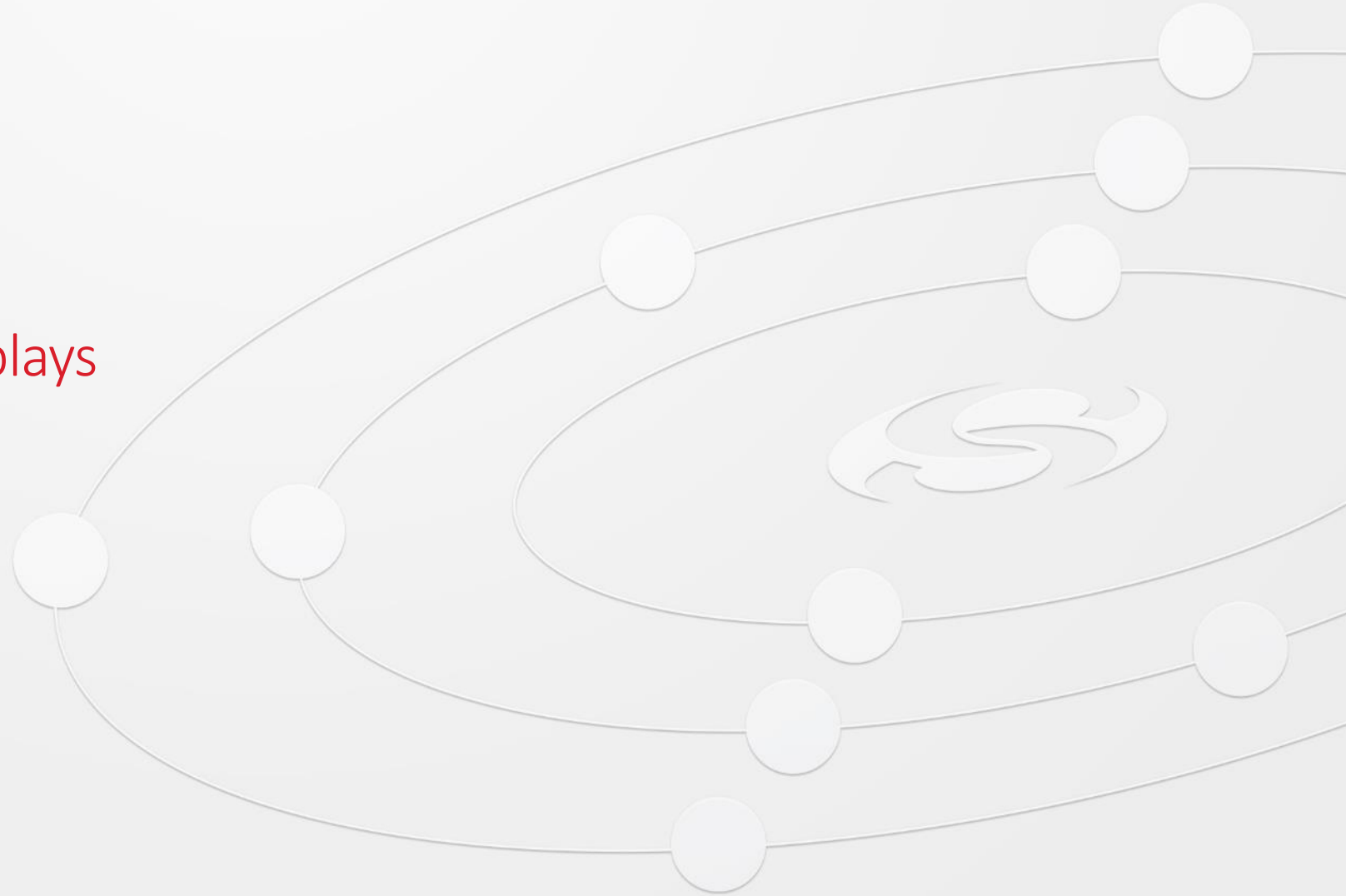




EFM32 Series 0: EBI and Displays

