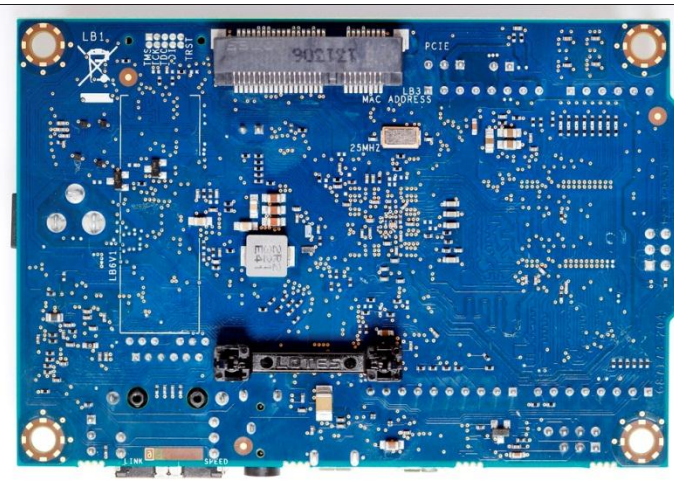# Galileo Datasheet

Galileo Front   *Galileo Back*

Overview

Galileo is a microcontroller board based on the Intel® Quark SoC X1000 Application Processor, a 32-bit Intel Pentium-class system on a chip (datasheet). It is the first board based on Intel® architecture designed to be hardware and software pin-compatible with Arduino shields designed for the Uno R3. Digital pins 0 to 13 (and the adjacent AREF and GND pins), Analog inputs 0 to 5, the power header, ICSP header, and the UART port pins (0 and 1), are all in the same locations as on the Arduino Uno R3. This is also known as the Arduino 1.0 pinout.

Order Number: 329681-001US

Galileo is designed to support shields that operate at either 3.3V or 5V. The core operating voltage of Galileo is 3.3V. However, a jumper on the board enables voltage translation to 5V at the I/O pins. This provides support for 5V Uno shields and is the default behavior. By switching the jumper position, the voltage translation can be disabled to provide 3.3V operation at the I/O pins. The input range of the analog inputs remains from ground to 5V regardless of the jumper position.

Of course, the Galileo board is also SW compatible with the Arduino SW Development Environment, which makes usability and introduction a snap.

In addition to Arduino HW and SW compatibility, the Galileo board has several PC industry standard I/O ports and features to expand native usage and capabilities beyond the Arduino shield ecosystem. A full sized mini-PCI Express slot, 100Mb Ethernet port, Micro-SD slot, RS-232 serial port, USB Host port, USB Client port, and 8MByte NOR flash come standard on the board.

Intel Galileo

Intel® Galileo Board Fab D
September/2013

IOREF Jumper selects 3.3V or 5V Shield Operation

ICSP

IO12	1	○ ○	2	5V
IO13	3	○ ○	4	~IO11
RESET	5	○ ○	6	GND

5V Brick Power Supply
Three-Output Voltage Regulator
VTT Regulator
FETs for S0/S3 states

POWER

1	○
IOREF	2	○
RESET	3	○
3.3V	4	○
5V	5	○
GND	6	○
GND	7	○
VIN	8	○

3.3V

VIN

5V

All GPIO PWM provided by a single I2C IO Expander

DDR3 x8   256 MB   DDR3 x8

ANALOG IN

A0	1	○
A1	2	○
A2	3	○
A3	4	○
A4	5	○
A5	6	○

MUX

MUX

4

4

2

2

6

GPIO PWM

ADC

FLASH

COIN HDR

JTAG

I2C

SPI

LSPI

DEDIPROG

25MHz

Intel® Quark™ SoC X1000 Application Processor

Clocks Out

PCIe

Mini-PCIe

Host USB 1

SDIO

Micro SD Connector

Host USB 0

Client USB

Host USB   Client USB

RMII [0]

PHY

10/100 Ethernet

UART 1

RS-232 XCVR

3 pin Jack (Not Audio)

