DuinoMite User's Manual

Revision 1.03 December 2011

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.hrml
DuinoMite-Mini	http://www.olimex.com/dev/DUINO/duinomite-mini.hrml
DuinoMite	http://www.olimex.com/dev/DUINO/duinomite.hrml

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

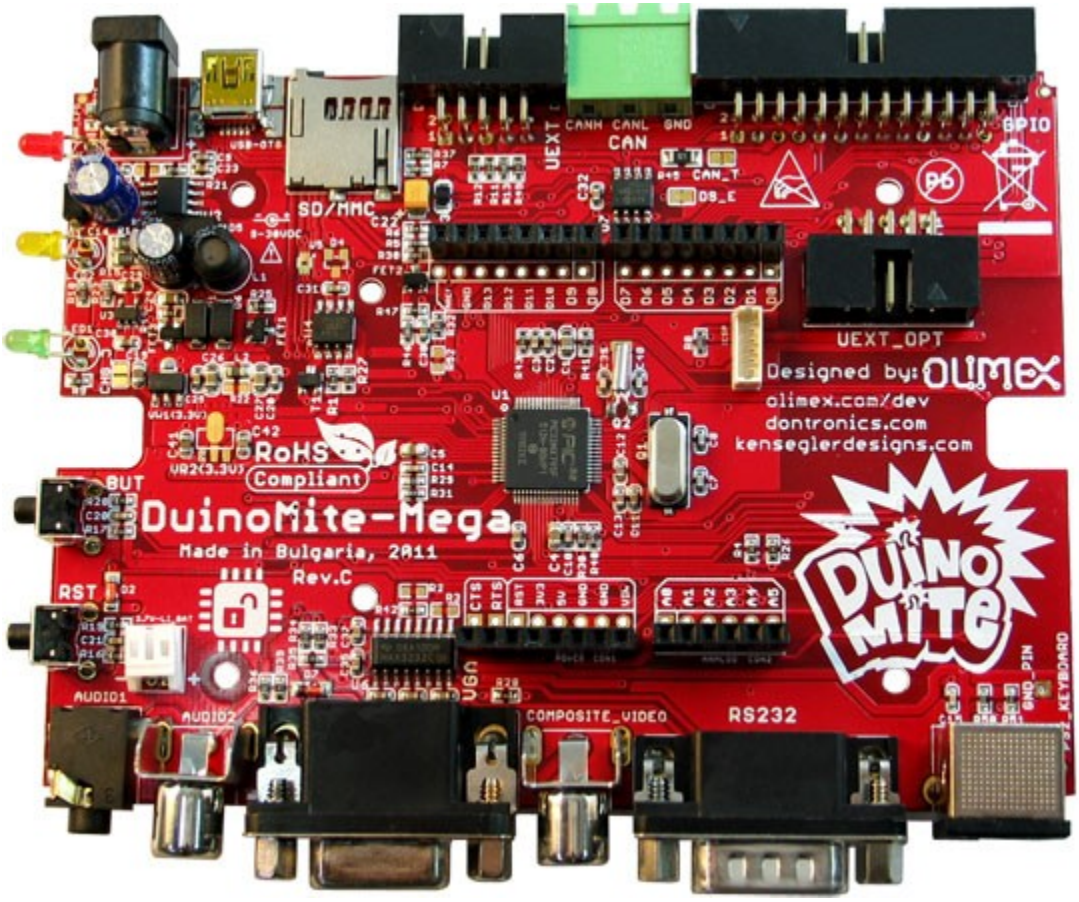
DuinoMite-eMega board with Ethernet, Internal Flash and PMP, with possibility for color VGA output.

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

2. BOARDS

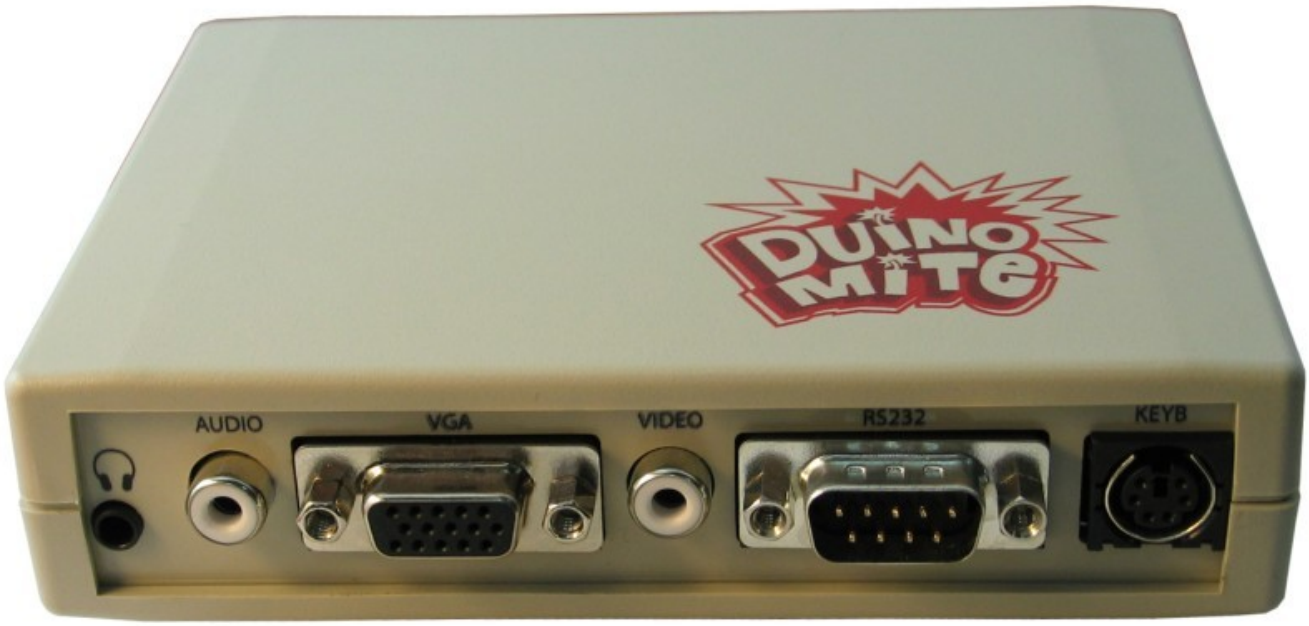
2.1. DuinoMite-Mega

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:

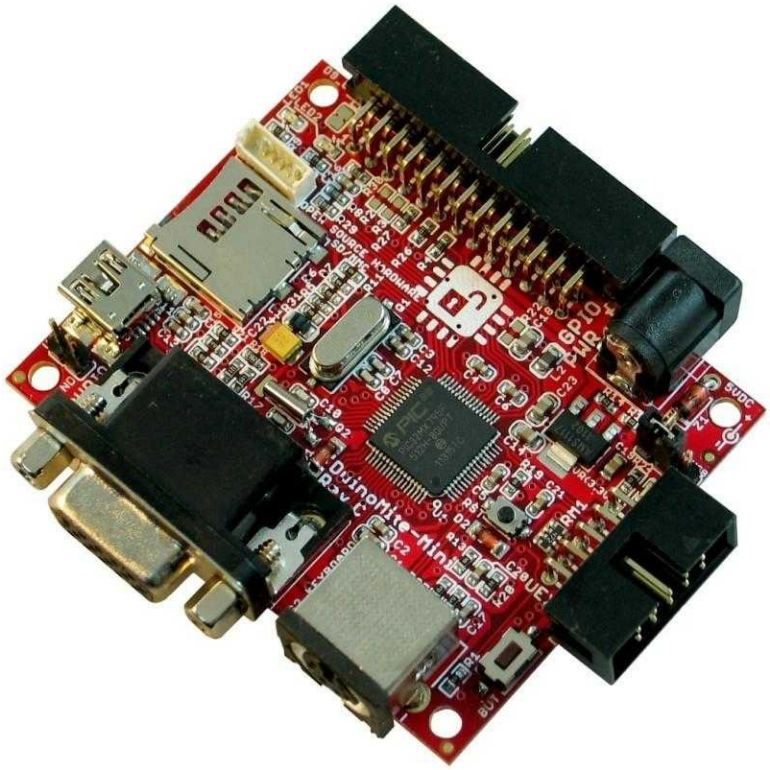


Hardware features:

- 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.



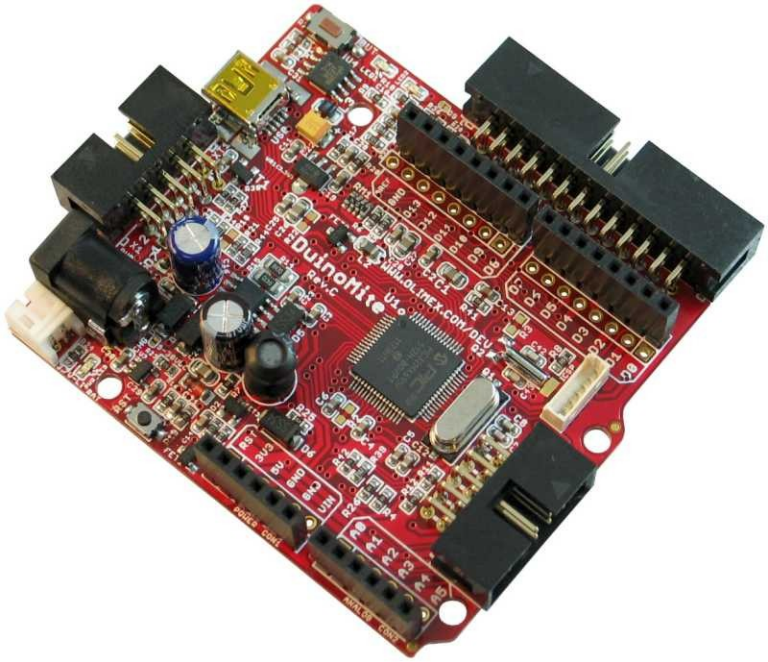
The schematic of the current revision of ***DuinoMite-Mini*** is at http://www.olimex.com/dev in the DUINO section, where you can also find the CAD schematic and board files.

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.

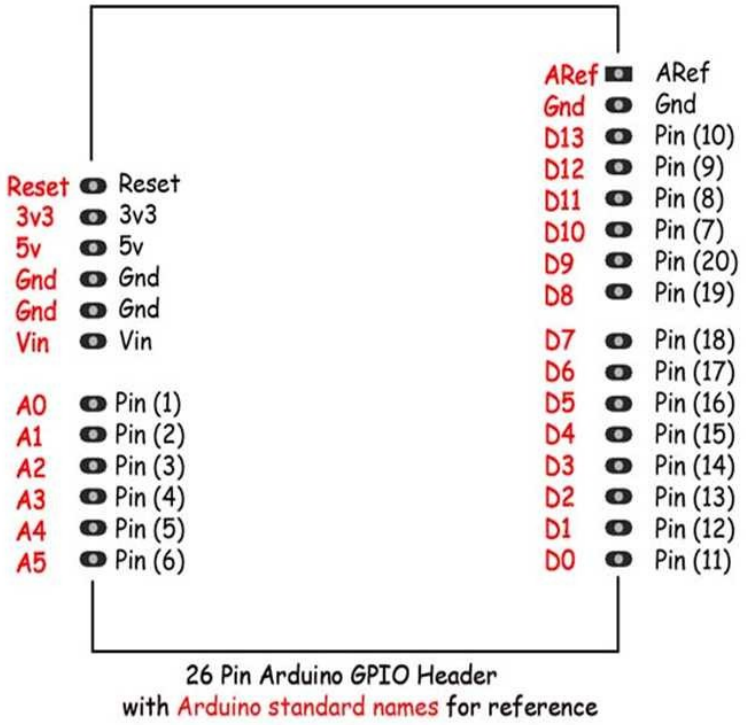
The CAN connector consists of these 3 signals:

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

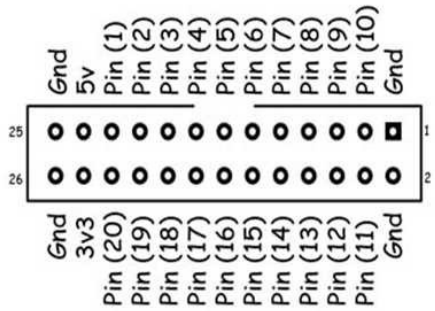
The CAN end node should have termination resistor and if CAN-T is soldered (shorted) add such termination resistor to the CAN bus.

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:



26 Pin Arduino GPIO Header
with Arduino standard names for reference



26 Pin Maximite/Duinomite
GPIO Header
(Looking into rear of male header)

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 Referrence:	Arduino Referrence	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 Polimer 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 vivider 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.

3.14. HARDWARE SIGNATURE

The ***DuinoMite*** hardware signature allows the firmware to be aware of which board it is running. This is very useful for the boot-loader to determine which firmware to download to it. The signature is done by a voltage divider made from R40/R30 read on RB14 initialized as analog input. For the current revision of the hardware the voltage divider is 1:10 so if 0.33V is read on this port your code runs on the ***DuinoMite*** hardware.

4. SOFTWARE

4.1. DIRECT PROGRAMMING USING MPLAB, C32, PIC-KIT3

By programming in C you will have access to all processor resources.

What you will need is:

–Obtain MPLAB-X and the C32 compiler from Microchip (http://www.microchip.com) and download the latest ***DuinoMite*** firmware from Olimex (http://www.olimex.com)

–we assume you already have a PIC32 programmer/debugger, if you do not have you may need to obtain the PIC-KIT3 and PIC-ICSP, note that you will need the PIC-ICSP even if you have the Microchip programmer as ***DuinoMite*** uses a small 0.05” ICSP connector instead of the more common 0.10" ICSP connector.

With this setup you have access to a complete development environment which works on Windows, Linux, MAC OS and you can use all of the hardware features of ***DuinoMite*** boards.

4.2. PINGUINO IDE

The ***Pinguino*** Project is a complete integrated IDE and C compiler. It works with the boot-loader so there is no need for programmers etc. when you program using the Pinguino IDE. The project page is at http://www.pinguino.cc

Pinguino implements the ARDUINO like language which is generally C++ libraries to allow easy programming of the hardware.

The ***DuinoMite*** boards are based on our PIC32-PINGUINO-OTG project hardware and evolved from there, so they can use the existing Pinguino programming environment, the only difference is that a different boot-loader should be programmed into the ***DuinoMite*** to support Pinguino IDE.

The Pinguino IDE allows you to program the ***DuinoMite*** in ARDUINO language or pure C/C++ and load the code with a single mouse click.

4.3. MM-BASIC

MM-BASIC was developed by Geoff Graham, you can see the original MaxiMite project at http://www.geoffg.net

What distinguishes the MM-BASIC, and the original MaxiMite design, from all other development boards and tools is that it is a single chip, complete computer solution with a PS2 keyboard and VGA monitor support, so all you need for development is one small computer board which is build around the powerful PIC32MX795 microcontroller.

DuinoMite was started with the ambition to improve the current MaxiMite hardware by adding some hardware features that we felt were missing in the original design, low power, battery operation, real UARTs, CAN, Arduino shield connector, UEXT connector, RTC support, Ethernet, etc.

4.3.1. SOFTWARE INSTALLATION AND UPGRADE

DuinoMite can reprogram itself with a new version of its firmware – also known as firmware upgrading . This is done with the help of small program called bootloader. The same firmware is loaded on all ***DuinoMite*** boards, there is no difference.

To start the bootloader software press and hold the BUT button then press and relese RESET button. The green and yellow LEDs will start flashing.

4.3.1.1 Bootloader.exe For Windows:

The firmware upgrades can be downloaded from Olimex web site. On your PC run the program called "BootLoader.exe", and follow the instructions included in the upgrade package to re program the ***DuinoMite*** with the new version.

4.3.1.2 MPHIDFLASH

For Linux:
Download mphidflash from http://code.google.com/p/mphidflash/

Before you install it, make sure you have installed libhid-dev on your computer:

```
$ sudo apt-get install libhid-dev
```

then go to the directory where you downloaded and unpacked mphidflash and do:

```
$ make
```

then:

```
$ sudo make install
```

now the mphidflash is installed in /usr/local/bin folder and you can access it from anywhere, to load new firmware put ***DuinoMite*** in bootloader mode then type:

```
$ mphidflash -w firmware.hex -v 15ba -p 0032 -r
```
For MAC OS:
download the mphidflash binary and use like this:

```
./mphidflash -w firmware.hex -v 15ba -p 0032 -r
```

4.3.1.3 PIC32PROG
For Linux:
Download PIC32PROG from http://code.google.com/p/pic32prog/
you can use svn*:*

```
$ svn checkout http://pic32prog.googlecode.com/svn/trunk/ pic32prog
```

4.3.2. GETTING STARTED

DuinoMite could work with PS2 keyboard and VGA monitor, or with terminal via PC. So to get started you will need either PS2 keyboard and VGA monitor, either USB cable and PC.

STAND ALONE USE:

If you use PS2 Keyboard and VGA just plug them to the board and power it.
You will see on the VGA monitor this message:

```
MaxiMite BASIC Version x.xx
Copyright 2011, Geoff Graham
Olimex Port By kenseglerdesigns.com

>
```

the "`>`" prompt show that ***DuinoMite*** is ready to complete your commands.

BASIC is interpreter language which means that the instructions are decoded at execution time. All Basic interpreters allow instructions to be executed at command prompt too.
First code on every language is to print "`HELLO WORLD`" this could be done in BASIC like this:

```
> PRINT "Hello world!"
```
the result will be :

```
Hello world!
>
```

CONSOLE USE:

If you do not have PS2 keyboard and VGA monitor but have PC you still can develop with ***Duinomite*** by using it's virtual USB console. To do this you need mini USB cable, which you should plug to your PC and ***DuinoMite***. When you do this the red LED power will turn on along with the yellow LED

which indicates the video sync and PIC32 CPU chip is good. The green LED indicates SD card activity.

LINUX:

If you use *Linux* the ***DuinoMite*** drivers will be automatically recognized and installed.

Open console and install minicom terminal program.

```
$ sudo apt-get install minicom
```

Then you should locate which virtual communication port is ***DuinoMite*** by running this command:.

```
$ dmesg | grep tty
```

You will see cdc_acm driver something like:

```
[103473.694556] cdc_acm 5-1:1.0: ttyACM0: USB ACM device
```

Please remember `ttyACM0:` as you have to setup minicom to use it:

```
$ minicom -s
```

Setup the serial port to `ttyACM0:` and you will see the greet message:

```
MaxiMite BASIC Version x.xx
Copyright 2011, Geoff Graham
Olimex Port By kenseglerdesigns.com

>
```

WINDOWS:

If you use *Windows* it will try to search for drivers and will / should fail, so you have to download files from the Olimex website under ***DuinoMite-Mega*** "software" the "Duinomite drivers for virutal com port console" Unzipped it and store it in a folder that can be easily remembered. Then under control panel, system, hardware, device manager go to the named device "Duinomite" and update its driver to point to the "files" unzipped. After the driver installation is complete the new port number will show up for the ***DuinoMite*** under [Ports - COM & LPT] Please take note of this port number!
Now you can use terminal program like Putty, Terraterm, MMIDE etc.

5. MM-BASIC LANGUAGE

5.1. MM-BASIC INTRODUCTION

BASIC is an interpreted language, this means as you type the commands on the command prompt they execute immediately, if you type a line number before the command it is stored in memory, then by using the RUN command you can execute the stored commands in the order defined by the line numbers.

For instance, if you type:

```
> PRINT 22/7
 3.14286
```

i.e. the command is executed immediately

But if you type

```
  20 PRINT 22/7
```

The code will be not executed until the command `RUN` is typed.
If you want to clear the screen first you can add:

```
  10 CLS
```

Now if you want to see what code is in memory, you can do this with the `LIST` command:

```
  > LIST
  10 CLS
  20 PRINT 22/7
  >
```

To replace a line you simply enter the new line with the same line number as the one you are replacing, to delete a line you enter the line number on its own (without any following text).

BASIC automatically keeps the lines sorted in ascending order so when you run or list a program it will start with the smallest line number first.

Pressing CTRL+C during a running program run will break the execution and return to the "`>`" prompt.

A program line held in memory can be changed using the `EDIT` command or by entering a new line with the same number thereby overwriting it. A line can be deleted by entering its number on its own.

All program lines may be cleared from working memory with the `NEW` command.

Multiple commands separated by a colon can be entered on the one line (as in INPUT A : PRINT B).

5.2. KEYBOARD / DISPLAY

Input can come from either a keyboard or from a computer using a terminal emulator via the USB or serial interfaces. Both the keyboard and the USB interface can be used simultaneously and can be detached or attached at any time without affecting a running program.

Output will be simultaneously sent to the USB interface and the video display (VGA or composite). Either can be attached or removed at any time.

Keyboard
A standard IBM compatible PS2 keyboard with a mini-DIN connector or a compatible USB keyboard and a USB/mini-DIN adapter.
Non ASCII keys (such as the function keys) are mapped to ASCII characters. Use a command like `PRINT HEX$(ASC(INKEY$))` to check the actual mapping.

VGA
Standard monochrome VGA (31.5KHz horizontal scanning with 60Hz vertical refresh). `480x432` pixel graphic screen. `80` characters per line and `36` lines per screen

Composite
Standard monochrome PAL (15.625KHz horizontal scanning with 50Hz vertical refresh non interlaced). `304x216` pixel graphic screen. `50` characters per line and `18` lines per screen. SECAM and NTSC output is also available and possible to be configured with the `SETUP` command.

Video Output selector
The ***DuinoMite*** hardware will auto detect when a VGA monitor is attached, so if the VGA monitor is attached MM-BASIC will generate a VGA signal, if no VGA monitor is attached it automatically will output Composite VIDEO. No need to open/close jumpers.

5.3. SD CARD STORAGE

DuinoMite will accept MMC, uSD or uSDHC memory cards formatted as FAT16 or FAT32. Note that there is no advantage in using a fast uSD card as the card is clocked at a fixed 20MHz, regardless of its speed rating.

