

LPM1162 Audio Module

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Firmware version.2.1R
Doc. Rev.0 (04/12/10)



Features

- Separate Analog/Digital Supplies for optimum performance
- Typical 3.3V Supply Voltage
- Non-volatile audio storage
- Internal Flash Filesystem to store wave files
- 95 seconds of audio recording
- 11.025KHz sample rate
- High quality voice/sounds reproduction
- UART interface for programming/playback (SERIAL-MODE)
- Input PIN reading for playback (KEY-MODE)
- Analog audio output for playback
- 5KHz audio bandwidth
- Small footprint device (20x28mm)
- Low power consumption
- Applications: automatic distributors, robots, industrial controllers, entertainment, gadgets

Description

LPM1162 is a simple integrated solution to store and reproduce high quality audio wave files in electronic circuits. Typical applications are automatic distributors, robots, speaking devices, gadgets and in general all the devices where it is required to program and play audio wave files.

The audio files (11KHz – 16bit) can be programmed in the internal 2Mbyte flash memory that is provided with an advanced filesystem. Programming is done on the UART port using simple filesystem commands. The baudrate for communication is programmable with the AutoBaudrate feature (up to 115200 bps).

The audio files can be reproduced on the analog output using the playback commands (SERIAL-MODE) or driving some input PIN (pressing keys, driving relè or transistors, ecc).

Typical Application

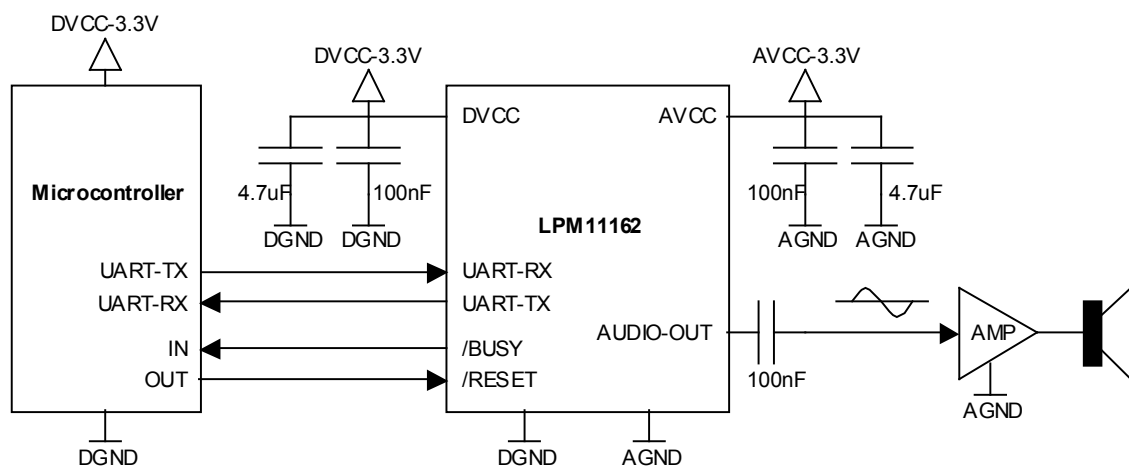


Figure 1 – Typical Application schematic

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Pin Diagram

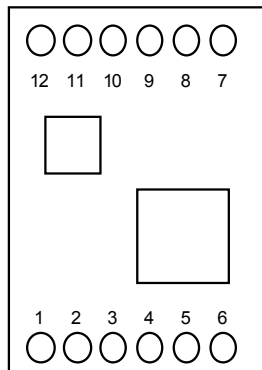


Figure 2 – Pin Diagram (Top View)

Pin Description

Pin number	Pin Name	Pin Type	Description
1	KEY2 - /BUSY	IN - OUT	In KEY-MODE this pin is named KEY2 and it is used in combination with other KEY pins to play wave files pressing keys. In SERIAL MODE this is an active low Busy pin. This signal is normally high, it is driven low by the module during a command execution (Busy condition). New commands are not accepted when the module is in Busy state.
2	/RESET	IN	Active low Reset pin. Low level is reset condition, high level is running condition.
3	DV _{CC}	POWER	Digital supply voltage.
4	DGND	POWER	Digital ground.
5	KEY1 - UART-TX	IN / OUT	In KEY-MODE this pin is named KEY1 and it is used in combination with other KEY pins to play wave files pressing keys. In SERIAL-MODE this is the UART transmit pin.