SPI1

GPIO PWM

GPIO LED

32.768 kHz GPIO (INT0/1)

GPIO PWM

UART 0

MUX

4

MUX

2

2

2

MUX

MUX

DIGITAL (PWM~)

○	10	SCL
○	9	SDA
○	8	AREF
○	7	GND
○	6	IO13
○	5	IO12
○	4	~IO11
○	3	~IO10
○	2	~IO9
○	1	IO8

○	8	IO7
○	7	~IO6
○	6	~IO5
○	5	IO4
○	4	~IO3
○	3	IO2
○	2	TX →
○	1	RX ←

3.3V <-> 5V Level Translation provided on board between all Clanton IO and Shield Headers

Order Number: 329681-001US

Getting Started

To get started, simply connect the board to power with the 5V AC-to-DC adapter and then connect to the computer with the micro-USB cable.

Galileo has a dedicated forum for discussing the board.

Details and Specifications

Arduino Shield Supported Features

Galileo is compatible with all Arduino Uno shields and is designed to support 3.3V or 5V shields, following the Arduino Uno Revision 3, including:

- **14 digital input/output pins,** of which 6 can be used as Pulse Width Modulation (PWM) outputs;
  - Each of the 14 digital pins on Galileo can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions.
  - The pins operate at 3.3 volts or 5 volts. Each pin can source a max of 10mA or sink a maximum of 25 mA and has an internal pull-up resistor (disconnected by default) of 5.6k to 10 kOhms.
- **A0 – A5 -** 6 analog inputs, via an AD7298 analog-to-digital (A/D) converter (datasheet)
  - Each of the 6 analog inputs, labeled A0 through A5, provides 12 bits of resolution (i.e., 4096 different values). By default they measure from ground to 5 volts.
- **I^2C bus, TWI,** with SDA and SCL pins that are near to the AREF pin.
  - TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.
- **SPI**
  - Defaults to 4MHz to support Arduino Uno shields. Programmable up to 25MHz.

- o **Note:** While Galileo has a native SPI controller, it will act as a master and not as an SPI slave. Therefore, Galileo cannot be a SPI slave to another SPI master. It can act, however, as a slave device via the USB Client connector.
- **UART** (serial port) Programmable speed UART port (Pins 0 (RX) and 1 (TX))
- **ICSP (SPI) -** a 6 pin in-circuit serial programming (ICSP) header, located appropriately to plug into existing shields. These pins support SPI communication using the SPI library.
- **VIN.** When using an external power source you can supply 5V through this pin.
  - o **Note:** When using this pin to supply power to the board, it must not be greater than 5V.
- **5V output pin.** This pin outputs 5V from the external source or the USB connector. Maximum current draw to the shield is 800 mA
- **3.3V output pin.** A 3.3 volt supply generated by the on-board regulator. Maximum current draw to the shield is 800 mA
- **GND.** Ground pins.
- **IOREF.** The IOREF pin on Galileo allows an attached shield with the proper configuration to adapt to the voltage provided by the board. The IOREF pin voltage is controlled by a jumper on the board, i.e., a selection jumper on the board is used to select between 3.3V and 5V shield operation.
- **RESET** button/pin
  - o Bring this line LOW to reset the sketch. Typically used to add a reset button to shields that block the one on the board.
- **AREF** is unused on Galileo. Providing an external reference voltage for the analog inputs is not supported.
  - o For Galileo it is not possible to change the upper end of the analog input range using the AREF pin and the analogReference() function.

Details of Intel® Architecture Supported Features

The genuine Intel processor and surrounding native I/O capabilities of the SoC provides for a fully featured offering for both the maker community and students alike. It will also be useful to professional developers who are looking for a more simple and cost effective development environment to the more complex Intel® Atom processor and Intel® Core processor-based designs.