Two "drives" are available for storing and loading programs and data:
Drive "A:" is a virtual drive using the PIC32's internal flash memory and has a size of 256KB.
Drive "B:" is the SD card (if connected). It supports MMC, uSD or uSDHC memory cards formatted as FAT16 or FAT32 with capacities up to the largest that you can purchase.

File names must be in 8.3 format prefixed with an optional drive prefix A: or B: (the same as DOS or Windows). Long file names and directories are not supported. The default drive is B: and this can be changed with the DRIVE command.

Note that the video output will go blank for a short time while writing data to the internal flash drive A:. This is normal and is caused by a requirement to shut off the video while reprogramming the flash memory.

On the uSD card both data and programs are stored using standard text and can be read and edited in Windows, Apple Mac, Linux, etc. A uSD card can have up to 10 files simultaneously open while the internal flash drive has a maximum of one file open at a time.

MM-BASIC has a number of commands for saving and loading programs from the SD card.

For example:

```
> SAVE "MYPROG.BAS"
```

will save the program currently in memory to a file on the SD card called MYPROG.BAS. You can later load that program back into memory with:

```
> LOAD "MYPROG.BAS"
```

or both load and run it at the same time with:

```
> RUN "MYPROG.BAS"
```

The filename AUTORUN.BAS has a special meaning. On startup MM-BASIC will look for a file called "AUTORUN.BAS" in the root directory of the internal flash drive (A:) then the SD card (B:). If the file is found it will be automatically loaded and run otherwise MM-BASIC will print a prompt (">") and wait for input.

MM-BASIC also has commands for managing the SD card. For example, the FILES command will list all of the files in the current directory (or folder as they are called in Windows). CHDIR can be used to change to a new directory, MKDIR will create a new directory and RMDIR will delete a directory. KILL will delete a file, NAME will rename file.

Whenever specified, a file name can be a string constant (i.e. enclosed in double quotes) or a string variable. This means you must use double quotes if you are directly specifying a file name. Eg,:

```
> RUN "TEST.BAS"
```

If the extension is omitted the .BAS extension will be added automatically i.e.

```
> RUN "TEST"
```

Inside a running program you can save and read data to and from the SD card. First a file must be opened using the `OPEN` command and then you can use the `PRINT`, `WRITE`, `INPUT`, `LINE INPUT`, `INPUT$` commands to write and read from the card.

For example, the following code example will save the values of three variables into a file:

```
200 OPEN "MYDAT.DAT" FOR OUTPUT AS #1
210 PRINT #1, VAR1
220 PRINT #1, VAR2
230 PRINT #1, VAR3
240 CLOSE #1
```

Files can be opened for input, output and append and you can have up to 10 files open simultaneously.

The `XMODEM` command can be used to copy files to and from the internal flash drive or SD card. This is particularly valuable when there is no SD card present and the internal flash drive is being used for storage.

5.5. GRAPHICS

Graphics commands operate on the video output only. Coordinates are measured in pixels with x being the horizontal coordinate and y the vertical coordinate.

The top left of the screen is at location `X=0` and `Y=0` and the bottom right of the screen defined by the read only variables `X = MM.HRES` and `Y = MM.VRES` which change depending on the video mode selected (VGA or composite).

Increasing positive numbers represent movement down the screen and to the right.

MM-BASIC has commands for clearing the screen (`CLS`), turning a pixel on or off (`PIXEL`), drawing lines and boxes (`LINE`), drawing a circle (`CIRCLE`) and saving the video screen as a BMP file (`SAVEBMP`).

You can also position text anywhere on the screen by using the `LOCATE` command.

For example, the following code example will draw a box and print the word STOP in the middle.

```
200 LINE(50,75)-(150,125),1,B
210 LOCATE 80,95
220 PRINT "STOP"
```

5.6. EXTERNAL IO

You can configure an external I/O pin using the SETPIN command, set its output using the PIN()= command and read the current input value using the PIN() function. Digital I/O uses the number zero to represent a low voltage and any non zero number for a high voltage. An analogue input will report the measured voltage as a floating point number.

Four serial ports are supported, COM1 and COM2 with speeds up to 19200 baud with configurable buffer sizes and optional hardware flow control. COM3 and COM4 with speeds up to 115200 baud. The serial ports are opened using the OPEN command and any command or function that uses a file number can be used to send and receive data.

Communications to slave or master devices on an I2C bus is supported with eight commands. MM-BASIC fully supports bus master and slave mode, 10 bit addressing, address masking and general call, as well as bus arbitration (i.e. bus collisions in a multi master environment).

The Serial Peripheral Interface (SPI) communications protocol is supported with the SPI command.

A high performance Pulse Width Modulation (PWM) output is also available by utilising the sound connector and specifying an optional duty cycle parameter to the SOUND command.

5.7. TIMING

You can get the current date/time using the DATE$ and TIME$ functions and you can set them by assigning the new date and time to them. If not set the calendar will start from midnight 1st Jan 2000 on power up.

You can freeze program execution for a number of milliseconds using PAUSE.

MM-BASIC also maintains an internal stopwatch function (the TIMER function) which counts up in milliseconds. You can reset the timer to zero or any other number by assigning a value to the TIMER.

Using SETTICK you can setup a “tick” which will generate a regular interrupt with a period from one millisecond to over a month.

5.8. INTERRUPTS

Any external GPIO I/O pin can be configured to generate an interrupt using the SETPIN command with up to 21 interrupts (including the tick interrupt) active at any one time.

Interrupts can be set up to occur on a rising or falling digital input signal and will cause an immediate branch to a specified line number (similar to a GOSUB). The target line number can be the same or different for each interrupt. Return from an interrupt is via the IRETURN statement. All statements (including GOSUB/RETURN) can be used within an interrupt.

If two or more interrupts occur at the same time they will be processed in order of pin numbers (ie, an interrupt on pin 1 will have the highest priority). During processing of an interrupt all other interrupts are disabled until the interrupt routine returns with an IRETURN. During an interrupt (and at all times) the value of the interrupt pin can be accessed using the PIN() function.

A periodic interrupt (or regular "tick") with a period specified in milliseconds can be setup using the SETTICK statement. This interrupt has the lowest priority.

Interrupts can occur at any time but they are disabled during INPUT statements. If you need to get input from the keyboard while still accepting interrupts you should use the INKEY$ function.

When using interrupts the main program is completely unaffected by the interrupt activity unless a variable used by the main program is changed during the interrupt.

For most programs MM-BASIC will respond to an interrupt in under 100uS. To prevent slowing the main program by too much an interrupt should be short and execute the IRETURN statement as soon as possible. Also remember to disable an interrupt if you have finished needing it – background interrupts can cause strange and non intuitive bugs.

5.9. SOUND

The `SOUND` command will generate a simple square wave between `20Hz` and `1MHz` lasting for a specified duration.

This command can also be used to generate a Pulse Width Modulation (`PWM`) signal.

5.10. VARIABLES

In MM-BASIC all numbers are *floating point* which means that they can contain a decimal point and are safe to use in any type of calculation.

Variables names can be up to 32 characters long and can contain alpha numeric letters, the full stop and underscore characters. This means that you can use meaningful variable names in your program.

For example: `BatteryVoltage` or `test_load2`.

MM-BASIC will also work with strings which are a collection of characters. A constant string must be surrounded by double quotes and string variables are designated with a $ character at the end of the variable name.

For example:

```
> FileName$ = "INFIX" + ".DAT"
> PRINT FileName$
INFIX.DAT
>
```

When used with strings the plus (+) operator will join strings so the above example will join the constant strings INFIX and .DAT and save the result in a string variable. There are many functions in MM-BASIC like this that can be used to pull apart and manipulate strings and this capability is one of the strengths of MM-BASIC.

Another type of variable is the array. MM-BASIC allows arrays of numbers or strings and they can have up to *eight* dimensions.

For example, the following sequence of commands will create a three dimensional array with 10 elements in each dimension (a total of 1000 individual numbers) and save a number into the array:

```
> DIM AData(10,10,10)
> AData(3,5,8) = 1234.5
> PRINT AData(3,5,8)
 1234.5
>
```

5.11. OPERATORS

The following operators, in order of precedence, are recognized.
Operators that are on the same level (for example + and -) are processed with a left to right precedence as they occur on the program line.

Arithmetic operators:

`^`	Exponentiation
`* / \ MOD`	Multiplication, division, integer division and modulus (remainder)
`+ -`	Addition and subtraction

examples:

```
7 ^ 2 = 49
7 * 2 = 14
7 / 2 = 3.5
7 MOD 2 = 1
7 \ 2 = 3
7 + 2 = 9
7 - 2 = 5
```

Logical operators:

`NOT`	logical inverse of the value on the right
`<> < > <= =< >= =>`	Not equal, less than, greater than, less than or equal to, less than or equal to (alternative version), greater than or equal to, greater than or equal to (alternative version)
`=`	
`AND OR XOR`	Logical AND, Logical OR, Logical Exclusive OR

The operators `AND`, `OR` and `XOR` are bitwise operators.
For example:
`> PRINT 3 AND 6` will output 2.

The other logical operations result in the number 0 (zero) for false and 1 for true. For example the statement `PRINT 4 >= 5` will print the number zero on the output and the expression `A= 3 > 2` will store +1 in `A`.

The `NOT` operator is highest in precedence so it will bind tightly to the next value. For normal use the expression to be negated should be placed in brackets.
For example: `IF NOT (A=3 OR A=8) THEN`

String operators:

`+`	Join two strings
`<> < > <= =< >= =>`	Not equal, less than, greater than, less than or equal to, less than or equal to, greater than or equal to, greater than or equal to
`=`	

Example:

```
"hello " + "world" = "hello world"
```

5.12. EXPRESSIONS

In most cases where a number or string is required you can also use an expression.

For example:

```
FILENAME$ = "TEST": RUN FILENAME$ + ".BAS"
```

Or, as an extreme (and not recommended) example:

```
NBR = 100: GOTO NBR*3+20
```

5.13. NAMING CONVERSION

Command names, function names, variable names, file names, etc are ***not case sensitive***, so that "`Run`" and "`RUN`" are equivalent and "`dOO`" and "`Doo`" refer to the same variable.

There are two types of variable; numeric which stores a floating point number (eg, 45.386) and string which stores a string of characters (eg, “Tom”). String variable names are terminated with a $ symbol (eg, name$) while numeric variables are not.

Variable names can start with an alphabetic character or underscore and can contain any alphabetic or numeric character, the period (.) and the underscore (_). They may be up to 32 characters long. A variable name must not be the same as a function or one of the following keywords: THEN, ELSE, GOTO, GOSUB, TO, STEP, FOR, WHILE, UNTIL, LOAD, MOD, NOT, AND, OR, XOR.

Example:

```
STEP = 5
```

is illegal as `STEP` is a keyword.

5.14. CONSTANTS

Numerical constants may begin with a numeric digit (0-9) for a decimal constant, `&H` for a hexadecimal constant, `&O` for an octal constant or `&B` for a binary constant.

For example:

`&B1000` is the same as the decimal constant `8`.

Decimal constants may be preceded with a minus (`-`) or plus (`+`) and may terminated with '`E`' followed by an exponent number to denote exponential notation.

For example:
`1.6E+4` is the same as `16000`.

String constants are surrounded by double quote (“) marks. e.g. “`Hello`”.

5.15. PRE-DEFINED CONSTANTS

MM.HRES The horizontal resolution of the current video display screen in pixels.

MM.VRES The vertical resolution of the current video display screen in pixels.

MM.VER The version number of the firmware in the form aa.bbcc where aa is the major version number, bb is the minor version number and cc is the revision number (normally zero but A = 01, B = 02, etc).

MM.DRIVE$ The current default drive returned as a string containing either “A:” or “B:”.

MM.FNAME$ The name of the file that will be used as the default for the SAVE command. This is set by LOAD, RUN and SAVE.

MM.ERRNO Is set to the error number if a statement involving the SD card fails or zero if the operation succeeds. This is dependent on the setting of OPTION ERROR. The possible values for MM.ERRNO are:

0 = No error

1 = No SD card found

2 = SD card is write protected

3 = Not enough space

4 = All root directory entries are taken

5 = Invalid filename

6 = Cannot find file

7 = Cannot find directory

8 = File is read only

9 = Cannot open file

10 = Error reading from file

11 = Error writing to file

12 = Not a file

13 = Not a directory

15 = Directory not empty

15 = Hardware error accessing the storage media

5.16. LIMITS

Maximum ***length of a command line*** is 255 characters.

Maximum ***length of a variable name*** is 32 characters.

Maximum ***number of dimensions*** to an array is 8.

Maximum ***number of arguments*** to commands that accept a variable number of arguments is 50.

Numbers are stored and manipulated as single precision floating point numbers. The ***maximum number*** that can be represented is 3.40282347e+38 and the minimum is 1.17549435e-38

The ***range of integers*** (whole numbers) than can be manipulated without loss of accuracy is ±16777100.

Maximum string length is 255 characters.

Maximum line number is 65000.

Maximum number of files simultaneously open is 10 on the SD card and one on the internal flash drive (A:).

Maximum SD card size is 2GB formatted with FAT16 or 2TB formatted with FAT32.

Size of the ***internal flash drive*** (A:) is 256KB.

Maximum size of a loadable video font is 64 pixels high x 255 pixels wide and 256 characters.

5.17. SPI Communication

The Serial Peripheral Interface (SPI) communications protocol is used to send and receive data between integrated circuits. As implemented this function is suitable for moving small amounts of data to and from a chip like an accelerometer but not for shifting large amounts of data from EEPROMS, etc. The SPI function in MM-BASIC acts as the master (i.e. MM-BASIC generates the clock).

The syntax of the SPI function is:

```
received_data = SPI(Rx,Tx,Clock[,data[,speed]])
```

Where:

Rx is the pin number for the data input (MISO)

Tx is the pin number for the data output (MOSI)

clock is the pin number for the clock generated by MM-BASIC (CLK)

data is optional and is an integer representing the data byte to send over the output pin. If it is not specified the 'tx' pin will be held low.

speed is optional and is the speed of the clock. It is a single letter either H, M or L where H is 500KHz, M is 50KHz and L is 5KHz. Default is H.

The SPI function will return the byte received during the transaction as an integer. Note that a single SPI transaction will send a byte while simultaneously receiving a byte (which is often discarded).

Transmission Format:

The format of the transmission matches the most common standard. The clock is high when inactive and the data is valid on the clock's trailing edge (ie, low to high transition). Data bytes are 8 bits, high voltage is logic 1 and the most significant bit is sent first.

In SPI parlance the MM-BASIC implementation of SPI has CPOL = 1 and CPHA = 1 or it operates in mode 3.

I/O Pins:

Before invoking this function the Rx pin must be configured as an input using the SETPIN command and the Tx and clock pins must be configured as outputs (either normal or open collector). The clock pin should also be set *high* (using the PIN function) before the SETPIN command so that it starts as inactive (i.e. high).

The SPI enable signal is often used to select a slave and "prime" it for data transfer. This signal is not generated by this function and (if required) should be generated using the PIN function on another pin.

The SPI function does not “take control” of the I/O pins like the serial and I2C protocols and the PIN command will continue to operate as normal on them. Also, because the I/O pins can be changed between function calls it is possible to communicate with many different SPI slaves on different I/O pins.

Example:

The following example will send the command &H80 and receive two bytes from the slave SPI device. Because the speed is not specified it defaults to high (500KHz):

```
10 SETPIN 1,2              'PIN(1) as Rx digital input
20 SETPIN 2,8              'PIN(2) as Tx digital output
30 PIN(3) = 1: SETPIN 3,8  'PIN(3) clock as output
40 PIN(4) = 1: SETPIN 4,8  'PIN(4) as slave select
50 '
100 PIN(4) = 0             'slave select
110 junk = SPI(1,2,3,&H80) 'send &H80
120 BYTE1 = SPI(1,2,3)     'read first byte
130 BYTE2 = SPI(1,2,3)     'read second byte
140 PIN(4) = 1             'slave de-select
```

5.18. I2C Communication

The Inter-Integrated-Circuit (I2C) bus was developed by the electronics giant Philips for the transfer of data between integrated circuits. It has been adopted by many manufacturers and can be used to communicate with many devices including memories, clocks, displays, speech modules, etc.

This implementation was developed by Gerard Sexton and fully supports master and slave operation, 10 bit addressing, address masking and general call, as well as bus arbitration (i.e. bus collisions in a multi master environment).

In the master mode, there is a choice of 2 modes - interrupt and normal. In normal mode, the I2C send and receive commands will not return until the command completes or a timeout occurs (if the timeout option has been specified). In interrupt mode, the send and receive commands return immediately allowing other MM-BASIC commands to be executed while the send and receive are in progress. When the send/receive transactions have completed, an MM-BASIC interrupt will be executed. This allows you to set a flag or perform some other processing when this occurs.

When enabled the I2C function will use UEXT pins 5 and 6, UEXT.5 becomes the I2C clock line (SCL) and UEXT.6 becomes the I2C data line (SDA). Both of these pins have pullup resistors (4.7k).

I2C is also connected via R4 and R26 to PIN(5) and PIN(6) → ARDUINO.A4 (SDA) and ARDUINO.A5 (SCL) .

Be aware that when running the I2C bus at above 150KHz the cabling between the devices becomes important. Ideally the cables should be as short as possible (to reduce capacitance) and also the data and clock lines should not run next to each other but have a ground wire between them (to reduce crosstalk). If the data line is not stable when the clock is high, or the clock line is jittery, the I2C peripherals can get "confused" and end up locking the bus (normally by holding the clock line low). If you do not need the higher speeds then operating at 100kHz is the safest choice.

There are four commands for master mode: I2CEN, I2CDIS, I2CSEND and I2RCV.

For slave mode the commands are: I2CSEN, I2SDIS, I2CSSEND and I2CSRCV. The master and slave modes can be enabled simultaneously however, once a master command is in progress, the slave function will be "idle" until the master releases the bus. Similarly, if a slave command is in progress, the master commands will be unavailable until the slave transaction completes.

Both the master and slave modes use an MM-BASIC interrupt to signal a change in status. These interrupt routines operate the same as a general interrupt on an external I/O pin and must be terminated with an IRETURN command to return control to the main program when completed. The automatic variable MM.I2C will hold the result of a command or action.

I2C Master Mode Commands

```
I2CEN speed, timeout [,interrupt-line]
```

Enables the I2C module in master mode.

speed is a value between 10 and 400 (for bus speeds 10kHz to 400kHz).

timeout is a value in milliseconds after which the master send and receive commands will be interrupted if they have not completed. The minimum value is 100. A value of zero will disable the timeout (though this is not recommended).

interrupt-line is optional. It specifies the line number of an interrupt routine to be run when the send or receive command completes. If this is not supplied, the send and receive command will only return when they have completed or timed out. If it is supplied then the send and receive will complete immediately and the command will execute in the background.

```
I2CDIS
```

Disables the slave I2C module. It will also send a stop if the bus is still held.

```
I2CSEND address, option, snd-len, snd-data [,snd-data]
```

Send data to the I2C slave device.

address is the slave I2C address.

cption is a number between 0 and 3 , 1 = keep control of the bus after the command (a stop condition will not be sent at the completion of the command); 2 = treat the address as a 10 bit address ; 3 = combine 1 and 2 (hold the bus and use 10 bit addresses).

snd-len is the number of bytes to send.

snd-data is the data to be sent - this can be specified in various ways (all values sent will be between 0 and 255):

The data can be supplied in the command as individual bytes. Example:

```
I2CSEND &H6F,1,3,&H23,&H43,&H25
```

The data can be in a one dimensional array (the subscript does not have to be zero and will be honoured, also bounds checking is performed). Example:

```
I2CSEND &H6F,1,3,ARRAY(0)
```

The data can be a string variable (not a constant). **Example:**

```
I2CSEND &H6F,1,3,STRING$
```

The automatic variable MM.I2C will hold the result of the transaction.

```
I2CRCV address, bus-hold, rcv-len, rcv-buf [, snd-len, snd-data]
```

Receive data from the I2C slave device with the optional ability to send some data first.

address is the slave I2C address (note that 10 bit addressing is not supported).

option is a number between 0 and 3 ; 1 = keep control of the bus after the command (a stop condition will not be sent at the completion of the command) ; 2 = treat the address as a 10 bit address; 3 = combine 1 and 2 (hold the bus and use 10 bit addresses).

rcv-len is the number of bytes to receive.

rcv-buf is the variable to receive the data - this is a one dimensional array or if rcv-len is 1 then this may be a normal variable. The array subscript does not have to be zero and will be honoured, also bounds checking is performed.

Optionally you can specify data to be sent first using snd-len and snd-data. These parameters are used the same as in the I2CSEND command (ie, snd-data can be a constant, an array or a string variable).

Examples:

```
I2CRCV &H6F,1,1,BYTE

I2CRCV &H6F,1,5, ARR(0)

I2CRCV &H6F,1,4,ARR(2),3,&H12,&H34,&H56

I2CRCV &H6F,1,3,RCVARRAY(0),4,SNDARRAY(0)
```

The automatic variable MM.I2C will hold the result of the transaction.

I2C Slave Mode Commands

`I2CSEN address, mask, option, send-int-line, rcv-int-line`

Enables the `I2C` module in slave mode. `address` is the slave `I2C` address

`mask` is the address mask (bits set as 1 will always match)

`option` is a number between 0 and 3 ; 1 = allows MM-BASIC to respond to the general call address. When this occurs the value of `MM.I2C` will be set to 4; 2 = treat the address as a 10 bit address ; 3 = combine 1 and 2 (respond to the general call address and use 10 bit addresses).

`send-int-line` is the line number of a send interrupt routine to be invoked when the module has detected that the master is expecting data

`rcv-int-line` is the line number of a receive interrupt routine to be invoked when the module has received data from the master.

`I2CSDIS`

Disables the slave `I2C` module.

`I2CSSEND snd-len, snd-data [,snd-data]`

Send the data to the `I2C` master. This command should be used in the send interrupt (ie in the `snd_int-line` when the master has requested data). Alternatively a flag can be set in the send interrupt routine and the command invoked from the main program loop when the flag is set.

