

Glamo3365 3D Engine

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Contents

| | |
|---------------------------------|----------|
| CONTENTS | 2 |
| 1. OVERVIEW | 3 |
| 2. ENGINE REGISTER | 4 |
| 2.1 BITBLT WITH ROP3 | 4 |
| 2.2 COLOR EXPANSION | 17 |
| 2.3 TRANSPARENT BITBLT | 20 |
| 2.4 LINE DRAWING | 24 |
| 2.5 STRETCH | 32 |
| 2.6 ALPHA BLENDING | 36 |
| 2.7 ANTI-ALIASING TEXT | 40 |
| 2.8 GRADIENT FILL | 43 |

1. Overview

Mobile Multimedia Processor (MMP) supports a powerful 2D graphics engine to enhance the performance. It only supports high color (16bpp) mode, and following functions:

1. BitBlt with ROP3
2. Color expansion
3. Transparent BitBlt with source and destination key
4. Line Drawing
5. Stretch
6. Alpha Blending, ARGB565 supports constant alpha.
ARGB1555, ARGB4444, ARGB8888 support source bitmap for per-pixel alpha.
ARGB8888 support source bitmap for pre-multiply alpha.
7. Anti-Aliasing Text
8. Gradient Fill

For each function, it can rotate by 90° , 180° , 270° , mirror, mirror + 90° , mirror + 180° (flip) and mirror + 270° the coordinate. The fill rate depends on the clock rate of 2D engine. For example, if the clock rate is 50MHz, the fill rate is 50M pixels per second.

2. Engine Register

2.1 BitBlit with ROP3

BitBlit means BIT BLock Transfer. It copies a rectangular region of one bitmap into another.

| D[15:8] | D[7:0] | I/O Address |
|----------------------------------|--------|-------------|
| Source Base Address [15:0] | | 1700 |
| Source Base Address [22:16] | | 1702 |
| Source Pitch | | 1704 |
| Source X | | 1706 |
| Source Y | | 1708 |
| Destination X | | 170A |
| Destination Y | | 170C |
| Destination Base Address [15:0] | | 170E |
| Destination Base Address [22:16] | | 1710 |
| Destination Pitch | | 1712 |
| Destination Height | | 1714 |
| Rectangular Width | | 1716 |
| Rectangular Height | | 1718 |
| Pattern Base Address [15:0] | | 171A |
| Pattern Base Address [22:16] | | 171C |
| Pattern Foreground Color | | 171E |
| Pattern Background Color | | 1720 |
| Source Foreground Color | | 1722 |
| Source Background Color | | 1724 |
| Mask1 | Mask0 | 1726 |
| Mask3 | Mask2 | 1728 |
| Mask5 | Mask4 | 172A |
| Mask7 | Mask6 | 172C |
| Rotation reference X | | 172E |
| Rotation reference Y | | 1730 |
| Left Clipping | | 1732 |
| Top Clipping | | 1734 |

| | |
|---------------------|------|
| Right Clipping | 1736 |
| Bottom Clipping | 1738 |
| Command Parameter 1 | 173A |
| Command Parameter 2 | 173C |
| Command Parameter 3 | 173E |
| Safe Register | 1740 |
| Engine Status | 1742 |
| BitBlt ID 1 | 1744 |
| BitBlt ID 2 | 1746 |
| BitBlt ID 3 | 1748 |

Source Base Address Register 1

Read/Write Port: 1700h

Default Value: 0000h

| Field | Bits | Type | Description |
|------------|------|------|---|
| SrcBaseAdr | 15:0 | RW | Source Base Address [15:0] The lower word of base linear address of source bitmap in byte. <i>Limit:</i> The address range of source bitmap is from 0 to 8M. <i>Limit:</i> It must align at word (16 bits) boundary, and the bit 0 is always zero for word boundary alignment. |

Source Base Address Register 2

Read/Write Port: 1702h

Default Value: 0000h

| Field | Bits | Type | Description |
|------------|------|------|---|
| - | 15:7 | - | Reserved |
| SrcBaseAdr | 6:0 | RW | Source Base Address [22:16] The higher word of base linear address of source bitmap in byte. |

Source Pitch Register

Read/Write Port: 1704h

Default Value: 0000h

| Field | Bits | Type | Description |
|----------|-------|------|---------------------|
| - | 15:11 | - | Reserved |
| SrcPitch | 10:0 | RW | Source Pitch [10:0] |

| | | | |
|--|--|--|--|
| | | | <p>The row pitch of source bitmap in byte. It is 11.0 formats.</p> <p><i>Limit:</i> The row pitch of source bitmap is from 0 to 1280.</p> <p><i>Limit:</i> It must align at 16 bit boundary, and the bit 0 is always zero for word boundary alignment.</p> |
|--|--|--|--|

Source X Register

Read/Write Port: 1706h

Default Value: 0000h

| Field | Bits | Type | Description |
|-------|-------|------|--|
| - | 15:11 | - | Reserved |
| SrcX | 10:0 | RW | <p>Source X [10:0]</p> <p>Start X coordinate of source bitmap in pixel. It is in S10.0 format.</p> <p><i>Limit:</i> The coordinate range of source bitmap is from -639 to 639.</p> |

Source Y Register

Read/Write Port: 1708h

Default Value: 0000h

| Field | Bits | Type | Description |
|-------|-------|------|--|
| - | 15:11 | - | Reserved |
| SrcY | 10:0 | RW | <p>Source Y [10:0]</p> <p>Start Y coordinate of source bitmap in pixel. It is in S10.0 format.</p> <p><i>Limit:</i> The coordinate range of source bitmap is from -639 to 639.</p> |

Destination X Register

Read/Write Port: 170Ah

Default Value: 0000h

| Field | Bits | Type | Description |
|-------|-------|------|--|
| - | 15:11 | - | Reserved |
| DstX | 10:0 | RW | <p>Start X coordinate of destination bitmap in pixel. It is in S10.0 format.</p> <p><i>Limit:</i> The coordinate range of source bitmap is from -639 to 639.</p> |

Destination Y Register

Read/Write Port: 170Ch

Default Value: 0000h

| Field | Bits | Type | Description |
|-------|-------|------|---|
| - | 15:11 | - | Reserved |
| DstY | 10:0 | RW | Start Y coordinate of destination bitmap in pixel. It is in S10.0 format. <i>Limit:</i> The coordinate range of source bitmap is from -639 to 639. |

Destination Base Address Register 1

Read/Write Port: 170Eh

Default Value: 0000h

| Field | Bits | Type | Description |
|------------|------|------|---|
| DstBaseAdr | 15:0 | RW | Destination Base Address [15:0] The lower word of base linear address of destination bitmap in byte. <i>Limit:</i> The address range of source bitmap is from 0 to 8M. <i>Limit:</i> It must align at word boundary, and the bit 0 is always zero for word boundary alignment. |

Destination Base Address Register 2

Read/Write Port: 1710h

Default Value: 0000h

| Field | Bits | Type | Description |
|------------|------|------|---|
| - | 15:7 | - | Reserved |
| DstBaseAdr | 6:0 | RW | Destination Base Address [22:16] The higher word of base linear address of destination bitmap in byte. |

Destination Pitch Register

Read/Write Port: 1712h

Default Value: 0000h

| Field | Bits | Type | Description |
|----------|-------|------|--|
| - | 15:11 | - | Reserved |
| DstPitch | 10:0 | RW | Destination Pitch [10:0] The row pitch of destination bitmap in byte. It is 11.0 formats. |

| | | | |
|--|--|--|--|
| | | | <p><i>Limit:</i> The row pitch of destination bitmap is from 0 to 1280.</p> <p><i>Limit:</i> It must align at 16 bit boundary, and the bit 0 is always zero for word boundary alignment.</p> <p><i>Notes:</i> If the destination bitmap is on the LCD display buffer, the destination pitch means the width of LCD size.</p> |
|--|--|--|--|

Destination Height Register

Read/Write Port: 1714h

Default Value: 0000h

| Field | Bits | Type | Description |
|-----------|-------|------|--|
| - | 15:10 | - | Reserved |
| DstHeight | 9:0 | RW | Destination Height [9:0] Device height of destination bitmap in pixel. It is 10.0 formats. <i>Limit:</i> Device height of destination bitmap is from 0 to 639. <i>Notes:</i> If the destination bitmap is on the LCD display buffer, the destination height means the height of LCD size. |

