

Chapter 9 - The Voodoo 3D Rasteriser

Voodoo is Intuition Engine's hardware triangle rasteriser. It draws flat-shaded, Gouraud-shaded, textured, depth-tested, alpha-tested, fogged, chroma-keyed, and dithered triangles into an RGBA framebuffer with an associated Z buffer. Voodoo is compositor layer 20, so its visible pixels sit above the other picture sources.

The programmer's path is the same as the rest of this guide: type BASIC commands first, then use POKE, PEEK, POKE8, and PEEK8 when direct register control is useful. The register names keep their Voodoo heritage, but the addresses, formats, side effects, and examples below are the Intuition Engine contract.

9.1 What Voodoo can show

Use Voodoo when a picture is easier to describe as triangles than as tiles or rectangles: a spinning sign, a shaded cockpit panel, a textured floor, a depth-tested overlay, or a sprite-like quad that needs alpha. It is still one card on the same bus. BASIC sets up the state, vertices become fixed-point register values, and the compositor places the finished frame above the other display chips.

Item	Value
Output	RGBA framebuffer with depth buffer
Default resolution	640 by 480
Maximum resolution	800 by 600
Primitive	Triangle, defined by three vertices
Per-vertex data	Position, RGBA, Z, S, T, and W
Texture memory	64 KB at \$D0000
Texture sizes	up to 256x256 in the texture memory
Texture formats	paletted, intensity, alpha, and ARGB
Depth functions	8 functions, numbered 0 to 7
Alpha test/blend	Yes
Fog	Per-pixel depth fog
Chroma key	Yes
Dither	Ordered 4x4 or 2x2

9.2 Programming model

Voodoo is state-machine driven:

1. Enable the chip with V00D00 ON.
2. Set the picture size with V00D00 DIM.
3. Set draw state, usually FBZ_MODE, ALPHA_MODE, and FBZCOLOR_PATH.
4. Clear the back buffer with V00D00 CLEAR.

5. Write vertices with VERTEX A, VERTEX B, and VERTEX C.
6. Write colour, depth, texture, or W values with VOODOO TRI... commands.
7. Submit the triangle with TRIANGLE.
8. Publish the frame with VOODOO SWAP.

The submission point matters. When TRIANGLE writes TRIANGLE_CMD, Voodoo latches the current raster state for that triangle: draw mode, alpha mode, colour combine, fog, chroma key, stipple, clip rectangle, slopes, texture mode, and the currently uploaded texture. Later writes to those registers, or a later TEXTURE UPLOAD, affect later triangles only. This lets one batch mix plain, shaded, textured, fogged, and clipped triangles before one final VOODOO SWAP.

The simplest triangle is a typed BASIC program:

```

10 REM VOODOO FIRST TRIANGLE
20 VOODOO ON
30 VOODOO DIM 640,480
40 POKE32 &H000F8110,&H00008200
50 VOODOO CLEAR &HFF101020
60 VERTEX A 320,70
70 VERTEX B 540,390
80 VERTEX C 100,390
90 VOODOO TRICOLOR 4096,0,0,4096
100 TRIANGLE
110 VOODOO SWAP

```

Line 40 enables RGB writes and selects the back draw target. Line 90 uses 12.12 fixed-point colour: 4096 means full intensity and 0 means off. The result is a red triangle on a dark background.

9.3 BASIC keywords

The VOODOO keyword introduces most Voodoo subcommands. VERTEX, TRIANGLE, ZBUFFER, and TEXTURE are companion hardware verbs that operate on the same state.