`snd-len` is the number of bytes to send.

`snd-data` is the data to be sent. This can be specified in various ways, see the `I2CSEND` commands for details.

`I2CSRCV rcv-len, rcv-buf, rcv-d`

Receive data from the `I2C` master device. This command should be used in the receive interrupt (ie in the `rcv-int-line` when the master has sent some data). Alternatively a flag can be set in the receive interrupt routine and the command invoked from the main program loop when the flag is set.

`rcv-len` is the maximum number of bytes to receive.

`rcv-buf` is the variable to receive the data - this is a one dimensional array or if `rcv-len` is 1 then this may be a normal variable. The array subscript does not have to be zero and will be honoured, also bounds checking is performed.

`rcv-d` will contain actual number of bytes received by the command.

I2C Automatic Variable

`MM.I2C`

Is set to indicate the result of an I2C operation.

0 = The command completed without error.

1 = Received a NACK response

2 = Command timed out

4 = Received a general call address (when in slave mode)

I2C Utility Command

`NUM2BYTE number, array(x)` or

`NUM2BYTE number, variable1, variable2, variable3, variable4`

Convert `number` to four numbers containing the four separate bytes of `number` (MM-BASIC numbers are stored as the C float type and are four bytes in length). The bytes can be returned as four separate variables, or as four elements of `array` starting at index `x`.

See the function `BYTE2NUM()` for the reverse of this command.

`BYTE2NUM(array(x))` or

`BYTE2NUM(byte1,byte2,byte3,byte4)`

Return the number created by storing the four arguments as consecutive bytes (MM-BASIC numbers are stored as the C float type and are four bytes in length).

The bytes can be supplied as four separate numbers or as four elements of `array` starting at index **`x`**.

See the command `NUM2BYTE` for the reverse of this function.

Example: This code changes MOD-IO address by I2C commands:

```
5 'edit line 40 to change new address
10 CLS
20 INPUT "Press Hold But on MOD-IO then hit enter ";a
30 CurI2c = &h58
40 NewI2c = &h5a
50 I2CEN 100,100 ' Enable I2C
60 I2CSEND CurI2c,1,2, &hf0, NewI2c
70 I2CDIS
80 END
```

5.19. SERIAL Communication

Four serial ports are available for asynchronous serial communications. They are labeled COM1:, COM2:, COM3: and COM4: and are opened in a manner similar to opening a file on the SD card.

After they have been opened they will have an associated file number (like an opened disk file) and you can use any commands that operate with a file number to read and write to/from the serial port. Finally the serial port can be closed using the CLOSE command.

The following is an example:

```
10 OPEN "COM1:9600" AS #3  'open serial port
20 PRINT #3, "HELLO"       'send hello
30 DATA$ = INPUT$(20,#3)   'read up to 20 characters
40 CLOSE #3
20 SETPIN 2,8              'PIN(2) as Tx digital output
```

Pin assignments:

COM1: RX is Arduino.D2 or GPIO.13;

TX is Arduino.D3 or GPIO.14;

RTS is Arduino.D4 or GPIO.15 (if *FC* is used);

CTS is Arduino.D5 or GPIO.16 (if *FC* is used);

COM2: RX is Arduino.D6 or GPIO.17;

TX is Arduino.D7 or GPIO.18;

COM3: RX is UEXT.4;

TX is UEXT.3;

COM4: RX is RS232.Rx if R2 is mounted also Arduino.D0 or GPIO.11;

TX is RS232.Tx if R3 is mounted also Arduino.D1 or GPIO.12;

When a serial port is opened the pins used by the port are automatically set to input or output as required and the SETPIN and PIN commands are disabled for the pins. When the port is closed (using the CLOSE command) all pins used by the serial port will be set to a `not configured' state and the SETPIN command can then be used to reconfigure them.

COM1: and COM2: are implemented with bit-bang by MM-BASIC and maximum speed is 19200 bps, COM3: and COM4: are real UARTs and maximum speed is 8,000,000 bps (speed over 115200 bps is not reliable in practice).

A serial port can be opened with "AS CONSOLE". In this case any data received will be treated the same as keystrokes received from the keyboard and any characters sent to the video output will also be transmitted via the serial port. This enables the remote control of MM-BASIC via a serial interface.

The signal polarity is standard for devices running at TTL voltages (not RS232). Idle is voltage high, the start bit is voltage low, data uses a high voltage for logic 1 and the stop bit is a high voltage. The flow control pins (RTS and CTS) use a low voltage to signal stop sending data and high as OK to send. The RS232 connector has a MAX3232 driver which translates the TTL levels to RS232 levels ±12V.

Reading and Writing

Once a serial port has been opened, you can use any commands or functions that use a file number to write and read from the port. Generally the PRINT command is the best method for transmitting data and the INPUT$() function is the most convenient way of getting data that has been received. When using the INPUT$() function the number of characters specified will be the maximum number of characters returned but it could be less if there are less characters in the receive buffer. In fact the INPUT$() function will immediately return an empty string if there are no characters available in the receive buffer.

The LOC() function is also handy, it will return the number of characters waiting in the receive buffer (ie, the number characters that can be retrieved by the INPUT$() function). The EOF() function will return true if there are no characters waiting. The LOF() function will return the space (in characters) remaining in the transmit buffer.

When outputting to a serial port (ie, using PRINT #) the command will pause if the output buffer is full and wait until there is sufficient space to place the new data in the buffer before returning. If the receive buffer overflows with incoming data the serial port will automatically discard the oldest data to make room for the new data.

Serial ports can be closed with the CLOSE command. This will discard any characters waiting in the buffers, return the buffer memory to the memory pool and set all pins used by the port to the `not configured' state. A serial port is also automatically closed when commands such as RUN and NEW are issued.

Interrupts

The interrupt routine (if specified) will operate the same as a general interrupt on an external I/O pin (see page 7 for a description) and must be terminated with an IRETURN command to return control to the main program when completed.

When using interrupts you need to be aware that it will take some time for MM-BASIC to respond to the interrupt and more characters could have arrived in the meantime, especially at high baud rates. So, for example, if you have specified the interrupt level as 200 characters and a buffer of 256 characters then quite easily the buffer will have overflowed by the time the interrupt routine can read the data. In this case the buffer should be increased to 512 characters or more.

Note that the RENUMBER command does not renumber the interrupt line number in "COMx:..."

Opening a Serial Port as the Console

A serial port can be opened as the console for MM-BASIC. The command is: `OPEN "COMx:..." AS CONSOLE`.

In this case any characters received from the serial port will be treated the same as keystrokes received from the keyboard and any characters sent to the video output will also be transmitted via the serial port. This enables a user with a terminal at the end of the serial link to exercise remote control of MM-BASIC. For example, via a modem.

Note that only one serial port can be opened "`AS CONSOLE`" at a time and it will remain open until explicitly closed using the `CLOSE CONSOLE` command. It will not be closed by commands such as `NEW` and `RUN`.

5.20. ASCII Table

Dec	Oct	Hex	Chr
0	0	0	NUL
1	1	1	SOH
2	2	2	STX
3	3	3	ETX
4	4	4	EOT
5	5	5	ENQ
6	6	6	ACK
7	7	7	BEL
8	10	8	BS
9	11	9	HT
10	12	0A	LF
11	13	0B	VT
12	14	0C	FF
13	15	0D	CR
14	16	0E	SO
15	17	0F	SI
16	20	10	DLE
17	21	11	DC1
18	22	12	DC2
19	23	13	DC3
20	24	14	DC4
21	25	15	NAK
22	26	16	SYN
23	27	17	ETB
24	30	18	CAN
25	31	19	EM
26	32	1A	SUB
27	33	1B	ESC
28	34	1C	FS
29	35	1D	GS
30	36	1E	RS
31	37	1F	US
32	40	20	SP
33	41	21	!
34	42	22	"
35	43	23	#
36	44	24	$
37	45	25	%
38	46	26	&
39	47	27	'
40	50	28	(
41	51	29	)
42	52	2A	*
43	53	2B	+
44	54	2C	,
45	55	2D	-
46	56	2E	.
47	57	2F	/

Dec	Oct	Hex	Chr
48	60	30	0
49	61	31	1
50	62	32	2
51	63	33	3
52	64	34	4
53	65	35	5
54	66	36	6
55	67	37	7
56	70	38	8
57	71	39	9
58	72	3A	:
59	73	3B	;
60	74	3C	<
61	75	3D	=
62	76	3E	>
63	77	3F	?
64	100	40	@
65	101	41	A
66	102	42	B
67	103	43	C
68	104	44	D
69	105	45	E
70	106	46	F
71	107	47	G
72	110	48	H
73	111	49	I
74	112	4A	J
75	113	4B	K
76	114	4C	L
77	115	4D	M
78	116	4E	N
79	117	4F	O
80	120	50	P
81	121	51	Q
82	122	52	R
83	123	53	S
84	124	54	T
85	125	55	U
86	126	56	V
87	127	57	W
88	130	58	X
89	131	59	Y
90	132	5A	Z
91	133	5B	[
92	134	5C	\
93	135	5D	]
94	136	5E	^
95	137	5F	-

Dec	Oct	Hex	Chr
96	140	60	`
97	141	61	a
98	142	62	b
99	143	63	c
100	144	64	d
101	145	65	e
102	146	66	f
103	147	67	g
104	150	68	h
105	151	69	i
106	152	6A	j
107	153	6B	k
108	154	6C	l
109	155	6D	m
110	156	6E	n
111	157	6F	o
112	160	70	p
113	161	71	q
114	162	72	r
115	163	73	s
116	164	74	t
117	165	75	u
118	166	76	v
119	167	77	w
120	170	78	x
121	171	79	y
122	172	7A	z
123	173	7B	{
124	174	7C	|
125	175	7D	}
126	176	7E	~
127	177	7F	DEL

Dec = Decimal
Oct = Octal
Hex = Hexadecimal
Chr = Character
LF = Line Feed
FF = Form Feed
CR = Carriage Return
DEL = Rubout

5.21. SPECIAL KEYBOARD KEYS

MMBasic generates a single unique character for the function keys and other special keys on the keyboard. These are shown in the table as hexadecimal numbers:

Keyboard Key	Key Code (Hex)
Up Arrow	80
Down Arrow	81
Left Arrow	82
Right Arrow	83
Insert	84
Home	86
End	87
Page Up	88
Page Down	89
Alt	8B
Num Lock	8C
F1	91
F2	92
F3	93
F4	94
F5	95
F6	96
F7	97
F8	98
F9	99
F10	9A
F11	9B
F12	9C

If the control key is simultaneously pressed then 20 (hex) is added to the code (this is the equivalent of setting bit 5). If the shift key is simultaneously pressed then 40 (hex) is added to the code (this is the equivalent of setting bit 6). If both are pressed 60 (hex) is added. For example Control-PageDown will generate A9 (hex).

The shift modifier only works with the function keys F1 to F12, it is ignored for the other keys.

MMBasic will translate most vt100 escape codes generated by terminal emulators such as Terra Term and Putty to these codes (excluding the shift and control modifiers). This means that a terminal emulator operating over a USB or a serial port opened as console will generate the same key codes as a directly attached keyboard. This is particularly useful when using the EDIT command.

COMMANDS LISTING

ABS Function

Purpose:

To return the absolute value of the expression *n*.

Syntax:

```
ABS(n)
```

Comments:

n must be a numeric expression.

Examples:

```
PRINT ABS(7*(-5))
 35
```

Prints 35 as the result of the action.

ASC Function

Purpose:

To return a numeric value that is the ASCII code for the first character of the string *x$*.

Syntax:

```
ASC(x$)
```

Comments:

If *x$* is null, 0 is returned.

If *x$* begins with an uppercase letter, the value returned will be within the range of 65 to 90.

If *x$* begins with a lowercase letter, the range is 97 to 122.

Numbers 0 to 9 return 48 to 57, sequentially.

See the CHR$ function for ASCII-to-string conversion.

See ASCII codes appendix for ASCII codes.

Examples:

```
10 X$="TEN"
20 PRINT ASC(X$)
RUN
84
```

84 is the ASCII code for the letter T.

ATN Function

Purpose:

To return the arctangent of *x*, when *x* is expressed in radians.

Syntax:

```
ATN(x)
```

Comments:

The result is within the range of -π/2 to π/2.

The expression x may be any numeric type.

To convert from degrees to radians, multiply by π/180.

Examples:

```
10 INPUT X
20 PRINT ATN(X)
RUN
? 3
1.24905
```

Prints the arctangent of 3 radians (1.24905).

AUTO Command

Purpose:

To generate and increment line numbers automatically each time you press the ENTER key.

Syntax:

```
AUTO [line number][,[increment]]
```

Comments:

`AUTO` is useful for program entry because it makes typing line numbers unnecessary.

`AUTO` begins numbering at *`line number`* and increments each subsequent line number by *`increment`*. The default for both values is 10.

If *`line number`* is not followed by a comma, and *`increment`* is not specified, the last increment specified in an `AUTO` command is assumed.

If `AUTO` generates a *`line number`* that is already being used, an asterisk appears after the number to warn that any input will replace the existing line. However, pressing ENTER immediately after the asterisk saves the line and generates the next line number.

`AUTO` is terminated by entering CTRL-BREAK or CTRL-C.

Note

The line in which CTRL-BREAK or CTRL-C is entered is not saved. To be sure that you save all desired text, use CTRL-BREAK and CTRL-C only on lines by themselves.

Examples:

```
AUTO 100, 50
```

Generates line numbers 100, 150, 200, and so on.

```
AUTO
```

Generates line numbers 10, 20, 30, 40, and so on.

CHDIR Statement

Purpose:

To change from one working directory to another.

Syntax:

```
CHDIR pathname$
```

Comments:

Pathname$ is a string expression of up to 63 characters.

To make *games* the working directory, type the following command:

```
CHDIR "GAMES"
```

The special entry ".." represents the parent of the current directory and "." represents the current directory.

CIRCLE Statement

Purpose:

To draw a circle on the screen.

Syntax:

```
CIRCLE(xcenter, ycenter), radius[,[color][,[F]]]
```

Comments:

Xcenter and *ycenter* are the x- and y- coordinates of the center of the circle, and *radius* is the radius (measured along the major axis) of the circle. The quantities *xcenter* and *ycenter* can be expressions.

Color specifies the color of the circle. 0 draws with black color, anything different than 0 draw with white color.

The *F* is fill parameter and fills the circle with the color specified in *color* . If the circle goes outside the drawing area it's truncated and no error is generated.

Example 1:

```
10 CIRCLE(100,100), 50
```

Draws a circle of radius 50, centered at 100x and 100y coordinates.

```
20 CIRCLE(100,100), 50, 0
```

Erases the circle drawn with the previous command.

Example 2:

```
10 CLS ' This will draw 16 circles
20 FOR R=160 TO 0 STEP-10
30 CIRCLE (160,160),R,1
40 NEXT
```

REM Statement

Purpose:

To allow explanatory remarks to be inserted in a program.

Syntax:

```
REM[comment]
'[comment]
```

Comments:

`REM` statements are not executed, but are output exactly as entered when the program is listed.

Once a `REM` or its abbreviation, an apostrophe (`'`), is encountered, the program ignores everything else until the next line number or program end is encountered.

`REM` statements may be branched into from a `GOTO` or `GOSUB` statement, and execution continues with the first executable statement after the `REM` statement. However, the program runs faster if the branch is made to the first statement.

Remarks may be added to the end of a line by preceding the remark with an apostrophe (`'`) instead of `REM`.

Examples:

```
120 REM CALCULATE AVERAGE VELOCITY
130 FOR I=1 TO 20
440 SUM=SUM+V(I)
450 NEXT I
```

or

```
129 FOR I=1 TO 20 'CALCULATED AVERAGE VELOCITY
130 SUM=SUM+V(I)
140 NEXT I
```

CLEAR Command

Purpose:

To set all numeric variables to zero, all string variables to null. See ERASE for deleting specific array variables.

Syntax:

```
CLEAR
```

Comments:

The CLEAR command:

- Clears all user variables
- Resets the strings

Examples:

```
CLEAR
```

Zeroes variables and nulls all strings.

CLOSE Statement

Purpose:

To terminate input/output to a disk file or a device.

Syntax:

```
CLOSE #filenumber[,[#]filenumber]...]
CLOSE CONSOLE
```

Comments:

Filenumber is the number under which the file was opened. The association between a particular file or device and file number terminates upon execution of a CLOSE statement. The file or device may then be reopened using the same or a different file number. A CLOSE statement with no file number specified will lead to error.

A CLOSE statement sent to a file or device opened for sequential output writes the final buffer of output to that file or device.

A CLOSE CONSOLE will close the serial port which is opened for console.

Examples:

```
250 CLOSE #1
```

This closes file #1.

```
300 CLOSE #2, #3
```

Closes all files and devices associated with file numbers 2, and 3.

CLS Statement

Purpose:

To clear the screen.

Syntax:

```
CLS
```

Comments:

`CLS` returns the cursor to the upper-left corner of the screen

Examples:

```
10 CLS
```

This clears the screen.

CONTINUE Command

Purpose:

To continue program execution after a break.

Syntax:

```
CONTINE
```

Comments:

Resumes program execution after CTRL-BREAK, or CTRL-C . Execution continues at the point where the break happened. If the break took place during an `INPUT` statement, execution continues after reprinting the prompt.

`CONTINUE` is useful in debugging, in that it lets you break code, modify variables using direct statements, continue program execution, or use `GOTO` to resume execution at a particular line number. If a program line is modified, `CONTINUE` will be invalid.

COPYRIGHT Command

Purpose:

To print copyright message.

Syntax:

```
COPYRIGHT
```

Comments:

Print copyright message.

DATA Statement

Purpose:

To store the numeric and string constants that are accessed by the program READ statement(s).

Syntax:

```
DATA constants
```

Comments:

Constants are numeric constants in any format (fixed point, floating-point, or integer), separated by commas. Numerical constants can also be expressions such as 5 * 60.

String constants in DATA statements must be surrounded by double quotation marks only if they contain commas, colons, a keyword (such as THEN, WHILE, etc) or significant leading or trailing spaces. Otherwise, quotation marks are not needed.

DATA statements are not executable and may be placed anywhere in the program. A DATA statement can contain as many constants that will fit on a line (separated by commas), and any number of DATA statements may be used in a program.

READ statements access the DATA statements in order (by line number). The data contained therein may be thought of as one continuous list of items, regardless of how many items are on a line or where the lines are placed in the program. The variable type (numeric or string) given in the READ statement must agree with the corresponding constant in the DATA statement, or a "Type Mismatch" error occurs.

DATA statements may be reread from the beginning by use of the RESTORE statement.

For further information and examples, see the RESTORE statement and the READ statement.

Example 1:

```
80 FOR I=1 TO 10
90 READ A(I)
100 NEXT I
110 DATA 3.08,5.19,3.12,3.98,4.24
120 DATA 5.08,5.55,4.00,3.16,3.37
```

This program segment reads the values from the DATA statements into array A. After execution, the value of A(1) is 3.08, and so on. The DATA statements (lines 110-120) may be placed anywhere in the program; they may even be placed ahead of the READ statement.

Example 2:

```
5 PRINT
10 PRINT "CITY","STATE","ZIP"
20 READ C$,S$,Z
30 DATA "DENVER,","COLORADO",80211
```

```
40 PRINT C$,S$,Z
RUN
 CITY STATE ZIP
 DENVER, COLORADO 80211
```

This program reads string and numeric data from the `DATA` statement in line 30.

DATE$ Statement and Variable

Purpose:

To set or retrieve the current date.

Syntax:

As a statement:

**DATE$**=*v$*

As a variable:

*v$*=**DATE$**

Comments:

The date is set to “01-01-2000” at power up. If MOD-RTC (Real-Time-Clock Module) is connected to UEXT the current date will be set form the read content from MOD-RTC.

V$ is a valid string literal or variable.

V$ can be any of the following formats when assigning the date:

dd-mm-yy

dd/mm/yy

dd-mm-yyyy

dd/mm/yyyy

If *v$* is not a valid string, a "Type Mismatch" error results. Previous values are retained.

If any of the values are out of range or missing, an "Invalid date" error is issued. Any previous date is retained.

The current date (as assigned when the operating system was initialized) is fetched and assigned to the string variable if DATE$ is the expression in a LET or PRINT statement.

The current date is stored if DATE$ is the target of a string assignment.

With *v$*=DATE$, DATE$ returns a 10-character string in the form *dd-mm-yyyy*. *dd* is the day (01 to 31), *mm* is the month (01 to 12) and *yyyy* is the year (2000 to 9999).

Examples:

```
V$=DATE$
PRINT V$
01-01-2000
```

DELETE Command

Purpose:

To delete program lines or line ranges.

Syntax:

```
DELETE [line number1][-line number2]
DELETE line number1-
```

Comments:

`line number1` is the first line to be deleted.

`line number2` is the last line to be deleted.

MM-BASIC always returns to command level after a `DELETE` command is executed. Unless at least one line number is given, an "`Invalid syntax`" error occurs.

If the line number do not exist "`Invalid line number`" error occurs.

Examples:

```
DELETE 40
```

Deletes line 40.

```
DELETE 40-100
```

Deletes lines 40 through 100, inclusively.

```
DELETE -40
```

Deletes all lines up to and including line 40.

```
DELETE 40-
```

Deletes all lines from line 40 to the end of the program.

DIM Statement

Purpose:

To specify the maximum values for array variable subscripts and allocate storage accordingly.

Syntax:

```
DIM variable(subscripts)[,variable(subscripts)]...
```

Comments:

If an array variable name is used without a `DIM` statement, a "`Array must be dimensioned first`" error occurs.

The maximum number of dimensions for an array is 8.

The minimum value for a subscript is always 0, unless otherwise specified with the `OPTION BASE` statement.

An array, once dimensioned, cannot be re-dimensioned within the program without first executing a `CLEAR` or `ERASE` statement.