Rectangular Width Register

Read/Write Port: 1716h

Default Value: 0000h

| Field | Bits | Type | Description |
|-----------|-------|------|---|
| - | 15:10 | - | Reserved |
| RectWidth | 9:0 | RW | Rectangular Width [9:0] Destination rectangular drawing width of destination bitmap in pixel. It is 10.0 formats. <i>Limit:</i> The size of rectangular of destination bitmap is from 0 to 640. <i>Notes:</i> It means the actual width for rectangular drawing. |

Rectangular Height Register

Read/Write Port: 1718h

Default Value: 0000h

| Field | Bits | Type | Description |
|------------|-------|------|--|
| - | 15:10 | - | Reserved |
| RectHeight | 9:0 | RW | Rectangular Height [9:0] Destination rectangular drawing height of destination bitmap in pixel. It is 10.0 formats. |

| | | | |
|--|--|--|---|
| | | | <p><i>Limit:</i> The size of rectangular of destination bitmap is from 0 to 640.</p> <p><i>Notes:</i> It means the actual height for rectangular drawing.</p> |
|--|--|--|---|

Pattern Base Address Register 1

Read/Write Port: 171Ah

Default Value: 0000h

| Field | Bits | Type | Description |
|------------|------|------|---|
| PatBaseAdr | 15:0 | RW | <p>Pattern Base Address [15:0]</p> <p>The lower word of base linear address of pattern bitmap in byte.</p> <p><i>Limit:</i> The address range of pattern bitmap is from 0 to 8M.</p> <p><i>Limit:</i> It must align at 16 bit boundary, and the bit 0 is always zero for word boundary alignment.</p> |

Pattern Base Address Register 2

Read/Write Port: 171Ch

Default Value: 0000h

| Field | Bits | Type | Description |
|------------|------|------|--|
| - | 15:7 | - | Reserved |
| PatBaseAdr | 6:0 | RW | <p>Pattern Base Address [22:16]</p> <p>The higher word of base linear address of pattern bitmap in byte.</p> |

Pattern Foreground Color Register

Read/Write Port: 171Eh

Default Value: 0000h

| Field | Bits | Type | Description |
|--------------|------|------|---|
| PatForeColor | 15:0 | RW | The foreground color of pattern. It is high color (16bpp) RGB565 format |

Pattern Background Color Register

Read/Write Port: 1720h

Default Value: 0000h

| Field | Bits | Type | Description |
|--------------|------|------|---|
| PatBackColor | 15:0 | RW | The background color of pattern. It is high color (16bpp) RGB565 format |

Source Foreground Color Register

Read/Write Port: 1722h

Default Value: 0000h

| Field | Bits | Type | Description |
|--------------|------|------|--|
| SrcForeColor | 15:0 | RW | The foreground color of source. It is high color (16bpp) RGB565 format |

Source Background Color Register

Read/Write Port: 1724h

Default Value: 0000h

| Field | Bits | Type | Description |
|--------------|------|------|--|
| SrcBackColor | 15:0 | RW | The background color of source. It is high color (16bpp) RGB565 format |

Mono Mask Register 1

Read/Write Port: 1726h

Default Value: 0000h

| Field | Bits | Type | Description |
|-------|------|------|---|
| Mask1 | 15:8 | RW | The monochrome mask register 1 of pattern. It is 8x8 monochrome mask patterns |
| Mask0 | 7:0 | RW | The monochrome mask register 0 of pattern. It is 8x8 monochrome mask patterns |

Mono Mask Register 2

Read/Write Port: 1728h

Default Value: 0000h

| Field | Bits | Type | Description |
|-------|------|------|---|
| Mask3 | 15:8 | RW | The monochrome mask register 3 of pattern. It is 8x8 monochrome mask patterns |
| Mask2 | 7:0 | RW | The monochrome mask register 2 of pattern. It is 8x8 monochrome mask patterns |

Mono Mask Register 3

Read/Write Port: 172Ah

Default Value: 0000h

| Field | Bits | Type | Description |
|-------|------|------|--|
| Mask5 | 15:8 | RW | The monochrome mask register 5 of pattern. It is 8x8 |

| | | | |
|-------|-----|----|---|
| | | | monochrome mask patterns |
| Mask4 | 7:0 | RW | The monochrome mask register 4 of pattern. It is 8x8 monochrome mask patterns |

Mono Mask Register 4

Read/Write Port: 172Ch

Default Value: 0000h

| Field | Bits | Type | Description |
|-------|------|------|---|
| Mask7 | 15:8 | RW | The monochrome mask register 7 of pattern. It is 8x8 monochrome mask patterns |
| Mask6 | 7:0 | RW | The monochrome mask register 6 of pattern. It is 8x8 monochrome mask patterns |

Rotation Reference X Register

Read/Write Port: 172Eh

Default Value: 0000h

| Field | Bits | Type | Description |
|------------|-------|------|--|
| - | 15:11 | - | Reserved |
| ReferenceX | 10:0 | RW | Rotation reference X coordinate of destination bitmap in pixel. It is in S10.0 format. <i>Limit:</i> The coordinate range of source bitmap is from -639 to 639. |

Rotation Reference Y Register

Read/Write Port: 1730h

Default Value: 0000h

| Field | Bits | Type | Description |
|------------|-------|------|--|
| - | 15:11 | - | Reserved |
| ReferenceY | 10:0 | RW | Rotation reference Y coordinate of destination bitmap in pixel. It is in S10.0 format. <i>Limit:</i> The coordinate range of source bitmap is from -639 to 639. |

Left Clipping Register

Read/Write Port: 1732h

Default Value: 0000h

| Field | Bits | Type | Description |
|-------|------|------|-------------|
|-------|------|------|-------------|

| | | | |
|----------|-------|----|---|
| - | 15:11 | - | Reserved |
| LeftClip | 10:0 | RW | Left bound of rectangular clipping in pixel. It is in S10.0 format. <i>Limit:</i> The clipping region is from -639 to 639. |

Top Clipping Register

Read/Write Port: 1734h

Default Value: 0000h

| Field | Bits | Type | Description |
|---------|-------|------|--|
| - | 15:11 | - | Reserved |
| TopClip | 10:0 | RW | Top bound of rectangular clipping in pixel. It is in S10.0 format. <i>Limit:</i> The clipping region is from -639 to 639. |

Right Clipping Register

Read/Write Port: 1736h

Default Value: 0000h

| Field | Bits | Type | Description |
|-----------|-------|------|--|
| - | 15:11 | - | Reserved |
| RightClip | 10:0 | RW | Right bound of rectangular clipping in pixel. It is in S10.0 format. <i>Limit:</i> The clipping region is from -639 to 639. |

Bottom Clipping Register

Read/Write Port: 1738h

Default Value: 0000h

| Field | Bits | Type | Description |
|------------|-------|------|---|
| - | 15:11 | - | Reserved |
| BottomClip | 10:0 | RW | Bottom bound of rectangular clipping in pixel. It is in S10.0 format. <i>Limit:</i> The clipping region is from -639 to 639. |

Command Parameter Register 1

Read/Write Port: 173Ah

Default Value: 0000h

| Field | Bits | Type | Description |
|-----------|------|------|--|
| - | 15:6 | - | Reserved |
| SrcRotate | 5:3 | RW | Source Coordinate Rotate 000 Not Rotate |

| | | | |
|-----------|-----|----|--|
| | | | 001 Rotate 90° 010 Rotate 180° 011 Rotate 270° 100 Mirror 101 Mirror + 90° 110 Mirror + 180° (Flip) 111 Mirror + 270° |
| DstRotate | 2:0 | RW | Destination Coordinate Rotate 000 Not Rotate 001 Rotate 90° 010 Rotate 180° 011 Rotate 270° 100 Mirror 101 Mirror + 90° 110 Mirror + 180° (Flip) 111 Mirror + 270° |