Form	Effect
VOODOO ON / VOODOO OFF	Enable or disable the chip.
VOODOO DIM w,h	Set output dimensions and resize the buffers if valid.
VOODOO CLEAR colour	Store a 32-bit clear word in COLOR0 and trigger FAST_FILL_CMD.
VOODOO SWAP	Flush queued triangles and publish the frame.
VOODOO CLIP x0,y0,x1,y1	Set the scissor rectangle.
VOODOO COMBINE mode	Write FBZCOLOR_PATH. Common values are 0 iterated, 1 texture, 97 modulate.
VOODOO LFB mode	Write LFB_MODE.
VOODOO PIXEL x,y,word	Write one 32-bit word into the linear texture/LFB aperture at \$D0000 + ((y * width + x) * 4).
VOODOO RGB ON / VOODOO RGB OFF	Set or clear the RGB-write bit in FBZ_MODE.
VOODOO TRICOLOR r,g,b[,a]	Write START_R, START_G, START_B, and optional START_A. Values are 12.12 fixed point.

Form	Effect
VOOD00 TRISHADE drdx, drdy, dgdX, dgdy, dbdx, dbdy	Write colour gradient registers.
VOOD00 TRIDEPTH start_z, dzdx, dzdy	Write depth start and gradient registers. Values are 20.12 fixed point.
VOOD00 TRIUV start_s, start_t, dsdx, dtdx, dsdy, dtdy	Write texture coordinate start and gradient registers. Values are 14.18 fixed point.
VOOD00 TRIW start_w, dwdx, dwdy	Write perspective W start and gradient registers. Values are 2.30 fixed point.
VOOD00 ALPHA TEST ON / OFF	Set or clear alpha-test enable.
VOOD00 ALPHA FUNC n	Set alpha-test function bits 1 to 3.
VOOD00 ALPHA BLEND ON / OFF	Set or clear alpha-blend enable.
VOOD00 ALPHA SRC n / VOOD00 ALPHA DST n	Set source and destination blend factors.
VOOD00 FOG ON / OFF	Set or clear fog enable.
VOOD00 FOG COLOR r, g, b	Set fog colour as an RGB triplet.
VOOD00 DITHER ON / OFF	Set or clear ordered dither.
VOOD00 CHROMAKEY ON / OFF	Set or clear chroma-key discard.
VOOD00 CHROMAKEY COLOR r, g, b	Set the chroma-key colour.
VERTEX A x, y	Write vertex A, converting integer coordinates to 12.4 format.
VERTEX B x, y	Write vertex B.
VERTEX C x, y	Write vertex C.
TRIANGLE	Queue the current triangle.
ZBUFFER ON / OFF	Set or clear depth-test enable.
ZBUFFER FUNC n	Set depth function bits 5 to 7.
ZBUFFER WRITE ON / OFF	Set or clear depth-buffer writes.
TEXTURE ON / OFF	Set or clear texture enable in TEXTURE_MODE.
TEXTURE MODE mode	Write TEXTURE_MODE.
TEXTURE BASE lod, addr	Write one texture base register.
TEXTURE DIM w, h	Set upload width and height.
TEXTURE UPLOAD	Commit texture memory into the texture sampler.

9.4 Data formats

Voodoo registers are 32-bit words. POKE32 writes a whole word. PEEK32 reads a whole word. POKE8 may be used for byte work, but register side effects happen only after byte 3 of a word has been written.

Value	Format	Unit
Vertex X/Y	12.4	1 pixel is 16

Value	Format	Unit
R/G/B/A	12.12	full intensity is 4096
Z	20.12	1.0 is 4096
S/T texture coordinate	14.18	1.0 is 262144
W	2.30	1.0 is 1073741824

VERTEX A, VERTEX B, and VERTEX C shift integer coordinates left by four for you. VOODOO TRICOLOR, VOODOO TRIDEPTH, VOODOO TRIUV, and VOODOO TRIW write the raw fixed-point words you supply.

VOODOO CLEAR and COLOR0 use a 32-bit ARGB word: \$AARRGGBB. The texture memory aperture is byte-addressed RGBA. When a 32-bit POKE32 writes one RGBA texel into little-endian texture memory, the word appears as \$AABBGRR. For example, &HFF0000FF stores an opaque red texture pixel.

9.5 Register block

Voodoo's register block runs from \$F8000 to \$F87FF. Registers are 32-bit words at 4-byte aligned addresses.

