

The Unofficial XM File Format Specification: FastTracker II, ADPCM and Stripped Module Subformats

Revision 2 – Jun 08, 2007

Introduction

This specification describes the structure of regular FastTracker II, ADPCM-compressed and Stripped XM files. It is unofficial because uFMOD doesn't hold the authorship or copyright of the XM file format. There are many extensions to the original XM format available nowadays, e.g.: ADPCM-compressed XM, OggVorbis-compressed XM, Stripped XM and others. Most XM files ain't 100% compliant with the original standard because of accidental or intentional modifications. So, it's hardly possible to think about a universal XM standard any more. Since the original specification is pretty much outdated and it doesn't cover the already mentioned extensions, the uFMOD development team decided to make this new document available to public domain.

The original FastTracker II file format was introduced by Triton team in the early 90s. It is commonly referred as the "eXtended Module" (hence the file extension). The XM format is an extended version of the original MOD format, featuring multisample instruments, volume and panning envelopes, portamento frequency tables, new extended effect commands, basic pattern compression, among other improvements.

The ADPCM-compressed XM extension is a non-standard XM subformat introduced in ModPlug tracker and player. It has the same XM file format structure, except that at least one of the samples is compressed in 4-bit ADPCM format. An ADPCM-compressed sample is almost 2 times smaller than its uncompressed equivalent. The drawback is the sound quality – significant distortion may arise when using ADPCM.

Another popular extension is OXM – OggVorbis-compressed XM. It preserves the original XM file structure, except the instrument samples, which are compressed in OggVorbis stream format. There are at least 2 known OXM subformats. None of them is covered in this document. You can use the Firelight Tech.'s FMOD library to play OXM files.

The Stripped XM file format is another non-standard XM subformat. It was introduced in uFMOD in 2006. A Stripped XM file is always smaller than a regular XM, because it uses a more compact set of headers. Supporting Stripped XM file format is not harder than supporting the original XM file format. The original XM file format becomes a subset of the Stripped one. So, a player supporting Stripped files will also support regular XM files. The audio content of the XM file is unaffected while "stripping" its file structure. Currently only uFMOD supports Stripped XM files.

Even more non-standard XM extensions exist. For example, some trackers introduce undocumented effect commands used as triggers for software events, Text2Speech (TTS) metadata, watermarks and so on. Unfortunately, very little or no documentation is provided for other people to support this new features or at least ignore them safely while loading a modified XM file.

Once again, this document describes only the original FastTracker II file format, the ADPCM extension and the Stripped subformat – all at once. As soon as uFMOD starts supporting any other XM extensions, they will appear here as well. No effect commands are actually described in this document. If looking for effects, take a look at Thunder's MODFIL10.TXT.

The current version of this specification is maintained on the Web at:

<http://ufmod.sourceforge.net/>

General layout of the XM file

XM header

header of 1st pattern

data of 1st pattern

header of 2nd pattern

data of 2nd pattern

...

header of last pattern

data of last pattern

1st part of 1st instrument header

If number of samples > 0, then this data follows:

2nd part of 1st instrument header

1st sampleheader

2nd sampleheader follows (if any)

...

last sampleheader (if any)

If the sample size > 0 (1st sample header), then
sampledata of 1st sample follows

If the sample size > 0 (2nd sample header), then
sampledata of 2nd sample follows

...

If the sample size > 0 (last sample header), then
sampledata of last sample follows

1st part of 2nd instrument header

... same layout as 1st instrument

...