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6	KEY0 - UART-RX	IN	In KEY-MODE this pin is named KEY0 and it is used in combination with other KEY pins to play wave files pressing keys. In SERIAL-MODE this is the UART receive pin.
7	NC	-	Not connected
8	AV _{CC}	POWER	Analog supply voltage.
9	AUDIO-OUT	OUTPUT	Analog audio output signal (single ended).
10	NC	-	Not connected
11	AGND	POWER	Analog ground.
12	NC	-	Not connected

Table 1 – Pin Description

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Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

Symbol	Parameter	Rating
DV _{CC}	Digital supply voltage	-0.3V to +4.0V
AV _{CC}	Analog supply voltage	0V to +5.5V
V _{IN}	Digital input pin voltage	-0.3V to +4.0V
T _A	Operating ambient temperature range	-20°C to +85°C
I _{OD}	DC maximum source/sink current from digital output pins	±10mA
I _{OA}	DC maximum source/sink current from analog output pin	±10mA

Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. It is not recommended exceeding them or designing to absolute maximum ratings.

Symbol	Parameter	Rating
DV _{CC}	Digital supply voltage	+2.7V to +3.6V
AV _{CC}	Analog supply voltage	+2.7V to +5.5V
V _{IN}	Digital input pin voltage	0V to DV _{CC}
T _A	Operating ambient temperature range	0°C to +70°C

Electrical Characteristics

Symbol	Parameter	Min	Max
I _{DCC}	DC maximum supply current on DV _{CC}	-	70mA
I _{ACC}	DC maximum supply current on AV _{CC}	-	1 mA
BW	Maximum analog output bandwidth	-	5 KHz
V _{IH}	High level input voltage on digital pin	0.8 DV _{CC}	-
V _{IL}	Low level input voltage on digital pin	-	0.2 DV _{CC}
V _{OH}	High level output voltage on digital pin	2.4V	-
V _{OL}	Low level output voltage on digital pin	-	0.4V

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1 – Introduction

1.1 – Filesystem

LPM11162 is designed with an internal filesystem that is able to store standard 11025Hz-16bit wave files. The UART interface makes possible to program/playback the wave files connecting LPM11162 to another device (for example a small microcontroller or a PC).

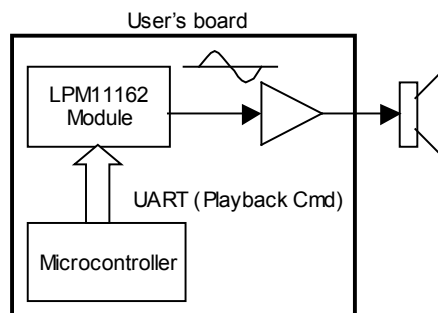


Figure 3 – Typical Programming and Playback block diagram

LPM11162 is equipped with a 2Mbyte flash memory that in 11KHz-16bit wave format allows to store a maximum of 95 seconds (maximum time for all the files). The maximum number of files is 16 and there is no limitation on the size of each file.

Parameter	Value
Max. number of files	128
Max. file name lenght	15 characters
Audio files sample rate	11025 Hz
Audio files data bits	16
Flash memory size	2.094.080 bytes

Table 2 – Filesystem Specification

1.2 – SERIAL-MODE and KEY-MODE

LPM11162 has two working modes: SERIAL-MODE and KEY-MODE.

In SERIAL-MODE it is able to receive commands from UART port in order to program audio wave files in the internal Flash memory or to reproduce them on the analog audio output. This mode is the most flexible and the user can program/reproduce a large quantity of wave files sending simple commands from a host microcontroller or a PC (download the LPM11162 ToolKit PC application).

There are cases where you don't have a microcontroller in your circuit, but would be nice to reproduce wave file if you have already programmed them on LPM11162.

This is the case of KEY-MODE, where 3 pins of LPM11162 are configured as input pins and the audio module is able to reproduce wave file when the pin's status changes. With KEY-MODE you can put LPM11162 in your circuit with a few of other components and reproduce audio wave files.

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1.2 – KEY-MODE

KEY-MODE is the default working mode of the module at startup.