9.5.1 Control and status

Address	Name	Purpose
\$F8000	VOODOO_STATUS	Status.
\$F8004	VOODOO_ENABLE	Bit 0 enables the chip.

VOODOO_STATUS bits:

Bits	Field	Meaning
0	FBI_BUSY	Framebuffer interface busy.
1	TMU_BUSY	Texture unit busy.
2	SST_BUSY	Overall chip busy.
6	VRETRACE	Vertical retrace active.
7	SWAPBUF	Buffer swap pending.
12-19	MEMFIFO	Coarse memory FIFO free-space field.
20-24	PCIFIFO	Command FIFO free-space field.

MEMFIFO is useful as a ready/not-ready field, not as a cycle-accurate historical FIFO depth. It is non-zero while the queued triangle batch can accept more triangles. It reads zero only while the current batch is exactly at its 4096 triangle limit. The next TRIANGLE_CMD at that point flushes the full batch into the drawing buffer without publishing the frame, then starts a fresh batch for the new triangle. PCIFIFO reports command space for the current high-level engine path.

FBI_BUSY and SST_BUSY are set while Voodoo is rendering a queued batch or publishing a frame. SWAPBUF is set while a publish swap is pending. Up to two swap jobs may be in flight, so a later SWAP_BUFFER_CMD waits only when that small pipeline is full. A simple BASIC program may not see these bits because small frames finish before the next PEEK, but machine code and IE Mon can still poll them around a large frame. TRIANGLE_CMD itself normally only appends work to the batch; when the batch is already full it first flushes that full batch as a render-only step.

9.5.2 Vertex and attribute registers

Address	Name	Format
\$F8008 to \$F801C	VERTEX_AX to VERTEX_CY	12.4 fixed point
\$F8020	START_R	12.12 fixed point
\$F8024	START_G	12.12 fixed point
\$F8028	START_B	12.12 fixed point
\$F802C	START_Z	20.12 fixed point
\$F8030	START_A	12.12 fixed point
\$F8034	START_S	14.18 fixed point
\$F8038	START_T	14.18 fixed point
\$F803C	START_W	2.30 fixed point
\$F8040 to \$F805C	DRDX to DWDX	per-X gradients
\$F8060 to \$F807C	DRDY to DWDY	per-Y gradients

Without `COLOR_SELECT`, every submitted triangle uses the current start values for all three vertices. Writing `COLOR_SELECT` with 0, 1, or 2 selects vertex A, B, or C as the target for later `START_*` writes. The selection applies to colour, Z, S, T, and W. After `TRIANGLE`, Gouraud selection is reset for the next triangle.

9.5.3 Command registers

Address	Name	Purpose
\$F8080	TRIANGLE_CMD	Queue one triangle using current state.
\$F8084	FTRIANGLECMD	Queue one triangle through the fast-triangle alias.
\$F8088	COLOR_SELECT	Select vertex 0, 1, or 2 for later attribute writes.
\$F8120	NOP_CMD	No operation.
\$F8124	FAST_FILL_CMD	Clear the drawing buffer with <code>COLOR0</code> .
\$F8128	SWAP_BUFFER_CMD	Flush triangles and publish the frame. Bit 0 waits for retrace; bit 1 clears after swap.

`TRIANGLE_CMD` queues work. It does not rasterise visible pixels and it does not wait for the rasteriser to draw the triangle. The current vertices, per-vertex attributes, raster state, and currently uploaded texture are latched into the triangle batch, up to 4096 triangles. Later writes to `FBZ_MODE`, `ALPHA_MODE`, `FBZCOLOR_PATH`, `TEXTURE_MODE`, fog, chroma, stipple, clip, slope, or texture upload state do not change triangles that are already queued.

If the batch is already full, the next `TRIANGLE_CMD` renders that full batch into the drawing buffer without publishing the frame, clears the batch, and then queues the new triangle. This is how very large frames remain complete.