1st part of last instrument header

... same layout as 1st instrument

Additional information

[Volume and Envelope Formulas](#)
[Periods and Frequencies](#)

XM header

Offset	Length	Type	Ref	Example
0	17	char	ID text	'Extended module: '
17	20	char	Module name	'Bellissima 99 (mix) '
37	1	byte	0x1A	1A
38	20	char	Tracker name	'FastTracker v2.00 '
58	2	word	Version number	04 01
60	4	dword	Header size	14 01 00 00
64	2	word	Song length	3E 00 (1..256)
66	2	word	Restart position	00 00
68	2	word	Number of channels	20 00 (0..32/64)
70	2	word	Number of patterns	37 00 (1..256)
72	2	word	Number of instruments	12 00 (0..128)
74	2	word	Flags	01 00
76	2	word	Default tempo	05 00
78	2	word	Default BPM	98 00
80	?	byte	Pattern order table	00 01 02 03 ...

ID text

Should read 'Extended module: ' in a normal XM file. In a Stripped XM this field usually contains just nulls. Some people clear or scramble this magic text in their XM files when embedding into an EXE to prevent others from ripping the track. Don't rely on this string when checking an XM file for validity.

Module name

Should be an ASCII string padded with spaces. Might be zero padded or empty as well (all spaces or all nulls). Some people store random data here. Don't rely on Module name being a valid ASCII string.

0x1A

The hex value 0x1A in a normal XM file or 0x00 in a Stripped on. Since most players check this field, XMStrip clears it to prevent players not actually supporting the stripped format from incorrectly loading a Stripped XM. Apparently the value 0x1A has a special "escape" meaning. For example, if you print the contents of an XM file using the shell's cat command, it will stop after dumping "Extended module: " and the module's name. None of the following binary garbage will be printed. At least that's the way it was supposed to be if people respected the standards. Oh, well...

Tracker name

Should read 'FastTracker v2.00 ' or 'FastTracker II ' but some trackers (e.g. DigiTracker) use this field for other purposes (DigiTracker stores the Composer's name here). Should contain nulls in a Stripped XM. This field being trashed doesn't necessarily mean that the XM file is corrupt.

Version number

Hi-byte major and low-byte minor version numbers in a normal XM or 0x0000 in a Stripped XM. For example, 0x0104 means v1.4. None of the extensions use this field for identifying themselves. So, v1.4 doesn't mean it's a standard XM file. It's not meaningful at all.

Header size

Total size of the following header data till header of 1st pattern. Using this value is the only way to locate the header of the 1st pattern. In a normal XM the minimal value is $20 + 256 = 0x00000114$. This is so because the pattern order table in a normal XM has a fixed size of 256 bytes. For example, if the pattern order table consists of the following indexes:

0 1 4 1

a normal XM file whould pad those values with zeroes:

```

00 01 04 01 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

```

Instead of zeroes, some trackers store negative values. The actual pattern order table length is given in the [Song length] field (see below). So, you can easily identify the padding bytes. That's why those bytes are not stored in a Stripped XM file and the [Header size] could be lower than 0x00000114. The minimal value is 20 + 1 (at least 1 pattern should exist, right?). In both normal and Stripped XM files [Header size] + 60 is the exact offset where the 1st pattern header begins. The only difference is that no padding exists in a Stripped XM. The same example pattern order in a Stripped XM would be:

```
00 01 04 01
```

Using only 4 bytes instead of 256. However, the formula is exactly the same in both cases.

Additional data may exist between the pattern order table and the 1st pattern header (normally you would just skip this additional data). Some trackers store the composer's name here, metadata and so on.

There is no practical maximum header size (except the obvious $2^{32}-1$ value), because nothing limits the amount of additional data. That's why you should always use the [Header size] value + 60 to jump directly to 1st pattern header.

Song length

This is really the pattern order table size in bytes, as mentioned above. Maximum value is 256. Minimum is 1, because a zero-length song doesn't make much sense.

Restart position

Zero-based index to pattern order table where the track should continue at after the end of the table is reached. Some trackers append an empty (silence) pattern at the end and set restart position to that pattern to prevent looping. When restart position holds an invalid index (greater than [Song length]), zero value should be used instead.

Number of channels

Number of mixing channels. Has nothing to do with mono/stereo. Defines the number of columns in pattern packets. In the original FastTracker II specification the maximum value was 32. However, XM files containing more than 32 channels do exist. uFMOD suggests 64 as a more realistic maximum value.