Command Parameter Register 2

Read/Write Port: 173Ch

Default Value: 0000h

| Field | Bits | Type | Description |
|---------------|------|------|--|
| RasterOp | 15:8 | RW | Raster Operations for ROP3 |
| PatSel | 7:6 | RW | Pattern select 00: Pattern is from pattern foreground color register 01: Pattern is from color pattern (8x8 Color Pattern) 10: Pattern is from monochrome mask register (8x8 Mono Mask) 11: Reserved |
| EnTrans | 5 | RW | Transparent Control 0: Opaque 1: Transparent |
| RectClipMerge | 4 | RW | Rectangular Clipping Merge Control 0: Merge clipping bound with screen bound 1: Do not merge clipping bound with screen bound |
| RectClip | 3 | RW | Rectangular Clipping Control 0: Disable rectangular clipping logic 1: Enable rectangular clipping logic |

Note: The definition of rectangular and merge screen boundary.

| | | |
|----------------------|--|-------------------------------|
| Rectangular Clipping | Merge Screen Boundary with Clipping Boundary | Clipping Boundary |
| No | X | Screen Boundary |
| Yes | Yes | Clipping with Screen Boundary |
| Yes | No | Rectangular Clipping Boundary |

Command Parameter Register 3

Read/Write Port: 173Eh

Default Value: 000Fh

| Field | Bits | Type | Description |
|---------------|------|------|---|
| - | 15:5 | - | Reserved |
| EnOnScreenRot | 4 | RW | Enable On-Screen Rotate . 0: Disable On-Screen Rotate 1: Enable On-Screen Rotate |
| Command | 3:0 | RW | Command 0000 BilBlit 0001 Color Expansion 0010 Transparent BitBlit 0011 Line Drawing 0100 Stretch 0101 Alpha Blending 0110 Anti-Aliasing Text 0111 Gradient Fill Others Reserved |

Safe Register

Read/Write Port: 1740h

Default Value: 0000h

| Field | Bits | Type | Description |
|-------------|-------|------|---|
| ProbeSel | 15:12 | RW | Probe signal select |
| - | 11 | RW | Reserved |
| PostBufSize | 10:8 | RW | Set the Post Write Buffer size |
| - | 7 | RW | Reserved |
| BufSize | 6:4 | RW | Set the Source and Destination buffers size |
| EnDebug | 3 | RW | Enable probe signal debug. 0 Disable |

| | | | | |
|--------------|---|----|---|---------|
| | | | 1 | Enable |
| PostBufBound | 2 | RW | 0 | Disable |
| | | | 1 | Enable |
| BufBound | 1 | RW | 0 | Disable |
| | | | 1 | Enable |
| EnBufMerge | 0 | RW | 0 | Enable |
| | | | 1 | Disable |

Engine Status Register

Read/Write Port: 1742h

Default Value: 0000h

| Field | Bits | Type | Description |
|-----------|-------|------|---|
| 2dStatus | 15:12 | R | 2d Status not (SRCCOORDIdle & DSTCOORDIdle & PATCOORDIdle & AD2SrcIdle) |
| 2dStatus | 11:8 | R | 2d Status not (AD2DstIdle & AD2PatIdle) & CommandErr & SRCBUFerr |
| 2dStatus | 7:4 | R | 2d Status DSTBUFerr & PATBUFerr & ATTRBUFerr & M2DInt |
| OverWrInt | 3 | R | Overwrite the Interrupt event. It indicates that the interrupt occurs more than twice before software clears the interrupt. |
| IntStatus | 2:1 | R | Status of Interrupt event 01 : The interrupt is raised on the BitBlit Service ID 1 10 : The interrupt is raised on the BitBlit Service ID 2 11 : The interrupt is raised on the BitBlit Service ID 3 Others: Reserved |
| 2DBusy | 0 | R | Engine Busy |

BitBlit ID Register 1

Read/Write Port: 1744h

Default Value: 0000h

| Field | Bits | Type | Description |
|-----------|------|------|-------------|
| BltID1Int | 15 | RW | Interrupt |

| | | | |
|------------|------|----|---------------------|
| | | | 0 Disable |
| | | | 1 Enable |
| BitID1Serv | 14:0 | RW | BitBlt Service ID 1 |

BitBlt ID Register 2

Read/Write Port: 1746h

Default Value: 0000h

| Field | Bits | Type | Description |
|------------|------|------|--|
| BltID2Int | 15 | RW | Interrupt 0 Disable 1 Enable |
| BitID2Serv | 14:0 | RW | BitBlt Service ID 2 |

BitBlt ID Register 3

Read/Write Port: 1748h

Default Value: 0000h

| Field | Bits | Type | Description |
|------------|------|------|--|
| BltID3Int | 15 | RW | Interrupt 0 Disable 1 Enable |
| BitID3Serv | 14:0 | RW | BitBlt Service ID 3 |

2.2 Color Expansion

Color expansion also called font expansion. It used to expand a monochrome bitmap to color bitmap.

| D[15:8] | D[7:0] | I/O Address |
|----------------------------------|--------|-------------|
| Source Base Address [15:0] | | 1700 |
| Source Base Address [22:16] | | 1702 |
| Source Pitch | | 1704 |
| Source X | | 1706 |
| Source Y | | 1708 |
| Destination X | | 170A |
| Destination Y | | 170C |
| Destination Base Address [15:0] | | 170E |
| Destination Base Address [22:16] | | 1710 |
| Destination Pitch | | 1712 |
| Destination Height | | 1714 |
| Rectangular Width | | 1716 |
| Rectangular Height | | 1718 |
| Pattern Base Address [15:0] | | 171A |
| Pattern Base Address [22:16] | | 171C |
| Pattern Foreground Color | | 171E |
| Pattern Background Color | | 1720 |
| Source Foreground Color | | 1722 |
| Source Background Color | | 1724 |
| Mask1 | Mask0 | 1726 |
| Mask3 | Mask2 | 1728 |
| Mask5 | Mask4 | 172A |
| Mask7 | Mask6 | 172C |
| Rotation reference X | | 172E |
| Rotation reference Y | | 1730 |
| Left Clipping | | 1732 |
| Top Clipping | | 1734 |
| Right Clipping | | 1736 |
| Bottom Clipping | | 1738 |
| Command Parameter 1 | | 173A |

| | |
|---------------------|------|
| Command Parameter 2 | 173C |
| Command Parameter 3 | 173E |
| Safe Register | 1740 |
| Engine Status | 1742 |
| BitBlt ID 1 | 1744 |
| BitBlt ID 2 | 1746 |
| BitBlt ID 3 | 1748 |

All register definition is the same as BitBlt ROP3. Please reference to its register definition. Just only Source Pitch and Command Parameter Register 3 have some difference.

Source Pitch Register

Read/Write Port: 1704h

Default Value: 0000h

| Field | Bits | Type | Description |
|----------|-------|------|---|
| - | 15:11 | - | Reserved |
| SrcPitch | 10:0 | RW | Source Pitch [10:0] The row pitch of source bitmap in byte. It is 11.0 formats. <i>Limit:</i> The row pitch of source bitmap is from 0 to 1280. <i>Limit:</i> It must align at 8 bit boundary, and the bit 0 is always zero for byte boundary alignment. |

Command Parameter Register 3

Read/Write Port: 173Eh

Default Value: 000Fh

| Field | Bits | Type | Description |
|---------------|------|------|---|
| - | 15:5 | - | Reserved |
| EnOnScreenRot | 4 | RW | Enable On-Screen Rotate . 0: Disable On-Screen Rotate 1: Enable On-Screen Rotate |
| Command | 3:0 | RW | Command 0000 BilBlt 0001 Color Expansion 0010 Transparent BitBlt 0011 Line Drawing 0100 Stretch 0101 Alpha Blending |

| | | | | |
|--|--|--|--------|--------------------|
| | | | 0110 | Anti-Aliasing Text |
| | | | 0111 | Gradient Fill |
| | | | Others | Reserved |

2.3 Transparent BitBlt

It copies a rectangular region of one bitmap into another, with some transparent pixels depends on the source and destination key.

| D[15:8] | D[7:0] | I/O Address |
|-------------------------------------|--------|-------------|
| Source Base Address [15:0] | | 1700 |
| Source Base Address [22:16] | | 1702 |
| Source Pitch | | 1704 |
| Source X | | 1706 |
| Source Y | | 1708 |
| Destination X | | 170A |
| Destination Y | | 170C |
| Destination Base Address [15:0] | | 170E |
| Destination Base Address [22:16] | | 1710 |
| Destination Pitch | | 1712 |
| Destination Height | | 1714 |
| Rectangular Width | | 1716 |
| Rectangular Height | | 1718 |
| High Value of Destination Color Key | | 171E |
| Low Value of Destination Color Key | | 1720 |
| High Value of Source Color Key | | 1722 |
| Low Value of Source Color Key | | 1724 |
| Rotation reference X | | 172E |
| Rotation reference Y | | 1730 |
| Left Clipping | | 1732 |
| Top Clipping | | 1734 |
| Right Clipping | | 1736 |
| Bottom Clipping | | 1738 |
| Command Parameter1 | | 173A |
| Command Parameter2 | | 173C |
| Command Parameter 3 | | 173E |
| Safe Register | | 1740 |
| Engine Status | | 1742 |
| BitBlt ID1 | | 1744 |
| BitBlt ID2 | | 1746 |

BitBlt ID3

1748

The absent of register number above the table means reserved register in this function

Most of the register definition are the same as BitBlt ROP3 excepting the following registers.

