

Chapter 15 - The SID Family

The SID family gives Intuition Engine three MOS 6581/8580 style sound chips: SID, SID2, and SID3. Each chip has three oscillators, ADSR envelopes, pulse width control, ring modulation, oscillator sync, a resonant filter, and a master volume register. BASIC drives the primary SID directly. The extra chips are available through the same byte registers at their own addresses.

Start with one pulse voice:

```
10 REM SID FIRST PULSE
20 POKE32 &H000F0800,1
30 SID VOLUME 15
40 REM START A GATED PULSE
50 SID VOICE 1,8582,2048,&H41,&H88,&HF4
60 FOR T=1 TO 3000
70 NEXT T
80 REM CLEAR GATE TO RELEASE
90 SID VOICE 1,8582,2048,&H40,&H88,&HF4
```

Line 50 sets voice 1 frequency, 50 per cent pulse width, pulse waveform plus gate, attack/decay byte &H88, and sustain/release byte &HF4. Line 90 clears the gate bit so the release phase begins.

Try changing the pulse width from 2048 to 1024. The pitch stays the same, but the tone becomes thinner.

15.1 Shape of one SID

Item	Value
Voices	3 per chip
Waveforms	Triangle, sawtooth, pulse, noise, and combined waveform masks
Envelope	Four-bit attack, decay, sustain, and release
Modulation	Sync and ring modulation from the previous voice
Pulse width	12-bit value, used by the pulse waveform
Filter	Low-pass, band-pass, high-pass, resonance, and voice routing
Master volume	Four-bit level in MODE_VOL
Readback	Oscillator 3 and envelope 3

SID+ is an enhanced processing mode. It keeps the same SID registers but uses a different volume curve with oversampling, light drive, and room processing for the selected SID chip.

15.2 Register blocks

Each SID register block is \$1D bytes wide.

Chip	Base	End	Voices
SID	\$F0E00	\$F0E1C	1 to 3
SID2	\$F0E30	\$F0E4C	1 to 3
SID3	\$F0E50	\$F0E6C	1 to 3

The offsets below are relative to the chip base.

Offset	Name	Purpose
\$00	V1_FREQ_LO	Voice 1 frequency low byte
\$01	V1_FREQ_HI	Voice 1 frequency high byte
\$02	V1_PW_LO	Voice 1 pulse width low byte
\$03	V1_PW_HI	Voice 1 pulse width high nibble
\$04	V1_CTRL	Voice 1 control
\$05	V1_AD	Voice 1 attack and decay
\$06	V1_SR	Voice 1 sustain and release
\$07 to \$0D	Voice 2	Same seven registers
\$0E to \$14	Voice 3	Same seven registers
\$15	FC_LO	Filter cutoff bits 0 to 2
\$16	FC_HI	Filter cutoff bits 3 to 10
\$17	RES_FILT	Resonance and filter routing
\$18	MODE_VOL	Filter mode, voice 3 off, and master volume
\$19	SID_PLUS_CTRL	Write bit 0 for SID+ on or off
\$1B	OSC3	Read oscillator 3 output
\$1C	ENV3	Read envelope 3 output

The original potentiometer registers are not connected to input hardware. The \$19 write path is used for SID_PLUS_CTRL.

15.3 Voice data formats

The frequency register is a 16-bit phase increment:

```
frequency = register * clock / 16777216
register = frequency * 16777216 / clock
```

The primary SID defaults to the PAL-style clock 985248 Hz. The NTSC-style clock value is 1022727 Hz.

Pulse width is a 12-bit value. 0 is fully low, 2048 is close to a square wave, and 4095 is almost fully high. Only the low nibble of PW_HI is used.

AD and SR pack two nibbles each:

Byte	High nibble	Low nibble
AD	Attack	Decay

Byte	High nibble	Low nibble
SR	Sustain	Release

The control byte is:

Bit	Name	Effect
0	GATE	1 attack/decay/sustain, 0 release
1	SYNC	Sync oscillator to the previous voice
2	RINGMOD	Ring modulation from the previous voice; triangle must be selected
3	TEST	Reset oscillator and mute gated output
4	TRIANGLE	Triangle waveform
5	SAWTOOTH	Sawtooth waveform
6	PULSE	Pulse waveform using PW
7	NOISE	Noise waveform

Multiple waveform bits may be set. The sound path keeps the combined waveform mask for SID-style mixed waveforms.