The `DIM` statement sets all the elements of the specified arrays to an initial value of zero.

Examples:

```
10 DIM A(20)
20 FOR I=0 TO 20
30 READ A(I)
40 NEXT I
```

This example reads 21 `DATA` statements elsewhere in the program and assigns their values to A(0) through A(20), sequentially and inclusively.

DO … LOOP Statement

Purpose:

To create endless loop.

Syntax:

```
DO
[ loop statements ]
LOOP
```

Comments:

This structure will loop forever; the EXIT command can be used to terminate the loop or control must be explicitly transferred outside of the loop by commands like GOTO or RETURN (if in a subroutine).

Example:

```
10 DO
20 PRINT "HELLO"
30 IF INKEY$ = "q" THEN EXIT
40 LOOP
50 PRINT "DONE"
```

This example will print `"HELLO"` until `"q"` key is pressed.

DO WHILE ... LOOP Statement

Purpose:

To execute a series of statements in a loop, as long as a given condition is True. This is equivalent to the old WHILE-WEND statement which is also implemented in MM-BASIC for compatibility.

Syntax:

```
DO WHILE expression
[loop statements]
LOOP
```

Comments:

If *expression* is nonzero (true), *loop statements* are executed until the LOOP statement is encountered. MM-BASIC then returns to the DO WHILE statement and checks expression. If it is still true, the process is repeated.

If it is not true, execution resumes with the statement following the LOOP statement.

DO WHILE and LOOP loops may be nested up to 20 times. Each LOOP matches the most recent DO WHILE.

An unmatched LOOP statement causes a "LOOP without matching DO" error.

Example 1:

```
10 DO WHILE INKEY$ <> "q"
20 PRINT "HELLO"
30 LOOP
40 PRINT "DONE."
```

Example 2:

```
90 'BUBBLE SORT ARRAY A$
100 FLIPS=1
110 DO WHILE FLIPS
115 FLIPS=0
120 FOR N=1 TO J-1
130 IF A$(N)>A$(N+1) THEN SWAP A$(N), A$(N+1): FLIPS=1
140 NEXT N
150 LOOP
```

DO ... LOOP UNTIL Statement

Purpose:

To execute a series of statements in a loop until a given condition is true.

Syntax:

```
DO
[loop statements]
LOOP UNTIL expression
```

Comments:

The *loop statements* between DO and LOOP are executed then if *expression* is zero (false) the process is repeated. If it is nonzero (true), execution resumes with the statement following the LOOP statement.

DO and LOOP UNTIL loops may be nested up to 20 times. Each LOOP matches the most recent DO.

An unmatched LOOP statement causes a "LOOP without matching DO" error.

Example:

```
10 DO
20 PRINT "HELLO"
30 LOOP UNTIL INKEY$ = "q"
40 PRINT "DONE."
```

EDIT Command

Purpose:

Edit the line ‘line-number’.

Syntax:

```
EDIT line_number
EDIT
```

Comments:

Line_number is the number of a line existing in the program. If no line number is used this command will edit the previous entry typed at the command prompt. If a running program has just terminated with an error this will automatically edit the line that caused the error.

On entering the edit mode the line will be displayed, the cursor placed at the end of the line and the editing mode set to over-type.

The *editing keys* are:

LEFT/RIGHT ARROWS	Moves the cursor within the line
HOME/END	Moves the cursor to the start or end of the line
DELETE	Delete the character over the cursor
BACKSPACE	Delete the character before the cursor
INSERT	Will switch between insert and overtype mode.

Use `ENTER’ to finish editing (even in insert mode). The line is added to the program just as if it had been typed at the command prompt. If the line number had been changed a new (edited) copy of the line will be added to memory, if it is unchanged the line will replace ‘line-number’.

When editing a program line the UP-ARROW will switch to the previous line and DOWN-ARROW to the next line number. When doing this any changes will be automatically saved (the same as using ENTER) before moving to the next line.

MM-BASIC is always in edit mode when entering data at the command prompt or for the `INPUT` and `LINE INPUT` commands. In these cases the ARROW KEYS can be used to move within the line to correct errors. If the UP-ARROW key is pressed at the command prompt it will act the same as `EDIT` with no line number (edit the last error line or entered command). Subsequent UP/DOWN-ARROW presses will move through the list of recent entries.

All the *editing keys* work with Terra Term and Putty (in *VT100* mode) so editing can also be accomplished over a USB or serial link using these terminal emulators or any other *VT100* compatible terminal emulator.

The *maximum line length* that can be edited is 79 chars in VGA mode and 49 chars in composite mode. If more than this number of characters are entered in over-type mode MM-BASIC will automatically enter normal text entry mode without the editing functions. If in insert mode any extra characters will be rejected.

The current line is always the last line referenced by an `EDIT` statement, `LIST` command, or error message.

If *`line number`* refers to a line which does not exist in the program, an "`Invalid Line Number`" error occurs.

Examples:

```
EDIT 150
```

Displays program line number 150 for editing.

END Statement

Purpose:

To terminate program execution, close all files, and return to command level.

Syntax:

```
END
```

Comments:

`END` statements may be placed anywhere in the program to terminate execution.

An `END` statement at the end of a program is optional. MM-BASIC always returns to command level after an `END` is executed.

`END` closes all files.

Example:

```
520 IF K>1000 THEN END ELSE GOTO 20
```

Ends the program and returns to command level whenever the value of K exceeds 1000.

ERASE Statement

Purpose:

To eliminate arrays from a program.

Syntax:

```
ERASE list of array variables
```

Comments:

Arrays may be re-dimensioned after they are erased, or the memory space previously allocated to the array may be used for other purposes.

If an attempt is made to re-dimension an array without first erasing it, an error occurs.

Examples:

```
200 DIM B (250)
.
450 ERASE A, B
460 DIM B(3, 4)
```

Arrays A and B are eliminated from the program. The B array is re-dimensioned to a 3-column by 4-row array (12 elements), all of which are set to a zero value.

ERROR Statement

Purpose:

To simulate the occurrence of an error, or to allow the user to define it.

Syntax:

```
ERROR error$
```

Comments:

The program execution stops and `error$` is displayed as error.

Example:

The following example simulate error 15 (the code for "`String too long`"):

```
10 INPUT “Number”;a
20 INPUT “div “;b
30 IF B = 0 THEN ERROR “DIVISION BY ZERO”
40 ELSE PRINT a/b
```

EXIT Statement

Purpose:

Exit from DO...LOOP or FOR...NEXT statement.

Syntax:

```
EXIT
EXIT FOR
```

Comments:

The program execution will continue after the LOOP or NEXT statement.

Examples:

This example will print "HELLO" until "q" key is pressed.

```
10 DO
20 PRINT "HELLO"
30 IF INKEY$ = "q" THEN EXIT
40 LOOP
50 PRINT "DONE"
```

This example will print the numbers from 1 to 5 instead to 10

```
10 FOR I = 1 TO 10
20 PRINT I; " ";
30 IF I = 5 THEN EXIT FOR
40 NEXT
```

FILES Command

Purpose:

List files in the current directory on the *SD card*.

Syntax:

```
FILES [search-pattern$]
```

Comments:

The *SD card* (drive B:) may use an optional `search-pattern$`. Question marks (`?`) will match any character and an asterisk (`*`) as the first character of the filename or extension will match any file or any extension. If omitted, all files will be listed.

Example:

```
FILES "*.BAS"
```

Will list all files on the SD card with .BAS extension.

FONT Statement

Purpose:

Select a font for the video output.

Syntax:

```
FONT [#number, [scale, [reverse]
```

Comments:

#number is the font number in the range of 1 to 10, the # symbol is optional.

scale is the multiply factor in the range of 1 to 8 (e.g. a scale of 2 will double the size of a pixel in both the vertical and horizontal). Default is 1.

If *reverse* is a number other than zero the font will be displayed in reverse video. Default is no reverse.

There are *three fonts* built into MM-BASIC:

#1 is the standard font of 10 x 5 pixels containing the full ASCII set.

#2 is a larger font of 16 x 11 pixels also with the full ASCII set.

#3 is a jumbo font of 30 x 22 pixels consisting of the numbers zero to nine and the characters plus, minus, comma and full stop.

Other fonts can be loaded into memory, see the FONT LOAD command.

Font #1 with a scale of one and no reverse is the default on power up and will be reinstated whenever control returns to the input prompt. So if you execute FONT statement at command prompt there will be no font change.

Examples:

```
10 FONT #3,2,1  'doubles scale and reverse video of font #3


10 FONT 3,2,1   'same as above
```

FONT LOAD Statement

Purpose:

Will load the font contained in file and install it as font number which can be any number between 3 and 10.

Syntax:

```
FONT LOAD filename$ AS #fontnumber
```

Comments:

filename$ is file name where the font is contained..

#number is the font number in the range of 3 to 10, the # symbol is optional.

The font is loaded into the memory area used by arrays and strings, use the MEMORY command to check the usage of this area.

A *font file* is just a text file containing ordinary characters which are loaded line by line to build the bitmap of each character in the font. Each character can be up to 64 pixels high and 255 pixels wide. Up to 255 characters can be defined.

The first non comment line in the file must be the specifications for the font as follows: *height, width, start, end*

Where *height and width* are the size of each character in pixels, *start* is the number in the ASCII chart where the first character sits and *end* is the last character. Each number is separated by a comma. So, for example, 16, 11, 48, 57 means that the font is 16 pixels high and 11 wide. The first character is decimal 48 (the zero character) and the last is 57 (number nine character).

The remainder of the lines specify the bitmap for each character.

Each line represents a horizontal row of pixels. A space means the pixel is not illuminated and any other character will turn the pixel on. If the font is 11 pixels wide there must be 11 characters in the line. The first line is the top row of pixels in the character, the next is the second and so on. If the character is 16 pixels high there must be 16 lines to define the character. This repeats until each character is drawn. Using the above example of a font 16x11 with 10 characters there must be a total of 160 lines with each line 11 characters wide. This is in addition to the specification line at the top.

A comment line has an apostrophe (') as the first character and can occur anywhere. A comment line is completely ignored, all other lines are significant.

Example:

The following example creates two arrow icons, up and down arrow. Each is 11x11 pixels with the first (up arrow) in the position of the zero character (0) and the down arrow in the position of number one (1). To display a up arrow your program would contain this:

```
10 FONT LOAD “ARROWS.FNT” AS #9 'load the font
20 FONT #9
30 PRINT “0”

'EXAMPLE OF FONT FILE
'ARROWS.FNT
11,11,48,49

     x
   xxxxx
 xxxxxxxxx
    x x
    x x
    x x
    x x
    x x
   xxxxx


   xxxxx
    x x
    x x
    x x
    x x
    x x
 xxxxxxxxx
   xxxxx
     x

'END OF FONT
```

FONT UNLOAD Statement

Purpose:

Will remove font `#fontnumber` and free the memory used, the # symbol is optional. You cannot unload the built in fonts.

Syntax:

```
FONT UNLOAD #fontnumber
```

Comments:

`#number` is the font number in the range of 3 to 10, the # symbol is optional.

IF ... THEN ... ELSE … Single line IF Statement

Purpose:

To make a decision regarding program flow based on the result returned by an expression.

Syntax:

```
IF expression THEN statement(s) [ELSE statement(s)]
IF expression GOTO line number  [ELSE statement(s)]
```

Comments:

If the result of *expression* is nonzero (logical true), the THEN or GOTO line number is executed.

If the result of *expression* is zero (false), the THEN or GOTO line number is ignored and the ELSE line number, if present, is executed. Otherwise, execution continues with the next executable statement. A comma is allowed before THEN and ELSE.

THEN and ELSE may be followed by either a line number for branching, or one or more statements to be executed.

GOTO is always followed by a line number.

If the statement does not contain the same number of ELSE's and THEN's line number, each ELSE is matched with the closest unmatched THEN. For example:

```
IF A=B THEN IF B=C THEN PRINT "A=C" ELSE PRINT "A < > C"
```

will not print "A < > C" when A < > B.

If an IF...THEN statement is followed by a line number in the direct mode, an "Invalid line number" error results, unless a statement with the specified line number was previously entered in the indirect mode.

Because IF ..THEN...ELSE is all one statement, the ELSE clause cannot be on a separate line. It must be all on one line.

Example:

In the following example, a test determines if N is greater than 10 and less than 20. If N is within this range, execution branches to line 200. If N is not within this range, execution continues with line 110.

```
100 IF(N<20) and (N>10) THEN 200
110 PRINT "OUT OF RANGE"
```

FOR ... NEXT Statements

Purpose:

To execute a series of instructions a specified number of times in a loop.

Syntax:

```
FOR variable=x TO y [STEP z]
[statements]
NEXT [variable][,variable...]
```

Comments:

Variable is used as a counter.

x,*y*, and *z* are numeric expressions.

STEP *z* specifies the counter increment for each loop.

The first numeric expression (*x*) is the initial value of the counter. The second numeric expression (*y*) is the final value of the counter.

Program lines following the FOR statement are executed until the NEXT statement is encountered. Then, the counter is incremented by the amount specified by STEP.

If STEP is not specified, the increment is assumed to be 1.

A check is performed to see if the value of the counter is now greater than the final value (*y*). If it is not greater, MM-BASIC branches back to the statement after the FOR statement, and the process is repeated. If it is greater, execution continues with the statement following the NEXT statement. This is a FOR-NEXT loop.

The body of the loop is skipped if the initial value of the loop times the sign of the step exceeds the final value times the sign of the step.

If STEP is negative, the final value of the counter is set to be less than the initial value. The counter is decremented each time through the loop, and the loop is executed until the counter is less than the final value.

Nested Loops:

FOR-NEXT loops may be nested; that is, a FOR-NEXT loop may be placed within the context of another FOR-NEXT loop. When loops are nested, each loop must have a unique variable name as its counter.

The NEXT statement for the inside loop must appear before that for the outside loop.

If nested loops have the same end point, a single NEXT statement may be used for all of them.

The *variable(s)* in the NEXT statement may be omitted, in which case the NEXT statement will match the most recent FOR statement.

If a NEXT statement is encountered before its corresponding FOR statement, a "Cannot find a matching FOR" error message is issued and execution is terminated.

If a `NEXT variable` statement is encountered before its corresponding `FOR variable` statement, a "`FOR without matching NEXT`" error message is issued and execution is terminated.

Examples:

The following example prints integer values 1 to 10.

```
20 FOR I =1 TO 10 STEP 1
30 PRINT I;
40 NEXT I
RUN
1 2 3 4 5 6 7 8 9 10
```

In the following example, the loop does not execute because the initial value of the loop exceeds the final value. Nothing is printed by this example.

```
10 R=0
20 FOR S=1 TO R
30 PRINT S
40 NEXT S
```

In the next example, the loop executes 10 times. The final value for the loop variable is always set before the initial value is set.

```
10 S=5
20 FOR S=1 TO S+5
30 PRINT S;
40 NEXT S
RUN
1 2 3 4 5 6 7 8 9 10
```

In the next example, the `NEXT` variable is wrong and error occurs.

```
10 FOR I=1 TO 5
20 PRINT I;
30 NEXT S
RUN
1
Error line 30: Cannot find variable
>
```

GOSUB ... RETURN Statement

Purpose:

To branch to, and return from, a subroutine.

Syntax:

```
GOSUB line number
RETURN
```

Comments:

line number is the first line number of the subroutine.

A subroutine may be called any number of times in a program, and a subroutine may be called from within another subroutine.

A RETURN statement in a subroutine causes MM-BASIC to return to the statement following the most recent GOSUB statement. A subroutine can contain more than one RETURN statement, should logic dictate a RETURN at different points in the subroutine.

Subroutines can appear anywhere in the program, but must be readily distinguishable from the main program.

To prevent inadvertent entry, precede the subroutine by an END, or GOTO statement to direct program control around the subroutine.

Examples:

```
10 GOSUB 40
20 PRINT "BACK FROM SUBROUTINE"
30 END
40 PRINT "SUBROUTINE";
50 PRINT " IN";
60 PRINT " PROGRESS"
70 RETURN
RUN
 SUBROUTINE IN PROGRESS
 BACK FROM SUBROUTINE
```

The END statement in line 30 prevents re-execution of the subroutine.

GOTO Statement

Purpose:

To branch unconditionally out of the normal program sequence to a specified line number.

Syntax:

```
GOTO line number
```

Comments:

line number is any valid line number within the program.

If *line number* is an executable statement, that statement and those following are executed. If it is a non-executable statement, execution proceeds at the first executable statement encountered after *line number*.

Examples:

```
10 READ R
20 PRINT "R ="; R;
30 A = 3.14*R^2
40 PRINT "AREA ="; A
50 GOTO 10
60 DATA 5, 7, 12
RUN
 R = 5 AREA = 78.5
 R = 7 AREA = 153.86
 R = 12 AREA = 452.16
 Error line 10: No more DATA to read
```

The "No more DATA to read" advisory is generated when the program attempts to read a fourth DATA statement (which does not exist) in line 60.

MKDIR Command

Purpose:

To create a subdirectory.

Syntax:

```
MKDIR pathname$
```

Comments:

pathname$ is a string expression, identifying the subdirectory to be created.

Examples:

```
MKDIR "SALES\JOHN"
```

Creates the subdirectory *JOHN* within the directory of *SALES*.

NAME Command

Purpose:

To change the name of a disk file.

Syntax:

```
NAME oldfilename$ AS newfilename$
```

Comments:

oldfilename$* must exist and *newfilename$ must not exist; otherwise, an error results.

After a NAME command, the file exists on the same diskette, in the same disk location, with the new name.

Examples:

```
NAME "ACCTS" AS "LEDGER"
```

The file formerly named *ACCTS* will now be named *LEDGER*. The file content and physical location on the diskette is unchanged. If *LEDGER* exist “Error: Cannot open file“ results.

NEW Command

Purpose:

To delete the program currently in memory and clear all variables.

Syntax:

```
NEW
```

Comments:

`NEW` is entered at command level to clear memory before entering a new program. MM-BASIC always returns to command level after a `NEW` is executed.

Examples:

```
NEW
```

or

```
980 PRINT "Do You Wish To Quit (Y/N)
990 ANS$=INKEY$: IF ANS$=""THEN 990
1000 IF ANS$="Y" THEN NEW
1010 IF ANS$="N" THEN 980
1020 GOTO 990
```

ON ... GOSUB and ON ... GOTO Statements

Purpose:

To branch to one of several specified line numbers, depending on the value returned when an expression is evaluated.

Syntax:

```
ON expression GOTO linenumbers
ON expression GOSUB linenumbers
```

Comments:

In the `ON ... GOTO` statement, the value of *`expression`* determines which line number in the list will be used for branching. For example, if the value is 3, the third line number in the list will be destination of the branch. If the value is a non-integer, the fractional portion is rounded.

In the `ON ... GOSUB` statement, each line number in the list must be the first line number of a subroutine.

If the value of *`expression`* is zero or greater than the number of items in the list (but less than or equal to 255), MM-BASIC continues with the next executable statement.

If the value of *`expression`* is negative, or greater than 255, an "`Number out of range`" error occurs.

Examples:

```
100 IF R<1 or R>4 then print "ERROR":END
```

If the integer value of R is less than 1, or greater than 4, program execution ends.

```
200 ON R GOTO 150,300,320,390
210 PRINT "NEXT"
```

If R=1, the program goes to line 150.

If R=2, the program branches to line 300 and continues from there.

If R=3, the branch will be to line 320.

If R=4, the branch will be to line 390.

OPEN Statement

Purpose:

To establish input/output (I/O) to a file.

Syntax:

```
OPEN filename$ [FOR mode] AS [#]filenumber
```

Comments:

filename$ is the name of the file 8 characters max with extension .XXX max 3 characters.

mode is a string expression: OUTPUT Sequential output mode, will overwrite existing file with same name. INPUT Sequential input mode. APPEND Sequential output mode, but from position at end of file. If there is no existing file the APPEND option will act the same as the OUTPUT mode (i.e. the file is created then opened for writing).

filenumber is a number between 1 and 10. The number associates an I/O buffer with a disk file or device. This association exists until a CLOSE or CLOSE file number statement is executed.

The INPUT, LINE INPUT, PRINT, WRITE and CLOSE commands as well as the EOF() and INPUT$() functions all use *filenumber* to identify the file being operated on. See also OPTION ERROR and MM.ERRNO for error handling.

More than one file can be opened for input at one time with different file numbers. For example, the following statements are allowed:

```
OPEN "TEMP.TXT" FOR INPUT AS #1
OPEN "TEMP.TXT" FOR INPUT AS #2
```

However, a file may be opened only once for output or appending. For example, the following statements are illegal:

```
OPEN "TEMP.TXT" FOR OUTPUT AS #1
OPEN "TEMP.TXT" FOR OUTPUT AS #2
```

Note

Be sure to close all files before removing SD card (see CLOSE).

When a disk file is opened for APPEND, the position is initially at the end of the file. PRINT then extends the file.

If the file is opened as INPUT, attempts to write to the file result in "Cannot find file" errors.

If the file is opened as OUTPUT, attempts to read the file result in "Cannot read from file" errors.

Opening a file for OUTPUT or APPEND fails, if the file is already open in any mode.

OPEN "COM(n) Statement

Purpose:

To allocate a buffer to support Serial asynchronous communications with other computers and peripheral devices in the same manner as `OPEN` for disk files.

Syntax:

```
OPEN "COM[n]:[speed][,buf,FC][,OC]" AS [#]filenum
OPEN "COM[n]:[speed][,buf,FC][,OC]" AS CONSOLE
```

Comments:

`COM[n]` is a valid communications device: com1: com2: com3: com4:

com1: RX is Arduino.D2 or GPIO.13;

TX is Arduino.D3 or GPIO.14;

RTS is Arduino.D4 or GPIO.15 (if `FC` is used);

CTS is Arduino.D5 or GPIO.16 (if `FC` is used);

com2: RX is Arduino.D6 or GPIO.17;

TX is Arduino.D7 or GPIO.18;

com3: RX is UEXT.4;

TX is UEXT.3;

com4: RX is RS232.Rx if R2 is mounted also Arduino.D0 or GPIO.11;

TX is RS232.Tx if R3 is mounted also Arduino.D1 or GPIO.12;

`speed` is a literal integer specifying the transmit/receive baud rate. The default is 1200 bps. Note com1: and com2: are implemented with bit-bang by MM-BASIC and maximum speed is 19200 bps, com3: and com4: are real UARTs and maximum speed is 8 000 000 bps (speed over 115200 bps is not reliable in practice).