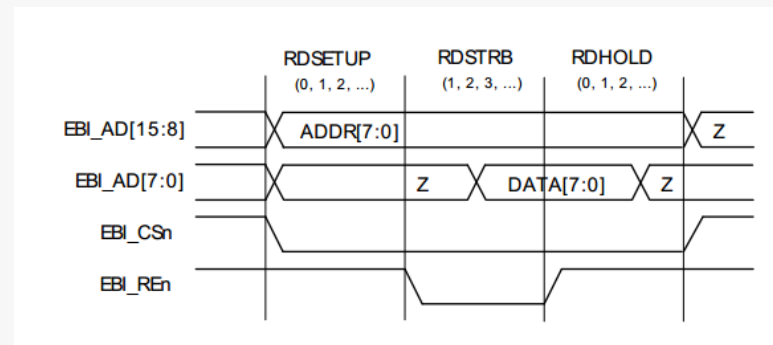
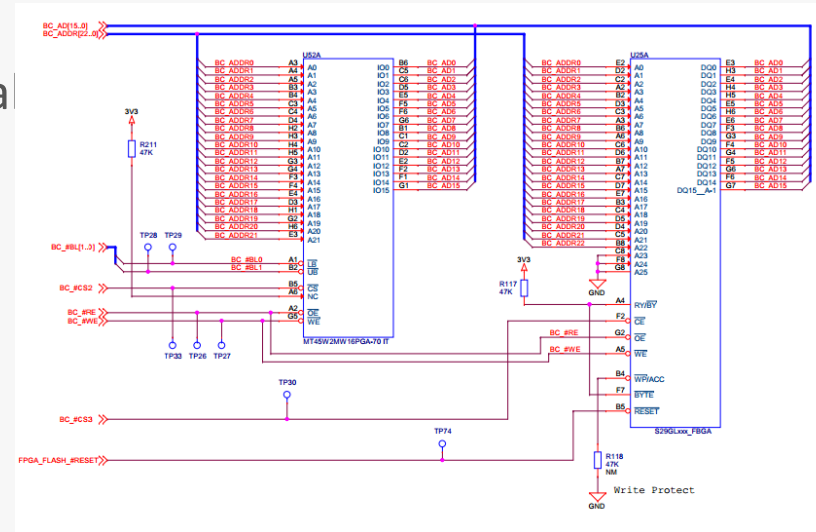