- 400MHz 32-bit Intel® Pentium instruction set architecture (ISA)-compatible processor
    - 16 KByte L1 cache
    - 512 KBytes of on-die embedded SRAM
    - Simple to program: Single thread, single core, constant speed
    - ACPI compatible CPU sleep states supported
    - An integrated Real Time Clock (RTC), with an optional 3V "coin cell" battery for operation between turn on cycles.
- 10/100 Ethernet connector
- Full PCI Express* mini-card slot, with PCIe 2.0 compliant features
    - Works with half mini-PCIe cards with optional converter plate
    - Provides USB 2.0 Host Port at mini-PCIe connector
- USB 2.0 Host connector
    - Support up to 128 USB end point devices
- USB Client connector, used for programming
    - Beyond just a programming port - a fully compliant USB 2.0 Device controller
- 10-pin Standard JTAG header for debugging
- Reboot button to reboot the processor
- Reset button to reset the sketch and any attached shields
- Storage options:
    - 8 MByte Legacy SPI Flash whose main purpose is to store the firmware (or bootloader) and the latest sketch. Between 256 KByte and 512 KByte is dedicated for sketch storage. The upload happens automatically from the development PC, so no action is required unless there is an upgrade that is being added to the firmware.

- 512 KByte embedded SRAM that is enabled by the firmware by default.
- 256 MByte DRAM, enabled by the firmware by default.
- Optional micro SD card offers up to 32GByte of storage
- USB storage works with any USB 2.0 compatible drive
- 11 KByte EEPROM can be programmed via the EEPROM library.

Schematic, Reference Design & Pin Mapping

- Schematic: Galileo-schematic.pdf
- Cadence® Allegro® files: Galileo-reference-design.zip

Power

Galileo is powered via an AC-to-DC adapter, connected by plugging a 2.1mm center-positive plug into the board's power jack. The recommended output rating of the power adapter is 5V at up to 3A.

Electrical Summary

Input Voltage (recommended)	5V
Input Voltage (limits)	5V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
Total DC Output Current on all I/O lines	80 mA
DC Current for 3.3V Pin	800 mA
DC Current for 5V Pin	800 mA

Communication

Galileo has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers.

Galileo provides **UART** TTL (5V/3.3V) serial communication, which is available on digital pin 0 (RX) and 1 (TX). In addition, a second UART provides RS-232 support and is connected via a 3.5mm jack.

The **USB Client** ports allows for serial (CDC-ACM) communications over USB. This provides a serial connection to the Serial Monitor or other applications on your computer. It is also used to upload sketches to the board.

The **USB Host** port allows Galileo act as a USB Host for connected peripherals such as mice, keyboards, and smartphones. To use these features, see the USBHost reference pages.

Galileo is the first Arduino board to provide a mini **PCI Express** (mPCIe) slot. This slot allows full size and half size (with adapter) mPCIe modules to be connected to the board and also provides an additional USB Host port via the mPCIe slot. Any standard mPCIe module can be connected and used to provide applications such as WiFi, Bluetooth or Cellular connectivity. Initially, the Galileo mPCie slot provides support for the WiFi Library. For additional information, see the Intel® Galileo Getting Started Guide.

An **Ethernet RJ45 Connector** is provided to allow Galileo to connect to wired networks. Full support of on-board Ethernet interface is fully supported and does not require the use of the SPI interface like existing Arduino shields.

The onboard **microSD** card reader is accessible through the SD Library. The communication between Galileo and the SD card is provided by an integrated SD controller and does not require the use of the SPI interface like other Arduino boards. The native SD interface runs at up to 50MHz depending on the class of card used.

The Arduino software includes a Wire library to simplify use of the **TWI/I^{2}C** bus; see the documentation for details.

For **SPI** communication, use the SPI library.

Programming

Galileo can be programmed with the Arduino software (<u>download</u>). When you are ready to upload the sketch to the board, program Galileo through the USB Client port by selecting "Intel Galileo" as your board in the Arduino IDE. Connect Galileo's port labelled USB Client (the one closest to the Ethernet) to your computer.
For details, see the <u>reference</u>, <u>tutorials</u> and <u>Intel® Galileo Getting Started Guide</u>.

