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DuinoMite User's Manual

Revision 1.03 December 2011



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1. INTRODUCTION

DuinoMite is a series of compact development boards based on the *PIC32* microcontroller from Microchip Technology Inc.

The **DuinoMite** is a complete computer, running a BASIC interpreter called MM-Basic (originally written by Geoff Graham), which when interfaced with a PS2 keyboard and VGA monitor, is reminiscent of the old retro APPLE][and TRS-80 personal computers. No need for a PC, no need for compilers IDEs, programmers, all you need to write embedded applications is **DuinoMite**.

DuinoMites have ARDUINO shield connectivity, allowing ARDUINO shields to be directly interfaced, making the **DuinoMite** the world's first stand alone ARDUINO Single Board Complete BASIC computer .

DuinoMite is a completely open source platform and the schematic and board files are available for download from the Olimex (www.olimex.com) web site and released under the *Creative Commons Attribution-Share Alike 3.0 United States License*, which generally means that you are free to use these files to create your own product providing you credit Olimex as the source and release your files with the same license as well.

The heart of **DuinoMite** is the *PIC32MX795F512* which, amongst others, includes the following features: On-Chip: 80Mhz clock operation, 512KB Flash memory, 128KB RAM memory, USB with OTG functionality, UARTs, SPIs, I2C, ADC, CAN, PMP.

Three **DuinoMite boards are in production:**

DuinoMite-Mega <http://www.olimex.com/dev/DUINO/duinomite-mega.html>

DuinoMite-Mini <http://www.olimex.com/dev/DUINO/duinomite-mini.html>

DuinoMite <http://www.olimex.com/dev/DUINO/duinomite.html>

and two more boards are in design phase at the current date:

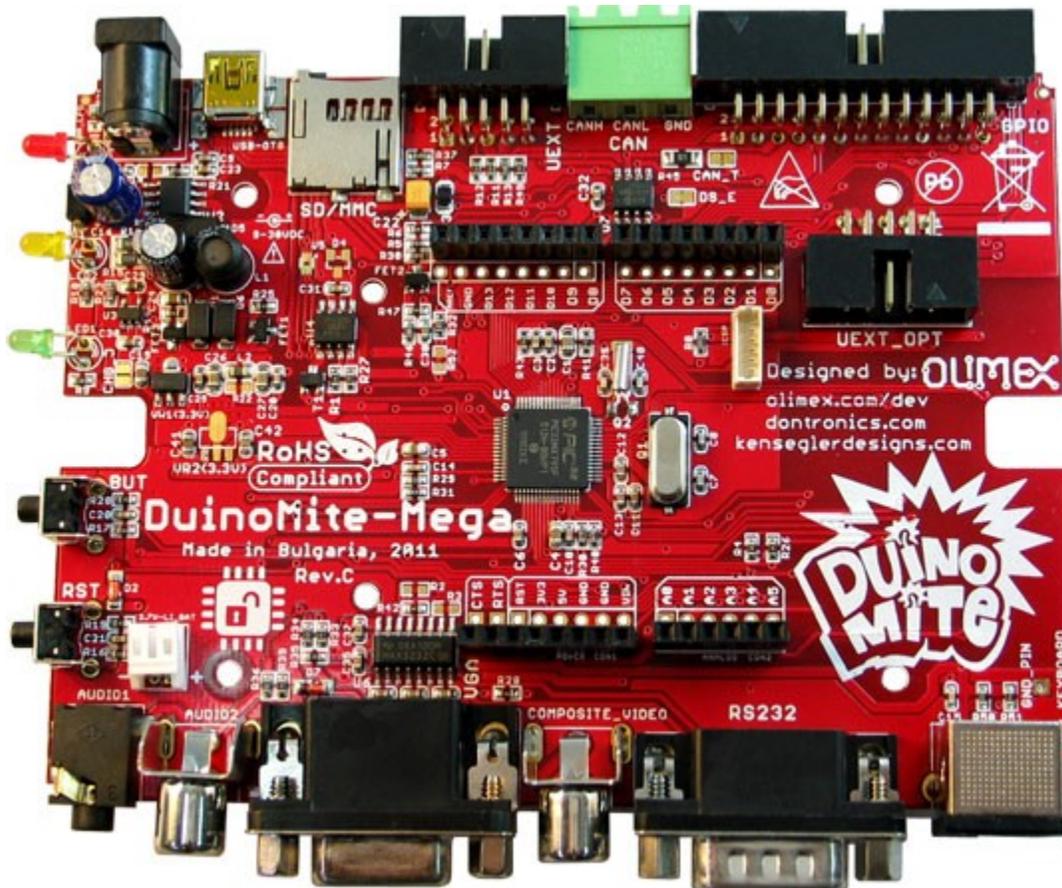
DuinoMite-eMega board with Ethernet, Internal Flash and PMP, with possibility for color VGA output.