Agenda

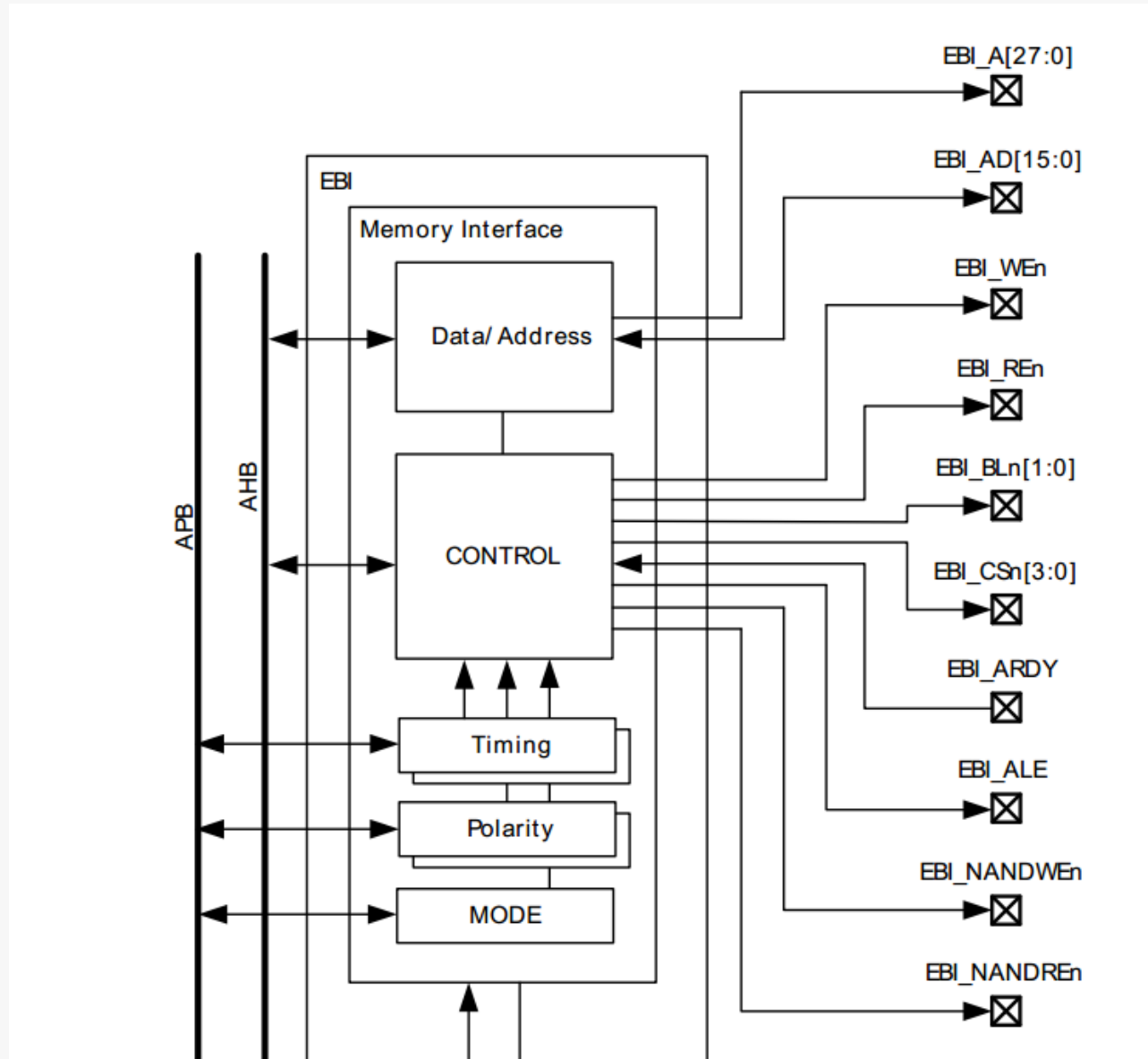
- External Bus Interface
 - Modes of operation
 - Configuration
 - Limitations
- TFT Direct Drive
- Segment LCD Controller
- emWin
- E-paper displays
- Memory LCDs
- TFT/emWin Hands-On