15.4 BASIC voice examples

SID VOICE *v*, *freq*, *pw*, *ctrl*, *ad*, *sr* writes the seven voice registers for primary SID voice *v*, where *v* is 1, 2, or 3.

```

10 REM SID THREE VOICES
20 POKE32 &H00F0800,1
30 SID VOLUME 15
40 REM START PULSE, SAWTOOTH, TRIANGLE
50 SID VOICE 1,4291,2048,&H41,&H48,&HF5
60 SID VOICE 2,5407,1024,&H21,&H46,&HC5
70 SID VOICE 3,6430,0,&H11,&H26,&HA8
80 FOR T=1 TO 4000
90 NEXT T
100 REM RELEASE ALL THREE GATES
110 SID VOICE 1,4291,2048,&H40,&H48,&HF5
120 SID VOICE 2,5407,1024,&H20,&H46,&HC5
130 SID VOICE 3,6430,0,&H10,&H26,&HA8

```

Expected result: a three-voice chord using pulse, sawtooth, and triangle, then all three gates release.

The three control bytes differ only in waveform and gate bits: &H41 is pulse plus gate, &H21 is sawtooth plus gate, and &H11 is triangle plus gate. The release lines keep the waveform bits but clear bit 0, so the envelopes enter their release phase instead of stopping abruptly.

Try changing line 70 to use &H81 for a noise voice in the third slot.

For a sync and ring-modulated lead, set up voice 1 as the source and voice 2 as the modulated voice:

```

10 REM SID SYNC RING LEAD
20 POKE32 &H000F0800,1
30 SID VOLUME 15
40 REM VOICE 1 IS THE MODULATION SOURCE
50 SID VOICE 1,3200,0,&H21,&H44,&HF6
60 SID VOICE 2,6400,0,&H17,&H44,&HF6
70 REM SWEEP THE MODULATED VOICE
80 FOR F=5200 TO 9000 STEP 160
90 SID VOICE 2,F,0,&H17,&H44,&HF6
100 FOR Q=1 TO 30
110 NEXT Q
120 NEXT F
130 REM RELEASE SOURCE AND LEAD
140 SID VOICE 1,3200,0,&H20,&H44,&HF6
150 SID VOICE 2,6400,0,&H16,&H44,&HF6

```

Voice 2 uses triangle, ring modulation, sync, and gate. The source is the previous voice.

Line 50 starts voice 1 as a sawtooth source. Line 60 starts voice 2 with triangle, ring modulation, sync, and gate all set. During the sweep only voice 2's frequency changes; the source keeps running so the modulation has something to lock against.

Try reducing the STEP in line 80 to 80. The sweep becomes smoother and lasts longer.

15.5 Filter and master volume

SID VOLUME level writes the low four bits of MODE_VOL and preserves the filter mode bits.

SID FILTER cutoff, resonance, routing, mode writes:

Argument	Register effect
cutoff	FC_LO = cutoff AND 7, FC_HI = INT(cutoff/8)
resonance	High nibble of RES_FILT
routing	Low nibble of RES_FILT; bit 0 voice 1, bit 1 voice 2, bit 2 voice 3
mode	Low nibble shifted into MODE_VOL bits 4 to 7

Filter mode bits are 1 low-pass, 2 band-pass, 4 high-pass, and 8 voice 3 off. Modes may be combined.

```

10 REM SID FILTER SWEEP
20 POKE32 &H000F0800,1
30 SID VOLUME 15
40 REM ROUTE VOICE 1 THROUGH LOW PASS
50 SID VOICE 1,4291,2048,&H41,&H44,&HF6
60 FOR C=80 TO 1800 STEP 40
70 SID FILTER C,12,1,1
80 FOR Q=1 TO 30
90 NEXT Q
100 NEXT C
110 REM RELEASE THE FILTERED VOICE
120 SID VOICE 1,4291,2048,&H40,&H44,&HF6

```

Expected result: a pulsed voice is routed through a resonant low-pass filter whose cutoff rises during the loop.

The filter command in line 70 writes cutoff C, resonance 12, routing bit 1 for voice 1, and mode 1 for low-pass. The volume set earlier is preserved while the mode bits change, so the sweep does not reset the master level.