Pixels appear after `SWAP_BUFFER_CMD`. That command hands the queued triangles to the rasteriser using the state each one latched when it was submitted, clears the batch, swaps buffers, and publishes the frame to the compositor. It returns while render or publish work may still be active. Voodoo can keep two swap jobs in flight, so a later swap waits only when that pipeline is full. During render or publish work the status register reports `FBI_BUSY` and `SST_BUSY`; during a pending publish it also reports `SWAPBUF`.

Long setup sequences may also be replayed from guest RAM. The command stream is a sequence of big-endian address/value longword pairs. Each address is an absolute Voodoo register address, and each value is the 32-bit word to

write there:

Address	Name	Purpose
\$F833C	V00D00_CMD_PTR	Pointer to the command stream in guest RAM.
\$F8340	V00D00_CMD_COUNT	Number of address/value pairs to replay.
\$F8344	V00D00_CMD_SUBMIT	Write 1 to replay the stream.

Replay uses the same register path as individual POKE32 or CPU MMIO writes. Misaligned addresses, addresses outside the Voodoo block, and recursive writes to the command-stream control registers are skipped. The maximum count is 65536 address/value pairs.

9.5.4 Mode and state

Address	Name	Purpose
\$F8104	FBZCOLOR_PATH	Colour combine and source selects.
\$F8108	FOG_MODE	Fog pipeline.
\$F810C	ALPHA_MODE	Alpha test and alpha blend.
\$F8110	FBZ_MODE	Framebuffer, Z, clipping, and draw enable.
\$F8114	LFB_MODE	Linear framebuffer mode latch.
\$F8118	CLIP_LEFT_RIGHT	(left << 16) right.
\$F811C	CLIP_LOW_Y_HIGH	(top << 16) bottom.

FBZ_MODE bits:

Bit	Field	Meaning
0	CLIPPING	Enable scissor.
1	CHROMAKEY	Enable chroma-key discard.
2	STIPPLE	Enable stipple mask.
3	WBUFFER	Use W-buffer interpretation for depth normalisation.
4	DEPTH_ENABLE	Enable depth test.
5-7	DEPTH_FUNC	Depth compare function.
8	DITHER	Enable ordered dither.
9	RGB_WRITE	Enable RGB writes.
10	DEPTH_WRITE	Enable depth writes.
11	DITHER_2X2	Use 2x2 dither instead of 4x4.
12	ALPHA_WRITE	Enable alpha buffer writes.
14	DRAW_FRONT	Draw to front buffer.
15	DRAW_BACK	Draw to back buffer.
16	DEPTH_SOURCE	Select depth source.
17	Y_ORIGIN	Use bottom-left Y origin when set.

Bit	Field	Meaning
18	ALPHA_PLANES	Preserve interpolated alpha in the target.
19	ALPHA_DITHER	Dither alpha.
20-31	DEPTH_OFFSET	Depth bias.

The default FBZ_MODE enables RGB, depth test, depth write, and depth function LESS. If neither draw-target bit is set, the normal back draw buffer is used.

Depth and alpha function numbers:

Value	Function
0	NEVER
1	LESS
2	EQUAL
3	LESSEQUAL
4	GREATER
5	NOTEQUAL
6	GREATEREQUAL
7	ALWAYS

ALPHA_MODE bits:

Bit	Field	Meaning
0	TEST_EN	Enable alpha test.
1-3	TEST_FUNC	Alpha test function.
4	BLEND_EN	Enable alpha blending.
5	ANTIALIAS	Antialias flag.
8-11	SRC_RGB	Source RGB blend factor.
12-15	DST_RGB	Destination RGB blend factor.
16-19	SRC_A	Source alpha blend factor.
20-23	DST_A	Destination alpha blend factor.
24-31	REF	Alpha-test reference value.