After power-on the module's pins 1, 5, 6 are configured as input pins and the module consider them as “not pressed” in high voltage level. No wave files are played until one or more pins change state. If one ore more pins becomes low voltage level then LPM11162 will reproduce a wave file accordingly to the following table:

KEY2 (pin 1)	KEY1 (pin 5)	KEY0 (pin 6)	Wave File Name
L	L	L	File0.wav
L	L	H	File1.wav
L	H	L	File2.wav
L	H	H	File3.wav
H	L	L	File4.wav
H	L	H	File5.wav
H	H	L	File6.wav
H	H	H	-

Table 3 – Filesystem Specification

When all the KEY pins are high level the LPM11162 is not reproducing any audio file, while in all other pin's configurations there is an associated wave file to be reproduced. Of course each wave file can be reproduced only if it was previously programmed using the proper commands in SERIAL-MODE.

In a typical application each KEY pin can be connected to the supply voltage with a pull-up resistor. Then some external keys, or open-collector transistors, or relè can drive the KEY pins low to enable the playback of a specific wave file.

The interesting LOOP function allows to reproduce a wave file in loop, so at the end of a file the playback will restart from the beginning if the pin's configuration that activated playback is still present.

1.3 – SERIAL-MODE

SERIAL-MODE can be entered after power-on by sending the auto-baudrate character. When this character is received LPM11162 switched to SERIAL-MODE, configuring the pin 1 and pin 5 as outputs for /BUSY and UART-TX functions and configuring pin 6 as UART-RX.

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2 – SERIAL-MODE

2.1 – Writing files

Wave files can be programmed on LPM11162 with only 3 simple commands: File Open, File Write, File Close.

The File Write command permits to write the content of the audio files on the Flash memory of LPM11162. Each File Write command permits to transfer a maximum of 256 bytes, so if the file size is greater than 256 bytes it is required to send more File Write commands in sequence for a complete file transfer.

The File Write commands are accepted only after the file has been opened with the File Open command that communicates to the module the name of the file that will be written. The file must be properly closed after all the data have been transferred by sending the File Close command.

For example suppose to write the file audio.wav that is a 612 bytes file, the sequence of commands is the following:

- 1) File Open command (audio.wav)
- 2) File Write command (first 256 data block)
- 3) File Write command (second 256 data block)
- 4) File Write command (last 100 data block)
- 5) File Close command

It is not possible to have two files with identical file names, so the File Open command will fail in case the file name is the same as another file that is already present in the Flash.

2.2 – Formatting memory

The entire content of the Flash memory can be erased with the File Format command. This command erases all the files that are present in the Flash memory. During the format procedure the /BUSY line is driven low to indicate the module cannot receive other commands.

The duration of the format procedure can take up to several seconds (see Timing Specifications).

2.3 – Power-up sequence with auto-baudrate

In the figure below shows the power-up sequence with the auto-baudrate feature that allows to connect the module to different host devices without any hardware configuration.

After the module is removed from reset, the first operation to do is to send the auto-baudrate character 0x55 (ASCII "U"). When this character is received the module is able to understand the baudrate of the transmitter device and to configure itself to work at the same baudrate.

After the auto-baudrate character is received the /BUSY line is driven low to indicate that the module cannot accept commands. It sends a Module ID response and Module Firmware Version response, then the /BUSY line is driven high and the module is ready to receive commands.

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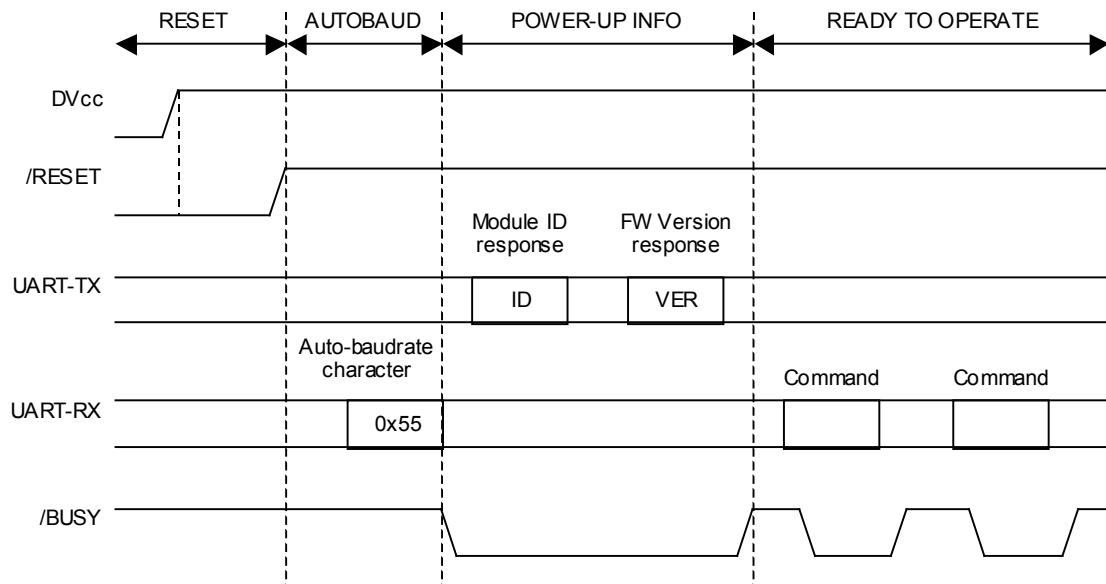