PIC32-T795 which is a low cost, general purpose, development board for easy bread-boarding using wire jumpers.

2. BOARDS

2.1. DuinoMite-Mega

This is, to date, the most sophisticated board from *DuinoMite* range of boards.



The schematic of the current revision of the *DuinoMite-Mega* can be found online in the DUINO section at <http://www.olimex.com/dev>, you will also find the CAD schematics and board files.

DuinoMite-Mega is available for sale as either a pre-assembled board only or alternatively, in a laser cut, custom made plastic enclosure:



Hardware features:

- PIC32MX795F512H processor running at 80Mhz with 128KB RAM and 512KB Flash
- DC-DC power supply 9-30V DC input
- USB Device / USB Host OTG
- mini SD card socket
- two UEXT connectors, one inside enclosure, one outside
- CAN connector
- GPIO connector
- ARDUINO shield connector
- PS2 Keyboard connector
- RS232 connector
- VGA connector
- Audio RCA jack
- Composite Video RCA jack
- Headphones 3.5 mm jack
- RESET and USER buttons
- three status LEDs
- build-in LiPo Lithium-Polimer battery charger
- ultra low power design which allow down to 30uA current consumption
- Industrial temperature operation -40+85C
- Noise immunity
- ICSP programming connector for programming and debugging
- 32,768 KHz low frequency crystal allow implementation of RTC and low power modes

2.2. DuinoMite-Mini

This is the compact, low cost, entry level board with size of only 65 mm x 50 mm.



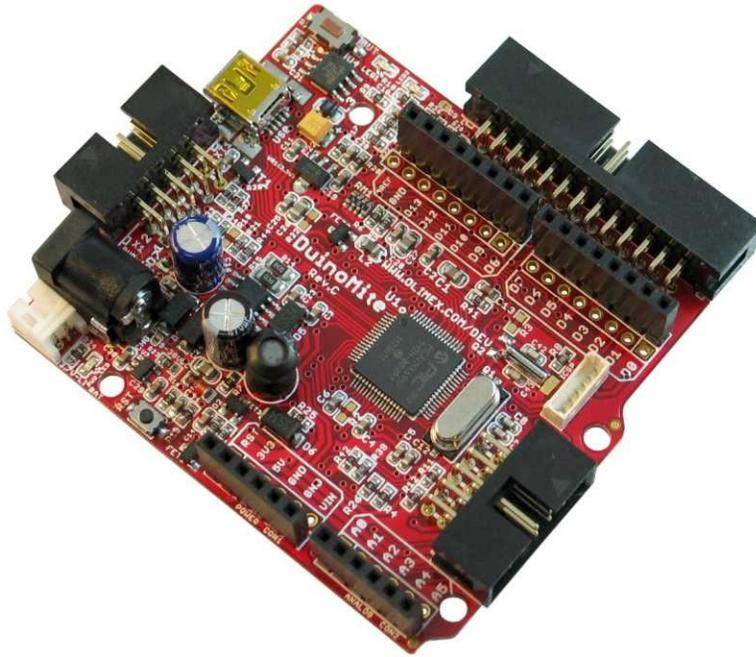
The schematic of the current revision of *DuinoMite-Mini* is at <http://www.olimex.com/dev> in the DUINO section, where you can also find the CAD schematic and board files.