External Bus Interface

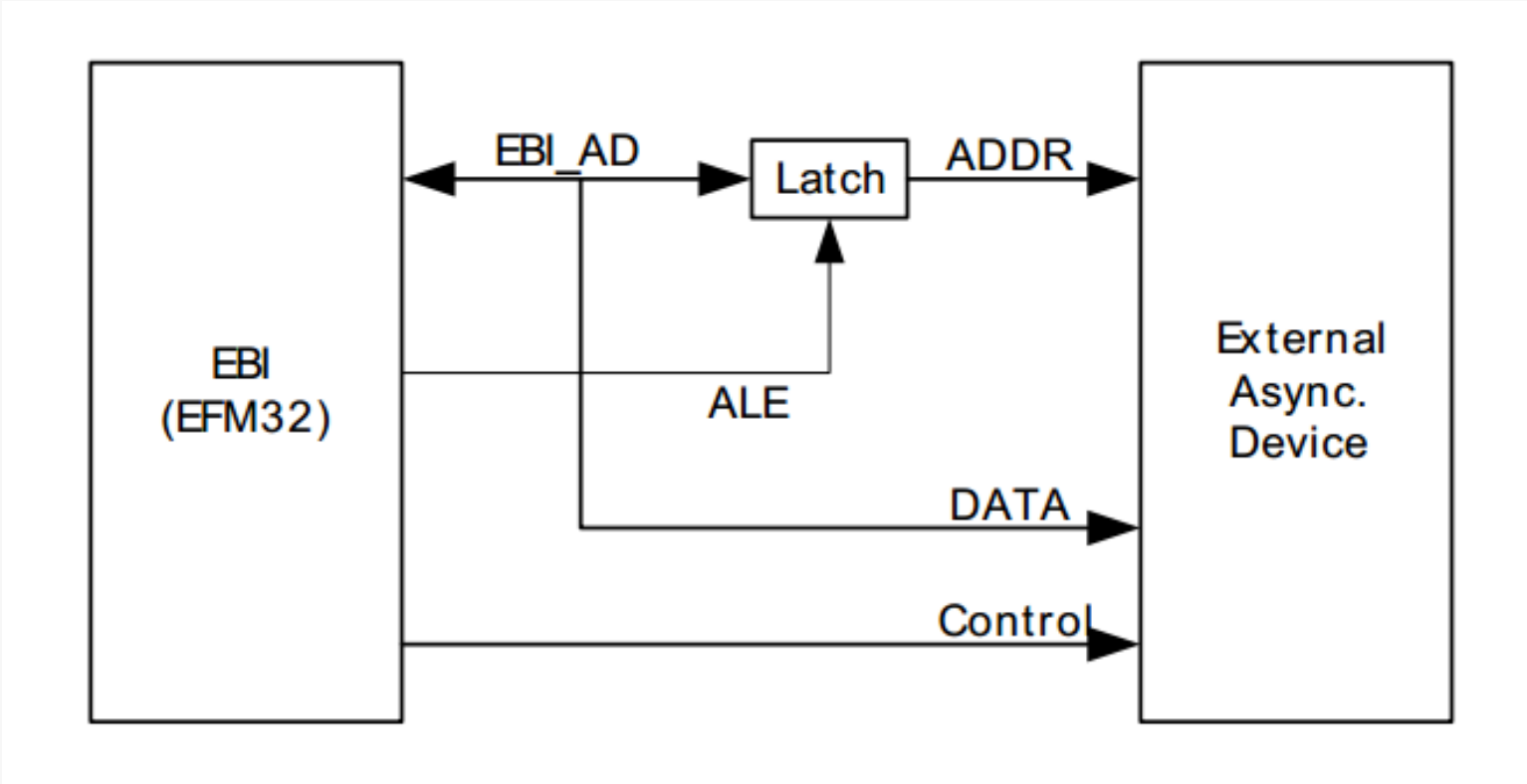
- EFM32's parallel interface
- 4 memory bank regions, with individual CS
- Timing control per bank
- Control signal polarity
- Multiplexed address and data lines
- 32-bit write buffer and prefetch unit
- DMA support