High Value of Destination Color Key Register

Read/Write Port: 171Eh

Default Value: 0000h

| Field | Bits | Type | Description |
|--------------|------|------|--|
| PatForeColor | 15:0 | RW | The high value of destination color key. It is high color (16bpp) RGB565 |

Low Value of Destination Color Key Register

Read/Write Port: 1720h

Default Value: 0000h

| Field | Bits | Type | Description |
|--------------|------|------|---|
| PatBackColor | 15:0 | RW | The low value of destination color key. It is high color (16bpp) RGB565 |

High Value of Source Color Key Register

Read/Write Port: 1722h

Default Value: 0000h

| Field | Bits | Type | Description |
|--------------|------|------|---|
| SrcForeColor | 15:0 | RW | The high value of source color key. It is high color (16bpp) RGB565 |

Low Value of Source Color Key Register

Read/Write Port: 1724h

Default Value: 0000h

| Field | Bits | Type | Description |
|--------------|------|------|--|
| SrcBackColor | 15:0 | RW | The low value of source color key. It is high color (16bpp) RGB565 |

Command Parameter Register 2

Read/Write Port: 173Ch

Default Value: 0000h

| Field | Bits | Type | Description |
|-------|-------|------|-------------|
| - | 15:12 | - | Reserved |

| | | | |
|---------------|------|----|---|
| RasterOp | 11:8 | RW | Raster Operations for Transparent BitBlt |
| - | 7:5 | - | Reserved |
| RectClipMerge | 4 | RW | Rectangular Clipping Merge Control 0: Merge clipping bound with screen bound 1: Do not merge clipping bound with screen bound |
| RectClip | 3 | RW | Rectangular Clipping Control 0: Disable rectangular clipping logic 1: Enable rectangular clipping logic |
| - | 2:0 | - | Reserved |

Table 2.3.1 The ROP for Transparent BitBlt:

| ROP | Source | Destination | Read DST |
|------|-----------------------------|-------------|----------|
| 0000 | Never | Always | No |
| 0001 | SRC key and DST key | Otherwise | Yes |
| 0010 | not SRC key and DST key | Otherwise | Yes |
| 0011 | DST key | Otherwise | Yes |
| 0100 | SRC key and not DST key | Otherwise | Yes |
| 0101 | SRC key | Otherwise | No |
| 0110 | SRC key xor DST key | Otherwise | Yes |
| 0111 | SRC key or DST key | Otherwise | Yes |
| 1000 | not SRC key and not DST key | Otherwise | Yes |
| 1001 | SRC key xnor DST key | Otherwise | Yes |
| 1010 | not SRC key | Otherwise | No |
| 1011 | not SRC key or DST key | Otherwise | Yes |
| 1100 | not DST key | Otherwise | Yes |
| 1101 | SRC key or not DST key | Otherwise | Yes |
| 1110 | not SRC key or not DST key | Otherwise | Yes |
| 1111 | Always | Never | No |

Command Parameter Register 3

Read/Write Port: 173Eh

Default Value: 000Fh

| Field | Bits | Type | Description |
|---------------|------|------|--|
| - | 15:5 | - | Reserved |
| EnOnScreenRot | 4 | RW | Enable On-Screen Rotate . 0: Disable On-Screen Rotate 1: Enable On-Screen Rotate |

| Command | 3:0 | RW | Command |
|---------|-----|----|------------------------------|
| | | | 0000 BitBlt |
| | | | 0001 Color Expansion |
| | | | 0010 Transparent BitBlt |
| | | | 0011 Line Drawing |
| | | | 0100 Stretch |
| | | | 0101 Alpha Blending |
| | | | 0110 Anti-Aliasing Text |
| | | | 0111 Gradient Fill |
| | | | Others Reserved |

2.4 Line Drawing

An accelerated graphics operation that draws one line on the destination bitmap.

| D[15:8] | D[7:0] | I/O Address |
|----------------------------------|--------|-------------|
| Major Axial Pixel Count | | 1704 |
| Start X | | 1706 |
| Start Y | | 1708 |
| Destination Base Address [15:0] | | 170E |
| Destination Base Address [22:16] | | 1710 |
| Destination Pitch | | 1712 |
| Destination Height | | 1714 |
| Style Period | | 1718 |
| Error Term[15:0] | | 171A |
| Error Term[19:16] | | 171C |
| K1 Term[15:0] | | 171E |
| K1 Term[19:16] | | 1720 |
| K2 Term[15:0] | | 1722 |
| K2 Term[19:16] | | 1724 |
| Foreground Color | | 1726 |
| Background Color | | 1728 |
| Line Style 0 | | 172A |
| Line Style 1 | | 172C |
| Rotation reference X | | 172E |
| Rotation reference Y | | 1730 |
| Left Clipping | | 1732 |
| Top Clipping | | 1734 |
| Right Clipping | | 1736 |
| Bottom Clipping | | 1738 |
| Command Parameter1 | | 173A |
| Command Parameter2 | | 173C |
| Command Parameter3 | | 173E |
| Safe Register | | 1740 |
| Engine Status | | 1742 |
| BitBlt ID1 | | 1744 |
| BitBlt ID2 | | 1746 |

| | |
|------------|------|
| BitBlt ID3 | 1748 |
|------------|------|

The absent of register number above the table means reserved register in this function

Most of the register definition are the same as BitBlt ROP3 excepting the following registers.

Major Axial Pixel Count

Read/Write Port: 1704h

Default Value: 0000h

| Field | Bits | Type | Description |
|------------|-------|------|---|
| - | 15:11 | - | Reserved |
| MajorWidth | 10:0 | RW | Major Axial Pixel Width [10:0] The major axial pixel width. It is 11.0 formats. <i>Limit:</i> The width range of major axial is from 0 to 1278. A value of 0 equals 1 pixel. i.e., the actual value is from 1 to 1279. <i>Notes:</i> Assume draws a line from (X1,Y1) to (X2,Y2). The major axial pixel width is $\max[\text{abs}(X2-X1), \text{abs}(Y2-Y1)]$. The X1, Y1, X2, and Y2 are in S10.0 format. |

Start X Register

Read/Write Port: 1706h

Default Value: 0000h

| Field | Bits | Type | Description |
|--------|-------|------|---|
| - | 15:11 | - | Reserved |
| StartX | 10:0 | RW | Start X [10:0] Start X coordinate of line drawing in pixel. It is in S10.0 format. <i>Limit:</i> The coordinate range of start X is from -639 to 639. |

Start Y Register

Read/Write Port: 1708h

Default Value: 0000h

| Field | Bits | Type | Description |
|--------|-------|------|---|
| - | 15:11 | - | Reserved |
| StartY | 10:0 | RW | Start Y [10:0] Start Y coordinate of line drawing in pixel. It is in S10.0 format. <i>Limit:</i> The coordinate range of start Y is from -639 to 639. |

Style Period Register

Read/Write Port: 1718h

Default Value: 0000h

| Field | Bits | Type | Description |
|-------------|------|------|--|
| - | 14:5 | - | Reserved |
| StylePeriod | 4:0 | RW | StylePeriod [4:0] Period of the line style in pixel. It is 5.0 formats. <i>Notes:</i> A value of 0 equals 1 pixel. i.e., the actual value is from 1 to 32. |