Hardware features:

- PIC32MX795F512H processor running at 80Mhz with 128KB RAM and 512KB Flash
- Linear power regulator, require EXACTLY 5V to the DC POWER JACK
- USB Device *DuinoMite-Mini* can take power from USB also, there is 3 way jumper which selects which source is used the DC POWER JACK or the USB
- mini SD card socket
- UEXT connector
- GPIO connector
- PS2 Keyboard connector
- VGA connector
- RESET button
- USER buttons
- three status LEDs
- Commercial temperature operation -0+70C
- Noise immunity
- ICSP programming connector for programming and debugging
- 32,768 KHz low frequency crystal allow implementation of RTC and low power modes

2.3. DuinoMite, DuinoMite-IO, DuinoMite-Shield

This is a compact, low cost board in ARDUINO form factor ready to interface with ARDUINO shields.



The schematic of the current revision of *DuinoMite*, *DuinoMite-IO*, *DuinoMite-Shield* is at <http://www.olimex.com/dev> in DUINO section, where you will also find the CAD schematics and board files.

Hardware features:

- PIC32MX795F512H processor running at 80Mhz with 128KB RAM and 512KB Flash
- DC-DC power supply 9-30V DC input
- USB Device / USB Host OTG
- mini SD card socket
- UEXT connector
- EXT connector to connect *DuinoMite-IO* with Keyboard, Video, Audio connectors
- GPIO connector
- ARDUINO shield connector
- DUINOMITE-IO connector
- RESET and USER buttons
- three status LEDs
- build-in LiPo Lithium-Polimer battery charger
- ultra low power design which allow down to 30uA current consumption
- Industrial temperature operation -40+85C
- Noise immunity
- ICSP programming connector for programming and debugging
- 32,768 KHz low frequency crystal allow implementation of RTC and low power modes

2.4. DuinoMite-eMega

This is a new Ethernet enabled board, still in development. The features will be similar to the DuinoMite-Mega, but with some additional features such as Ethernet connector and PHY controller, which will add a 100Mbit Ethernet interface to DuinoMite, 2MB on board Data Flash which could be used as disk for data and code storage. PMP external connector with 80Mhz clock which could be used to interface to TFT displays, fast ADCs, allowing Duinomite to be used as Logic Analyzer, Digital Storage oscilloscope, capture for fast external signals.

2.3. PIC32-T795 (breadboarding PIC32MX795)

This is a new breadboard based on Ken Segler's design. It is T-shaped and is intended to plug into a breadboard. It incorporates a UEXT connector and USB with Device and Host (OTG)

PIC32-T795 is the fastest way to make something with a breadboard and Jumper wires without the need to solder.

PIC32-T795 can be reused many times as no soldering is required.

3. HARDWARE

3.1. POWER Supply

3.1.1. DuinoMite-Mega

DuinoMite-Mega can be powered by four different sources:

- *POWER JACK* with a 2.1 mm internal pin and 6 mm outer diameter, the inner pin is positive, the voltage that the *DuinoMite-Mega* accepts on this connector is in range 9–30V DC, note that there is a DC / DC power supply implemented, so the power consumption of this board is the same no matter what the input voltage is, other similar boards we have seen use linear voltage regulators heat up when a higher voltage is applied and wastes energy. There is a reverse voltage protection diode on this connector, to protect against reverse polarity.

- *USB power supply*, when *DuinoMite-Mega* is connected via a USB cable to a USB host it will take its 5V power supply from the USB host source to power the board, note that depending on what frequency the *DuinoMite-Mega* runs at, it may consume up to 140mA, so the USB port needs to be able to provide this current, some USB ports are set to 100mA maximum current supply and may be not able to power the *DuinoMite-Mega*.