Number of patterns

Number of patterns stored in file. There should be at least 1 pattern if you expect to hear anything out of the speakers. The maximum value is 256. Don't confuse this with [Song length]!

Number of instruments

In the range from 0 to 128.

Flags

Only LSB (bit 0) used. It defines the frequency table:

0 = Amiga
1 = Linear

See [below](#) for additional info.

Default tempo & Default BPM

Initial playback speed and BPM (Beats Per Minute).

Pattern order table

Defines the exact order in which XM patterns should be played. The size of this table in bytes is the song length. For example:

05 08 03 08 ...

Pattern #5 will be the first one to play, if it exists in the file. If it doesn't exist, an empty pattern (aka dummy pattern) should be used instead. After #5 finishes playback, #8 will be triggered (once again, if it exists). Then, #3 will start playing. Then, #8 will be used once again and so on.

Pattern header

Offset	Length	Type	Ref	Example
?	4	dword	Pattern header length	09 00 00 00
+4	1	byte	Packing type	00
+5	2	word	Number of rows in pattern	20 00 (1..256)
+7	2	word	Packed pattern data size	3B 02
?	?		Packed pattern data	87 3F 01 1A 80 ...

Pattern header length

Size of pattern header in bytes. A typical value is 9, unless some overhead data is stored between the pattern header and the actual pattern data.

Packing type

Almost always 0. Doesn't mean anything.

Number of rows in pattern

In the range from 1 to 256.

Packed pattern data size

If it's set to 0, this pattern is *NOT* stored in the XM; in other words, you need to create an empty pattern if the module needs one. In fact, to be save, you'll always have to create a "standard" empty pattern: allocate 64*(number of channels) bytes and set them to value 0x80. Initialise the header of this pattern with the standard values:

```
pattern header length    = 9
Packing type             = 0
Number of rows in pattern = 64
Packed patterndata size  = 64 * (number of channels)
```

Also note that whenever a pattern number in the pattern sequence table is higher than the actual number of patterns (common for converted S3M's), you should play the standard empty pattern. If packed pattern data size is not 0, it might not match the exact size in bytes. This is more like a boolean value. So, it's recommended to parse the following pattern data until you read in a total of (number of rows) * (number of channels) patterns.

Instrument header

Offset	Length	Type	Ref	Example
?	4	dword	Instrument size	07 01 00 00
+4	22	char	Instrument name	'chip-lovers!'
+26	1	byte	Instrument type	00
+27	2	word	Number of samples	01 00

If the number of samples is greater than 0, then this will follow:

+29	4	dword	Sample header size	28 00 00 00
+33	96	byte	Sample keymap assignments	00 00 00 00 00 ...
+129	48	word	Points for volume envelope	00 00 40 00 01 ...
+177	48	word	Points for panning envelope	00 00 00 00 00 ...

Envelope points: x,y...x,y... in couples (2 words/point => a maximum of 12 points).

+225	1	byte	Number of volume points	09
+226	1	byte	Number of panning points	00
+227	1	byte	Volume sustain point	02
+228	1	byte	Volume loop start point	00
+229	1	byte	Volume loop end point	00
+230	1	byte	Panning sustain point	00
+231	1	byte	Panning loop start point	00
+232	1	byte	Panning loop end point	00
+233	1	byte	Volume type: bit 0: On; 1: Sustain; 2: Loop	03
+234	1	byte	Panning type: bit 0: On; 1: Sustain; 2: Loop	00
+235	1	byte	Vibrato type	00
+236	1	byte	Vibrato sweep	00
+237	1	byte	Vibrato depth	00
+238	1	byte	Vibrato rate	00
+239	2	word	Volume fadeout	00 04
+241	22	word	Reserved	00 00 00 00 ...

Instrument size

Instrument header size in bytes. Standard minimal value is 29, meaning a totally empty instrument. Stripped minimal value is 4 and any of the following fields which offset is greater than instrument size should be set to zero.

