

Chapter 16 - TED Audio

TED audio is a small two-voice sound generator. Voice 1 is a square wave. Voice 2 is a square wave or an 8-bit TED noise source. The chip has one shared control byte for volume, voice enables, noise mode, and the stored direct-output bit.

The quickest audible setup is:

```
10 REM TED FIRST TONE
20 POKE32 &H00F0800,1
30 REM SET FREQUENCY, THEN ENABLE OUTPUT
40 TED TONE 1,900
50 POKE8 &H00F0F03,&H18
```

TED TONE writes the frequency registers. It does not enable a voice. Line 50 sets voice 1 on and master volume 8.

Try changing the tone value in line 40 to 960. TED frequency values count up towards higher notes.

16.1 Shape of the chip

Item	Value
Voices	2
Voice 1	Square wave
Voice 2	Square wave or TED noise
Frequency	10-bit register per voice
Volume	Shared level 0 to 8; stored values 9 to 15 play as 8
Noise	Voice 2 replacement, controlled by bit 6 of TED_SND_CTRL
TED Plus	Enhanced processing mode at TED_PLUS_CTRL bit 0

TED audio uses the main TED clock divided by 8. PAL is 110840 Hz and NTSC is 111860 Hz.

16.2 Register block

The audio register block is byte-wide from \$F0F00 to \$F0F05.

Address	Name	Purpose
\$F0F00	TED_FREQ1_LO	Voice 1 frequency low byte
\$F0F01	TED_FREQ2_LO	Voice 2 frequency low byte
\$F0F02	TED_FREQ2_HI	Voice 2 frequency bits 8 to 9
\$F0F03	TED_SND_CTRL	Volume, enables, noise, direct-output bit
\$F0F04	TED_FREQ1_HI	Voice 1 frequency bits 8 to 9
\$F0F05	TED_PLUS_CTRL	Bit 0 enables TED Plus

Use POKE8 for direct register work. These are byte registers; the music player registers later in this chapter are 32-bit pointer and length registers.

16.3 Frequency registers

Each voice has a 10-bit register value:

```
register = low + 256 * (high AND 3)
frequency = sound_clock / (1024 - register)
```

If the register value is 1024 or higher, it is treated as 1023, giving the highest pitch. Low register values produce low pitches.

TED TONE ch,value writes the two frequency bytes for voice 1 or 2:

```
10 REM TED TWO VOICES
20 POKE32 &H000F0800,1
30 REM LOAD BOTH 10 BIT FREQUENCIES
40 TED TONE 1,900
50 TED TONE 2,940
60 REM ENABLE BOTH VOICES AT VOLUME 8
70 POKE8 &H000F0F03,&H38
```

Expected result: both square voices play together at volume 8. &H38 is voice 1 on, voice 2 on, volume 8.

The two TED TONE lines only fill the frequency registers. Line 70 is the line that makes the sound audible: bit 4 enables voice 1, bit 5 enables voice 2, and the low nibble sets the shared volume.

Try changing line 70 to POKE8 &H000F0F03,&H28; only voice 2 remains enabled.

16.4 Sound control byte

TED_SND_CTRL at \$F0F03 is the central audio control byte.

Bit	Field	Meaning
0 to 3	VOLUME	Shared volume. Values above 8 are clamped by the sound path
4	SND1ON	Voice 1 output enable
5	SND2ON	Voice 2 output enable
6	SND2NOISE	Voice 2 uses TED noise instead of square wave
7	SNDDC	Stored direct-output bit

TED VOL level changes only bits 0 to 3 and preserves the upper control bits. TED NOISE ON sets bit 6; TED NOISE OFF clears bit 6. Neither command enables voice 2 by itself.

```

10 REM TED NOISE HIT
20 POKE32 &H000F0800,1
30 REM VOICE 2 CLOCKS THE NOISE
40 TED TONE 2,990
50 FOR V=8 TO 0 STEP -1
60 REM VOICE 2 ON, NOISE ON, VOLUME V
70 POKE8 &H000F0F03,&H60+V
80 FOR Q=1 TO 80
90 NEXT Q
100 NEXT V
110 POKE8 &H000F0F03,0

```

Expected result: voice 2 makes a short noisy hit. &H60 is voice 2 on plus noise; the loop fades the shared volume.