- *Lithium-Polimer battery*, *DuinoMite-Mega* hardware is build to be very power efficient. In Low Power mode *DuinoMite-Mega* consumes only 30uA (plus current draw from the I/O pins) while the RTC low frequency clock is running, so this allows handheld and battery powered devices to be built with the DuinoMite.

- *VIN port* on the Arduino platform Connector 1. Note that on this connector there is NO reverse protection diode, so you should make sure 9–30V DC is applied to this port.

DuinoMite-Mega could be powered by more than one power source at the same time, for instance POWER JACK and USB at same time. The different power sources have different priorities, this means when two or more power sources are available at the same time only one of them is used. The priority is the POWER JACK and VIN, if the power supply is applied to any of these two connectors, the power is sourced from them and not from the USB and/or the battery, second priority is USB, if there is no power applied to POWER JACK or VIN and USB is active then the power will be taken from the USB. The battery power supply is with lowest priority and board will take power from it only if there is no power supply to any of the other sources.

DuinoMite-Mega has a built in LiPo battery charger, so once it senses power on POWER JACK, USB or VIN it will charge the LiPo battery (If present) until the battery is charged to 100%.

The switching between the different power supplies is done automatically and glitch free with no need to change jumpers. Board power is not lost during voltage source switching.

The LiPo battery with 3.7V 1400mA capacity and JST connector for **DuinoMite-Mega** is available from Olimex. At maximum frequency with a VGA monitor connected the consumption is 125mA which will allow the **DuinoMite-Mega** to run about 10 hours on battery.

As the external power supply utilises a DC/DC converter and not a linear voltage regulator the **DuinoMite-Mega** power consumption when running at maximum frequency and with a VGA monitor and keyboard attached is 100mA when the input power supply is 12VDC. (at 30VDC the current will drop to 40mA and will rise to 130mA at 9VDC) .

3.1.2. DuinoMite-Mini

The **DuinoMite-Mini** power supply is made with a linear voltage regulator to save cost (an LM1117 is used). The power source could be USB connector or POWER JACK. The source is selected with a 3-way jumper. The board has a protection ZENER diode (6.8V) on the input to protect the board from over-voltage spikes on the power supply.

Note

The external power supply applied to the POWER JACK must be 5V REGULATED. Note that applying non-regulated or voltage above 5V could DESTROY the **DuinoMite-Mini**.

Our recommendation is to use USB to power this board or the cheap `under \$2' power supply adapters for iPods, iPads, e-readers etc. which are with specification 5V/1A and are available on eBay.

3.1.3. DuinoMite

The **DuinoMite** has same sophisticated power supply like **DuinoMite-Mega** and allows power supply 9–30VDC.

3.2. USB

The PIC32MX795 has a USB controller which can work in two modes:

- USB device, in this mode you can make USB HID devices or USB CDC devices and emulate such devices like Keyboard, Mouse, Serial port etc., this mode is supported by all **DuinoMite** boards.

- USB On-The-Go (OTG) host/device mode in which the USB host PIC32 can interface USB mouse, USB keyboard, USB camera, USB printers, USB Bluetooth, WiFi modules, USB memory stick etc. Of course all of these devices need proper drivers to be implemented. This mode is not yet supported by **DuinoMite-Mini** board.

Special care is taken in the **DuinoMite** design for USB noise immunity and protection when it works in host mode.

When working as USB host **DuinoMite** may provide up to 500mA to the USB devices attached, so this should be taken into account when you size the power supply input voltage/current.

MM-BASIC uses USB as an HID device during boot-loading when new firmware is updating, then as a CDC serial port to establish a virtual console from which you can write your MM-BASIC code via a terminal program with a USB connection, thus there is no need to use a VGA monitor or PS2 Keyboard.