`FC` enables flow control on com1:

`filenum` is a number between 1 and 10. A communications device may be opened to only one file number at a time. If you try to open com other than com1:- com4: "`Invalid syntax`" error will occur, if you try to open already opened filenumber "`COMx is already open`" error will occur.

When the port `filenum` is opened the port can be written to and read from using any commands or functions that use a file number.

`buf` is the maximum number of bytes which can be read from the communications buffer default of 128 bytes.

A serial port can be opened with “AS CONSOLE”. In this case any data received will be treated the same as keystrokes received from the keyboard and any characters sent to the video output will also be transmitted via the serial port. This enables the remote control of MMBasic via a serial interface.

Examples:

In the following, File 1 is opened for communications with all defaults: speed at 300 bps, even parity, seven data bits, and one stop bit.

```
10 OPEN "COM1:" AS 1
```

In the following, File 2 is opened for communications at 2400 bps. Parity and number of data bits are defaulted.

```
20 OPEN "COM1:2400" AS #2
```

In the following, File 1 is opened for asynchronous I/O at 1200 bits/second. No parity is to be produced or checked.

```
10 OPEN "COM1:1200,N,8" AS #1
```

OPTION BASE Statement

Purpose:

To declare the minimum value for array subscripts.

Syntax:

```
OPTION BASE n
```

Comments:

n is 1 or 0. The default base is 0.

If the statement `OPTION BASE 1` is executed, the lowest value an array subscript can have is 1.

An array subscript may never have a negative value.

`OPTION BASE` gives an error only if you change the base value. This allows chained programs to have `OPTION BASE` statements as long as the value is not changed from the initial setting.

Note

You must code the `OPTION BASE` statement before you can define or use any arrays. If an attempt is made to change the option base value after any arrays are in use, an error results.

OPTION ERROR Statement

Purpose:

Sets the treatment for errors in file input/output.

Syntax:

```
OPTION ERROR CONTINUE
OPTION ERROR ABORT
```

Comments:

The option `CONTINUE` will cause MM-BASIC to ignore file related errors. The program must check the variable `MM.ERRNO` to determine if and what error has occurred.

The option `ABORT` sets the normal behavior (ie, stop the program and print an error message). The default is `ABORT`.

Note that this option only relates to errors reading or writing from the SD card, it does not affect the handling of syntax and other program errors.

Examples:

In the following example if “123.TXT” exist on the SD card 0 will be printed. If “123.TXT” do not exist will be printed 6 - “Cannot find file”

```
10 OPTION ERROR CONTINUE
20 OPEN "123.TXT" FOR INPUT AS #1
30 PRINT MM.ERRNO
```

OPTION PROMPT Statement

Purpose:

Sets the command prompt to the contents of *prompt$*.

Syntax:

```
OPTION PROMPT prompt$
```

Comments:

prompt$ can be an expression which will be evaluated when the prompt is printed.

Maximum length of the prompt string is 48 characters. The prompt is reset to the default (“> “) on power up but you can automatically set it by saving the following example program as “AUTORUN.BAS” on the internal flash drive A:.

```
10 OPTION PROMPT "MY PROMPT: "
20 NEW
```

Examples:

Next example changes the prompt as in APPLE][:

```
OPTION PROMPT "]"
```

This is also valid prompt:

```
OPTION PROMPT TIME$+" : "
```

or

```
OPTION PROMPT CWD$+" : "
```

OPTION Fnn Statement

Purpose:

Sets the programmable function key `Fnn` to the contents of *`string$`*.

Syntax:

```
OPTION Fnn string$
```

Comments:

`Fnn` is the function key `F1` to `F12`. Maximum string length is 12 characters.

`string$` can also be an expression which will be evaluated at the time of running the `OPTION` command. This is most often used to append the ENTER key (chr$(13)), or double quotes (chr$(34)).

Normally these commands should be included in an "AUTORUN.BAS" file (see `OPTION PROMPT` for an example).

Examples:

```
OPTION F1 "RUN" + CHR$(13)
OPTION F2 "SAVE " +CHR$(34)
```

PAUSE Statement

Purpose:

Will halt execution of the running program for *number* milliseconds.

Syntax:

PAUSE *number*

Comments:

The maximum value of *number* is 4294967295 (about 49 days).

Examples:

Next code blink LED which anode (+) is connected to Arduino.A0 and cathode (-) is connected to GND.

```
10 SETPIN 1,8    'set A0 as Digital ooutput
20 DO      'do loop
30 PIN(1) = 1    'switch ON the LED
30 PAUSE 500     'wait ½ second
40 PIN(1) = 0    'switch OFF the LED
50 PAUSE 500     'wait ½ second
60 LOOP          'loop forever
```

PIN(nn) = Statement

Purpose:

Will halt execution of the running program for *number* milliseconds.

Syntax:

```
PIN(n) = value
```

Comments:

For a PIN() configured as digital output this will set the output to low if *value* is zero or high if *value* is non zero. You can set an output high or low before it is configured as an output and that setting will be the default output when the SETPIN command takes effect.

See the function PIN() for reading from a pin and the command SETPIN for configuring it.

Examples:

Next code blink LED which anode (+) is connected to Arduino.A0 and cathode (-) is connected to GND.

```
10 SETPIN 1,8    'set A0 as Digital ooutput
20 DO       'do loop
30 PIN(1) = 1    'switch ON the LED
30 PAUSE 500     'wait ½ second
40 PIN(1) = 0    'switch OFF the LED
50 PAUSE 500     'wait ½ second
60 LOOP          'loop forever
```

PIXEL Statements

Purpose:

To display a point at a specified place on the screen.

Syntax:

```
PIXEL (x,y) = value
```

Comments:

`(x,y)` represents the coordinates of the point.

`value` if zero the point is with black color otherwise with white.

The function `PIXEL(x,y)` returns the value of a pixel with coordinates `(x,y)`.

Coordinate values can be beyond the edge of the screen.

(0,0) is always the upper-left corner and (MM.HRES, MM.VRES) is the lower-right corner.

Example 1:

The following draws a diagonal line from (0,0) to (100,100).

```
10 CLS
20 FOR I=0 TO 100
30 PIXEL(I,I)=1
40 NEXT
```

Example 2:

The following clears out the line by setting each pixel to 0.

```
50 FOR I=100 TO 0 STEP -1
60 PIXEL(I,I) = 0
70 NEXT I
```

POKE Statement

Purpose:

To write (poke) a byte of data into a memory location.

Syntax:

```
POKE hiword,loword,byte
```

Comments:

hiword is the upper 16 bit of the memory address.

loword is the low 16 bit of the memory address.

Byte must be within the range of 0 to 255.

The PIC32 maps all control registers, flash (program) memory and volatile (RAM) memory into a single address space. The PIC32MX7XX Family Data Sheet lists the details of this address space while the source code will provide the symbolic names used in the firmware and the .map file (produced after a successful compile) will list the addresses of these symbols. These addresses will change with each version of the firmware so programs should use the predefined variable MM.VER to determine the currently running version.

Note

This command is for expert users only.

If you use this facility to access an invalid memory address the MIPS CPU will throw an exception which causes the processor to reset and clear all memory. To see this effect try `POKE 0,0,0`.

The complementary function to `POKE` is `PEEK`. The argument to `PEEK` is an address from which a byte is to be read.

`POKE` and `PEEK` are useful for efficient data storage, loading assembly language subroutines, and for passing arguments and results to and from assembly language subroutines.

PRINT Statement

Purpose:

To output a text to the screen.

Syntax:

```
PRINT [list of expressions][;,]
? [list of expressions][;,]
```

Comments:

If *list of expressions* is omitted, a blank line is displayed.

If *list of expressions* is included, the values of the expressions are displayed. Expressions in the list may be numeric and/or string expressions, separated by commas, spaces, or semicolons. String constants in the list must be enclosed in double quotation marks. A semicolon (;) at the end of the expression list will suppress the automatic output of a carriage return/ newline at the end of a print statement.

A question mark (?) may be used in place of the word PRINT.

When numbers are printed on the screen, the numbers are always followed by a space. Positive numbers are preceded by a space. Negative numbers are preceded by a minus (-) sign. Single-precision numbers are represented with seven or fewer digits in a fixed-point or integer format.

Integers (whole numbers) are printed without a decimal point while fractions are printed with the decimal point and the significant decimal digits. Large numbers (greater than six digits) are printed in scientific format.

The function FORMAT$() can be used to format numbers. The function TAB() can be used to space to a certain column and the string functions can be used to justify or otherwise format strings.

Examples:

```
10 X$= "---"
20 PRINT X$"MONTHLY REPORT" X$
RUN
---MONTHLY REPORT---
```

The ',' will space up to 10 characters.

```
10 PRINT 1,2,3,4,5,6,7,8,9,10
RUN
1          2          3          4          5          6          7          8          9
10
```

PRINT # Statements

Purpose:

To write data to a SD card file.

Syntax:

```
PRINT #filenumber, list of expressions [,;]
```

Comments:

filenumber is the number used when the file was opened for OUTPUT or APPEND.

List of expressions consists of the numeric and/or string expressions to be written to the file.

Double quotation marks are used as delimiters for numeric and/or string expressions. The first double quotation mark opens the line for input; the second double quotation mark closes it.

If numeric or string expressions are to be printed as they are input, they must be surrounded by double quotation marks. If the double quotation marks are omitted, the value assigned to the numeric or string expression is printed. If no value has been assigned, 0 is assumed. The double quotation marks do not appear on the screen. For example:

```
10 PRINT #1, A
 0

10 A=26
20 PRINT#1, A
 26

10 A=26
20 PRINT#1, "A"
 A
```

If double quotation marks are required within a string, use CHR$(34) (the ASCII character for double quotation marks). For example:

```
100 PRINT #1,"He said,"Hello", I think"
 He said, 0, I think
```

because the machine assigns the value 0 the variable "Hello."

```
100 PRINT #1, "He said, "CHR$(34) "Hello,"CHR$(34) " I think."
 He said, "Hello," I think
```

In *listofexpressions*, numeric expressions must be delimited by semicolons. For example:

```
PRINT#1, A; B; C; X; Y; Z
```

If commas are used as delimiters, the extra blanks inserted between print fields will also be written to the diskette. Commas have no effect, however, if used with the exponential format.

String expressions must be separated by semicolons in the list. To format the string expressions correctly on the file, use explicit delimiters in *listofexpressions*. For example, the following:

```
10 A$="12345": B$="67890"
20 PRINT#1, A$, B$
```

gives a file image of:

```
12345 67890
```

```
30 PRINT#1, A$; B$
```

gives a file image of:

```
1234567890
```

RANDOMIZE Statement

Purpose:

To reseed the random number generator.

Syntax:

```
RANDOMIZE [expression]
RANDOMIZE TIMER
```

Comments:

If expression is omitted, MM-BASIC will generate error "`Invalid syntax`"

If the random number generator is not reseeded, the `RND()` function returns the same sequence of random numbers each time the program is run.

To change the sequence of random numbers every time the program is run, place a `RANDOMIZE` statement at the beginning of the program, and change the argument with each run. One good way to do this is use the TIMER function.

```
RANDOMIZE TIMER
```

Examples:

```
10 RANDOMIZE TIMER
20 FOR I=1 to 5
30 PRINT RND(1)*100;
40 NEXT I
```

READ Statement

Purpose:

To read values from a `DATA` statement and assign them to variables.

Syntax:

```
READ list of variables
```

Comments:

A `READ` statement must always be used with a `DATA` statement.

`READ` statements assign variables to `DATA` statement values on a one-to-one basis.

`READ` statement variables may be numeric or string. If DATA value is string but you attempt to read number "`Expected a number`" error results. The opposite is acceptable i.e. DATA value to be number but to read it in string variable.

A single `READ` statement may access one or more `DATA` statements. They are accessed in order. Several `READ` statements may access the same `DATA` statement.

If the number of variables in *`list of variables`* exceeds the number of elements in the `DATA` statement(s), an "`No more DATA to read`" error occurs.

If the number of variables specified is fewer than the number of elements in the `DATA` statement(s), subsequent `READ` statements begin reading data at the first unread element. If there are no subsequent `READ` statements, the extra data is ignored.

To reread `DATA` statements from the start, use the `RESTORE` statement.

Examples:

```
10 DATA 1, 2, 3, "A", "B", "C"
20 READ V1, V2, V3, S1$, S2$, S3$
30 PRINT V1, V2, V3
40 PRINT S1$, S2$, S3$
RUN
 1         2           3
A        B          C


10 DATA 11, 22, 33
20 READ A$, B$, C$    'strings are read with numbers as DATA
30 PRINT A$; B$; C$
RUN
112233
```

RENUMBER Command

Purpose:

To renumber program lines currently held in memory including all references to line numbers in commands such as `ELSE`, `GOTO`, `GOSUB`, `THEN`, `ON...GOTO`, `ON...GOSUB`.

Syntax:

```
RENUMBER [first],[increment][,start]]
```

Comments:

`first` is the first line number to be used in the new sequence. The default is 10.

`increment` is the increment for each line. The default is 10.

`start` is the line number in the old program where renumbering should commence from. The default is the first line of the program.

This command will first check for errors that may disrupt the renumbering process and it will only change the program in memory if no errors are found. However, it is prudent to save the program before running this command in case there are some errors that are not caught.

If a nonexistent line number appears after one of these statements `ELSE`, `GOTO`, `GOSUB`, `THEN`, `ON...GOTO`, `ON...GOSUB`, the error message "`Line number does not exist. Cancelling RENUMBER`" appears.

`RENUMBER` cannot be used to change the order of program lines or to create line numbers greater than 65000.

Examples:

```
RENUMBER
```

Renumbers the entire program. The first new line number will be 10. Lines increment by 10.

```
RENUMBER 1000,10
```

Renumbers the entire program. The first new line number will be 1000. Lines increment by 10.

```
RENUM 1000,10,200
```

Renumbers the lines from 200 up so they start with line number 1000 and are incremented by 10.

RESTORE Statement

Purpose:

To allow `DATA` statements to be reread from the start.

Syntax:

```
RESTORE
```

Comments:

After `RESTORE` the next `READ` statement accesses the first item in the first `DATA` statement.

Example:

```
10 READ A, B, C,
20 RESTORE
30 READ D, E, F
40 DATA 57, 68, 79
```

Assigns the value 57 to both A and D variables, 68 to B and E, and so on.

RMDIR Command

Purpose:

To delete a subdirectory.

Syntax:

```
RMDIR pathname$
```

Comments:

pathname$ is a string expression, identifying the subdirectory to be removed from its parent.

The subdirectory to be deleted must be empty of all files except "`.`" and "`..`" or a "`Directory not empty`" error occurs.

Example:

```
RMDIR "SALES"
```

RUN Command

Purpose:

To execute the program currently in memory, or to load a file from the SD card into memory and run it.

Syntax:

```
RUN [linenumber]
RUN filename$
```

Comments:

`RUN` or `RUN linenumber` runs the program currently in memory.

If `linenumber` is specified, execution begins on that line. Otherwise, execution begins at the lower line number.

If there is no program in memory when `RUN` will do nothing.

`RUN filename$` closes all open files and deletes the current memory contents before loading the specified file from SD card into memory and executing it. If an extension is not specified ".BAS" will be added to the file name.

Examples:

```
RUN "HELLO"
```

Runs *HELLO.BAS* .

SAVE Command

Purpose:

To save a program file the SD card.

Syntax:

```
SAVE filename$
```

Comments:

filename$* is a quoted string that follows the normal MS-DOS naming conventions i.e. 8 characters name and 3 characters extension. If *filename$ already exists, the file will be written over. If the extension is omitted, *.bas* will be used.

Examples:

The following command saves the file *TEST.BAS* :

```
SAVE "TEST"
```

SAVEBMP Command

Purpose:

To save the current VGA or composite screen as a BMP file in the current working directory on the SD card.

Syntax:

```
SAVEBMP filename$
```

Comments:

filename$* is a quoted string that follows the normal MS-DOS naming conventions i.e. 8 characters name and 3 characters extension. If *filename$ already exists, the file will be written over. If the extension is omitted, *.BMP* will be added.

Note

Note that Windows 7 Paint has trouble displaying the image. This appears to be a bug in Paint as all other software tested (including Windows XP Paint) can display the image without fault. To save a program file the SD card.

Examples:

The following command saves the file *IMAGE.BMP* :

```
SAVEBMP "IMAGE"
```

SETPIN Statement

Purpose:

To configure external IO port .

Syntax:

```
SETPIN pin-number, config
SETPIN pin-number, config, line-number
```

Comments:

pin-number is the number of the GPIO port. It's in range 1..20 for ***DuinoMite-Mega***, ***DuinoMite-Mini*** and ***DuinoMite***.

config defines how the port is configured for use.

0	Not configured or inactive	
1	Analog input	(reads input voltage 0-3.3V, accuracy better than ±1%)
2	Digital input	(read 0 if input voltage is 0..0.65V, 1 if voltage is 2.5..3.3V/5.5V) (5V tolerant ports are: ….) (All digital inputs are Schmitt Trigger buffered.)
3	Frequency input	(measure frequency up to 200KHz)
4	Period input	(measure period pulse width 10nS or more)
5	Counting input	(counts pulses up to 200KHz pulse width 10nS or more)
6	Interrupt on low to high input change	(configure as digital input and interrupt is generator on level change low to high)
7	Interrupt on high to low input change	(configure as digital input and interrupt is generator on level change high to low)
8	Digital output	(output 3.3V when 1 and 0V when 0) (Typical current draw or sink ability on any I/O pin: 10mA) (Maximum current draw or sink on any I/O pin: 25mA) (Maximum current draw or sink for all I/O pins combined: 150mA)
9	Open collector digital output to 5V	(0V when 0, Vcc when 1) (Maximum open collector voltage (I/O pins 11 to 20): 5.5V)

line-number could be add only if `config` is 6 or 7 and configure the GPIO port to generate interrupt on level change. `line-number` is the start of the interrupt routine. This mode also configures the GPIO port as a digital input so the value of the port can always be retrieved using the function `PIN()`.

See also `IRETURN` to return from the interrupt.

See the function `PIN()` for reading inputs and the statement `PIN()=` for outputs.

Examples:

```
10 SETPIN 1,8    'make GPIO.1 / ARDUINO.A0 as OUTPUT
20 PIN(1) = 1    'output 3.3V to the port
30 PIN(1) = 0    'output 0V to the port
```

SETTICK Statement

Purpose:

To setup periodic interrupt and forward the execution to interrupt routing.

Syntax:

SETTICK *period, line-number*

Comments:

period is the time in milliseconds between interrupts. The period can range from 1 to 4294967295 mSec (about 49 days).

line-number is the line number of the interrupt routine. See also IRETURN to return from the interrupt. This interrupt can be disabled by setting *line-number* to zero (i.e., SETTICK 0,0).

Examples:

In the following example, LED connected to GPIO.1 (ARDUINO.A0) will start blinking when "1" is pressed and will stop when "2" is pressed.

```
10 SETPIN 1,8                              'ARDUINO.A0 is output
20 DO                                   'loop forever
30 C$=INKEY$: IF C$="" THEN 30             'wait key pressed
40 IF C$="1" THEN SETTICK 100,100          'set interrupt every 0.1 sec
50 IF C$="2" THEN SETTICK 0,0: PIN(1)=0    'clear the interrupts
60 LOOP
100 IF I=0 THEN I=1: PIN(1)=1: IRETURN     'toggle LED
110 IF I=1 THEN I=0: PIN(1)=0: IRETURN
```

SOUND Statement

Purpose:

To generate single tone sound.

Syntax:

```
SOUND freq, duration, duty
```

Comments:

freq is the tone frequency in Hertz (cycles per second). *freq* is a numeric expression within the range of 20 and 1,000,000, which corresponds to frequencies from 20Hz to 1Mhz for *duration* of milliseconds. The sound is played in the background and does not stop program execution.

If *duration* is zero, any active SOUND statement is turned off. If no SOUND statement is running, a *duration* of zero has no effect.

duty is the optional duty cycle of the waveform in percent. If it is close to zero the output will be a narrow positive pulse, if 50 a square wave will be generated and if close to 100 it will be a very wide positive pulse. If it is not specified the *duty* cycle will default to 50%.

Setting the duty cycle allows the sound output to be used as a *Pulse Width Modulation (PWM)* output for driving analogue circuits. The signal will be available at the sound connector and the voltage divider on this output should be removed so that the full signal level is available. The frequency of the output is locked to the PIC32 crystal and is very accurate and for frequencies below 100KHz the duty cycle will be accurate to 0.1%.

Examples:

The following example creates random sounds of short duration:

```
10 SOUND RND(1)*1000+100, 10
20 GOTO 10
```

TIME$ Statement and Variable

Purpose:

To set or retrieve the current time.

Syntax:

As a statement:

```
TIME$ = string exp
```

As a variable:

```
string exp=TIME$
```

Comments:

string exp is a valid string literal or variable that lets you set hours (*hh*), hours and minutes (*hh:mm*), or hours, minutes, and seconds (*hh:mm:ss*).

hh sets the hour (0-23). Minutes and seconds default to 00.

hh:mm sets the hour and minutes (0-59). Seconds default to 00.

hh:mm:ss sets the hour, minutes, and seconds (0-59).

If *string exp* is not a valid string "*Invalid Syntax*" error will occur.

As you enter any of the above values, you may omit the leading zero, if any. You must, however, enter at least one digit. If you wanted to set the time as a half hour after midnight, you could enter `TIME$= "0:30"`, but not `TIME$= ":30"`.