Instrument name

Supposed to be a space-padded or zero-padded ASCII string, identifying the current instrument's name, but could be an arbitrary sequence of bytes.

Instrument type

Almost always 0. Doesn't mean anything.

Number of samples in instrument

If it's 0, none of the following values are stored.

Sample header size

Size of the sample header in bytes. You should use the "sample header size" (first field of second part of instrumentheader) to compute the total size of the 2 headers as stored in the file.

Sample header

Offset	Length	Type	Ref	Example
?	4	dword	Sample length	8C 0B 00 00
+4	4	dword	Sample loop start	00 00 00 00
+8	4	dword	Sample loop length	00 00 00 00

Note: If the sample loop length is 0, the sample is **NOT** a looping one, even if the "Forward loop" bit is set in the "TYPE" field.

+12	1	byte	Volume	40	
+13	1	byte	Finetune	00	(-128..+127)
+14	1	byte	Type:	00	
			Bit 0-1: 0 = No loop		
			1 = Forward loop		
			2 = Bidirectional loop (aka ping-pong)		
			Bit 4 : 0 = 8-bit samples		
			1 = 16-bit samples		
+15	1	byte	Panning	7C	(0..255)
+16	1	byte	Relative note number	1D	(signed value)
+17	1	byte	Known values:	00	
			00 = regular delta packed sample data		
			AD = 4-bit ADPCM-compressed sample data		
+18	22	char	Sample name	'-----'	

Sample data

Offset	Length	Type	Ref	Example
?	?	byte	Sample data	00 00 DA 2D 08 ...

Regular samples are stored as either 8- or 16-bit signed delta values. The size of the sample buffer in bytes is given in the [Sample header].[Sample length] field. To convert to real data:

```
old = 0;
for(i = 0; i < len; i++){
    old += sample[i];
    real_sample[i] = old;
}
```

For example, an 8-bit sample:

00 01 FF 02 01 FE ...

In decimal:

0 1 -1 2 1 -2 ...

Let's convert it to real data. First sample value would be 0. The second one would be the previous (0) plus the delta value (1): $0 + 1 = 1$. Next one: $1 + (-1) = 0$ and so on:

0 1 0 2 3 1 ...

ADPCM-compressed samples are stored in the following format:

?	16	byte	Compression table	00 01 02 04 08 ...
+16	?	byte	Compressed sample data	00 08 00 18 31 ...

The compression table is a 16-byte array, similar to a color palette in a bitmap file. Every byte in the array represents a delta value. Instead of storing the delta values directly in the sample data buffer, an ADPCM sample contains 4-bit indexes into the compression table, where the actual deltas are stored. The contents of the compression table are almost always the same:

```
00 01 02 04 08 10 20 40 FF FE FC F8 F0 E0 D0 C0
```

or in decimal:

```
0 1 2 4 8 16 32 64 -1 -2 -4 -8 -16 -32 -48 -64
```

However, the actual values may be different (at least in theory). The compressed sample data is located at offset 16 just after the compression table. It's size should be calculated as follows:

```
len = ([Sample header].[Sample length] + 1) >> 1
```

To convert to real data:

```
old = 0;
for(i = 0, j = 0; i < len; i++, j += 2){
    index = sample[16 + i];
    old += sample[index & 0xF];
    real_sample[j] = old;
    old += sample[index >> 4];
    real_sample[j + 1] = old;
}
```

An ADPCM example:

```
00 01 02 04 08 10 20 40 FF FE FC F8 F0 E0 D0 C0 00 08 00 18 31 02 81 ...
```

Bytes in **red** are the compression table. The 4-bit indexes begin at offset 16. Every sample byte holds 2 indexes. For example, 0x31 holds index 1 in the low-order nibble and index 3 in the high-order nibble. Let's extract all indexes starting at byte offset 16 (low-order nibble goes first):

```
0 0 8 0 0 0 8 1 1 3 2 0 1 8 ...
```

The corresponding delta values (from the preceding compression table) are:

```
00 00 FF 00 00 00 FF 01 01 04 02 00 01 FF ...
```

In decimal:

```
0 0 -1 0 0 0 -1 1 1 4 2 0 1 -1 ...
```

Now, let's perform the delta conversion, as we did in the previous example:

```
0 0 -1 -1 -1 -1 -2 -1 0 4 6 6 7 6 ...
```

Pattern format

XM patterns are stored as following:

A pattern is a sequence of lines.