Error Term Register 1

Read/Write Port: 171Ah

Default Value: 0000h

| Field | Bits | Type | Description |
|-----------|------|------|---|
| ErrorTerm | 15:0 | RW | ErrorTerm [15:0] Error Term. It is S20.0 formats. <i>Notes:</i> Assume draws a line from (X1,Y1) to (X2,Y2). The Error Term is $2 * \min[\text{abs}(X2-X1), \text{abs}(Y2-Y1)] - \max[\text{abs}(X2-X1), \text{abs}(Y2-Y1)]$. The X1, Y1, X2, and Y2 are in S9.0 format. |

Error Term Register 2

Read/Write Port: 171Ch

Default Value: 0000h

| Field | Bits | Type | Description |
|-----------|------|------|--|
| - | 15:5 | - | Reserved |
| ErrorTerm | 4:0 | RW | ErrorTerm [20:16] Error Term. It is S20.0 formats. <i>Notes:</i> Assume draws a line from (X1,Y1) to (X2,Y2). The Error Term is $2 * \min[\text{abs}(X2-X1), \text{abs}(Y2-Y1)] - \max[\text{abs}(X2-X1), \text{abs}(Y2-Y1)]$. The X1, Y1, X2, and Y2 are in S9.0 format. |

K1 Term Register 1

Read/Write Port: 171Eh

Default Value: 0000h

| Field | Bits | Type | Description |
|--------|------|------|----------------|
| K1Term | 15:0 | RW | K1 Term [15:0] |

| | | | |
|--|--|--|--|
| | | | <p>K1 Term. It is S20.0 formats.</p> <p><i>Notes:</i> Assume draws a line from (X1,Y1) to (X2,Y2). The K1 Term is $2 * \min[\text{abs}(X2-X1), \text{abs}(Y2-Y1)]$. The X1, Y1, X2, and Y2 are in S10.0 format.</p> |
|--|--|--|--|

K1 Term Register 2

Read/Write Port: 1720h

Default Value: 0000h

| Field | Bits | Type | Description |
|--------|------|------|---|
| - | 15:5 | - | Reserved |
| K1Term | 4:0 | RW | <p>K1 Term [20:16]</p> <p>K1 Term. It is S20.0 formats.</p> <p><i>Notes:</i> Assume draws a line from (X1,Y1) to (X2,Y2). The K1 Term is $2 * \min[\text{abs}(X2-X1), \text{abs}(Y2-Y1)]$. The X1, Y1, X2, and Y2 are in S10.0 format.</p> |

K2 Term Register 1

Read/Write Port: 1722h

Default Value: 0000h

| Field | Bits | Type | Description |
|--------|------|------|---|
| K2Term | 15:0 | RW | <p>K2 Term [15:0]</p> <p>K2 Term. It is S20.0 formats.</p> <p><i>Notes:</i> Assume draws a line from (X1,Y1) to (X2,Y2). The K2 Term is $2 * (\min[\text{abs}(X2-X1), \text{abs}(Y2-Y1)] - \max[\text{abs}(X2-X1), \text{abs}(Y2-Y1)])$. The X1, Y1, X2, and Y2 are in S10.0 format.</p> |

K2 Term Register 2

Read/Write Port: 1724h

Default Value: 0000h

| Field | Bits | Type | Description |
|--------|------|------|--|
| - | 15:5 | - | Reserved |
| K2Term | 4:0 | RW | <p>K2 Term [20:16]</p> <p>K2 Term. It is S20.0 formats.</p> <p><i>Notes:</i> Assume draws a line from (X1,Y1) to (X2,Y2). The K2 Term is $2 * (\min[\text{abs}(X2-X1), \text{abs}(Y2-Y1)] - \max[\text{abs}(X2-X1), \text{abs}(Y2-Y1)])$. The X1, Y1, X2, and Y2 are in S10.0 format.</p> |

Foreground Color Register

Read/Write Port: 1726h

Default Value: 0000h

| Field | Bits | Type | Description |
|-----------|------|------|--|
| ForeColor | 15:0 | RW | The foreground color of line. It is high color (16bpp) RGB565 format |

Background Color Register

Read/Write Port: 1728h

Default Value: 0000h

| Field | Bits | Type | Description |
|-----------|------|------|--|
| BackColor | 15:0 | RW | The background color of line. It is high color (16bpp) RGB565 format |

Line Style 0 Register

Read/Write Port: 172Ah

Default Value: 0000h

| Field | Bits | Type | Description |
|------------|------|------|---------------------------------|
| LineStyle0 | 15:0 | RW | Patterns of line style 0 [15:0] |

Line Style 1 Register

Read/Write Port: 172Ch

Default Value: 0000h

| Field | Bits | Type | Description |
|------------|------|------|---------------------------------|
| LineStyle1 | 15:0 | RW | Patterns of line style 1 [15:0] |

Command Parameter Register 1

Read/Write Port: 173Ah

Default Value: 0000h

| Field | Bits | Type | Description |
|---------------|-------|------|--|
| LineStyleType | 15 | RW | Line style type 0 MSB first 1 LSB first |
| - | 14:12 | - | Reserved |
| MajorAxialSel | 11 | RW | Line drawing major axial selection 0 Y-axial is major 1 X-axial is major |

| | | | |
|------------------|-----|----|--|
| YDirection | 10 | RW | Y Direction Control 0 Y counter decrease 1 Y counter increase |
| XDirection | 9 | RW | X Direction Control 0 X counter decrease 1 X counter increase |
| LastPixelDraw | 8 | RW | Line drawing last pixel draw 0 Last pixels will not be drawn 1 Last pixels will be drawn |
| EnLineStyle | 7 | RW | Enable Line style 0 Disable line style 1 Enable line style |
| StyleCntNotReset | 6 | RW | Style counter not reset 0 Style counter will be reset 1 Style counter will not be reset |
| - | 5:3 | - | Reserved |
| DstRotate | 2:0 | RW | Destination Coordinate Rotate 000 Not Rotate 001 Rotate 90° 010 Rotate 180° 011 Rotate 270° 100 Mirror 101 Mirror + 90° 110 Mirror + 180° (Flip) 111 Mirror + 270° |

Command Parameter Register 2

Read/Write Port: 173Ch

Default Value: 0000h

| Field | Bits | Type | Description |
|----------|------|------|--|
| RasterOp | 15:8 | RW | Raster Operations for ROP3 <i>Limit:</i> The line drawing function just supports ROP2 operation. It's same as ROP3 Boolean truth table but without Source components. The Pattern components comes from line style, the Destination components comes from destination bitmap. |
| - | 7:6 | - | Reserved |
| EnTrans | 5 | RW | Transparent Control |

| | | | |
|---------------|-----|----|---|
| | | | 0 Opaque 1 Transparent |
| RectClipMerge | 4 | RW | Rectangular Clipping Merge Control 0: Merge clipping bound with screen bound 1: Do not merge clipping bound with screen bound |
| RectClip | 3 | RW | Rectangular Clipping Control 0: Disable rectangular clipping logic 1: Enable rectangular clipping logic |
| | 2:0 | | Reserved |

Command Parameter Register 3

Read/Write Port: 173Eh

Default Value: 000Fh

| Field | Bits | Type | Description |
|---------------|------|------|---|
| - | 15:5 | - | Reserved |
| EnOnScreenRot | 4 | RW | Enable On-Screen Rotate . 0: Disable On-Screen Rotate 1: Enable On-Screen Rotate |
| Command | 3:0 | RW | Command 0000 BilBlT 0001 Color Expansion 0010 Transparent BitBlT 0011 Line Drawing 0100 Stretch 0101 Alpha Blending 0110 Anti-Aliasing Text 0111 Gradient Fill Others Reserved |

Parameters Algorithm:

Assume draw a line from (X1,Y1) to (X2,Y2).

$\text{min} = \min(\text{abs}(X2-X1), \text{abs}(Y2-Y1));$

$\text{Max} = \max(\text{abs}(X2-X1), \text{abs}(Y2-Y1));$

$K1_Term = 2 * \text{min};$

$K2_Term = 2 * (\text{min} - \text{Max});$

$\text{Error_Term} = 2 * \text{min} - \text{Max};$

$\text{Major_Axial_Pixel_Count} = \text{Max};$

Limitation:

The Max-min should less or equal than 639.

Software workaround

If the (Max-min) bigger than 639, adjust the end point of coordinate to the positive coordinate.