If any of the values are out of range, an "`Invalid time`" error is issued. The previous time is retained.

The current time is stored if `TIME$` is the target of a string assignment.

The current time is fetched and assigned to the string variable if `TIME$` is the expression in a `LET` or `PRINT` statement.

If *string exp* = `TIME$`, `TIME$` returns an 8-character string in the form *hh:mm:ss*.

The time is set to "00:00:00" at power up.

Examples:

The following example sets the time at 8:00 o'clock :

```
TIME$ = "08:00"
PRINT TIME$
 08:00:05
```

TIMER= Statement and TIMER Function

Purpose:

To set the timer to a number of milliseconds.

To read TIMER value.

Syntax:

```
TIMER = value
var = TIMER
```

Comments:

`TIMER =` sets the `TIMER` to number of milliseconds. Normally this is used to reset the timer to zero, but you can set it to any positive integer value.

`TIMER` function returns the elapsed time in milliseconds (e.g. 1/1000 of a second) since reset. If not specifically reset this count will wrap around to zero after 49 days.

The timer is reset to zero on power up and you can also reset it by using `TIMER =` command.

TRON/TROFF Commands

Purpose:

To trace the execution of program statements.

Syntax:

```
TRON
TROFF
```

Comments:

As an aid in debugging, the `TRON` (trace on) command enables a trace flag that prints each line number of the program as it is executed. The numbers appear enclosed in square brackets.

`TRON` may be executed in either the direct or indirect mode.

The trace flag is disabled with the `TROFF` (trace off) command, or when a `NEW` command is executed.

Examples:

```
TRON
10 K=10
20 FOR J=1 TO 2
30 L=K + 10
40 PRINT J; K; L
50 K=K+10
60 NEXT
70 END
RUN
 [10][20][30][40] 1 10 20
 [50][60][30][40] 2 20 30
 [50][60][70]
TROFF
```

XMODEM Commands

Purpose:

To transfer a file to or from a remote computer using the XModem protocol.

Syntax:

```
XMODEM SEND file$
XMODEM RECEIVE file$
```

Comments:

Transfers a file to or from a remote computer using the XModem protocol. The transfer is done over the USB connection or, if a serial port is opened as console, over that serial port.

file$ is the file (on the SD card or internal flash) to be sent or received.

The XModem protocol requires a cooperating software program running on the remote computer and connected to its serial port. It has been tested on Terra Term running on Windows and it is recommended that this be used. After running the XMODEM command in MM-BASIC select:

File -> Transfer -> XMODEM -> Receive/Send from the Terra Term menu to start the transfer.

The transfer can take up to 15 seconds to start and if the XMODEM command fails to establish communications it will return to the MMBasic prompt after 30 seconds.

Download Terra Term from http://ttssh2.sourceforge.jp/

For Linux we recommend to use MINICOM.

Examples:

```
XMODEM RECEIVE "FILE.TXT"
XMODEM SEND "DATA.BAS"
```

CHR$ Function

Purpose:

To convert an ASCII code to its equivalent character.

Syntax:

```
CHR$(n)
```

Comments:

`n` is a value from 0 to 255.

`CHR$` is commonly used to send a special character to the terminal or printer. For example, you could add `CHR$(13)` or `CHR$(34)` in string.

See the `ASC()` function for ASCII-to-numeric conversion.

ASCII Codes are listed in page xxx.

Examples:

```
PRINT CHR$(66);
 B
```

This prints the ASCII character code 66, which is the uppercase letter B.

```
PRINT CHR$(13);
```

This command prints a carriage return.

CINT Function

Purpose:

To round numbers with fractional portions to the next whole number or integer.

Syntax:

```
CINT(x)
```

Comments:

x should integer number range. See also INT() and FIX() both of which return integers.

Examples:

```
PRINT CINT(45.67)
 46
```

45.67 is rounded up to 46.

```
PRINT CINT(-35.54)
-36
```

-35.54 is rounded up to -36.

COS Function

Purpose:

To return the cosine of the argument *x* in radians.

Syntax:

```
COS(x)
```

Comments:

x must be in radians. COS is the trigonometric cosine function. To convert from degrees to radians, multiply by π/180.

Example 1:

```
10 X=2*COS(.4)
20 PRINT X
RUN
1.84212
```

Example 2:

```
10 PI=3.14159
20 PRINT COS(PI)
30 DEGREES=180
40 RADIANS=DEGREES*PI/180
50 PRINT COS(RADIANS)
RUN
 -1
 -1
```

CWD$ Function

Purpose:

To return the current working directory on the SD card as a string.

Syntax:

```
CWD$
```

Comments:

Can be used in string expression.

Example 1:

```
PRINT "CURRENT WORKING DIRECTORY IS: ";CWD$
CURRENT WORKING DIRECTORY IS: \
```

DATE$ Statement and Variable

Purpose:

To set or retrieve the current date.

Syntax:

As a statement:

**DATE$**=*v$*

As a variable:

*v$*=**DATE$**

Comments:

The internal clock/calendar will keep track of the time and date including leap years. The date is set to "1-1-2000" on power up. To set the date use the command DATE$ =v$.

v$ is a valid string literal or variable.

v$ can be any of the following formats when assigning the date:

dd-mm-yy

dd/mm/yy

dd-mm-yyyy

dd/mm/yyyy

If *v$* is not a valid string, a "Invalid syntax" error results. Previous values are retained.

DATE$ returns the current date based on MM-BASIC internal clock as a string in the form "DD-MM-YYYY". For example, "26-06-2011".

With *v$*=DATE$, DATE$ returns a 10-character string in the form *dd-mm-yyyy*.

dd is the day (01 to 31), *mm* is the month (01 to 12) and *yyyy* is the year (2000 to 9999).

Examples:

```
v$=DATE$
PRINT V$
 01-12-2011
```

EOF Function

Purpose:

To return ***true*** if the end of file has been reached, or to return 0 if end of file (EOF) has not been found.

Syntax:

```
v=EOF([#]file-number)
```

Comments:

Will return true if the file previously opened for `INPUT` with the *`file-number`* is positioned at the end of the file.

If used on a *`file-number`* opened as a serial port this function will return ***true*** if there are no characters waiting in the receive buffer.

The `#` is optional. Also see the `OPEN`, `INPUT` and `LINE INPUT` commands and the `INPUT$` function.

Examples:

```
10 OPEN "COM1:19200" AS #5
20 IF NOT EOF(#5) THEN PRINT INPUT$(1,#5);
30 GOTO 20
```

Open the COM1 serial port and if character is received in the buffer print it on the screen.

EXP Function

Purpose:

To return *e* (the base of natural logarithms) to the power of *x*.

Syntax:

```
EXP(x)
```

Comments:

X must not cause overflow.

Examples:

```
10 X = 5
20 PRINT EXP(X-1)
RUN
 54.5981
```

Prints the value of *e* to the 4th power.

FIX Function

Purpose:

To truncate `x` to a whole number.

Syntax:

```
FIX(x)
```

Comments:

`FIX` does not round off numbers, it simply eliminates the decimal point and all characters to the right of the decimal point.

`FIX(x)` is equivalent to `SGN(x)*INT(ABS(x))`. The major difference between `FIX` and `INT` is that `FIX` does not return the next lower number for negative `x`. This behavior is for Microsoft compatibility.

`FIX` is useful in modulus arithmetic.

See also `CINT()` .

Examples:

```
PRINT FIX(9.89)
 9
PRINT FIX(-2.11)
 -2
```

FORMAT$ Function

Purpose:

To return a string representing *number* formatted according to the specifications in the string *format$*.

Syntax:

**FORMAT$**(*number, format$*)

Comments:

The *format$* specification starts with a % character and ends with a letter. Anything outside of this construct is copied to the output as is.

The structure of a format specification is:

% [flags] [width] [.precision] type

Where *flags* can be:

-	Left justify the value within a given field width
0	Use 0 for the pad character instead of space
+	Forces the + sign to be shown for positive numbers
space	Causes a positive value to display a space for the sign. Negative values still show the – sign

width is the minimum number of characters to output, less than this the number will be padded, more than this the width will be expanded.

precision specifies the number of fraction digits to generate with an *e*, or *f* type or the maximum number of significant digits to generate with a *g* type. If specified the precision must be preceded by a dot (**.**).

type can be one of:

g	Automatically format the number for the best presentation.
f	Format the number with the decimal point and following digits
e	Format the number in exponential format

If uppercase *G* or *F* is used the exponential output will use an uppercase *E*. If the format specification is not specified "*%g*" is assumed.

Examples:

format$(45) will return *45*

format$(45,"%g") will return *45*

format$(24.1,"%g") will return *24.1*

format$(24.1,"%f") *will return* *24.100000*

format$(24.1,"%e") *will return* *2.410000e+01*

`format$(24.1,"%09.3f")` will return `00024.100`

`format$(24.1,"%+.3f")` *will return* `+24.100`

`format$(24.1,"**%-9.3f**")` *will return* `**24.100  **`

HEX$ Function

Purpose:

To return a string which represents the hexadecimal value of the numeric argument.

Syntax:

```
v$=HEX$(x)
```

Comments:

`HEX$` converts decimal values within the range of ±1677100 string expression within the range of 0 to FFFFFFFF.

Hexadecimal numbers are numbers to the base 16, rather than base 10 (decimal numbers).

`x` is rounded to an integer before `HEX$(x)` is evaluated.

If `x` is negative, 2's (binary) complement form is used i.e. -1 is FFFFFFFF

Example:

```
10 CLS: INPUT "INPUT DECIMAL NUMBER";X
20 A$=HEX$(X)
30 PRINT X "DECIMAL IS "A$" HEXADECIMAL"
RUN
 INPUT DECIMAL NUMBER? 32
 32 DECIMAL IS 20 HEXADECIMAL
```

INKEY$ Variable

Purpose:

To return one character read from the keyboard.

Syntax:

*v$*=**INKEY$**

Comments:

If no character is pending in the keyboard buffer, a null string (length zero) is returned.

If several characters are pending, only the first is returned.

No characters are displayed on the screen, and all characters except the following are passed to the program:

CTRL-BREAK
CTRL-NUM LOCK
CTRL-ALT-DEL
CTRL-PRTSCR
PRTSCR

Example:

```
10 CLS     'game moves rectangle on the screen 1,2,3 keys are used
20 X = 0 : D = 1
30 LINE (X*20,100)-(X*20+20,105),1,BF
40 PAUSE 100
50 LINE (X*20,100)-(X*20+20,105),0,BF
60 C$ = INKEY$
70 IF C$ = "1" THEN D = -1 'move right to left
80 IF C$ = "2" THEN D = 1        'move left to right
90 IF C$ = "3" THEN END          'quit
100 X = X + D
110 IF X > 23 THEN X = 0
120 IF X < 0 THEN X = 23
130 GOTO 30
```

INPUT$() Function

Purpose:

To read and return characters from file.

Syntax:

```
v$=INPUT$(number, [#]file-number)
```

Comments:

Will return a string composed of *number* characters read from a file previously opened for INPUT with the file number *file-number*. This function will read all characters including carriage return and new line without translation.

When reading from a serial communications port this will return as many characters as are waiting in the receive buffer up to *number*. If there are no characters waiting it will immediately return with an empty string.

The # is optional. Also see the OPEN command.

Examples:

In the following example, ***MOD-GPS*** is connected to ***DuinoMite-Mega*** UEXT and the GPS message in NMEA format is read and will display it on the screen.

```
10 OPEN "COM3:19200" AS #3
20 PRINT INPUT$(1,#3);
30 GOTO 20
```

INSTR Function

Purpose:

To search for the first occurrence of string *y$* in *x$*, starting from position *n* and return the position at which the string is found.

Syntax:

```
INSTR([n,]x$,y$)
```

Comments:

Optional offset *n* sets the position for starting the search. The default value for *n* is 1. If *n* equals zero, the error message "Number out of bounds" is returned. *n* must be within the range of 1 to 255. If *n* is out of this range, an "Number out of bounds" error is returned.

INSTR returns 0 if:

- *n* > LEN(*x$*)
- *x$* is null
- *y$* cannot be found

If *y$* is “”, INSTR returns *n*.

x$* and *y$ may be string variables, string expressions, or string literals.

Examples:

```
10 X$="ABCDEBXYZ"
20 Y$="B"
30 PRINT INSTR(X$, Y$); INSTR(4, X$, Y$)
RUN
 2 6
```

The interpreter searches the string "ABCDFBXYZ" and finds the first occurrence of the character B at position 2 in the string. It then starts another search at position 4 (D) and finds the second match at position 6 (B). The last three characters are ignored, since all conditions set out in line 30 were satisfied.

INT Function

Purpose:

To truncate an expression to a whole number.

Syntax:

```
INT(n)
```

Comments:

Negative numbers return the next lowest number. This behaviour is for Microsoft compatibility, the `FIX()` function provides a true integer function.

The `FIX` and `CINT` functions also return integer values.

Examples:

```
PRINT INT(98.89)
 98
PRINT INT(-12.11)
 -13
```

LEFT$ Function

Purpose:

To return a string that comprises the left-most n characters of *x$*.

Syntax:

**LEFT$**(*x$*,*n*)

Comments:

n must be within the range of 0 to 255. If *n* is greater than LEN(*x$*), the entire string (*x$*) will be returned. If *n* equals zero, the null string (length zero) is returned (see the MID$() and RIGHT$() substring functions).

Example:

```
10 A$="BASIC"
20 B$=LEFT$(A$, 3)
30 PRINT B$
RUN
 BAS
```

The left-most three letters of the string "BASIC" are printed on the screen.

LEN FUNCTION

Purpose:

To return the number of characters in *x$*.

Syntax:

```
LEN(x$)
```

Comments:

x$ is any string expression. Non-printing characters and blanks are counted.

Example:

```
10 X$="PORTLAND, OREGON"
20 PRINT LEN(X$)
RUN
 16
```

Note that the comma and space are included in the character count of 16.

LOC Function

Purpose:

To return the number of bytes waiting in the receive buffer of a serial port (ie, COM1:, COM2:, COM3: or COM4:).

Syntax:

```
LOC([#]file-number)
```

Comments:

file-number is the file number used when the Serial port was opened. The # is optional.

When transmitting or receiving a file through a communication port, LOC returns the number of characters in the input buffer waiting to be read. The default size for the input buffer is 127 characters. If there are more than 127 characters received only the last 127 remain in the buffer, LOC returns 127. If fewer than 127 characters remain in the buffer, then LOC returns the actual count.

Examples:

```
200 IF LOC(#1)>5 THEN 300  'process the input message when 5 are read
```

The program jumps to line 300 after 5 characters are read.

LOF Function

Purpose:

To return the free space in the transmit buffer.

Syntax:

```
LOF([#]file-number)
```

Comments:

file-number is the number of the file that the file was opened under.

With communications files, LOF returns the amount of free space in the input buffers.

Examples:

The following example reads message only when the buffer is half filled:

```
10 OPEN "COM1:9600" AS #1
20 IF LOF(#1) > 64 THEN MSG$=INPUT$(64,#1)
```

LOG Function

Purpose:

To return the natural logarithm of *x*.

Syntax:

```
LOG(x)
```

Comments:

x must be a number greater than zero.

Examples:

```
PRINT LOG(2)
 .693147
PRINT LOG(1)
 0
PRINT LOG(0.0001)
-9.21034
```

LCASE$ Function

Purpose:

To return x$ converted to lowercase characters.

Syntax:

```
LCASE$(x$)
```

Comments:

x$ may be empty string.

Example:

```
PRINT LCASE$("qWeRTyUIop")
qwertyuiop
```

MID$ Function

Purpose:

To return a string of *m* characters from *x$* beginning with the *nth* character.

Syntax:

**MID$**(*x$*,*n*[,*m*])

Comments:

n must be within the range of 1 to 255.

m must be within the range of 0 to 255.

If *m* is omitted, or if there are fewer than *m* characters to the right of *n*, all rightmost characters beginning with *n* are returned.

If *n* > LEN(*x$*), MID$ function returns a null string.

If *m* equals 0, the MID$ function returns a null string.

If either *n* or *m* is out of range, an "Number out of bounds" is returned.

Example:

```
10 A$="GOOD"
20 B$="MORNING EVENING AFTERNOON"
30 PRINT A$; MID$(B$, 8, 8)
RUN
 GOOD EVENING
```

Line 30 concatenates (joins) the A$ string to another string with a length of eight characters, beginning at position 8 within the B$ string.

OCT$ Function

Purpose:

To convert a decimal value to an octal value.

Syntax:

```
OCT$(x)
```

Comments:

`x` is rounded to an integer before `OCT$(x)` is evaluated.

`OCT$` converts decimal values within the range of ±1677100 to an octal string expression.

Octal numbers are numbers to the base 8 rather than base 10 (decimal numbers).

See the `HEX$` function for hexadecimal conversion.

Examples:

```
10 PRINT OCT$(18)
RUN
 22
```

Decimal 18 equates to Octal 22.

PEEK Function

Purpose:

To read from a specified memory location.

Syntax:

```
PEEK(hiword,loword)
```

Comments:

Returns the byte (decimal integer within the range of 0 to 255) read from the specified memory location. *hiword* is the top 16 bits of the address while *loword* is the bottom 16 bits.

See the POKE command for notes and warnings related to memory access.

PEEK is the complementary function to the POKE statement.

PIN() Function

Purpose:

To read from a specified external GPIO port.

Syntax:

```
PIN(n)
```

Comments:

If the GPIO ports is initialized as Digital Input with the SETPIN command, zero means digital low, read 1 means digital high.

For GPIO ports initialized with SETPIN command as analogue inputs, it will return the measured voltage as a floating point number between 0 and 3.3 which corresponds to 0V to 3.3V.

For GPIO ports initialized with SETPIN command as Frequency inputs, will return the frequency in Hz (maximum 200KHz).

For GPIO ports initialized with SETPIN command as Period inputs, will return the period in milliseconds.

For GPIO ports initialized with SETPIN command as Count input, will return the count since reset (counting is done on the positive rising edge). The count input can be reset to zero by resetting the pin to counting input (even if it is already so configured).

PIN(0) is a special case which will always return the state of the *user* push button on the PC board (non zero means that the button is down).

Also see the SETPIN and PIN()= commands.

Example:

In the following example, a LED connected to ARDUINO.A0 and GND will light ON when User button is pressed.

```
10 SETPIN 1,8
20 PIN(1) = PIN(0)
30 GOTO 20
```

POS Function

Purpose:

To return the current cursor position.

Syntax:

```
POS
```

Comments:

The leftmost position is 1.

Example:

```
10 CLS
20 A$ = INKEY$ :IF A$ = "" THEN GOTO 30 ELSE PRINT A$;
40 IF POS > 10 THEN PRINT CHR$(13);CHR$(10);
50 GOTO 30
```

Causes a carriage return and line feed after the 10th character is printed on each line of the screen.

PIXEL Function

Purpose:

To return the current value of a pixel on the VGA or composite screen.

Syntax:

```
PIXEL(x,y)
```

Comments:

Zero is off, 1 is on. Most upper-left coordinate is 0,0 the most right-down coordinates are `MM.HRES,MM.VRES`.

See the statement `PIXEL(x,y)=` for setting the value of a pixel.

Example:

```
CLS
PRINT PIXEL(100,100)
 0
```

RIGHT$ Function

Purpose:

To return the rightmost *n* characters of string *x$*.

Syntax:

```
RIGHT$(x$,n)
```

Comments:

If *n* is equal to or greater than LEN(*x$*), RIGHT$ returns *x$*. If *n* equals zero, the null string (length zero) is returned (see the MID$ and LEFT$ functions).

Example:

```
10 A$="DISK BASIC"
20 PRINT RIGHT$(A$, 5)
RUN
 BASIC
```

Prints the rightmost five characters in the A$ string.

RND Function

Purpose:

To return a random number between 0 and 0.99999.

Syntax:

```
RND[(x)]
```

Comments:

The same sequence of random numbers is generated each time the program is run unless the random number generator is reseeded (see `RANDOMIZE` statement).

x value is ignored if supplied.

To get a random number within the range of zero through *n*, use the following formula:

```
INT(RND*(n+1))
```

Examples:

```
PRINT RND
 0.513871

PRINT RND (1)    'prints two numbers due to the space between RND and (
 0.175726 1

PRINT RND(-1)
 0.94763

PRINT INT(RND*101)    'prints random number 0 - 100
 53
```

SGN Function

Purpose:

To return the sign of *x*.

Syntax:

SGN(*x*)

Comments:

x is any numeric expression.

If *x* is positive, SGN(*x*) returns 1.
If *x* is 0, SGN(*x*) returns 0.
If *x* is negative, SGN(*x*) returns -1.

Examples:

```
10 INPUT "Enter value", x
20 ON SGN(X)+2 GOTO 100, 200, 300
```

MM-BASIC branches to 100 if X is negative, 200 if X is 0, and 300 if X is positive.

SIN Function

Purpose:

To calculate the trigonometric sine of *x*, in radians.

Syntax:

```
SIN(x)
```

Comments:

To obtain `SIN(x)` when *x* is in degrees, use `SIN(x*π/180)`.

Examples:

```
PRINT SIN(1.5)
 0.997495
```

The sine of 1.5 radians is 0.997495.

SPACE$ Function

Purpose:

To return a string of *x* spaces.

Syntax:

```
SPACE$(x)
```

Comments:

x is rounded to an integer and must be within the range of 0 to 255. If the number is outside this range error "Number out of bounds" results.

Example:

```
10 FOR N=1 TO 5
20 X$=SPACE$(N)
30 PRINT X$; N
40 NEXT N
RUN
 1
  2
   3
    4
     5
```

Line 20 adds one space for each loop execution.

SPC Function

Purpose:

To skip a specified number of spaces in a `PRINT`.

Syntax:

```
SPC(n)
```

Comments:

n must be within the range of 0 to 255.

If *n* is greater than the defined width of the printer or the screen, the value used will be n `MOD` width.

This function is similar to the `SPACE$()` function and is only included for Microsoft compatibility.