USB-FAULT signal is low when there is no power supplied to either the USB or the POWER JACK. It is connected to port RG7 and could be used to detect when you are powered only on battery.

3.3. SD-CARD

A micro SD card connector is available on *DuinoMite-Mega*, *DuinoMite-Mini*, *DuinoMite-eMega* and *DuinoMite* boards, this connector is with push-push action to insert and remove the card.

The uSD power supply is designed with ferrite bead filtering to minimise noise problems.

As *DuinoMite*, and *DuinoMite-Mega* are designed to be low power boards there is provision for the SD-card power supply to be shut down, this is done with FET2 connected to STB_E on RB13 port of PIC32.

SD-CARD presence is sensed by the SD_#CS connected to RD5 port, there is low pull down made with 100K on this port so when there is no card inserted RD5 is read as 0, when SD card is inserted it have 10K pullup inside which pull RD5 high and it's read as 1.

Note that the SPI used for the SD card is also wired to UEXT and ARDUINO connectors, so programmer should take care of this when writing their code.

3.4. UEXT

The UEXT connector is a 10 pin connector which have the following signals: 3.3V power supply, GND, Serial RX, Serial TX, SPI MOSI, SPI MISO, SPI CLK, I2C CLK, I2C DATA.

By having these signals available on a fixed interface allows us to develop different modules which can be used on any board with a UEXT connector.

All DuinoMite boards have UEXT connectors and can interface Olimex's UEXT modules.

For more information on UEXT see: <http://www.olimex.com/dev/OTHER/UEXT.pdf>

Please look at the example section of this manual for sample MM-BASIC code for various modules.

The *DuinoMite-Mega* has two UEXT connectors one internal and one external.

3.5. ARDUINO SHIELDS

ARDUINO is popular platform for development by beginners and people with little knowledge in electronics. This platform is gaining popularity and there are lot of projects using it. Arduino allows various hardware modules to be stacked on top of each other. They are called *SHIELDS*.

DuinoMite and **DuinoMite-Mega** have this connector to allow ARDUINO SHIELDS to be connected.

This connector is also very useful for jumper wiring to an external breadboard.

The DuinoMite-Mini has no ARDUINO shield connector on board but has the 26pin GPIO connector which can be connected to an external **DuinoMite-Shield** board, which adds the ARDUINO SHIELD, connected via a 26 pin ribbon cable.

The ARDUINO SHIELD has these signals:

D0,D1,D2,D3,D4,D5,D6,D7,D8,D9,D10,D11,D12,D13,
AREF, A0,A1,A2,A3,A4,A5
VIN, GND, 5V, 3.3V, RST, CTS, RTS

D0 – D13 are digital I/Os,

A0-A5 are analog I/Os,

VIN – input power which allows you to power **DuinoMite (or Mega)** by an external power supply

RST – reset

CTS, RTS – handshake signals from the **Mega's** RS232 connector, they are TTL levels.

MM-BASIC can access ARDUINIO SHIELDS with the PIN() function.

These ports may be digital inputs, digital outputs and analog inputs, note max voltage to these ports should not exceed 3.3V as they may be damaged:

ARDUINO.A0	→	PIN(1)
ARDUINO.A1	→	PIN(2)
ARDUINO.A2	→	PIN(3)
ARDUINO.A3	→	PIN(4)
ARDUINO.A4	→	PIN(5)
ARDUINO.A5	→	PIN(6)

These ports may be digital inputs, digital outputs, they are 5V tolerant, so the maximum input voltage which you should apply to them should not exceed 5V.

ARDUINO.D0	→	PIN(11)	→	COM1:RX	→	COM4:RX from RS232 connector
ARDUINO.D1	→	PIN(12)	→	COM1:TX	→	COM4:TX from RS232 connector
ARDUINO.D2	→	PIN(13)	→	COM1:RTS		
ARDUINO.D3	→	PIN(14)	→	COM1:CTS		
ARDUINO.D4	→	PIN(15)	→	COM2:RX		
ARDUINO.D5	→	PIN(16)	→	COM2:TX		
ARDUINO.D6	→	PIN(17)				
ARDUINO.D7	→	PIN(18)				

NOTES!