2.5 Stretch

It scales up/down a rectangular region of one bitmap into another.

| D[15:8] | D[7:0] | I/O Address |
|----------------------------------|--------|-------------|
| Source Base Address [15:0] | | 1700 |
| Source Base Address [22:16] | | 1702 |
| Source Pitch | | 1704 |
| Source X | | 1706 |
| Source Y | | 1708 |
| Destination X | | 170A |
| Destination Y | | 170C |
| Destination Base Address [15:0] | | 170E |
| Destination Base Address [22:16] | | 1710 |
| Destination Pitch | | 1712 |
| Destination Height | | 1714 |
| Rectangular Width | | 1716 |
| Rectangular Height | | 1718 |
| Source Width | | 171E |
| Source Height | | 1720 |
| X Error Term K1 | | 1722 |
| X Error Term K2 | | 1724 |
| Y Error Term K1 | | 1726 |
| Y Error Term K2 | | 1728 |
| X Initial Error | | 172A |
| Y Initial Error | | 172C |
| Rotation reference X | | 172E |
| Rotation reference Y | | 1730 |
| Left Clipping | | 1732 |
| Top Clipping | | 1734 |
| Right Clipping | | 1736 |
| Bottom Clipping | | 1738 |
| Command Parameter1 | | 173A |
| Command Parameter2 | | 173C |
| Command Parameter3 | | 173E |
| Safe Register | | 1740 |

| | |
|---------------|------|
| Engine Status | 1742 |
| BitBlt ID1 | 1744 |
| BitBlt ID2 | 1746 |
| BitBlt ID3 | 1748 |

The absent of register number above the table means reserved register in this function
Most of the register definition are the same as BitBlt ROP3 excepting the following registers.

Source Width Register

Read/Write Port: 171Eh

Default Value: 0000h

| Field | Bits | Type | Description |
|----------|-------|------|--|
| - | 15:10 | - | Reserved |
| SrcWidth | 9:0 | RW | The width of source bitmap in pixel. It is 10.0 formats. <i>Limit:</i> The size of rectangular of source bitmap is from 0 to 640. |

Source Height Register

Read/Write Port: 1720h

Default Value: 0000h

| Field | Bits | Type | Description |
|-----------|-------|------|---|
| - | 15:10 | - | Reserved |
| SrcHeight | 9:0 | RW | The height of source bitmap in pixel. It is 10.0 formats. <i>Limit:</i> The size of rectangular of source bitmap is from 0 to 640. |

X Error Term K1 Register

Read/Write Port: 1722h

Default Value: 0000h

| Field | Bits | Type | Description |
|--------|-------|------|---|
| - | 15:12 | - | Reserved |
| XErrK1 | 11:0 | RW | Stretch error term K1 in X-direction. It is S11.0 formats. <i>Notes:</i> See the 'Related Parameters Algorithm' section for more detail information. |

X Error Term K2 Register

Read/Write Port: 1724h

Default Value: 0000h

| Field | Bits | Type | Description |
|--------|-------|------|---|
| - | 15:12 | - | Reserved |
| XErrK2 | 11:0 | RW | Stretch error term K2 in X-direction. It is S11.0 formats. <i>Notes:</i> See the 'Related Parameters Algorithm' section for more detail information. |

Y Error Term K1 Register

Read/Write Port: 1726h

Default Value: 0000h

| Field | Bits | Type | Description |
|--------|-------|------|---|
| - | 15:12 | - | Reserved |
| YErrK1 | 11:0 | RW | Stretch error term K1 in Y-direction. It is S11.0 formats. <i>Notes:</i> See the 'Related Parameters Algorithm' section for more detail information. |

Y Error Term K2 Register

Read/Write Port: 1728h

Default Value: 0000h

| Field | Bits | Type | Description |
|--------|-------|------|---|
| - | 15:12 | - | Reserved |
| YErrK2 | 11:0 | RW | Stretch error term K2 in Y-direction. It is S11.0 formats. <i>Notes:</i> See the 'Related Parameters Algorithm' section for more detail information. |

X Initial Error Register

Read/Write Port: 172Ah

Default Value: 0000h

| Field | Bits | Type | Description |
|----------|-------|------|--|
| - | 15:12 | - | Reserved |
| XInitErr | 11:0 | RW | Stretch initial error term in X-direction. It is S11.0 formats. <i>Notes:</i> See the 'Related Parameters Algorithm' section for more detail information. |

Y Initial Error Register

Read/Write Port: 172Ch

Default Value: 0000h

| Field | Bits | Type | Description |
|-------|------|------|-------------|
|-------|------|------|-------------|

| | | | |
|----------|-------|----|--|
| - | 15:12 | - | Reserved |
| YInitErr | 11:0 | RW | Stretch initial error term in Y-direction. It is S11.0 formats. <i>Notes:</i> See the 'Related Parameters Algorithm' section for more detail information. |

Command Parameter Register 2

Read/Write Port: 173Ch

Default Value: 0000h

| Field | Bits | Type | Description |
|---------------|------|------|---|
| - | 15:5 | - | Reserved |
| RectClipMerge | 4 | RW | Rectangular Clipping Merge Control 0: Merge clipping bound with screen bound 1: Do not merge clipping bound with screen bound |
| RectClip | 3 | RW | Rectangular Clipping Control 0: Disable rectangular clipping logic 1: Enable rectangular clipping logic |
| - | 2:0 | - | Reserved |

Command Parameter Register 3

Read/Write Port: 173Eh

Default Value: 000Fh

| Field | Bits | Type | Description |
|---------------|------|------|---|
| - | 15:5 | - | Reserved |
| EnOnScreenRot | 4 | RW | Enable On-Screen Rotate . 0: Disable On-Screen Rotate 1: Enable On-Screen Rotate |
| Command | 3:0 | RW | Command 0000 BiBlIt 0001 Color Expansion 0010 Transparent BitBlt 0011 Line Drawing 0100 Stretch 0101 Alpha Blending 0110 Anti-Aliasing Text 0111 Gradient Fill Others Reserved |

2.6 Alpha Blending

An accelerated graphics operation that copies a rectangular region of one bitmap into another, using alpha blending.

| D[15:8] | D[7:0] | I/O Address |
|----------------------------------|--------|-------------|
| Source Base Address [15:0] | | 1700 |
| Source Base Address [22:16] | | 1702 |
| Source Pitch | | 1704 |
| Source X | | 1706 |
| Source Y | | 1708 |
| Destination X | | 170A |
| Destination Y | | 170C |
| Destination Base Address [15:0] | | 170E |
| Destination Base Address [22:16] | | 1710 |
| Destination Pitch | | 1712 |
| Destination Height | | 1714 |
| Rectangular Width | | 1716 |
| Rectangular Height | | 1718 |
| Constant Alpha Value | | 171E |
| Rotation reference X | | 172E |
| Rotation reference Y | | 1730 |
| Left Clipping | | 1732 |
| Top Clipping | | 1734 |
| Right Clipping | | 1736 |
| Bottom Clipping | | 1738 |
| Command Parameter1 | | 173A |
| Command Parameter2 | | 173C |
| Command Parameter3 | | 173E |
| Safe Register | | 1740 |
| Engine Status | | 1742 |
| BitBlt ID1 | | 1744 |
| BitBlt ID2 | | 1746 |
| BitBlt ID3 | | 1748 |

Constant Alpha Value Register

Read/Write Port: 171Eh

Default Value: 0000h

| Field | Bits | Type | Description |
|------------|------|------|----------------------------|
| - | 15:8 | - | Reserved |
| AlphaValue | 7:0 | RW | Constant Alpha Value [7:0] |