Line 40 sets the voice 2 frequency, which also gives the noise generator its pace. Line 70 builds the control byte from &H60 plus the current volume: bit 5 enables voice 2, bit 6 selects noise, and V fades from loud to silent.

Try changing the delay loop in lines 80 to 90 from 80 to 30 for a shorter percussion tick.

The SNDDC bit is stored in the register. The current TED audio path uses the square/noise voices and shared volume; there is no separate BASIC DAC sample register for TED audio.

16.5 Arpeggios

TED is especially good at quick single-voice arpeggios:

```

10 REM TED TINY ARP
20 POKE32 &H000F0800,1
30 REM VOICE 1 ON AT VOLUME 8
40 POKE8 &H000F0F03,&H18
50 FOR I=0 TO 127
60 REM REPEAT FOUR REGISTER VALUES
70 N=I-INT(I/4)*4
80 IF N=0 THEN D=860
90 IF N=1 THEN D=900
100 IF N=2 THEN D=930
110 IF N=3 THEN D=960
120 TED TONE 1,D
130 FOR Q=1 TO 40
140 NEXT Q
150 NEXT I
160 POKE8 &H000F0F03,0

```

Expected result: a bright four-step arpeggio, then silence.

Line 40 opens voice 1 before the loop starts. Lines 70 to 110 choose one of four frequency register values. Line 120 writes the selected value, and the short delay lets the ear hear each step before the next write.

Try changing line 110 from 960 to 980 for a sharper top note.

16.6 TED Plus

TED Plus follows the shared Plus rule from Chapter 11. TED PLUS ON writes 1 to TED_PLUS_CTRL at \$F0F05; TED PLUS OFF writes 0. TED keeps the same six audio registers. The TED-specific difference is an enhanced volume curve, per-voice

mix gains, oversampling, low-pass smoothing, drive, and room processing.

```
10 REM TED PLUS COMPARE
20 POKE32 &H000F0800,1
30 TED TONE 1,920
40 POKE8 &H000F0F03,&H18
50 REM LISTEN TO PLAIN TED FIRST
60 FOR T=1 TO 2500
70 NEXT T
80 TED PLUS ON
90 PRINT PEEK8(&H000F0F05)
100 REM NOW LISTEN TO TED PLUS
110 FOR T=1 TO 2500
120 NEXT T
130 TED PLUS OFF
140 PRINT PEEK8(&H000F0F05)
150 POKE8 &H000F0F03,0
```

The tone continues while line 80 switches to the enhanced processing path. Lines 90 and 140 print 1 and then 0, so the listing proves the control byte as well as changing the sound.

Try changing line 30 to TED TONE 1,980; the Plus comparison still uses the same TED registers.

16.7 Player registers

The TED player streams TED music data from memory.

Address	Name	Purpose
\$F0F10	TED_PLAY_PTR	Start address of the music data
\$F0F14	TED_PLAY_LEN	Length in bytes
\$F0F18	TED_PLAY_CTRL	Write 1 start, 2 stop, 5 start loop
\$F0F1C	TED_PLAY_STATUS	Bit 0 busy, bit 1 error

```
10 REM TED MEMORY PLAYBACK
20 REM START A TED MUSIC BLOCK
30 TED PLAY &H00010000,4096
40 S=TED STATUS
50 PRINT S
60 IF S AND 2 THEN PRINT "TED ERROR"
```

If the memory block contains valid TED music data, TED STATUS reports busy while playback is active. If the pointer, length, or data is invalid, bit 1 is set.

Line 30 writes the pointer, length, and start command. Lines 40 to 60 sample the status and report only the error bit. They do not stop playback; a valid TED music block should continue until it ends, loops, or a later stop command is typed.

To stop TED playback later:

```
10 TED STOP
20 PRINT TED STATUS
```

16.8 Side effects and limits

Frequency, volume, enable, noise, and TED Plus changes take effect immediately. Noise uses voice 2's output path, so voice 2 must be enabled for noise to be heard. The same master volume controls both voices.

The TED VOL helper stores four bits because that is what the control register contains. The sound output clamps values above 8 to the maximum TED volume.

The next chapter covers POKEY, a four-channel chip with richer timer and noise controls.