Figure 4 – Power-up sequence

2.4 – /BUSY Signal

The /BUSY signal indicates when the module is able to receive commands or when it is busy to execute the previous command and cannot accept a new incoming command.

The /BUSY line is normally high and it is driven low by the module when the first character of a command is received to indicate that the command processing is going on. The line will remain low for the time required to receive the entire command and to execute it. After the command execution is terminated the /BUSY line will go high and another command can be accepted.

Exception is made for STOP and VOLUME commands. After the PLAY command is received the module is considered busy until the playback of the audio file is completed. During this time the /BUSY signal remains low, however the STOP and VOLUME commands can be sent in order to stop the file playback or adjust the volume level while playback is in progress.

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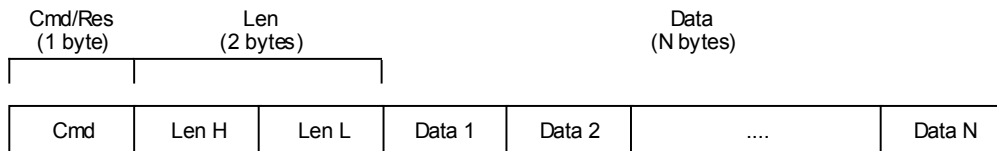
2.5 - General Commands/Responses Format

The module's operations are controlled via a simple UART protocol where another device can send commands to the module and the module can reply with responses.

The commands are divided in Filesystem commands and Playback commands. Using Filesystem commands another device can program wave files with voice messages on the module and then using the Playback commands it is very simple to reproduce the voice messages.

All the commands/responses have the same general structure: the first byte indicates the command/responses type, the second and third bytes indicates the number of data bytes that will be sent into the command/response, then the data bytes are transmitted.

The general commands/responses structure is illustrated here:



Cmd/Res (1 byte):

- 0x01 – File Open command
- 0x02 – File Write command
- 0x03 – File Close command
- 0x04 – File Format command
- 0x10 – Play command
- 0x11 – Stop command
- 0x12 – Volume command
- 0x81 – Module ID response
- 0x82 – Module Firmware Version response

Len (2 bytes):

- Number of data bytes in the command/response. Len is sent as high byte first.

Data 1...Data N (N bytes):

- Sequence of generic N data bytes. Data bytes can be present or not (Len=0) depending on the command/response.

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Command	Description	Cmd	Len	Data
File Open	Open a new file on the module. Required before writing data into the file.	0x01	Number of characters in the file name.	File name characters.
File Write	Write data bytes into the file that is currently open for writing.	0x02	Number of data bytes in current command to write in the file.	Data bytes.
File Close	Close the file. Required after writing all data bytes into the file.	0x03	0x0000	Not present.
File Format	Erase all the files that are currently present in Flash memory.	0x04	0x0000	Not present.
Play	Start playback of a selected file.	0x10	Number of characters in the name file to be played.	File name characters.
Stop	Stop playback of the file that is currently playing.	0x11	0x0000	Not present.
Volume	Set the playback volume level	0x12	0x0001	0-100

Table 4 – Commands Table

Response	Description	Res	Len	Data
Module ID	Send to the host device the module's ID.	0x81	0x0002	Module's ID
Module Firmware Version	Send to the host device the module's firmware version and date.	0x82	0x000D	Module's firmware version and date..

Table 5 – Responses Table

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2.6 - File Open command

The first operation to do to access a file is send the File Open command. This command informs the module that a new file must be created with file name that is specified by the data bytes in the command.