Examples:

```
PRINT "OVER" SPC(15) "THERE"
 OVER               THERE
```

SPI Command

Purpose:

To send and receive a byte using SPI protocol.

Syntax:

```
SPI(rx, tx, clock, data, speed)
```

Comments:

MM-BASIC is the master (i.e. it generates the clock).

`rx` is the `GPIO` port number for the data input (aka `MISO` master-input slave-output)

`tx` is the `GPIO` port number for the data output (aka `MOSI` master-output slave-input)

`clock` is the `GPIO` port number for the clock generated by MM-MASIC (aka `CLK`)

`data` is optional and is an integer representing the data byte to send over the data output pin. If it is not specified the `tx` pin will be held low as if the `data` is 0.

`speed` is optional and is the speed of the clock. It is a single letter either `H`, `M` or `L` where `H` is 500KHz, `M` is 50KHz and `L` is 5KHz. Default is `H`.

Examples:

```
10 SETPIN 1,2   'define Rx as input
20 SETPIN 2,8   'define Tx as output
30 SETPIN 3,8   'define clock as output
40 PRINT SPI(1,2,3,255,H)  'send FF and receive one byte
RUN
 255
```

SQR Function

Purpose:

Returns the square root of *x*.

Syntax:

```
SQR(x)
```

Comments:

x must be greater than or equal to 0.

Example:

```
10 FOR X=10 TO 25 STEP 5
20 PRINT X; SQR(X)
30 NEXT
RUN
 10 3.16228
 15 3.87298
 20 4.47214
 25 5
```

STR$ Function

Purpose:

To return a string representation of the decimal (base 10) value of *x*.

Syntax:

STR$(*x*)

Comments:

STR$(*x*) is the complementary function to VAL(*x$*).

Examples:

```
10 INPUT "TYPE A NUMBER: ", N
20 PRINT "THIS IS A";LEN(STR$(N));" DIGIT NUMBER"
> RUN
TYPE A NUMBER: 123
THIS IS A 3 DIGIT NUMBER
```

STRING$ Function

Purpose:

To return

- a string of length *n* whose characters all have ASCII code *j*, or
- the first character of *x$*

Syntax:

```
STRING$(n,j)
STRING$(n,x$)
```

Comments:

STRING$ is also useful for printing top and bottom borders on the screen.

n and *j* are integer expressions in the range 0 to 255.

Example:

```
10 X$ = STRING$(10, 45)
20 PRINT X$ "MONTHLY REPORT" X$
RUN
 ----------MONTHLY REPORT----------
```

45 is the decimal equivalent of the ASCII symbol for the minus (-) sign.

TAB Function

Purpose:

Spaces to position *n* on the screen.

Syntax:

```
TAB(n)
```

Comments:

If the current print position is already beyond space *n*, TAB goes to that position on the next line.

Space 1 is the leftmost position. The rightmost position is the screen width.

n must be within the range of 1 to 255.

It is as though the TAB function has an implied semicolon after it.

TAB may be used only PRINT or PRINT # statements.

Examples:

```
10 PRINT "HELLO" TAB(3) "WORLD"
RUN
HELLO
  WORLD

10 PRINT “HELLO” TAB(10) “WORLD”
RUN
HELLO    WORLD
```

TAN Function

Purpose:

To calculate the trigonometric tangent of *x*, in radians.

Syntax:

```
TAN(x)
```

Comments:

To obtain `TAN(x)` when *x* is in degrees, use `TAN(x*pi/180)`.

Examples:

```
10 Y = TAN(X)
```

When executed, Y will contain the value of the tangent of X radians.

UCASE$ Function

Purpose:

To return x$ converted to uppercase characters.

Syntax:

```
UCASE$(x$)
```

Comments:

x$ may be empty string.

Examples:

```
PRINT UCASE$("qWeRTyUIop")
QWERTYUIOP
```

VAL Function

Purpose:

Returns the numerical value of string *x$*.

Syntax:

```
VAL(x$)
```

Comments:

The VAL function also strips leading blanks, tabs, and line feeds from the argument string. For example, the following line returns -3:

```
VAL(" -3")
```

The STR$ function (for numeric to string conversion) is the complement to the VAL(*x$*) function.

If the first character of *x$* is not numeric, the VAL(*x$*) will return zero.

This function will recognize the &H prefix for a hexadecimal number, &O for octal and &B for binary.

Example:

```
10 INPUT "ENTER ZIP:"; ZIP$
20 IF VAL(ZIP$)<1000 OR VAL(ZIP$)>9000 THEN PRINT "INVALID ZIP"
30 IF VAL(ZIP$) = 4000 THEN PRINT "THIS IS THE ZIP POST CODE FOR THE CITY
OF PLOVDIV WHERE DUINOMITE WAS BORN :)"
```

IF ... THEN ... ELSE/ELSEIF...ENDIF Multi line IF Statement

Purpose:

To make a decision regarding program flow based on the result returned by an expression.

Syntax:

```
IF expression THEN
  statement(s)
[ELSE
  statement(s)]
[ENDIF]

IF expression THEN
  statement(s)
[ELSEIF expression THEN
  statement(s)]
[ENDIF]
```

Comments:

If the result of *expression* is nonzero (logical true), the statements after THEN are executed, otherwise the statements after ELSE are executed.

THEN and ELSE may be followed by either a line number for branching, or one or more statements to be executed.

Example:

In the following example, a test determines if N is greater than 10 and less than 20. If N is within this range, execution branches to line 200. If N is not within this range, execution continues with line 110.

```
100 FOR A = 3 TO 7
110 PRINT A
120 IF A < 5 THEN
130 PRINT "A < 5"
140 ELSEIF A = 5 THEN
150 PRINT "A = 5"
160 ELSE
170 PRINT "A > 5"
180 ENDIF
190 NEXT
```

LINE INPUT Statement

Purpose:

To input an entire line (up to 255 characters) from the keyboard into a string variable, ignoring delimiters.

Syntax:

```
LINE INPUT [prompt$] [;] [,] string-variable
```

Comments:

prompt$ is a string literal, displayed on the screen, that allows user input during program execution.

A question mark is not printed no matter if the delimiter is [;] or [,] unless it is part of *prompt$*.

String-variable accepts all input from the end of the prompt to the carriage return. Trailing blanks are not ignored.

LINE INPUT is almost the same as the INPUT statement, except that it accepts special characters (such as commas) in operator input during program execution.

If a line-feed/carriage return sequence (this order only) is encountered, both characters are input and echoed. Data input continues.

A LINE INPUT may be escaped by typing CTRL-BREAK. MM-BASIC returns to command level and displays '>'.

Typing CONT resumes execution after the LINE INPUT line.

Example:

```
100 LINE INPUT A$
```

Program execution pauses at line 100, and all keyboard characters typed thereafter are input to string A$ until ENTER, CTRL-M, CTRL-C, or CTRL-BREAK is entered.

LINE INPUT # Statement

Purpose:

To read an entire line (up to 255 characters), without delimiters, from a sequential disk file to a string variable.

Syntax:

```
LINE INPUT #filenumber, string-variable
```

Comments:

Filenumber is the number under which the file was opened.

string-variable is the variable name to which the line will be assigned.

LINE INPUT # reads all characters in the sequential file up to a carriage return. If a line feed/carriage return sequence (this order only) is encountered, it is input.

LINE INPUT # is especially useful if each line of a data file has been broken into fields, or if a BASIC program saved in ASCII mode is being read as data by another program.

Example:

```
10 OPEN "INFO.TXT" AS OUTPUT #1
20 LINE INPUT "CUSTOMER INFORMATION?"; C$
30 PRINT #1, C$
40 CLOSE #1
50 OPEN "INFO.TXT" AS INPUT #1
60 LINE INPUT #1, C$
70 PRINT C$
80 CLOSE #1
RUN
 CUSTOMER INFORMATION?
```

If the operator enters

```
LINDA JONES 234, 4 MEMPHIS
```

then the program continues with the following:

```
LINDA JONES 234, 4 MEMPHIS
```

LIST Command

Purpose:

To list all or part of a program to the screen, line printer, or file.

Syntax:

```
LIST [linenumber][-linenumber]
LIST [linenumber-]
```

Comments:

linenumber is a valid line number within the range of 0 to 65000.

Use the hyphen to specify a line range. If the line range is omitted, the entire program is listed. *linenumber-* lists that line and all higher numbered lines. *-linenumber* lists lines from the beginning of the program through the specified line.

Any listing may be interrupted by pressing CTRL-BREAK. If the lines are more than size of the screen the list will display first lines then “PRESS ANY KEY ...” message will be displaying and listing will continue after key is pressed for the next screen of lines.

Examples:

```
LIST
```

Lists all lines in the program.

```
LIST -20
```

Lists lines 1 through 20.

```
LIST 10-20
```

Lists lines 10 through 20.

```
LIST 20-
```

Lists lines 20 through the end of the program.

LOAD Command

Purpose:

To load a file from diskette into memory.

Syntax:

```
LOAD filename$
```

Comments:

filename$ is the filename used when the file was saved. If the extension was omitted, .BAS will be used.

LOAD closes all open files and deletes all variables and program lines currently residing in memory before it loads the designated program. Second " could be omited.

Examples:

```
LOAD "DEMO
```

Loads the file *DEMO.BAS* .

LOCATE Statement

Purpose:

To move the cursor to the specified `X,Y` pixel position on the screen. Subsequent `PRINT` command will place its output at this location

Syntax:

```
LOCATE X,Y
```

Comments:

X is the horizontal pixel position with value from 0 to MM.HRES.

Y is the vertical pixel position with value from 0 to MM.VRES.

If *X* value is over MM.HRES *X* will be assigned to 0.

If *Y* value is over MM.VRES *Y* will be assigned to MM.VRES.

Example:

```
10 LOCATE 100,100
20 PRINT "HI" ' print HI on position 100,100
```

MEMORY Command

Purpose:

List the amount of memory currently in use.

Syntax:

```
MEMORY
```

Comments:

Program memory is cleared by the NEW command. Variable, array and string memory spaces are cleared by many commands (eg, NEW, RUN, LOAD, etc) as well as the specific commands CLEAR and ERASE.

Example:

```
>MEMORY
      5kB   (17%) Program memory used
      3kB   (16%) Variable memory used
      12kB  (30%) Array and string memory used
>
```

MERGE Command

Purpose:

Adds program lines from *filename$* to the program in memory. Unlike LOAD, it does not clear the program currently in memory.

Syntax:

MERGE *filename$*

Comments:

filename$ is a valid string expression containing the filename. If no extension is specified, then MM-BASIC assumes an extension of .BAS.

The SD card is searched for the named file. If found, the program lines on the SD card are merged with the lines in memory. After the MERGE command, the merged program resides in memory, and MM-BASIC returns to the direct mode.

If any line numbers in the file have the same number as lines in the program in memory, the lines from the file replace the corresponding lines in memory.

Examples:

```
MERGE "CODE.BAS"
```

Merges the file *code.bas* with the program currently in memory, provided *code.bas* was previously saved.

INPUT Statement

Purpose:

To prepare the program for input from the terminal during program execution.

Syntax:

```
INPUT [prompt string;] list of variables
INPUT [prompt string,] list of variables
```

Comments:

prompt string is a request for data to be supplied during program execution.

list of variables contains the variable(s) that stores the data in the prompt string.

Each data item in the prompt string must be surrounded by double quotation marks, followed by a semicolon or comma and the name of the variable to which it will be assigned. If more than one *variable* is given, data items must be separated by commas.

The data entered is assigned to the variable list. The number of data items supplied must be the same as the number of variables in the list.

The variable names in the list may be numeric or string variable names (including subscripted variables). The type of each data item input must agree with the type specified by the variable name.

If more than the list of variables is entered only the first are used and the extra inputs are ignored.

```
INPUT A,B,C
? 1,2,3,4,5
```

will assign A=1 B=2 C=3 and the 4 and 5 entries will be ignored

If the variable is number but string is entered then 0 will be assigned to the variable

```
INPUT A,B,C
? 1,hi
```

will assign A=1 B=0 C=0

A comma may be used instead of a semicolon after prompt string to suppress the question mark. For example, the following line prints the prompt with no question mark:

```
INPUT "ENTER BIRTHDATE",B$
```

When an INPUT statement is encountered during program execution, the program halts, the prompt string is displayed, and the operator types in the requested data. When the operator presses the ENTER key, program execution continues.

Example 1:

To find the square of a number:

```
10 INPUT X
20 PRINT X "SQUARED IS" X^2
30 END
RUN
 ?
```

The operator types a number (5) in response to the question mark.

```
5 SQUARED IS 25
```

Example 2:

To find the area of a circle when the radius is known:

```
10 PI=3.14
20 INPUT "WHAT IS THE RADIUS"; R
30 A=PI*R^2
40 PRINT "THE AREA OF THE CIRCLE IS"; A
50 PRINT
60 GOTO 20
RUN
WHAT IS THE RADIUS? 7.4
THE AREA OF THE CIRCLE IS 171.9464
```

INPUT #filenumber Statement

Purpose:

To read data items from a sequential file and assign them to program variables.

Syntax:

```
INPUT #filenumber, variable list
```

Comments:

file number is the number used when the file was opened for input.

variable list contains the variable names to be assigned to the items in the file.

The data items in the file appear just as they would if data were being typed on the keyboard in response to an INPUT statement.

The variable type must match the type specified by the variable name.

With INPUT #, no question mark is printed, as it is with INPUT.

Numeric Values

For numeric values, leading spaces and line feeds are ignored. The first character encountered (not a space or line feed) is assumed to be the start of a number. The number terminates on a space, carriage return, line feed, or comma.

Strings

If MM-BASIC is scanning the sequential data file for a string, leading spaces and line feeds are ignored.

If the first character is a double quotation mark ("), the string will consist of all characters read between the first double quotation mark and the second. A quoted string may not contain a double quotation mark as a character. The second double quotation mark always terminates the string.

If the first character of the string is not a double quotation mark, the string terminates on a comma, carriage return, line feed, or after 255 characters have been read.

If end of the file is reached when a numeric or string item is being INPUT, the item is terminated.

IRETURN Statement

Purpose:

To return from a interrupt.

Syntax:

```
IRETURN
```

Comments:

The `IRETURN` statement causes MM-BASIC to branch back to the statement where interrupt occurs. A subroutine may contain more than one `IRETURN` statement to return from different points in the subroutine. Subroutines may appear anywhere in the program.

KILL Command

Purpose:

To delete a file from a disk.

Syntax:

```
KILL filename$
```

Comments:

filename$ can be a program file or data file.

KILL is used for all types of disk files.

Note

You must specify the filename's extension when using the KILL command. Remember that files saved in MM-BASIC are given the default extension *.BAS*.

If a KILL command is given for a file that is currently open, no error will occurs.

Examples:

The following command deletes the MM-BASIC file *DATA1*, and makes the space available for reallocation to another file:

```
200 KILL "DATA1.BAS"
```

The following command deletes the MM-BASIC file *RAINING* from the subdirectory *dogs*:

```
KILL "CATS\DOGS\RAINING.BAS"
```

LET Statement

Purpose:

To assign the value of an expression to a variable.

Syntax:

```
[LET] variable=expression
```

Comments:

The word `LET` is optional; that is, the equal sign is sufficient when assigning an expression to a variable name.

The `LET` statement is seldom used. It is included here to ensure compatibility with previous versions of BASIC that require it.

When using `LET`, remember that the type of the variable and the type of the expression must match. If they don't, an error occurs.

```
A = "Hello"
Error: Expected a number
```

Example 1:

The following example lets you have downward compatibility with an older system. If this downward compatibility is not required, use the second example, as it requires less memory.

```
110 LET D=12
120 LET E=12^2
130 LET F=12^4
140 LET SUM=D+E+F
```

Example 2:

```
110 D=12
120 E=12^2
130 F=12^4
140 SUM=D+E+F
```

LINE Statement

Purpose:

To draw lines and boxes on the screen.

Syntax:

```
LINE [(x1,y1)]-(x2,y2) [,[color][,B[F]]
```

Comments:

x1,y1 and *x2,y2* specify the end points of a line.

color draw with white if nonzero

B (box) draws a box with the points (*x1,y1*) and (*x2,y2*) at opposite corners.

BF (filled box) draws a box (as ,**B**) and fills in the interior with points.

Note

If *x1,y1* is not specified last *x,y* coordinates are used.

```
LINE (100,100)-(200,200),1,BF    'draw box 100,100,200,200
LINE -(300,100),1,BF             'draw box 200,200,300,100
```

Examples:

```
LINE (MM.HRES \2,0)-(MM.HRES \2,MM.VRES)
```

Draws a vertical line which divides the screen in half from top to bottom.

```
LINE (0,MM.VRES \2)-(MM.HRES,MM.VRES \2)
```

Draws a horizontal line which divides the screen in half from left to right.

```
LINE (0,0)-(MM.HRES,MM.VRES)
```

Draws a diagonal line from the top left to lower right corner of the screen.

```
LINE (10,10)-(20,20),1
```

Draws a line from 10,10 to 20,20 with white color.

```
LINE (10,10)-(20,20),0
```

Draws a line from 10,10 to 20,20 with black color (erases the line drawn above).

```
10 CLS
20 LINE -(RND(1)*MM.HRES,RND(1)*MM.VRES)
30 PAUSE RND(1)*100
40 GOTO 20
```

Draw random lines with random speed.

```
10 CLS
20 FOR I = 1 TO MM.HRES STEP 5
30 LINE (0,0)-(I,MM.VRES)
40 LINE (MM.HRES,0)-(I,MM.VRES)
50 NEXT
60 DO : LOOP UNTIL INKEY$ = " "
```

Draws pattern and waits until SPACE is pressed.

DEPRECIATED COMMANDS

These commands are only included to assist in converting programs written for Microsoft BASIC. For new programs the corresponding commands in MM-BASIC should be used.

PSET PRESET Statements

Purpose:

To display a point at a specified place on the screen. Please for new code do use `PIXEL(x,y)`.

Syntax:

```
PSET(x,y)
PRESET(x,y)
```

Comments:

`(x,y)` represents the coordinates of the point.

`PSET` display pixel with white, `PRESET` display pixel with black color.

Coordinate values can be beyond the edge of the screen.

(0,0) is always the upper-left corner and (MM.HRES, MM.VRES) is the lower-right corner.

Example 1:

The following draws a diagonal line from (0,0) to (100,100).

```
10 CLS
20 FOR I=0 TO 100
30 PSET(I,I)
40 NEXT
```

Example 2:

The following clears out the line by setting each pixel to 0.

```
50 FOR I=100 TO 0 STEP -1
60 PRESET(I,I)
70 NEXT I
```

WHILE ... WEND Statement

Purpose:

To execute a series of statements in a loop as long as a given condition is true. Please for new code use `DO` … `LOOP` statements.

Syntax:

```
WHILE expression
  [loop statements]
WEND
```

Comments:

If *`expression`* is non-zero (true), *`loop statements`* are executed until the `WEND` statement is encountered. MM-BASIC then returns to the `WHILE` statement and checks expression. If it is still true, the process is repeated.

If it is not true, execution resumes with the statement following the `WEND` statement.

`WHILE` and `WEND` loops may be nested to any level. Each `WEND` matches the most recent `WHILE`.

An unmatched `WHILE` statement causes a "`WHILE without matching WEND`" error. An unmatched `WEND` statement causes a "`LOOP without matching DO`" error.

Examples:

```
10 SETPIN 1,8
20 WHILE PIN(0)=0     'blink LED on ARDUINO.A0 until USER button is press
30 PIN(1) = 1: PAUSE 100: PIN(1) = 0: PAUSE 100
40 WEND
```

WRITE Statement

Purpose:

To write data to a sequential file. Please use `PRINT` for new code.

Syntax:

```
WRITE [#filenum,] list-of-expressions
```

Comments:

Outputs the value of each *expression* separated by commas (,).

filenum is the number under which the file was opened for output or append, if missing writes to screen.

List-of-expressions is a list of string and/or numeric expressions separated by commas or semicolons.

The `WRITE` and `PRINT` statements differ in that `WRITE` inserts commas between the items as they are written and delimits strings with quotation marks, making explicit delimiters in the list unnecessary. Another difference is that `WRITE` does not put a blank in front of a positive number. After the last item in the list is written, a carriage return/line feed sequence is inserted.

If the *expression* is a number it is outputted without preceding or trailing spaces. If it is a string it is surrounded by double quotes (“). The list is terminated with a new line.

Examples:

```
WRITE 1, 2, 3, 4, 5, “HELLO”
1,2,3,4,5,”HELLO”
```

As you can see `WRITE` removes the spaces, add commas between the expressions and keeps the “”

Let A$ = "CAMERA" and B$ = "93604-1". The following statement:

```
WRITE #1, A$, B$
```

writes the following image to disk:

```
"CAMERA", "93604-1"
```

A subsequent `INPUT$` statement, such as the following, would input "CAMERA" to A$ and "93604-1" to B$:

```
INPUT #1, A$, B$
```

6. CODE EXAMPLES

BLINK LED:

```
10 SETPIN 1,8              'ARDUINO.A0 as output
20 PIN(1) = 1: PAUSE 500   'set high and wait ½ second
30 PIN(0) = 0: PAUSE 500   'set low and wait ½ second
40 GOTO 20
```

BLINK LED WITH INTERRUPTS:

```
10 SETPIN 1,8              'ARDUINO.A0 as output
20 LED=0                   'LED state variable
30 SETTICK 500,100         'set high and wait ½ second
40 DO: LOOP                'endless loop
100 IF LED=0 THEN PIN(1)=1: LED=1: IRETURN
110 IF LED=1 THEN PIN(1)=0: LED=0: IRETURN
```

BLINK LED WITH POTENTIOMETER

```
10 SETPIN 1,8              'ARDUINO.A0 as output
20 SETPIN 2,1              'read potentiometer on ARDUINO.A1
30 PIN(1) = 1              'set high ARDUINO.A0
40 PAUSE (PIN(2)*100)      'wait depend on potentiometer reading
50 PIN(1) = 0              'set low ARDUINO.A0
60 PAUSE (PIN(2)*100)      'wait depend on potentiometer reading
70 GOTO 30
```

BRICK GAME http://www.thebackshed.com/forum/forum_posts.asp?TID=4365&PN=1

3D GRAPHICS http://www.thebackshed.com/forum/forum_posts.asp?TID=4353&PN=1

MOON LANDER: http://www.thebackshed.com/forum/forum_posts.asp?TID=4377&PN=1

7. UEXT HARDWARE DEMO CODE

7.1. PLAYING WITH MOD-GPS

How to use GPS with DuinoMite

Global Positioning System (GPS) is a satellite based global navigation system that provides location and time information in all weather, anywhere on (or near) Earth, where there is an unobstructed line of sight to four or more GPS satellites.