Rather than requiring a physical press of the reset button before an upload, Galileo is designed to be reset by software running on a connected computer.

When the board boots up two scenarios are possible:
- If a sketch is present in persistent storage, it is executed.
- If no sketch present, the board waits for upload commands from the IDE.

If a sketch is executing, you can upload from the IDE without having to press the reset button on the board. The sketch is stopped; the IDE waits for the upload state, and then starts the newly uploaded sketch.

Pressing the reset button on the board restarts a sketch if it is executing and resets any attached shields.

Properties of Pins Configured as OUTPUT

Pins configured as OUTPUT with pinMode() are said to be in a low-impedance state. On Galileo, when a pin is configured as OUTPUT, the functionality is provided via an I^{2}C-based Cypress I/O expander (datasheet). Digital pins 0 to 13 and Analog pins A0 to A5 can be configured as OUTPUT pins on Galileo.

The I/O expander's pins, when configured as OUTPUT, can source (provide positive current) up to 10 mA (milliamps) and can sink (provide negative current) up to 25 mA of current to other devices/circuits. The individual per pin current sourcing capability of 10 mA is subject to an overall limit of 80 mA combined between all OUTPUT pins. The per pin capability current sinking capability is subject to an overall limit of 200 mA. The following table provides a breakdown of the overall OUTPUT capabilities of the pins.

	Current Source (mA)	Current Sink (mA)
Per Pin Capability	10	25
Digital Pins 3,5,9,10,12, 13 Combined	40	100
Digital Pins 0,1,2,4,6,7,8,11 and Analog Pins A0,A1,A2,A3,A4, A5 Combined	40	100
Digital Pins 0-13 and Analog Pins A0-A5 Combined	80	200

Galileo Jumper Configuration

There are three jumpers on Galileo that are used to vary the configuration of the board.

IOREF Jumper

To allow Galileo support both 3.3V and 5V shields, the external operating voltage is controlled via a jumper. When the jumper is connected to 5V, Galileo is configured to be compatible with 5V shields and IOREF is set to 5V. When the jumper is connected 3.3V, Galileo is configured to be compatible with 3.3V shields and IOREF is set to 3.3V.

The input range of the Analog pins is also controlled by the IOREF jumper and must not exceed the chosen operating voltage. However, the resolution of AnalogRead() remains at 5 V/1024 units for the default 10-bit resolution or, 0.0049V (4.9mV) per unit regardless of IOREF jumper setting.

Warning: The IOREF jumper should be used to match the board and shield operating voltages. Incorrectly setting the voltage could damage the board or the shield.

I2C Address Jumper

To prevent a clash between the I2C Slave address of the on board I/O expander and EEPROM with any external I2C Slave devices, jumper J2 can be used to vary the I2C address of the on-board devices.

With J2 connected to pin 1 (marked with white triangle), the 7-bit I/O Expander address is 0100001 and the 7-bit EEPROM address is 1010001. Changing the jumper position changes the I/O Expander address to 0100000 and the EEPROM address to 1010000.

VIN Jumper

On Galileo, the VIN pin can be used to supply 5V to connected shields or devices. However, VIN should not be used to supply voltage to Galileo. If there is a need to supply additional external voltage to a shield using VIN then the VIN jumper should be removed from Galileo to break the connection between the on-board 5V supply and the VIN connection on the board header.