D0 & D1 are wired via protection resistors to the RS232 connector (COM4) on the *DuinoMite-Mega* this means that if there are signals on the RS232 connector they will affect D0, if D1 is initialized as INPUT this signal will merge with the signal on ARDUINO.D0 connector. Also if D1 is initialized as output it will affect COM4 port transmission. If you want to separate COM4 from D0 and D1 you can do this by removing R2 and R3.

As COM1: TX, RX are available on same D0 D1 ports anyway, R2 and R3 may be removed unless you need a fast UART there.

These ports share more than one function together and should be used with care:

ARDUINO.D8	→	PIN(19)	→	UEXT.CS/VIDEO.SELECT
ARDUINO.D9	→	PIN(20)	→	LED2(YELLOW) VGA.SYNC
ARDUINO.D10	→	PIN(7)	→	UEXT/SD.CARD.SS
ARDUINO.D11	→	PIN(8)	→	UEXT/SD.CARD.MOSI
ARDUINO.D12	→	PIN(9)	→	UEXT/SD.CARD.MISO
ARDUINO.D13	→	PIN(10)	→	UEXT/SD.CARD.CLK

NOTES!!

If you use UEXT.SPI or SD-CARD note that the SPI signals also go to ARDUINO.D10-D13. ARDUINO.D8 is shared with VIDEO.SELECT and UEXT.CS

3.6. CAN

Controller Area Network (CAN or CAN-bus) is a bus standard, generally used in the automotive industry, designed to allow micro-controllers and devices to communicate with each other within a vehicle, and without a host computer.

CAN is available only on the *DuinoMite-Mega*.

CAN is a very useful interface, it's the de-facto standard for automotive bus applications, so by having CAN it would be possible to connect to your car and read all of the data sensors for speed, temperatures, fuel consumption, etc. This video can give you rough idea what you can do with CAN and *DuinoMite-Mega*. http://www.youtube.com/watch?v=PbA_bOO2mMw

Being a robust and noise immune protocol, CAN is used not only in automotive but also in industrial robot applications – For more information see the following links
<http://en.wikipedia.org/wiki/DeviceNet>
<http://en.wikipedia.org/wiki/CANopen>

CAN is not supported currently in MM-BASIC, but in a future firmware CAN will be implemented to be seen as a file, the same as the COM ports, so you will be able to do OPEN "CAN" AS #1 and use INPUT # , INPUT\$ and PRINT # to send and receive CAN messages.

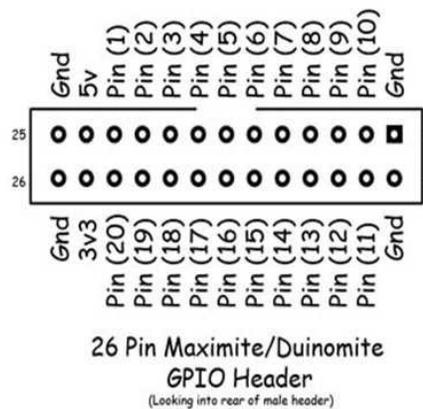
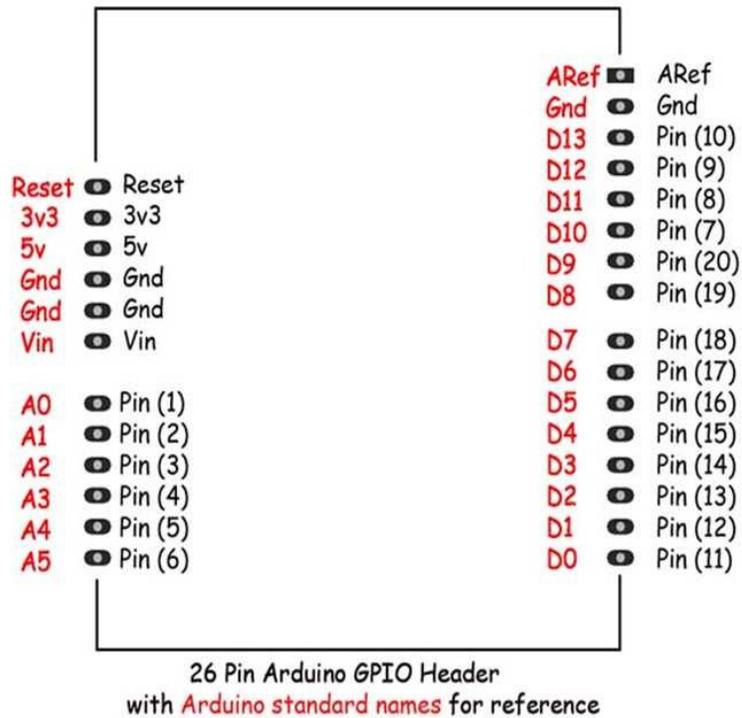
The CAN connector consists of these 3 signals:

CAN-H, CAN-L – these are the CAN physical layer twisted pair
GND - the shielding connection

The CAN end node should have termination resistor and if CAN-T is soldered (shorted) add such termination resistor to the CAN bus.

3.7. GPIO

The original MaxiMite introduced the 26 pin GPIO connector. With the emergence of the DuinoMite and support for ARDUINO we expanded the GPIO layout as shown below:



MM-BASIC allows the GPIO ports to be accessed with the PIN() command and function, and different functions to be set with SETPIN command.

SETPIN configurations:

- 0 - not defined
- 1 - analog input AI
- 2 - digital input DI
- 3 - frequency input FI

- 4 - period input PI
- 5 - counter input CI
- 6 - interrupt low-to-high IP
- 7 - interrupt high-to-low IN
- 8 - digital output DO
- 9 - digital output open collector OC

MMBasic Reference:	Arduino Reference	26pin header Pin No.	Allowable SETPIN Configurations
PIN(1)→	ARDUINO.A0	21	AI, DI, , , , IP, IN, DO,
PIN(2)→	ARDUINO.A1	19	AI, DI, , , , IP, IN, DO,
PIN(3)→	ARDUINO.A2	17	AI, DI, , , , , DO,
PIN(4)→	ARDUINO.A3	15	AI, DI, , , , , DO,
PIN(5)→	ARDUINO.A4	13	AI, DI, FI, PI, CI, IP, IN, DO,
PIN(6)→	ARDUINO.A5	11	AI, DI, FI, PI, CI, IP, IN, DO,
PIN(7)→	ARDUINO.D10	9	AI, DI, FI, PI, CI, IP, IN, DO,
PIN(8)→	ARDUINO.D11	7	, DI, , , , , DO, OC
PIN(9)→	ARDUINO.D12	5	, DI, , , , , DO, OC
PIN(10)→	ARDUINO.D13	3	, DI, , , , , DO, OC
PIN(11)→	ARDUINO.D0	4	, DI, , , , , DO,
PIN(12)→	ARDUINO.D1	6	, DI, , , , , DO,
PIN(13)→	ARDUINO.D2	8	, DI, , , , , DO, OC
PIN(14)→	ARDUINO.D3	10	, DI, , , , , DO, OC
PIN(15)→	ARDUINO.D4	12	, DI, , , , , DO, OC
PIN(16)→	ARDUINO.D5	14	, DI, , , , , DO, OC
PIN(17)→	ARDUINO.D6	16	, DI, , , , , DO, OC
PIN(18)→	ARDUINO.D7	18	, DI, , , , , DO, OC
PIN(19)→	ARDUINO.D8	20	AI, DI, , , , , DO,
PIN(20)→	ARDUINO.D9	22	AI, DI, , , , , DO,
GND→	GND (x3)	1,2,25,26	
+5V→	+5v (1)	23	
+3.3V →	+3.3v (1)	24	

NOTE!!