Pin overview

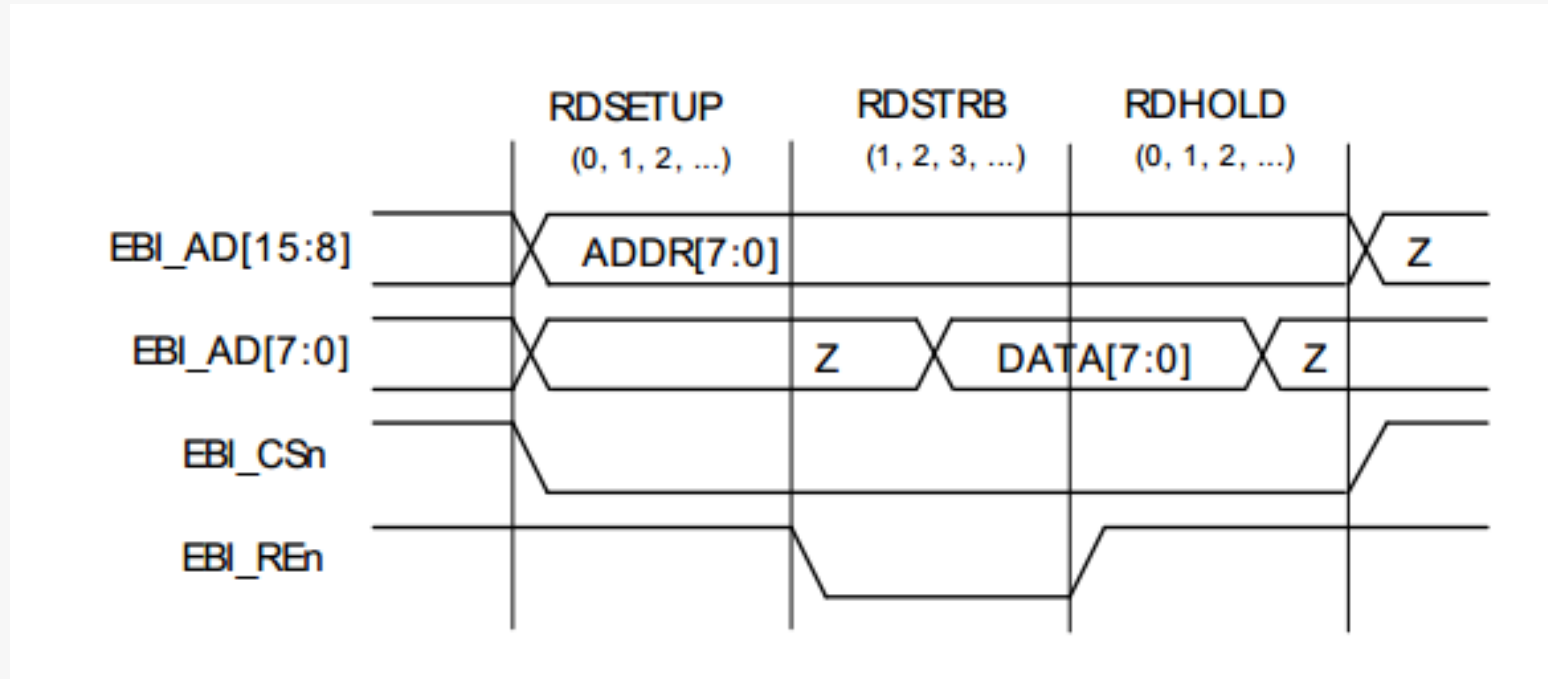


Address Latch



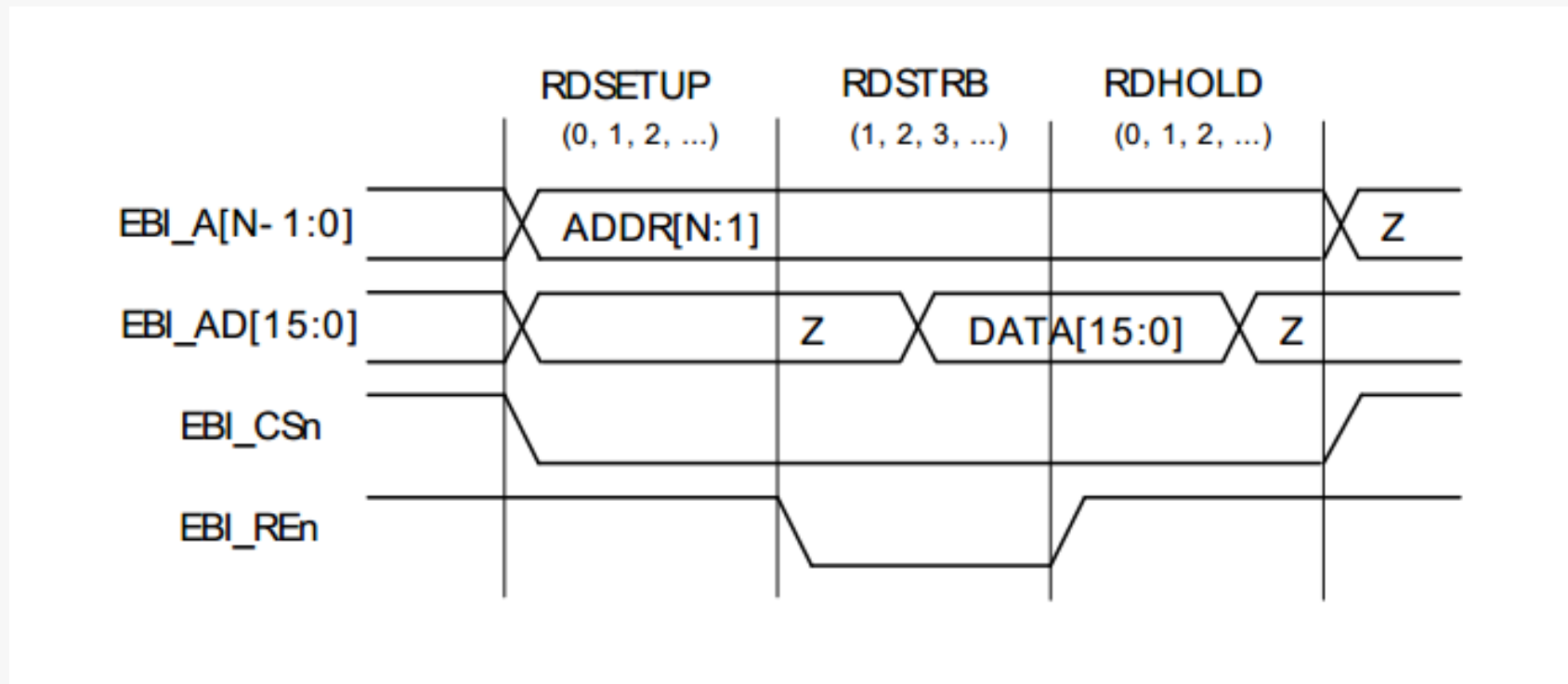
Modes

- Non-multiplexed 8-bit data, 8-bit address
- Address can be extended with EBI_A lines