Warning: If the VIN jumper is not removed and more than 5V is connected to VIN, it may damage the board or lead to unreliable operation.
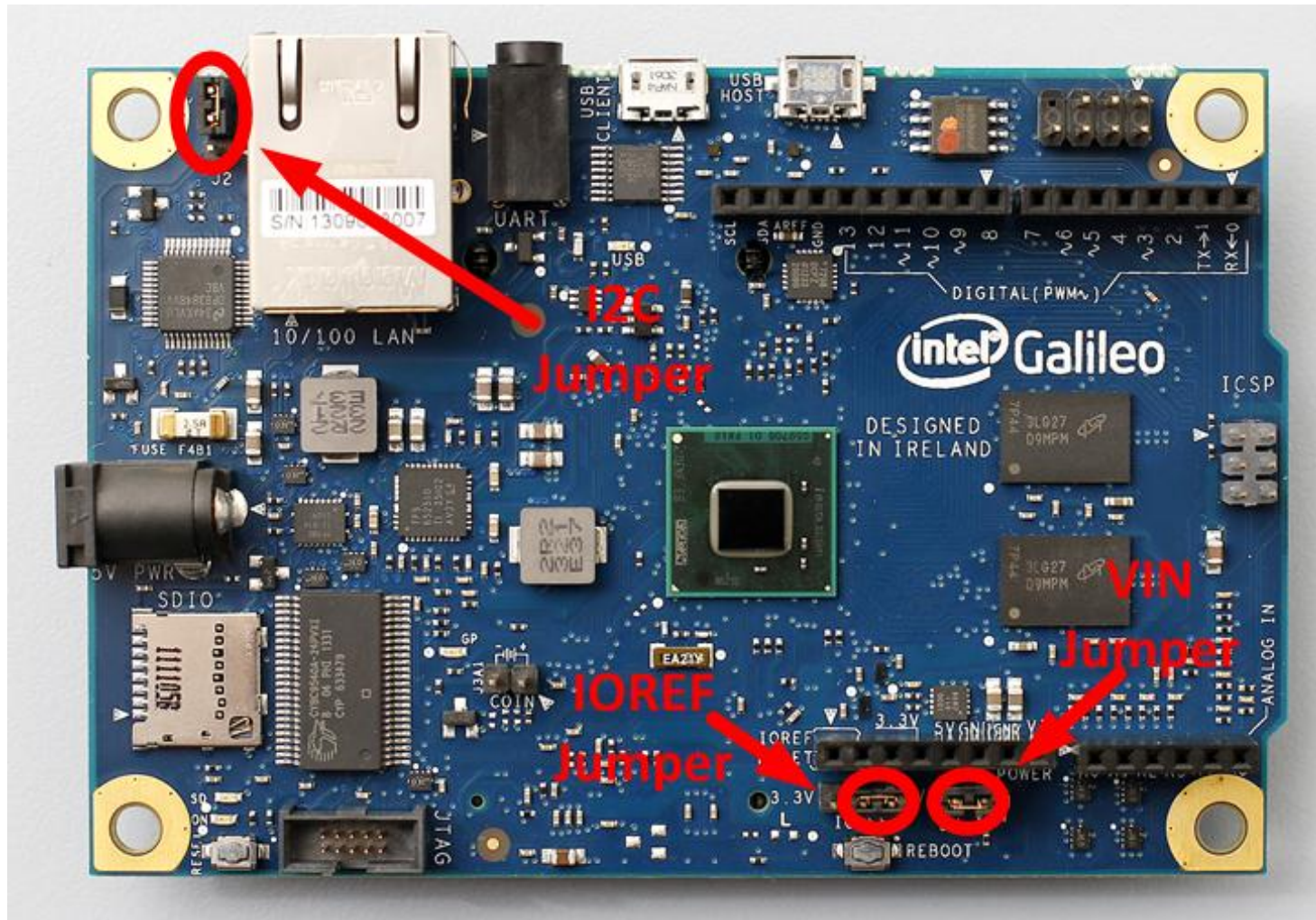
Automatic (Software) Reset

Rather than requiring a physical press of the reset button before an upload, Galileo is designed in a way that allows it to be reset by software running on a connected computer. USB CDC-ACM control signals are used to transition Galileo from run-time to bootloader mode. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. For details, see the Intel® Galileo Getting Started Guide.

Physical Characteristics

Galileo is 4.2 inches long and 2.8 inches wide respectively, with the USB connectors, UART jack, Ethernet connector, and power jack extending beyond the former dimension. Four screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), is not an even multiple of the 100 mil spacing of the other pins.

Intel® Galileo Design Document