The general format of File Open command is composed as follows:

Cmd	Len (2 bytes)		Data (N bytes)			
0x01	Len H	Len L	Char 1	Char 2	Char N

Cmd (1 byte):

- 0x01 – File Open

Len (2 bytes):

- Number of characters in the file name ($N \leq 15$).

Char 1...Char N (N bytes):

- Sequence of N characters of the file name (no terminating char).

Here is shown an example of creating a new file called “fl.wav”:

0x01	0x00	0x06	'f'	'l'	'.'	'w'	'a'	'v'
------	------	------	-----	-----	-----	-----	-----	-----

2.7 - File Write command

After a file has been opened the File Write command can be used to write the file's data bytes on the internal memory of the audio module.

The general format of File Write command is composed as follows:

Cmd	Len (2 bytes)		Data (N bytes)			
0x02	Len H	Len L	Data 1	Data 2	Data N

Cmd (1 byte):

- 0x02 – File Write

Len (2 bytes):

- Number of data bytes in current command to write in the file ($N \leq 256$).

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Data 1...Data N (N bytes):

- Sequence of N data bytes to write in the open file.

Here is shown an example of writing 4 bytes (0x0A, 0x0B, 0x0C, 0x0D) to an open file:

0x02	0x00	0x04	0x0A	0x0B	0x0C	0x0D
------	------	------	------	------	------	------

2.8 - File Close command

After finished to write all the data bytes to an open file, the file must be closed by sending the File Close command. The general format of File Close command is composed as follows:

Cmd	Len (2 bytes)	
0x03	0x00	0x00

Cmd (1 byte):

- 0x03 – File Close

Len (2 bytes):

- Len is 0x0000 because no data bytes are present in the command.

2.9 - File Format command

The File Format command is used to erase all the file that are present in the internal memory. This command is accepted only when there are no open files.

The general format of File Format command is composed as follows:

Cmd	Len (2 bytes)	
0x04	0x00	0x00

Cmd (1 byte):

- 0x04 – File Format

Len (2 bytes):

- Len is 0x0000 because no data bytes are present in the command.

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2.10 - Play command

The Play command starts playing an audio file that was previously written to the internal memory. The Play command for an audio file is accepted only if no other audio files are currently playing.

The general format of Play command is composed as follows:

Cmd	Len (2 bytes)		Data (N bytes)			
0x10	Len H	Len L	Char 1	Char 2	Char N

Cmd (1 byte):

- 0x10 – Play

Len (2 bytes):

- Number of characters in the audio file name ($N \leq 15$).

Char 1...Char N (N bytes):

- Sequence of N characters of the audio file name (no terminating char).

Here is shown an example of playing the file “fl.wav”:

0x10	0x00	0x06	'f'	'l'	'.'	'w'	'a'	'v'
------	------	------	-----	-----	-----	-----	-----	-----

2.11 - Stop command

The play of an audio file can be stopped sending the Stop command.

The general format of Stop command is composed as follows:

Cmd	Len (2 bytes)	
0x11	0x00	0x00

Cmd (1 byte):

- 0x11 – Stop

Len (2 bytes):

- Len is 0x0000 because no data bytes are present in the command.

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2.12 - Volume command

The Volume command allows to set the volume level for audio reproduction. The volume level is expressed in the range 0-100:

The general format of Volume command is composed as follows:

Cmd	Len (2 bytes)	Data
0x12	0x00	0x01 Vol

Cmd (1 byte):

- 0x12 – Volume

Len (2 bytes):

- Len is 0x0001 because there is only 1 data byte for the volume value.

Vol (1 byte):

- Volume level in the range 0-100 (default is 50).

Here is shown an example of setting volume to 70%:

0x12	0x00	0x01	0x46
------	------	------	------

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2.13 - Module ID response

Each module has a unique ID that permits to recognize the module. The module's ID is sent by the module to the host controller during the power-up sequence..

The general format of Module ID response is composed as follows:

Res	Len (2 bytes)		Data (2 bytes)	
0x81	0x00	0x04	ID 1	ID 2

Res (1 byte):

- 0x81 – Module's ID

Len (2 bytes):

- Len is 0x0002 because the module's ID is 2 bytes long.

ID 1...ID 2 (2 bytes):

- Sequence of 2 module's ID bytes.

2.14 - Module Firmware Version response

The module's firmware version and release date are sent by the module to the host controller during the power-up sequence.