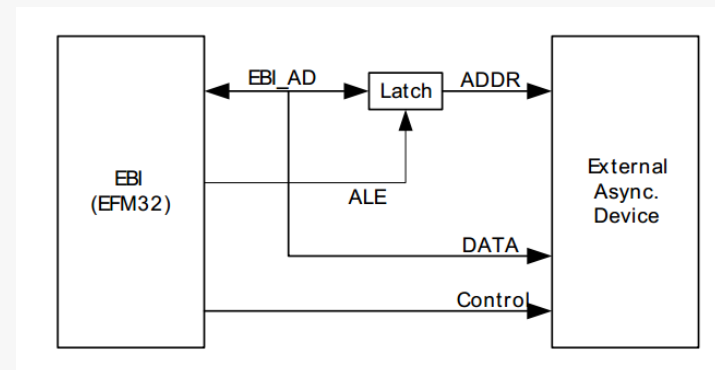
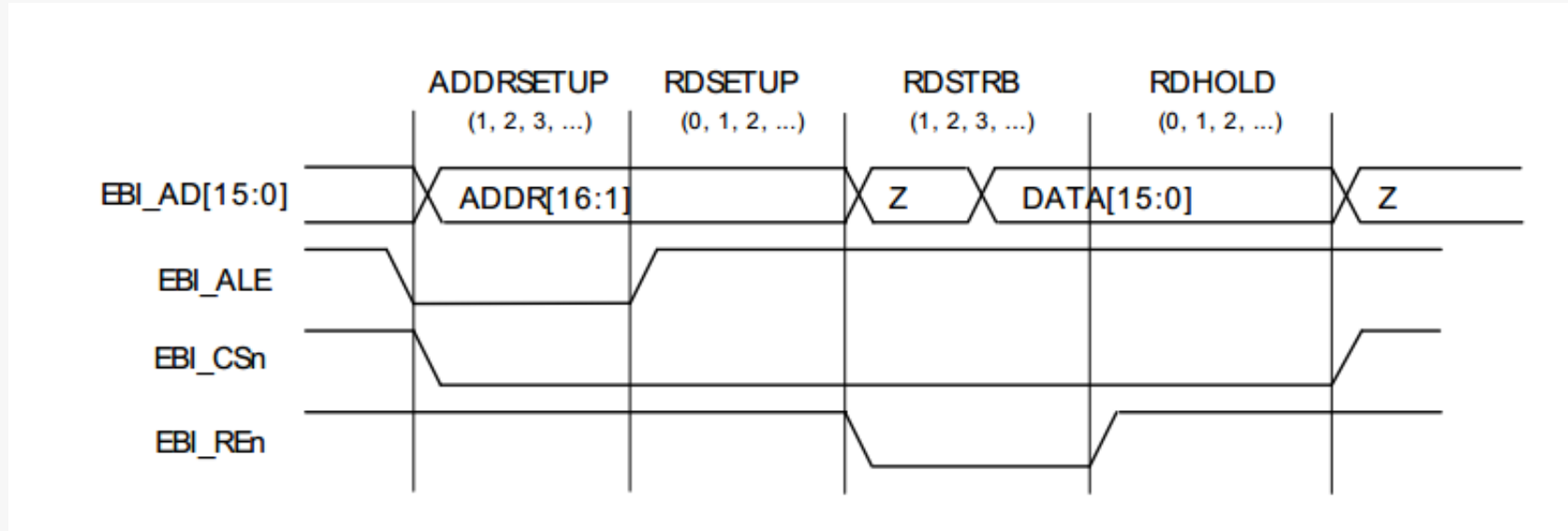
Modes