Command Parameter Register 1

Read/Write Port: 173Ah

Default Value: 0000h

| Field | Bits | Type | Description |
|----------------|-------|------|---|
| - | 15 | - | Reserved |
| SrcFormat | 14:13 | RW | The source format for alpha blending 00: ARGB8888 source bitmap 01: ARGB1555 source bitmap 10: ARGB4444 source bitmap 11: ARGB565 source bitmap (for Constant Alpha Only) |
| OutFormat | 12 | RW | Output Format 0 RGB565 format 1 RGB555 format |
| DisDither | 11 | RW | Dither function (only active on source bitmap is ARGB8888 format) 0: Enable 1: Disable |
| - | 10:8 | - | Reserved |
| AlphaBlendMode | 7:6 | RW | Alpha Blending Mode 00: Constant Alpha $Dst = (Src * Ac + (255 - Ac)) * Dst. / 255.$ 01: Per-Pixel Alpha $Dst = (Src * Src.A + (255 - Src.A)) * Dst. / 255$ 10: No Destination Constant Alpha (only for source ARGB8888) $SrcNew.A = Src.A * Ac / 255$ $SrcNew.R = Src.R * Ac / 255$ $SrcNew.G = Src.G * Ac / 255$ $SrcNew.B = Src.B * Ac / 255$ 11: Premultiply Alpha (only for source ARGB8888) $Dst.R = SrcNew.R + ((255 - SrcNew.A) * Dst.R) / 255$ $Dst.G = SrcNew.G + ((255 - SrcNew.A) * Dst.G) / 255$ |

| | | | |
|-----------|-----|----|--|
| | | | $\text{Dst.B} = \text{SrcNew.B} + ((255 - \text{SrcNew.A}) * \text{Dst.B}) / 255$ |
| SrcRotate | 5:3 | RW | Source Coordinate Rotate 000 Not Rotate 001 Rotate 90° 010 Rotate 180° 011 Rotate 270° 100 Mirror 101 Mirror + 90° 110 Mirror + 180° (Flip) 111 Mirror + 270° |
| DstRotate | 2:0 | RW | Destination Coordinate Rotate 000 Not Rotate 001 Rotate 90° 010 Rotate 180° 011 Rotate 270° 100 Mirror 101 Mirror + 90° 110 Mirror + 180° (Flip) 111 Mirror + 270° |

Limitation:

| Alpha Mode | Source Color Mode | Source Rotate | Dest. Color Mode | Dest. Rotate |
|-----------------|-------------------|---------------|------------------|--------------|
| Constant Alpha | ARGB8888 | No | RGB565 | Yes |
| | ARGB1555 | Yes | | |
| | ARGB4444 | Yes | | |
| Per-Pixel Alpha | ARGB8888 | No | RGB565 | Yes |
| | ARGB1555 | Yes | | |
| | ARGB4444 | Yes | | |

Command Parameter Register 2

Read/Write Port: 173Ch

Default Value: 0000h

| Field | Bits | Type | Description |
|---------------|------|------|---|
| - | 15:5 | - | Reserved |
| RectClipMerge | 4 | RW | Rectangular Clipping Merge Control 0: Merge clipping bound with screen bound 1: Do not merge clipping bound with screen bound |

| | | | |
|----------|-----|----|---|
| RectClip | 3 | RW | Rectangular Clipping Control 0: Disable rectangular clipping logic 1: Enable rectangular clipping logic |
| - | 2:0 | - | Reserved |

Command Parameter Register 3

Read/Write Port: 173Eh

Default Value: 000Fh

| Field | Bits | Type | Description |
|---------------|------|------|---|
| - | 15:5 | - | Reserved |
| EnOnScreenRot | 4 | RW | Enable On-Screen Rotate . 0: Disable On-Screen Rotate 1: Enable On-Screen Rotate |
| Command | 3:0 | RW | Command 0000 BilBlit 0001 Color Expansion 0010 Transparent BitBlit 0011 Line Drawing 0100 Stretch 0101 Alpha Blending 0110 Anti-Aliasing Text 0111 Gradient Fill Others Reserved |

2.7 Anti-Aliasing Text

Glyphs are provide as packed 4bpp system memory surfaces, the 4bpp glyph data only needs to specify the corresponding per-pixel alpha value.

| D[15:8] | D[7:0] | I/O Address |
|----------------------------------|--------|-------------|
| Source Base Address [15:0] | | 1700 |
| Source Base Address [22:16] | | 1702 |
| Source Pitch | | 1704 |
| Source X | | 1706 |
| Source Y | | 1708 |
| Destination X | | 170A |
| Destination Y | | 170C |
| Destination Base Address [15:0] | | 170E |
| Destination Base Address [22:16] | | 1710 |
| Destination Pitch | | 1712 |
| Destination Height | | 1714 |
| Rectangular Width | | 1716 |
| Rectangular Height | | 1718 |
| Foreground Color | | 1722 |
| Background Color | | 1724 |
| Rotation reference X | | 172E |
| Rotation reference Y | | 1730 |
| Left Clipping | | 1732 |
| Top Clipping | | 1734 |
| Right Clipping | | 1736 |
| Bottom Clipping | | 1738 |
| Command Parameter1 | | 173A |
| Command Parameter2 | | 173C |
| Command Parameter3 | | 173E |
| Safe Register | | 1740 |
| Engine Status | | 1742 |
| BitBlt ID1 | | 1744 |
| BitBlt ID2 | | 1746 |
| BitBlt ID3 | | 1748 |

Source Pitch Register

Read/Write Port: 1704h

Default Value: 0000h

| Field | Bits | Type | Description |
|----------|-------|------|---|
| - | 15:11 | - | Reserved |
| SrcPitch | 10:0 | RW | Source Pitch [10:0] The row pitch of source bitmap in byte. It is 11.0 formats. <i>Limit:</i> The row pitch of source bitmap is from 0 to 1280. <i>Limit:</i> It must align at 8 bit boundary, and the bit 0 is always zero for byte boundary alignment. |

Command Parameter Register 1

Read/Write Port: 173Ah

Default Value: 0000h

| Field | Bits | Type | Description |
|-----------|------|------|--|
| - | 15:3 | - | Reserved |
| DstRotate | 2:0 | RW | Destination Coordinate Rotate 000 Not Rotate 001 Rotate 90° 010 Rotate 180° 011 Rotate 270° 100 Mirror 101 Mirror + 90° 110 Mirror + 180° (Flip) 111 Mirror + 270° |

Command Parameter Register 2

Read/Write Port: 173Ch

Default Value: 0000h

| Field | Bits | Type | Description |
|---------------|------|------|---|
| - | 15:6 | - | Reserved |
| EnTrans | 5 | RW | Transparent Control 0 Opaque 1 Transparent |
| RectClipMerge | 4 | RW | Rectangular Clipping Merge Control 0: Merge clipping bound with screen bound 1: Do not merge clipping bound with screen bound |
| RectClip | 3 | RW | Rectangular Clipping Control |

| | | | |
|---|-----|---|---|
| | | | 0: Disable rectangular clipping logic 1: Enable rectangular clipping logic |
| - | 2:0 | - | Reserved |

Command Parameter Register 3

Read/Write Port: 173Eh

Default Value: 000Fh

| Field | Bits | Type | Description |
|---------------|------|------|---|
| - | 15:5 | - | Reserved |
| EnOnScreenRot | 4 | RW | Enable On-Screen Rotate . 0: Disable On-Screen Rotate 1: Enable On-Screen Rotate |
| Command | 3:0 | RW | Command 0000 BilBlit 0001 Color Expansion 0010 Transparent BitBlit 0011 Line Drawing 0100 Stretch 0101 Alpha Blending 0110 Anti-Aliasing Text 0111 Gradient Fill Others Reserved |

2.8 Gradient Fill

To fill a rectangular area with smooth color.

| D[15:8] | D[7:0] | I/O Address |
|----------------------------------|--------|-------------|
| Y Delta B [15:0] | | 1700 |
| Y Delta B [2:0] | | 1702 |
| Initial Color [15:0] (RGB) | | 1706 |
| Initial Color [23:16] | | 1708 |
| Destination X | | 170A |
| Destination Y | | 170C |
| Destination Base Address [15:0] | | 170E |
| Destination Base Address [22:16] | | 1710 |
| Destination Pitch | | 1712 |
| Destination Height | | 1714 |
| Rectangular Width | | 1716 |
| Rectangular Height | | 1718 |
| X Delta R [15:0] | | 171A |
| X Delta R [2:0] | | 171C |
| X Delta G [15:0] | | 171E |
| X Delta G [2:0] | | 1720 |
| X Delta B [15:0] | | 1722 |
| X Delta B [2:0] | | 1724 |
| Y Delta R [15:0] | | 1726 |
| Y Delta R [2:0] | | 1728 |
| Y Delta G [15:0] | | 172A |
| Y Delta G [2:0] | | 172C |
| Rotation reference X | | 172E |
| Rotation reference Y | | 1730 |
| Left Clipping | | 1732 |
| Top Clipping | | 1734 |
| Right Clipping | | 1736 |
| Bottom Clipping | | 1738 |
| Command Parameter1 | | 173A |
| Command Parameter2 | | 173C |
| Command Parameter3 | | 173E |

| | |
|---------------|------|
| Safe Register | 1740 |
| Engine Status | 1742 |
| BitBlt ID1 | 1744 |
| BitBlt ID2 | 1746 |
| BitBlt ID3 | 1748 |