You can read more about how GPS was created and how it works in Wikipedia
http://en.wikipedia.org/wiki/Global_Positioning_System
Also some theory is available in this web site: http://lea.hamradio.si/~s53mv/navsats/theory.html.

It's very easy to use GPS with DuinoMite using Olimex's UEXT GPS module 'MOD-GPS' (http://www.olimex.com/dev/mod-gps.html) which interfaces using DuinoMite's UEXT connector.

MOD-GPS is based on the SiRF StarIII chipset which provides high precision, low power and high sensitivity, so MOD-GPS is even able to lock onto satellites inside buildings.

MOD-GPS output is via serial 19200 bps 8bits,1 stop bit, No Parity.

It is easy to access MOD-GPS data with DuinoMite using MMBasic, for example, you can view MOD-GPS output using this small program:

```
10 OPEN "COM3:19200" AS #5
20 PRINT INPUT$(1,#5);
30 GOTO 20
```

Running this code will generate something like this:

$GPRMC,192157.110,A,4208.3427,N,02445.0243,E,0.13,92.58,211111,,,A*5E
$GPGGA,192158.110,4208.3427,N,02445.0243,E,1,03,2.2,134.8,M,37.1,M,,0000*5C
$GPGSA,A,2,07,23,20,,,,,,,,,,2.5,2.2,1.0*31
$GPRMC,192158.110,A,4208.3427,N,02445.0243,E,0.11,83.24,211111,,,A*58
$GPGGA,192159.110,4208.3428,N,02445.0242,E,1,03,2.2,134.8,M,37.1,M,,0000*53
$GPGSA,A,2,07,23,20,,,,,,,,,,2.5,2.2,1.0*31
$GPGSV,3,1,12,23,63,042,38,20,38,124,35,07,38,197,39,13,72,313,24*70
$GPGSV,3,2,12,04,43,277,22,10,35,306,25,16,20,087,,02,16,316,24*72
$GPGSV,3,3,12,32,14,118,20,30,14,047,,08,10,203,24,01,01,169,*71
$GPRMC,192159.110,A,4208.3428,N,02445.0242,E,0.10,84.84,211111,,,A*5B

This will continue forever, each message starts with $Gpxxx then some data separated with "," and ends with *xx which is the checksum in Hex.

Some messages contain several ,,, i.e. empty parameters.
When the GPS receiver is started for the very first time or after it was moved any distance without being powered the GPS receiver will have lost connection to some satellites, it takes time to lock onto them again (called `cold start time' and is usually about 1 minute).

If you are inside a building or the signal is weak due to other obstacles the GPS receiver may not lock to some satellites at all, MOD-GPS can lock onto 12 satellites, but even 4 are enough to calculate it's correct location.

There are 4 types of messages which MOD-GPS sends:

$GPGGA,192839.000,4208.3343,N,02445.0342,E,1,07,1.5,171.8,M,37.1,M,,0000*56

$GPGSA,A,3,07,23,20,10,13,08,04,,,,,3.1,1.5,2.7*3A

$GPGSV,3,1,11,13,72,323,37,23,61,046,34,04,43,273,20,07,41,198,37*78
$GPGSV,3,2,11,10,38,307,30,20,35,126,24,16,21,084,25,02,18,314,22*70
$GPGSV,3,3,11,30,13,044,18,08,12,203,36,32,12,119,19*4D

$GPRMC,192840.000,A,4208.3343,N,02445.0342,E,0.00,37.14,211111,,,A*51

These messages are in NMEA0183 format and the prefix $GP means that the message is ordinated from the GPS receiver.

http://www.gpsinformation.org/dale/nmea.htm has an explanation of the different NMEA messages.

RMC - Recommended Minimum Essential GPS Data.

$GPRMC,192840.000,A,4208.3343,N,02445.0342,E,0.00,37.14,211111,,,A*51

let's decode our message:

$GPRMC	- message ID
192840.000	- 19:28:40 UTC time stamp
A	- Status A=active or V=Void
4208.3343,N	- Plovdiv Latitude 42 deg 08.3343' N
02445.0342,E	- Longitude 24 deg 45.0342' E
0.00	- Speed over the ground in knots
37.14	- Track angle in degrees True
211111	- Date – 11th of November 2011
(empty field)	- Magnetic Variation
(empty field)	- Magnetic Variation direction
*51	- The checksum data, always begins with *

With this message we get information about time, date, our location and our speed, the speed is calculated very precisely and you can even calibrate your car or motorcycle speedometer with the value read by the GPS, as the car's mechanical speedometers usually have about +-5% error.

This immediately leads me to an interesting project: Car performance logger. Having the change of speed of your car and the time, you can calculate the acceleration, and if you know the weight of your car you can also calculate the moment power as P=A*m i.e. you can monitor and log exactly how much horsepower or kw are used when your car accelerates.

GGA - Essential 3D Location Fix Data.

Let's decode our message:

$GPGGA,192839.000,4208.3343,N,02445.0342,E,1,07,1.5,171.8,M,37.1,M,,0000*56

$GPGGA	- Global Positioning System Fix Data
192839.000	- Fix taken at 19:28:39 UTC
4208.3343,N	- Latitude 42 deg 08.3343' N
02445.0342,E	- Longitude 24 deg 45.0342' E
1	- Fix quality: 0 = invalid 1 = GPS fix (SPS) 2 = DGPS fix 3 = PPS fix 4 = Real Time Kinematic 5 = Float RTK 6 = estimated (dead reckoning) (2.3 feature) 7 = Manual input mode 8 = Simulation mode
07	- Number of satellites being tracked
1.5	- Horizontal dilution of position
171.8,M	- Altitude, Meters, above mean sea level
37.1,M	-Height of geoid (mean sea level) above WGS84 ellipsoid
(empty field)	- time in seconds since last DGPS update
(empty field)	- DGPS station ID number
*56	- the checksum data, always begins with *

GSA - GPS DOP and active satellites.

This sentence provides details on the nature of the fix. It includes the number of the satellites being used in the current fix and the DOP. DOP (dilution of precision) is an indication of the effect of satellite geometry on the accuracy of the fix. It is a unit-less number where smaller is better. For 3D fixes using 4 satellites a 1.0 would be considered to be a perfect number, however for multi-satellite fixes it is possible to see numbers below 1.0.

There are differences in the way the PRN's (Pseudorandom Noise) are presented which can affect the ability of some programs to display this data. For example, in the example shown below there are 5 satellites in the solution and the null fields are scattered indicating that the almanac would show satellites in the null positions that are not being used as part of this solution. Other receivers might output all of the satellites used at the beginning of the sentence with the null fields stacked up at the end. This difference accounts for some satellite display programs sometimes, not being able to display the satellites being tracked. Some units may show all satellites that have ephemeris data without regard to their use as part of the solution but this is non-standard.

$GPGSA,A,3,07,23,20,10,13,08,04,,,,,,3.1,1.5,2.7*3A

let's decode our message :

$GPGSA - Satellite status message
A - Auto selection of 2D or 3D fix (M = manual)
3 - 3D fix - values include: 1 = no fix
2 = 2D fix
3 = 3D fix
07,23,20,10,13,08,04 - PRNs of satellites used for fix (space for 12)
3.1 - PDOP (dilution of precision)
1.5 - Horizontal dilution of precision (HDOP)
2.7 - Vertical dilution of precision (VDOP)
*3A - the checksum data, always begins with *

GSV - Satellites in View

Shows data about the satellites that the unit might be able to find based on its viewing mask and almanac data. It also shows current ability to track this data. Note that one GSV sentence only can provide data for up to 4 satellites and thus there may need to be 3 sentences for the full information. It is reasonable for the GSV sentence to contain more satellites than GGA might indicate since GSV may include satellites that are not used as part of the solution. It is not a requirement that the GSV sentences appear in sequence. To avoid overloading the data bandwidth some receivers may place the various sentences in different samples since each sentence identifies which one it is.

The field called SNR (Signal to Noise Ratio) in the NMEA standard is often referred to as signal strength. SNR is an indirect but more useful value than raw signal strength. It can range from 0 to 99 and has units of dB according to the NMEA standard, but the various manufacturers send different ranges of numbers with different starting numbers so the values themselves cannot necessarily be used to evaluate different units. The range of working values in a given GPS will usually show a difference of about 25 to 35 between the lowest and highest values, however 0 is a special case and may be shown on satellites that are in view but not being tracked.

$GPGSV,3,1,11,13,72,323,37,23,61,046,34,04,43,273,20,07,41,198,37*78
$GPGSV,3,2,11,10,38,307,30,20,35,126,24,16,21,084,25,02,18,314,22*70
$GPGSV,3,3,11,30,13,044,18,08,12,203,36,32,12,119,19*4D

$GPGSV - Satellites in view
3 - Number of sentences for full data
1 - sentence 1 of 3
11 - Number of satellites in view

13,72,323,37
13 - Satellite PRN number
72 - Elevation, degrees
323 - Azimuth, degrees
37 - SNR - higher is better
(for up to 4 satellites per sentence)

*78 - the checksum data, always begins with *

The three messages contain the info for all 12 satellites.

Example:
The following code reads RMC message and extract the time, date, latitude, longitude

```
10 CLS
20 PRINT "GPS DEMO CODE"
30 OPEN "COM3:19200" AS #5      'open UEXT UART at COM3
40 IF NOT EOF(#5) THEN 60       'if something is received
50 GOTO 40
60 C$=INPUT$(1,#5)              'get character
70 IF C$ = CHR$(10) THEN 100    'until LF is received
80 MSG$=MSG$+C$                 'store in MSG$
90 GOTO 40
100 'LOCATE 0,100: ? MSG$       'used for debug
110 IF LEFT$(MSG$,6) = "$GPRMC" THEN 140  'wait for RMC message
120 MSG$=""
130 GOTO 40
140 LOCATE 0,100: PRINT MSG$    'RMC message received
150 LOCATE 0,20: PRINT "UTC TIME: ";
160 A$ = MID$(MSG$,INSTR(MSG$,",")+1)
170 PRINT MID$(A$,1,2);":";MID$(A$,3,2);".";MID$(A$,5,2)
180 GOSUB 500
190 GOSUB 500
200 LATITUDE$ = LEFT$(A$,INSTR(A$,",")-1)
210 LOCATE 0,50: PRINT "LATITUDE  :";LATITUDE$;" ";
220 GOSUB 500
230 NS$ = LEFT$(A$,1)
240 PRINT NS$
250 GOSUB 500
260 LONGITUDE$ = LEFT$(A$,INSTR(A$,",")-1)
270 LOCATE 0,60: PRINT "LONGITUDE :";LONGITUDE$;" ";
280 GOSUB 500
290 EW$ = LEFT$(A$,1)
300 PRINT EW$
310 GOSUB 500
320 SP$ = LEFT$(A$,INSTR(A$,",")-1)
330 LOCATE 0,70: PRINT "SPEED KNTS:";VAL(SP$)
340 GOSUB 500
330 GOSUB 500
340 LOCATE 0,30: PRINT "UTC DATE: ";
350 PRINT MID$(A$,1,2);"-";MID$(A$,3,2);"-20";MID$(A$,5,2)
360 GOTO 120
500 A$ = MID$(A$,INSTR(A$,",")+1) 'skip to next ','
510 RETURN
```

7.2. MOD-BT

Adding BLUETOOTH connectivity to ***DuinoMite*** is very easy. All you need is to connect a MOD-BT to the ***DuinoMite*** UEXT connector.

The following example code sets up the MOD-BT as a serial SPP Bluetooth profile device via a Serial 115200 bps link between ***DuinoMite*** and another Bluetooth enabled device e.g. a computer or even a mobile phone.

```
10 OPEN "COM3:115200" AS #1
20 PRINT #1, "ATZ": PAUSE 250              'ATZ MOD-BT
30 PRINT #1, "AT+BTAUT=1,0": PAUSE 250     'set auto connect mode
40 PRINT #1, "AT+BTSRV=1" : PAUSE 250      'start SPP service now
41                                         'other devices can
42                                         'discover MOD-BT as
43                                         '"BGB203-1SPP" bluetooth
44                                         'device and pair with it
50 CLOSE #1                                'now MOD-BT make serial
51                                         'bridge to COM3:
60 OPEN "COM3:115200" AS CONSOLE           'lets use this serial
65                                         'bridge as console then
```

After this code is executed you can pair to BGB203-1SPP with any bluetooth device and work with ***DuinoMite*** in console mode.

If you replace line 60 with just OPEN "COM3:115200" AS #1 you can use INPUT #1 and PRINT #1 to communicate with other bluetooth devices paired to MOD-BT.

7.3. MOD-GSM

Adding GSM connectivity to ***DuinoMite*** is as easy as it is to add Bluetooth connectivity as we saw in the previous example. All you need is to connect a MOD-GSM to the ***DuinoMite*** UEXT connector.

7.4. MOD-MAG

MAG3110 is a 3-axis magnetometer with high sensitivity. MOD-MAG is a MAG3110 on a small board with a UEXT connector and ribbon cable to connect directly to ***Duinomite*** and read magnetic fields.

What you can do with this board? As it's so sensitive that it can detect the Earth's magnetic field you can build an electronic compass, or scan for deviations in the magnetic field (usually caused by buried metals) you can use it to search for treasure :-)

The MAG3110 datasheet is available on the Freescale web site:

http://cache.freescale.com/files/sensors/doc/data_sheet/MAG3110.pdf

It's I2C device and the code to setup and read it is:

```
10 OPTION BASE 0                 'to make sure we have base 0
20 ID = 0: DIM AXES(6)           'ID variable and AXES array
30 I2CEN 100,100                 'enable I2C
40 I2CRCV &H0E, 0, 1, ID, 1, 7  'read MAG3110 ID (C4)
50 PRINT "ID = ";HEX$(ID)  'should print C4 if MOD-MAG is attached
60 I2CSEND &H0E, 1, 2, &H11, &H80    'ctrl reg2, auto resets enbl
70 I2CSEND &H0E, 0, 2, &H10, &H01    'ctrl reg1, active mode
80 I2CRCV &H0E, 6, AXES(0), 1, 1     'read 6 bytes from addr 1
90 PRINT "X ="; HEX$(AXES(0)*256+AXES(1)); TAB(10)  'X axe
100 PRINT "Y ="; HEX$(AXES(2)*256+AXES(3)); TAB(20) 'Y axe
110 PRINT "Z ="; HEX$(AXES(4)*256+AXES(5))          'Z axe
120 IF INKEY$ <> "" THEN 200     'end if key is pressed
130 PAUSE 300                    'wait a little
140 GOTO 80                      'read and print again
200 I2CDIS                       'disable I2C
```

7.5. MOD-LCD1x9

MOD-LCD1x9 is a nice black and white display which is controllable by I2C. MOD-LCD1x9 allows a low power, LCD display to be attached to ***Duinomite*** and display useful information when used in a hand-held device.

The datasheet of the LCD is at Olimex web site. Inside MOD-LCD1x9 is Philips' PCF8576.

Sample code to setup and write to LCD1x9 is here:

```
10 OPTION BASE 0      'to make sure we have base 0
20 DIM LCD(22)        'LCD memory is 20 bytes
30 FOR I = 2 TO 21: LCD(I) = &hFF: NEXT  'all segments ON
40 LCD(0) = &hE0: LCD(1) = 0    'set data pointer 0
50 I2CEN 100,100
60 I2CSEND &H38, 1, 2, &HC8, &HF0    'set
70 I2CSEND &H38, 0, 22, LCD(0)
80 C$ = INKEY$
90 IF C$ = "" THEN 80
100 IF C$ = "Q" THEN 200
110 FOR I = 2 TO 21
120 LCD(I) = RND * 255
130 NEXT
140 GOTO 70
200 I2CDIS
```

7.6. MOD-IO

MOD-IO is a board with 4 RELAYS, 4 opto-isolated inputs, 4 analog inputs and a UEXT connector. MOD-IO boards can be cascaded thus allowing many relays and inputs to be added to ***DuinoMite*** or any other development board that has a UEXT connector.

The latest firmware of MOD-IO allow I2C control of the board, the cascaded boards need to be addressed at different I2C addresses. Initially they are set to respond to address 0x58 but this address is programmable.

This code changes the MOD-IO address by I2C commands:

```
5 'edit line 40 to change new address
10 CLS
20 INPUT "Press Hold But on MOD-IO then hit enter ";a
30 CurI2c = &h58
40 NewI2c = &h5a
50 I2CEN 100,100 ' Enable I2C
60 I2CSEND CurI2c,1,2, &hf0, NewI2c
70 I2CDIS
80 END
```

Sample code to drive the RELAYs:

```
10 I2CEN 100,100      'init I2C
20 I2CSEND &H58, 0, 2, &H10, &H0F    'cmd 0x10 all relays ON
30 PAUSE 1000
40 I2CSEND &H58, 0, 2, &H10, &H0F    'cmd 0x10 all relays OFF
50 I2CDIS
```

Sample code to read Digital Inputs, INP bit 0 is IN1, bit 1 is IN2, bit 2 is IN3 and bit4 is IN4. i.e. if IN1 is “1” INP will be 1, if IN4 is “1” INP will be 8:

```
10 I2CEN 100,100      'init I2C
20 INP = 0            'input
30 I2CRCV &H58, 0, 1, INP, 1, &H20, &H0F 'cmd 0x20 read INP
40 PRINT INP
50 I2CDIS
```

Sample code to read Analog input 1, (change &H30 to &H31, &H32 or &H33 for AIN2, 3 or 4)

```
10 OPTION BASE 0
20 DIM ADC(2)
30 I2CEN 100,100      'init I2C
40 I2CRCV &H58, 0, 2, ADC(0), 1, &H30     '&H30-&H33 AIN1-AIN4
50 PRINT "ADC: ";HEX$(ADC(0)+ADC(1)*256); " voltage: ";
(3.3/1024)*(ADC(0)+ADC(1)*256)
60 PAUSE 500: GOTO 40
```

7.7 MOD-TC

MOD-TC board is UEXT module with MAX6675 IC which allow type K thermocouple to be attached and to read temperature in 0-1023.75 C range with 0.25C resolution.

```
10 PIN(1) = 0: PIN(2) = 1
20 SETPIN 1,8  'SCK
30 SETPIN 2,8  'CS
40 SETPIN 3,2  'MISO
50 SETPIN 4,8  'MOSI we do not use this
60 PIN(2) = 0  'enable MOD-TC
70 PAUSE 1     'wait MAX6675 to settle
80 TEMP = SPI(3,4,1)  'read first 8 bit
90 TEMP2 = SPI(3,4,1) 'read next 8 bit
100 TEMP = TEMP *256 + TEMP2
110 TEMP = TEMP \ 8   'remove last 3 bits
120 PRINT "Temperature = ";TEMP*0.25 '12 bit 0-1023.75C
130 PIN(2) = 1 'disable MAX6675
140 PAUSE 300
150 GOTO 60    'read again
```

7.8 MOD-IRDA

The MOD-IRDA board sends and receives IR remote control codes.

7.9 MOD-LCD3310

The MOD-LCD3310 board is a Black and White 84x48 pixel graphical display.

7.7 MOD-LCD6610

The MOD-LCD6610 board is a color TFT 128x128 pixel 4096 color LCD.

7.8 MOD-MP3-X

The MOD-MP3-X board adds MP3 music and voice to your embedded projects.

7.9 MOD-RFID125-BOX

The MOD-RFID125-BOX board reads RFID tags at 125 KHz

7.10 MOD-RFID1356-BOX

The MOD-RFID1356-BOX board reads RFID tags at 13.56MHz.

7.11 MOD-EKG

The MOD-EKG board can monitor your heart activity.

7.12 MOD-RS485

The MOD-RS485 board can provide DMX control and interface to equipment using industrial protocols.

7.13 MOD-SMB380

The MOD-SMB380 board is a 3-axis digital accelerometer.

7.14 PIC-WEB

The PIC-WEB board adds internet connectivity to DuinoMite.

7.15 MOD-AD

The PIC-AD board has Serial DAC and ADC.

7.16 MOD-HRH

The PIC-HRH board measures humidity.

7.17 MOD-HDPMT

The PIC-HDTP board has a 2-axes digital compass as well as temperature and pressure measurement.

MATERIALS USED TO COMPLETE THIS USER MANUAL:

1. Maximite User Manual 2.7

http://www.geoffg.net/Downloads/Maximite/Maximite%20User%20Manual%20V2.7.pdf

2. GW-BASIC User's Manual

http://hwiegman.home.xs4all.nl/gw-man/

USEFUL RESOURCES:

Please do remember the ***DuinoMite*** project is a work in progress, here are a few places where you can check for the latest information:

1. For the latest hardware, manuals, examples and news your main source is the Olimex ***DuinoMite*** web pages at http://www.olimex.com/dev where you can always find the latest firmware and CAD files.

2. Don McKenzie hosts various documents for both the MaxiMite and the DuinoMite at http://www.themaximitecomputer.com/

3. Ken Segler is hosting the DuinoMite MM-BASIC firmware forum where you can report bugs, post example code etc. http://www.kenseglerdesigns.com/cms/forums/index.php

4. The Pinguino IDE and forum are located at http://www.pinguino.cc

5. A MaxiMite / DuinoMite MM-BASIC forum is located at http://www.thebackshed.com/forum/forum_topics.asp?FID=16