Blend-factor numbers:

Value	Factor
0	zero
1	source alpha
2	colour average
3	destination alpha
4	one

Value	Factor
5	one minus source alpha
6	one minus colour average
7	one minus destination alpha
15	source-alpha saturate

9.6 Fog, chroma, stipple, and constants

Address	Name	Purpose
\$F8140 to \$F823C	FOG_TABLE_BASE	64 fog-table entries.
\$F81C4	FOG_COLOR	Fog RGB.
\$F81C8	ZA_COLOR	Z/A constant.
\$F81CC	CHROMA_KEY	Chroma-key colour.
\$F81D0	CHROMA_RANGE	Chroma-key range.
\$F81D4	STIPPLE	Stipple pattern.
\$F81D8	COLOR0	Constant colour 0, used by fast fill.
\$F81DC	COLOR1	Constant colour 1.

`V00D00 FOG COLOR r,g,b` and `V00D00 CHROMAKEY COLOR r,g,b` pack the triplet as $(b \ll 16) | (g \ll 8) | r$. Fog blends the triangle colour towards the fog colour by the fragment Z value clamped to 0.0 to 1.0. Chroma key discards a pixel if the final RGB colour matches the key within a one-count tolerance; if `CHROMA_RANGE` is non-zero, the key becomes the low RGB bound and range becomes the high RGB bound.

Stipple uses the low 32 bits as a 4 row by 8 column mask. A zero stipple word lets every pixel through.

9.7 Texture unit

Address	Name	Purpose
\$F8300	TEXTURE_MODE	Texture mode and format.
\$F8304	TLOD	Level-of-detail control.
\$F8308	TDETAIL	Detail texture control.
\$F830C to \$F832C	TEX_BASE0 to TEX_BASE8	Base address per level.
\$F8330	TEX_WIDTH	Upload width.
\$F8334	TEX_HEIGHT	Upload height.
\$F8338	TEX_UPLOAD	Commit texture memory to the sampler.
\$F8348	TEX_SRC_PTR	Guest RAM bulk texture source.
\$F834C	TEX_SRC_BYTES	Bulk texture source byte count.
\$F8400 to \$F87FF	PALETTE_BASE	256 texture palette entries.

TEXTURE_MODE bits:

Bit	Field	Meaning
0	ENABLE	Enable texture sampling.
1-3	MINIFY	Minification filter.
4	MAGNIFY	Magnification filter.
5	CLAMP_S	Clamp S to 0.0 through 1.0.
6	CLAMP_T	Clamp T to 0.0 through 1.0.
8-11	FORMAT	Texture format.
12	CHROMA	Texture chroma key flag.
13	TRILINEAR	Trilinear flag.
14	PERSPECTIVE	Perspective-correct S/T interpolation.
15	DETAIL	Detail texture flag.
16	SEQUENCE	Sequence flag.

Texture format numbers:

Code	Format
0	8-bit palette
1	YIQ
2	A8
3	I8
4	AI44
5	P8
6	ARGB8332
7	AI88
8	ARGB1555
9	ARGB4444
10	ARGB8888

Upload sequence:

1. Write texels into \$D0000.
2. Set TEXTURE_DIM w, h.
3. Set TEXTURE_MODE.
4. Use TEXTURE_UPLOAD.
5. Enable texturing with TEXTURE_ON.
6. Select a texture combine path with V00D00_COMBINE.

Upload is ignored if width or height is zero, or if $w * h * 4$ exceeds 64 KB.

TEXTURE_UPLOAD makes the current texture available for later triangle submissions. A triangle samples the texture that was current when TRIANGLE_CMD queued it. Uploading a different texture afterwards does not change triangles already in the

queue.

9.8 Colour pipeline

FBZCOLOR_PATH selects the local colour, the other colour, and the combine function used when texturing is active.

Bits	Field	Meaning
0-1	RGB source	0 iterated, 1 texture, 2 COLOR1, 3 LFB.
2-3	Alpha source	Same encoding as RGB.
4-6	Combine mode	One of the combine functions below.
27	Texture enable	Include texture colour in the path.

Combine code	Function	Meaning
0	ZERO	Output black.
1	CSUB_CL	Other minus local.
2	ALOCAL	Local times local alpha.
3	AOTHER	Local times other alpha.
4	CLOCAL	Local pass through.
5	ALOCAL_T	Local alpha times texture.
6	CLOC_MUL	Local times other.
7	AOTHER_T	Other alpha times texture.