A line is a sequence of notes.

A note is stored as described below:

Offset	Length	Type	Ref	Example
?	1	byte	Note	01 (0..96, 97)
+1	1	byte	Instrument	01 (0..128)
+2	1	byte	Volume column byte	00 (0..64, 255)
+3	1	byte	Effect type	05 (0..26)
+4	1	byte	Effect parameter	1F (0..255)

Note

Possible values (when MSB = 0):

Value	English	Spanish
0	No note	
1	C-1	Do
2	C#1	Do sostenido
3	D-1	Re
4	D#1	Re sostenido
5	E-1	Mi
6	F-1	Fa
7	F#1	Fa sostenido
8	G-1	Sol
9	G#1	Sol sostenido
10	A-1	La
11	A#1	La sostenido
12	B-1	Si
13	C-2	Do 2ª octava
...		
96	B-8	Si 8ª octava
97	Key off (aka 'Note off')	

A simple packing scheme is also adopted, so that the patterns not become TOO large: Since the MSB in the note value is never used, it is used for the compression. If the bit is set, then the other bits are interpreted as follows:

```
bit 0 set: Note follows
  1 set: Instrument follows
  2 set: Volume column byte follows
  3 set: Effect type follows
  4 set: Effect parameter follows
```

For example, the following 2 packets are equivalent:

```
01 01 00 00 00
```

and

```
83 01 01
```

0x83 in binary is 10000011. Since the MSB is set, the low-order nibble is interpreted as follows: note follows, instrument follows, volume column not present, effect type not present, effect parameter not present. So, the volume column, the effect type and the effect parameter should be cleared to 0.

Volume column byte

All effects in the volume column should work as the standard effects. The volume column is interpreted before the standard effects, so some standard effects may override volume column effects. The high-order nibble specifies one of the following commands: V, D, C, B, A, U, H, P, L, R, G. The low-order nibble specifies the command argument. The following values are defined:

Value	Mnemonic	Command	Argument range
00..0F		<do nothing>	
10..1F	V	Set volume	(0..15)
20..2F	V	Set volume	(16..31)
30..3F	V	Set volume	(32..47)
40..4F	V	Set volume	(48..63)
50	V	Set volume	(64)
51..5F		<undefined>	
60..6F	D	Volume slide down	(0..15)
70..7F	C	Volume slide up	(0..15)
80..8F	B	Fine volume down	(0..15)
90..9F	A	Fine volume up	(0..15)
A0..AF	U	Vibrato speed	(0..15)
B0..BF	H	Vibrato deph	(0..15)
C0..CF	P	Set panning	(2,6,10,14..62)
D0..DF	L	Pan slide left	(0..15)
E0..EF	R	Pan slide right	(0..15)
F0..FF	G	Tone portamento	(0..15)

Effects

0	Appregio
1 (*)	Porta up
2 (*)	Porta down
3 (*)	Tone porta
4 (*)	Vibrato
5 (*)	Tone porta+Volume slide
6 (*)	Vibrato+Volume slide
7 (*)	Tremolo
8	Set panning
9	Sample offset
A (*)	Volume slide
B	Position jump
C	Set volume
D	Pattern break
E1 (*)	Fine porta up
E2 (*)	Fine porta down
E3	Set gliss control
E4	Set vibrato control
E5	Set finetune
E6	Set loop begin/loop
E7	Set tremolo control
E9	Retrig note
EA (*)	Fine volume slide up
EB (*)	Fine volume slide down
EC	Note cut
ED	Note delay
EE	Pattern delay
F	Set tempo/BPM
G	(010h) Set global volume
H (*)	(011h) Global volume slide
I	(012h) Unused
J	(013h) Unused
K	(014h) Unused
L	(015h) Set envelope position
M	(016h) Unused