The PIN(7), PIN(8), PIN(9), PIN(10) are marked with blue as they are multiplexed with SPI which is used for UEXT and SD-card, this means that if UEXT or SD-card is accessed these lines will change their states. Please do not use or use with care if you use also UEXT and SD-card operations in your code.

PIN(19), PIN(20) are marked with blue as they are multiplexed with VGA.VSYNC and VGA.VIDEO-DETECT. Please do not use or use with care if you use also VGA monitor.

3.8. PS-2 KEYBOARD

PS2 keyboard CLOCK is connected to RD6 and DATA is connected to RD7.

Note that the Keyboard requires 5V to work correctly, so the keyboard will not work when the *DuinoMite-Mega* is powered by 3.7V LiPo battery.

3.9. VGA / Video

The VGA monitor is uses the PIC32 SPI to generate the video signal.

VGA.HSYNC is generated by RD4, VGA.VSYNC is generated by RB12 which is also connected to LED2 (YELLOW) and ARDUINO.D9.

VGA R/G/B signals are connected together via small SMD jumpers if you selectively cut them you can make your Video output RED, GREEN, BLUE, AMBER or YELLOW in color.

PIC32 RG8, RG9 generates the Video signal.

Composite video signal is also generated if VGA monitor is not detected. The composite video is output to the VIDEO RCA connector. PAL, SECAM, NTSC modes are supported, note that in Composite Video mode the screen resolution is lower than VGA mode.

3.10. AUDIO

The *DuinoMite* has two connectors, an AUDIO RCA jack connector and a 3.5mm headphone connector. MM-BASIC can output to these connectors with the SOUND command, with frequencies up to 1Mhz, and by using the duty cycle parameter, PWM will be available from these connectors.

3.11. LEDS

The *DuinoMite* has three LEDs:

- RED power supply LED, is ON when the board is powered by external power supply or USB, and is OFF if the power supply is the LiPo battery.
- YELLOW is the system RUN status, if this LED is ON, VGA video is generated correctly and the board is ready to work.
- GREEN this is SD card activity LED and is ON when SD-card is accessed. PIN(0) will also drive this LED on and off.

3.12. BUTTONS

The *DuinoMite* has two buttons: RESET and USER BUTTON.

RESET button does a hardware reset (hot start) and all code in memory is cleared and board initialized as if it was just powered up.

The *DuinoMite* has a boot-loader which allows the firmware to be upgraded without need of an external programmer. To enter the boot-loader the USER button should be pressed at power-up or RESET. To enter the boot-loader press and hold USER button, then press and release RESET button. When you release the USER button the YELLOW and GREEN LEDs will blink alternately to show that the board is in boot-loading mode. To load the new firmware run the Bootloader.exe and select the new HEX code.

The USER button status can also be read with the PIN(0) function.

3.13. BATTERY

The *DuinoMite* and *DuinoMite-Mega* have a built-in LiPo battery charger and the hardware is designed to allow them to run in low power mode for battery operation.

USB-FAULT is connected to RG7 to allow the firmware to be aware that it is running on battery instead of an external power supply. If USB-FAULT is read as 0 the board is powered by battery.

The battery charge state can be monitored by measuring the power supply on BAT port RB2.

The Lithium Polymer battery is connected via the R31/R29 voltage divider (0.319727891) to RB2 port as RB2 can handle a maximum voltage of 3.3V but the battery voltage can go up to 4.2V when completely charged.

DM firmware adds PIN(21) analog input pin which could be used for Battery voltage monitoring. Note that voltage is sensed through voltage divider as PIC32 inputs can't measure more than 3.3V while Li-Po battery voltage may go up to 4.2V when completely loaded. This is why the measured values from PIN(21) should be multiplied by the magic number 3.13 to get the real battery voltage.