Convenience values accepted by V00D00 COMBINE:

Value	Meaning
0	Iterated vertex colour.
1	Texture colour.
97	Texture times vertex colour.

9.9 Examples

9.9.1 Gouraud colour fan

COLOR_SELECT lets a program write a different colour at each vertex. This produces a smooth red, green, and blue triangle.

```

10 REM VOODOO GOURAUD FAN
20 VOODOO ON
30 VOODOO DIM 640,480
40 POKE32 &H000F8110,&H00008200
50 VOODOO CLEAR &HFF000018
60 VERTEX A 320,60
70 VERTEX B 560,410
80 VERTEX C 80,410
90 POKE32 &H000F8088,0
100 VOODOO TRICOLOR 4096,0,0,4096
110 POKE32 &H000F8088,1
120 VOODOO TRICOLOR 0,4096,0,4096
130 POKE32 &H000F8088,2
140 VOODOO TRICOLOR 0,0,4096,4096
150 TRIANGLE
160 VOODOO SWAP

```

Expected result: a large triangle blends smoothly between red at the top, green at the lower right, and blue at the lower left.

9.9.2 Depth-tested overlap

This draws a far blue triangle first and a nearer yellow triangle second. With depth function LESS, the nearer triangle wins where the two overlap.

```

10 REM VOODOO Z OVERLAP
20 VOODOO ON
30 VOODOO DIM 640,480
40 POKE32 &H000F8110,&H00008630
50 VOODOO CLEAR &HFF000000
60 VERTEX A 220,80
70 VERTEX B 520,390
80 VERTEX C 80,390
90 VOODOO TRICOLOR 0,0,4096,4096
100 VOODOO TRIDEPTH 3277,0,0
110 TRIANGLE
120 VERTEX A 330,120
130 VERTEX B 560,350
140 VERTEX C 160,350
150 VOODOO TRICOLOR 4096,4096,0,4096
160 VOODOO TRIDEPTH 819,0,0
170 TRIANGLE
180 VOODOO SWAP

```

Line 40 sets DRAW_BACK, DEPTH_WRITE, RGB_WRITE, DEPTH_ENABLE, and depth function LESS. 3277 is about 0.8 in 20.12 fixed point. 819 is about 0.2.

9.9.3 Texture upload and textured triangle

This builds a four-pixel texture in texture memory and maps it across a triangle.

```

10 REM V00D00 2 BY 2 TEXTURE
20 V00D00 ON
30 V00D00 DIM 640,480
40 POKE32 &H000F8110,&H00008200
50 V00D00 CLEAR &HFF080808
60 POKE32 &H000D0000,&HFF0000FF
70 POKE32 &H000D0004,&HFF00FF00
80 POKE32 &H000D0008,&HFFFF0000
90 POKE32 &H000D000C,&HFFFFFFF
100 TEXTURE DIM 2,2
110 TEXTURE MODE &H0A61
120 TEXTURE UPLOAD
130 TEXTURE ON
140 V00D00 COMBINE 1
150 VERTEX A 320,60
160 VERTEX B 570,410
170 VERTEX C 70,410
180 POKE32 &H000F8088,0
190 V00D00 TRICOLOR 4096,4096,4096,4096
200 V00D00 TRIUV 0,0,0,0,0,0
210 POKE32 &H000F8088,1
220 V00D00 TRICOLOR 4096,4096,4096,4096
230 V00D00 TRIUV 262144,0,0,0,0,0
240 POKE32 &H000F8088,2
250 V00D00 TRICOLOR 4096,4096,4096,4096
260 V00D00 TRIUV 0,262144,0,0,0,0
270 TRIANGLE
280 V00D00 SWAP

```

&H0A61 enables texturing, selects ARGB8888 format, and clamps S and T. The texture words are written as little-endian RGBA texels. Expected result: the triangle samples red, green, blue, and white texels.