Y Delta B Register 1

Read/Write Port: 1700h

Default Value: 0000h

| Field | Bits | Type | Description |
|---------|------|------|---|
| YDeltaB | 15:0 | RW | YDeltaB [18:0] Y Delta B Color. <i>Limit:</i> It is in the S8.10 format. <i>Formula :</i> $YDeltaB = (ColorB_End - ColorB_Initial) / (Height - 1) * (2^{10})$ |

Y Delta B Register 2

Read/Write Port: 1702h

Default Value: 0000h

| Field | Bits | Type | Description |
|---------|------|------|---|
| - | 15:3 | - | Reserved |
| YDeltaB | 2:0 | RW | YDeltaB [18:0] Y Delta B Color. <i>Limit:</i> It is in the S8.10 format. <i>Formula :</i> $YDeltaB = (ColorB_End - ColorB_Initial) / (Height - 1) * (2^{10})$ |

Initial Color Register 1

Read/Write Port: 1706h

Default Value: 0000h

| Field | Bits | Type | Description |
|-----------|------|------|---|
| InitColor | 15:0 | RW | InitColor [23:0] Initial Color for RGB when RGB888 Color |

Initial Color Register 2

Read/Write Port: 1708h

Default Value: 0000h

| Field | Bits | Type | Description |
|---------|------|------|---|
| - | 15:8 | - | Reserved |
| YDeltaB | 7:0 | RW | InitColor [23:0] Initial Color for RGB when RGB888 Color |

X Delta R Register 1

Read/Write Port: 171Ah

Default Value: 0000h

| Field | Bits | Type | Description |
|---------|------|------|--|
| XDeltaR | 15:0 | RW | XDeltaR [18:0] X Delta R Color. <i>Limit:</i> It is in the S8.10 format. <i>Formula :</i> $XDeltaR = (ColorR_End - ColorR_Initial) / (Width - 1) * (2^{10})$ |

X Delta R Register 2

Read/Write Port: 171Ch

Default Value: 0000h

| Field | Bits | Type | Description |
|---------|------|------|--|
| - | 15:3 | - | Reserved |
| XDeltaR | 2:0 | RW | XDeltaR [18:0] X Delta R Color. <i>Limit:</i> It is in the S8.10 format. <i>Formula :</i> $XDeltaR = (ColorR_End - ColorR_Initial) / (Width - 1) * (2^{10})$ |

X Delta G Register 1

Read/Write Port: 171Eh

Default Value: 0000h

| Field | Bits | Type | Description |
|---------|------|------|--|
| XDeltaG | 15:0 | RW | XDeltaG [18:0] X Delta G Color. <i>Limit:</i> It is in the S8.10 format. <i>Formula :</i> $XDeltaG = (ColorG_End - ColorG_Initial) / (Width - 1) * (2^{10})$ |

X Delta G Register 2

Read/Write Port: 1720h

Default Value: 0000h

| Field | Bits | Type | Description |
|---------|------|------|--|
| - | 15:3 | - | Reserved |
| XDeltaG | 2:0 | RW | XDeltaG [18:0] X Delta G Color. <i>Limit:</i> It is in the S8.10 format. <i>Formula :</i> $XDeltaG = (ColorG_End - ColorG_Initial) / (Width - 1) * (2^{10})$ |

X Delta B Register 1

Read/Write Port: 1722h

Default Value: 0000h

| Field | Bits | Type | Description |
|---------|------|------|--|
| XDeltaB | 15:0 | RW | XDeltaB [18:0] X Delta B Color. <i>Limit:</i> It is in the S8.10 format. <i>Formula :</i> $XDeltaB = (ColorB_End - ColorB_Initial) / (Width - 1) * (2^{10})$ |

X Delta B Register 2

Read/Write Port: 1724h

Default Value: 0000h

| Field | Bits | Type | Description |
|---------|------|------|--|
| - | 15:3 | - | Reserved |
| XDeltaB | 2:0 | RW | XDeltaB [18:0] X Delta B Color. <i>Limit:</i> It is in the S8.10 format. <i>Formula :</i> $XDeltaB = (ColorB_End - ColorB_Initial) / (Width - 1) * (2^{10})$ |

Y Delta R Register 1

Read/Write Port: 1726h

Default Value: 0000h

| Field | Bits | Type | Description |
|---------|------|------|------------------------------------|
| YDeltaR | 15:0 | RW | YDeltaR [18:0] Y Delta R Color. |

| | | | |
|--|--|--|---|
| | | | <i>Limit:</i> It is in the S8.10 format. <i>Formula :</i> $Y\Delta R = (ColorR_End - ColorR_Initial) / (Height - 1) * (2^{10})$ |
|--|--|--|---|

Y Delta B Register 2

Read/Write Port: 1728h

Default Value: 0000h

| Field | Bits | Type | Description |
|---------|------|------|---|
| - | 15:3 | - | Reserved |
| YDeltaR | 2:0 | RW | YDeltaR [18:0] Y Delta R Color. <i>Limit:</i> It is in the S8.10 format. <i>Formula :</i> $Y\Delta R = (ColorR_End - ColorR_Initial) / (Height - 1) * (2^{10})$ |

Y Delta G Register 1

Read/Write Port: 172Ah

Default Value: 0000h

| Field | Bits | Type | Description |
|---------|------|------|---|
| YDeltaG | 15:0 | RW | YDeltaG [18:0] Y Delta G Color. <i>Limit:</i> It is in the S8.10 format. <i>Formula :</i> $Y\Delta G = (ColorG_End - ColorG_Initial) / (Height - 1) * (2^{10})$ |

Y Delta G Register 2

Read/Write Port: 172Ch

Default Value: 0000h

| Field | Bits | Type | Description |
|---------|------|------|---|
| - | 15:3 | - | Reserved |
| YDeltaG | 2:0 | RW | YDeltaG [18:0] Y Delta G Color. <i>Limit:</i> It is in the S8.10 format. <i>Formula :</i> $Y\Delta G = (ColorG_End - ColorG_Initial) / (Height - 1) * (2^{10})$ |

Command Parameter Register 1

Read/Write Port: 173Ah

Default Value: 0000h

| Field | Bits | Type | Description |
|-----------|-------|------|--|
| - | 15:12 | - | Reserved |
| DisDither | 11 | RW | Dither function 0 Enable 1 Disable |
| - | 10:3 | - | Reserved |
| DstRotate | 2:0 | RW | Destination Coordinate Rotate 000 Not Rotate 001 Rotate 90° 010 Rotate 180° 011 Rotate 270° 100 Mirror 101 Mirror + 90° 110 Mirror + 180° (Flip) 111 Mirror + 270° |

Command Parameter Register 2

Read/Write Port: 173Ch

Default Value: 0000h

| Field | Bits | Type | Description |
|----------------|------|------|---|
| - | 15:7 | - | Reserved |
| GradientDirect | 6:5 | RW | Gradient Fill Direction 00: Horizontal Direction 01: Vertical Direction 10: Triangle 11: Reserved |
| RectClipMerge | 4 | RW | Rectangular Clipping Merge Control 0: Merge clipping bound with screen bound 1: Do not merge clipping bound with screen bound |
| RectClip | 3 | RW | Rectangular Clipping Control 0: Disable rectangular clipping logic 1: Enable rectangular clipping logic |
| - | 2:0 | - | Reserved |

Command Parameter Register 3

Read/Write Port: 173Eh

Default Value: 000Fh

| Field | Bits | Type | Description |
|---------------|------|------|--|
| - | 15:5 | - | Reserved |
| EnOnScreenRot | 4 | RW | Enable On-Screen Rotate . 0: Disable On-Screen Rotate 1: Enable On-Screen Rotate |
| Command | 3:0 | RW | Command 0000 BilBlit 0001 Color Expansion 0010 Transparent BitBlt 0011 Line Drawing 0100 Stretch 0101 Alpha Blending 0110 Anti-Aliasing Text 0111 Gradient Fill Others Reserved |