The general format of Module Firmware Version response is composed as follows:

Res	Len (2 bytes)		Data (9 bytes)									
0x82	0x00	0x09	Ver	Rev	Status	Day 1	Day 2	Month 1	Month 2	Year 1	Year 2

Res (1 byte):

- 0x82 – Module's Firmware Version

Len (2 bytes):

- Len is 0x0009 because there are 3 bytes for the firmware version and 6 bytes for the date.

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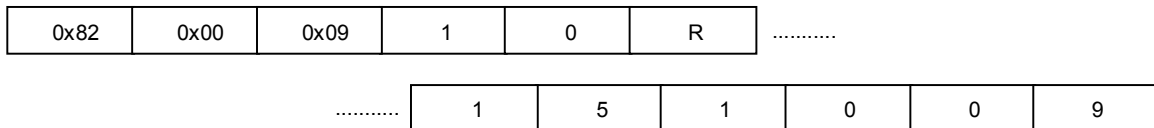
Ver...Status (3 bytes):

- The firmware version is composed by one Version character, one Revision character and one Status character. Each character is expressed in ASCII format, so for example the firmware version 1.0R will be expressed by the characters '10R' in the response.

Day 1...Year 2 (6 bytes):

- The firmware release date is two bytes for the day, two bytes for the month and two bytes for the year. For example the date 15/10/09 is expressed by characters '151009' in the response.

Here is shown an example of firmware version 1.0R (15/10/09):



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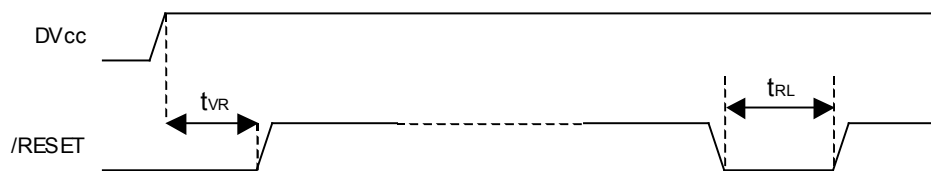
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3 – Timing Specifications

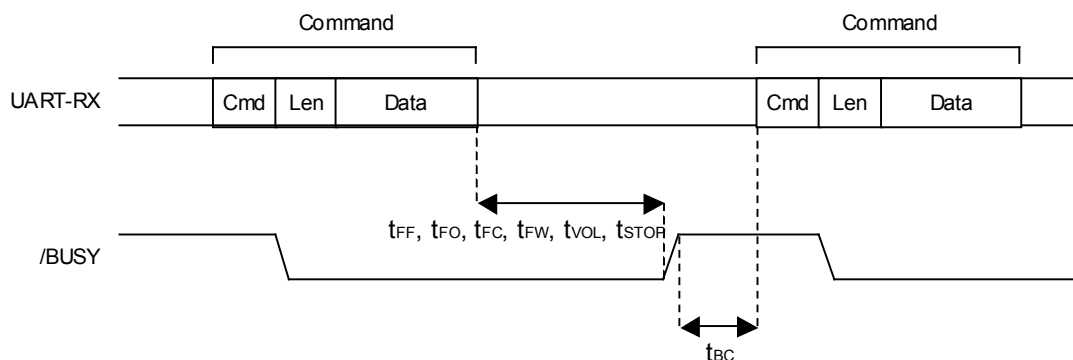
3.1 – Reset Timing Specifications

Symbol	Parameter	Min	Max
t_{VR}	Minimum time between DV_{CC} and /RESET high	1 ms	-
t_{RL}	Minimum /RESET low time	10 ms	-



3.2 – Commands Timing Specifications

Symbol	Parameter	Min	Max
t_{FF}	Maximum File Format command time (/BUSY low)	-	65 sec
t_{FO}	Maximum File Open command time (/BUSY low)	-	40 μ s
t_{FC}	Maximum File Close command time (/BUSY low)	-	25 μ s
t_{FW}	Maximum File Write command time (/BUSY low)	-	2.5 ms
t_{STOP}	Maximum Stop command time (/BUSY low)	-	250 ms
t_{VOL}	Maximum Volume command time (/BUSY low)	-	25 μ s
t_{BC}	Minimum time between /BUSY high and next command	200 μ s	-