N	(017h)	Unused
O	(018h)	Unused
P (*)	(019h)	Panning slide
Q	(01ah)	Unused
R (*)	(01bh)	Multi retrig note
S	(01ch)	Unused
T	(01dh)	Tremor
U	(01eh)	Unused
V	(01fh)	Unused
W	(020h)	Unused
X1 (*)	(021h)	Extra fine porta up
X2 (*)	(021h)	Extra fine porta down

(*) = If the command byte is zero, the last nonzero byte for the command should be used.

Volumes and envelopes

The volume formula:

$$FinalVol = \frac{FadeOutVol}{65536} \cdot \frac{EnvelopeVol}{64} \cdot \frac{GlobalVol}{64} \cdot \frac{Vol}{64} \cdot Scale$$

The panning formula:

$$FinalPan = Pan + (EnvelopePan - 32) \cdot \frac{(128 - |Pan - 128|)}{32}$$

If no envelope is active, use the value 32 instead of "EnvelopePan".

The envelopes are processed once per frame, instead of every frame where no new notes are read. This is also true for the instrument vibrato and the fadeout.

```
max x value: 0x144 = 324
max y value: 0x40  = 64
```

Periods and frequencies

```
PatternNote = 1..96      (1 = C-1, 96 = B-8)
FineTune     = -128..+127 (-128 = -1 halftone, +127 = +127/128 halftones)
RelativeTone = -96..95    (0 = C-4)
RealNote     = PatternNote + RelativeTone = 0..118 (0 = C-0, 118 = A#9)
```

Linear frequency table

$$Period = 10 \cdot 12 \cdot 16 \cdot 4 - Note \cdot 16 \cdot 4 - FineTune / 2$$

$$Frequency = 8363 \cdot 2^{\frac{6 \cdot 12 \cdot 16 \cdot 4 - Period}{12 \cdot 16 \cdot 4}}$$

Don't attempt to implement the 2^N operation as a bit shift, because N is actually a real number! Most players use floating point arithmetics to implement the latter formula. If you can't or don't want to use floating point operations, you can use a 768 doubleword array, like ModPlug does. No other known way exists to compute the linear Frequency values.

When using linear Freq Tables, the distance between two octaves is 255 portamento units. e.g. the effect "1FF" at speed 1 will slide the pitch one octave up.

Amiga frequency table

```
Pos      = (Note % 12) * 8 + FineTune / 16
Frac     = FineTune / 16 - Int(FineTune / 16)
Period   = (PeriodTab[Pos] * (1 - Frac) + PeriodTab[Pos+1] * Frac) * 16 / 2Note / 12
```

The period is interpolated for finer finetune values.

Frequency = 8363 * 1712 / Period

```
WORD PeriodTab[] = {  
    907,900,894,887,881,875,868,862,856,850,844,838,832,826,820,814,  
    808,802,796,791,785,779,774,768,762,757,752,746,741,736,730,725,  
    720,715,709,704,699,694,689,684,678,675,670,665,660,655,651,646,  
    640,636,632,628,623,619,614,610,604,601,597,592,588,584,580,575,  
    570,567,563,559,555,551,547,543,538,535,532,528,524,520,516,513,  
    508,505,502,498,494,491,487,484,480,477,474,470,467,463,460,457  
};
```

That's it!

History:

Originally written by Fredrik Huss/Mr.H of Triton in 1994.

Some additions and a corrections were made by ByteRaver & Wodan from TNT/NO-ID.

Furthermore additions and corrections made by Quantum in 2006 - 2007.