9.9.4 Linear aperture inspection

V00D00 PIXEL writes a 32-bit word into the texture/LFB aperture. It is useful for building texture memory and for checking address maths.

```

10 REM V00D00 PIXEL INSPECT
20 V00D00 ON
30 V00D00 DIM 320,200
40 V00D00 PIXEL 10,5,42
50 PRINT PEEK32(&H000D1928)

```

The printed value is 42, because $(5 * 320 + 10) * 4$ is 6440, and $\$D0000 + 6440$ is $\$D1928$.

9.9.5 Alpha, fog, chroma key, and dither

This draws translucent fogged colour over a green keyed triangle. The green triangle is discarded by the chroma key; the magenta triangle is drawn with alpha blending and dither.

```

10 REM VOODOO PIPELINE FLAGS
20 VOODOO ON
30 VOODOO DIM 640,480
40 POKE32 &H000F8110,&H00048202
50 VOODOO CLEAR &HFF202020
60 VOODOO CHROMAKEY COLOR 0,255,0
70 VOODOO CHROMAKEY ON
80 VOODOO DITHER ON
90 VOODOO FOG COLOR 40,40,80
100 VOODOO FOG ON
110 POKE32 &H000F810C,&H00005110
120 VERTEX A 320,80
130 VERTEX B 540,390
140 VERTEX C 100,390
150 VOODOO TRICOLOR 0,4096,0,4096
160 VOODOO TRIDEPTH 3000,0,0
170 TRIANGLE
180 VOODOO CHROMAKEY OFF
190 VERTEX A 330,110
200 VERTEX B 520,360
210 VERTEX C 140,360
220 VOODOO TRICOLOR 4096,0,4096,2048
230 VOODOO TRIDEPTH 1800,0,0
240 TRIANGLE
250 VOODOO SWAP

```

Line 40 keeps alpha planes so the 2048 alpha on line 220 reaches the blend unit. Line 110 sets blend enable, source factor SRC_ALPHA, and destination factor ONE_MINUS_SRC_ALPHA. Expected result: the green triangle leaves the cleared background untouched, while the magenta triangle appears softened by fog, alpha, and dither.

9.10 Side effects and limits

Voodoo has these programming boundaries:

Action	Side effect or limit
VOODOO OFF	Voodoo contributes no picture to the compositor.
VOODOO DIM w, h	Ignored unless both dimensions are positive and no larger than 800 by 600.
VOODOO CLEAR colour	Clears the drawing buffer and resets depth to a far value for LESS style depth functions.
TRIANGLE	Queues one triangle and latches its raster state and current texture. A full 4096-triangle batch is rendered into the drawing buffer without publishing, then the new triangle starts the next batch.
VOODOO SWAP	Hands queued triangles to the rasteriser, sets busy while render or publish work runs, swaps buffers, publishes the frame, and clears the batch. Up to two swap jobs may be active; a later swap waits when that pipeline is full.
SWAP_BUFFER_CMD bit 1	Clears the drawing buffer after the swap using current COLOR0.
POKE8 to registers	Updates the shadow byte immediately, but command side effects run only when byte 3 of the word is written.
Texture upload	Copies $w * h * 4$ bytes from \$D00000 if the size fits in 64 KB.
Command stream	Replays up to 65536 big-endian address/value pairs from guest RAM through the normal Voodoo register path.

Action	Side effect or limit
Texture sampling	Uses point sampling, with wrap by default and clamp when CLAMP_S or CLAMP_T is set.
Chroma key	Discards a final pixel colour that matches the key or keyed range.
Fog	Blends by the clamped Z value.
Dither	Quantises RGB through an ordered matrix before writing.
Draw targets	Front, back, or both may be selected; if no target bit is set, the normal back draw buffer is used.

Degenerate triangles with zero area are ignored. The rasteriser clips to the picture bounds and then to the scissor rectangle when clipping is enabled. Back-facing triangles are reordered internally so that clockwise and anticlockwise vertex order both draw.