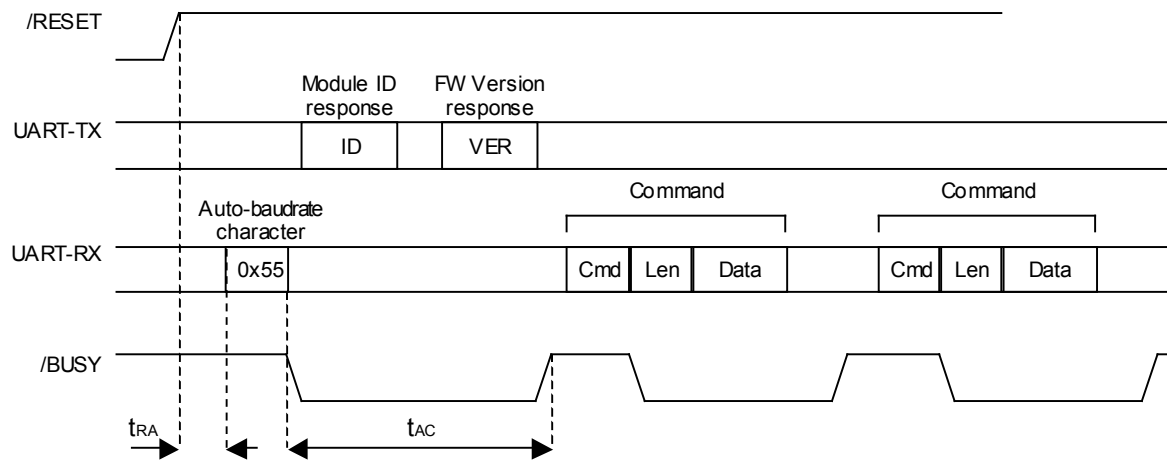
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3.3 – Power-up Timing Specifications

Symbol	Parameter	Min	Max
t_{RA}	Minimum time between /RESET high and auto-baudrate character	600 ms	-
t_{AC}	Maximum time between auto-baudrate character and module ready to receive commands (1200 bps worst case)	-	150 ms
	Baudrate values	1200 bps	115200 bps

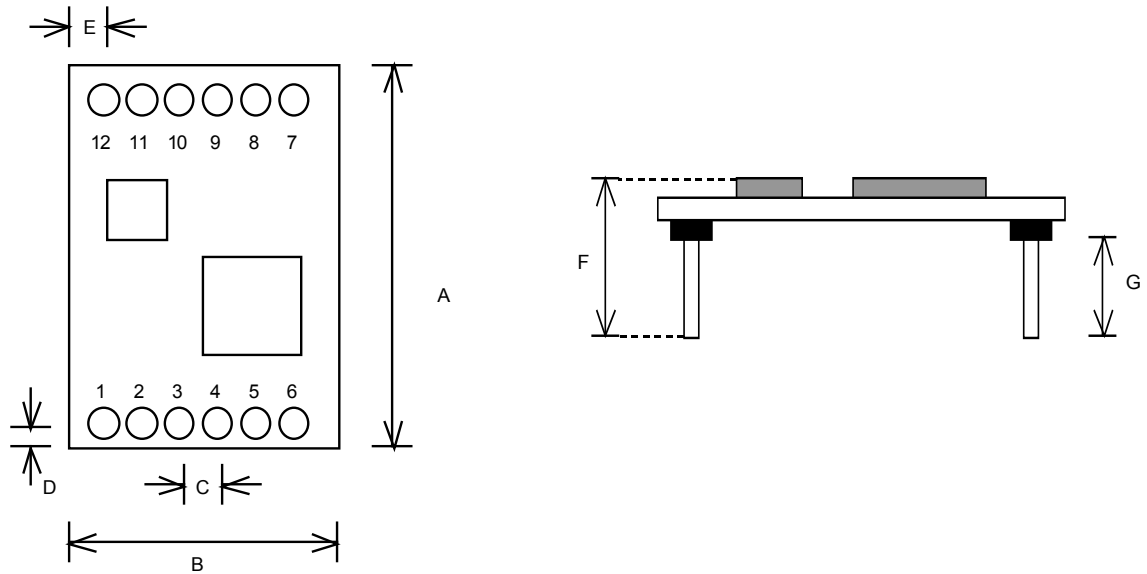


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Packaging Informations



Dim	Millimeters	Inches
A	28.0	1.100
B	20.0	0.787
C	2.54	0.100
D	1.40	0.550
E	3.53	0.139
F	12.0	0.472
G	6.0	0.236

Figure 5 – Package Dimensions