Try changing the mode argument in line 70 from 1 to 4 for a high-pass sweep.

15.6 SID2 and SID3 by POKE8

BASIC keywords target the primary SID. Use POKE8 for the second and third chips. This example plays a sawtooth voice on SID2:

```
10 REM SID2 SAW VOICE
20 POKE32 &H000F0800,1
30 REM POINT B AT THE SID2 REGISTER BLOCK
40 B=&H000F0E30
50 F=4291
60 POKE8 B+24,15
70 REM VOICE 1 FREQUENCY AND PULSE WIDTH
80 POKE8 B+0,F AND 255
90 POKE8 B+1,INT(F/256) AND 255
100 POKE8 B+2,0
110 POKE8 B+3,0
120 REM ENVELOPE THEN CONTROL
130 POKE8 B+5,&H44
140 POKE8 B+6,&HF6
150 POKE8 B+4,&H21
160 FOR T=1 TO 3000
170 NEXT T
180 POKE8 B+4,&H20
```

This is the same seven-register voice layout used by primary SID, but addressed through B. Lines 80 and 90 split the frequency word. Lines 130 and 140 set the envelope bytes. Line 150 starts a gated sawtooth voice, and line 180 clears the gate.

Try changing line 40 to B=&H000F0E50 to move the same voice to SID3.

15.7 SID Plus

SID Plus follows the shared Plus rule from Chapter 11. SID PLUS ON writes 1 to SID_PLUS_CTRL at \$F0E19 for the primary SID; SID PLUS OFF writes 0. The normal SID registers stay active. The SID-specific difference is a different volume curve and per-voice mix gains for the selected SID chip.

```

10 REM SID PLUS COMPARE
20 POKE32 &H000F0800,1
30 SID VOLUME 15
40 SID VOICE 1,8582,2048,&H41,&H88,&HF4
50 REM LISTEN TO THE PLAIN SID FIRST
60 FOR T=1 TO 3000
70 NEXT T
80 SID PLUS ON
90 PRINT PEEK8(&H000F0E19)
100 REM NOW LISTEN TO SID PLUS
110 FOR T=1 TO 3000
120 NEXT T
130 SID PLUS OFF
140 PRINT PEEK8(&H000F0E19)
150 SID VOICE 1,8582,2048,&H40,&H88,&HF4

```

Lines 80 and 130 change only the processing path. The voice registers keep their SID meanings. The two PEEK8 lines print 1 and then 0, confirming the control byte.

Try changing the control byte in line 40 from &H41 to &H21; the comparison uses sawtooth instead of pulse.

15.8 Player registers

The primary SID also has a memory playback controller.

Address	Name	Purpose
\$F0E20	SID_PLAY_PTR	Start address of the music data
\$F0E24	SID_PLAY_LEN	Length in bytes
\$F0E28	SID_PLAY_CTRL	Write 1 start, 2 stop, 5 start loop
\$F0E2C	SID_PLAY_STATUS	Bit 0 busy, bit 1 error
\$F0E2D	SID_SUBSONG	Subsong number

```

10 REM SID MEMORY PLAYBACK
20 REM START SUBSONG 0 FROM MEMORY
30 SID PLAY &H0000C000,4096,0
40 S=SID STATUS
50 PRINT S
60 IF S AND 2 THEN PRINT "SID ERROR"

```

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

Line 30 writes the playback pointer, length, subsong, and start command. Lines 40 to 60 sample the status and report only errors. They do not stop playback; a successful SID tune should keep playing until it ends, loops, or a later stop command is typed.

To stop SID playback later:

```

10 SID STOP
20 PRINT SID STATUS

```

15.9 Side effects and limits

Voice register writes take effect immediately. Raising a GATE bit starts that voice's attack phase; clearing it starts release. The TEST bit resets the oscillator phase and mutes gated output until cleared. SYNC and RINGMOD use the previous voice, wrapping voice 1 to voice 3.

OSC3 and ENV3 read the current oscillator and envelope outputs for voice 3. MODE_VOL bit 7 mutes voice 3 unless voice 3 is routed through the filter. The filter external-input routing bit is stored, but there is no separate external audio input for BASIC programs.

The next chapter covers TED audio, the two-voice sound chip from the same home computer family as TED video.