- Non-multiplexed 16-bit data N-bit address



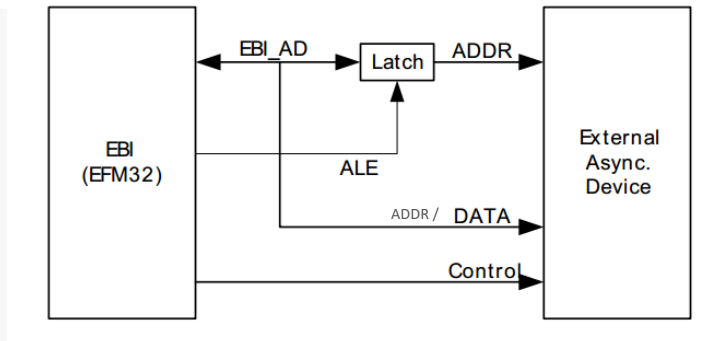
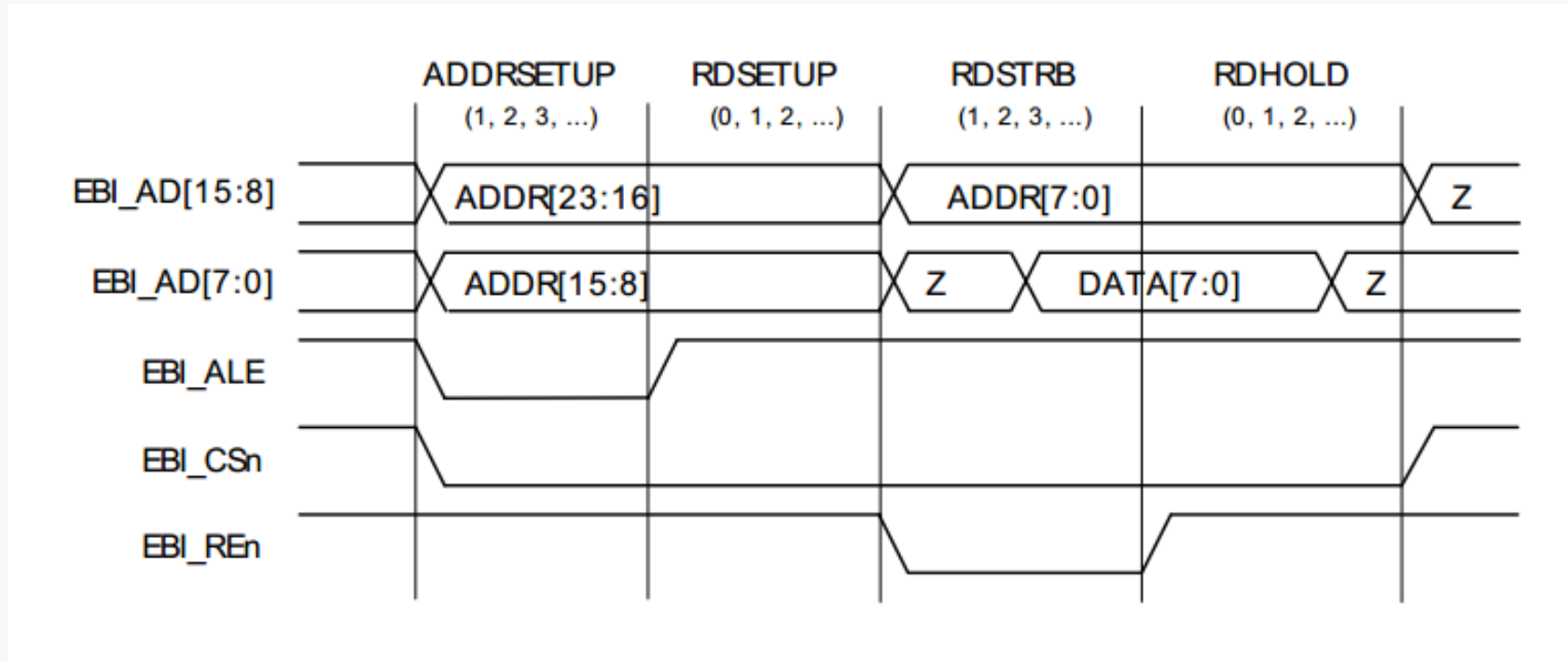
Modes

- Multiplexed 16-bit data, 16-bit address
- Address can be extended with EBI_A lines



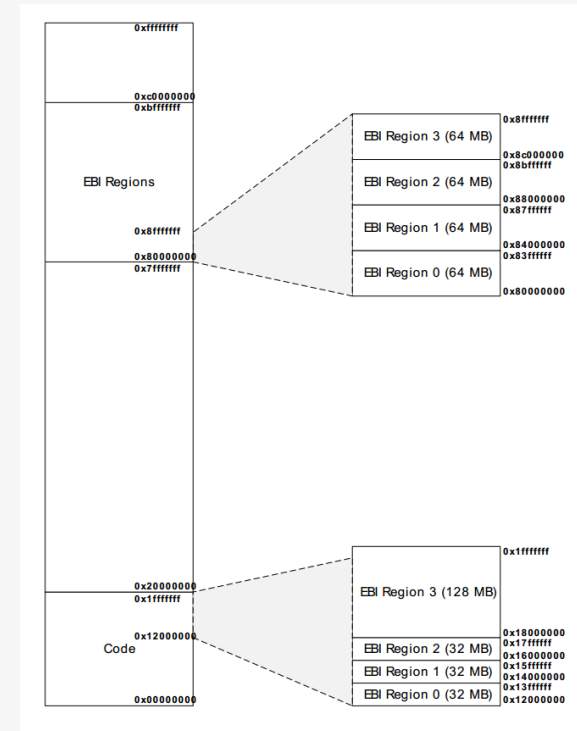
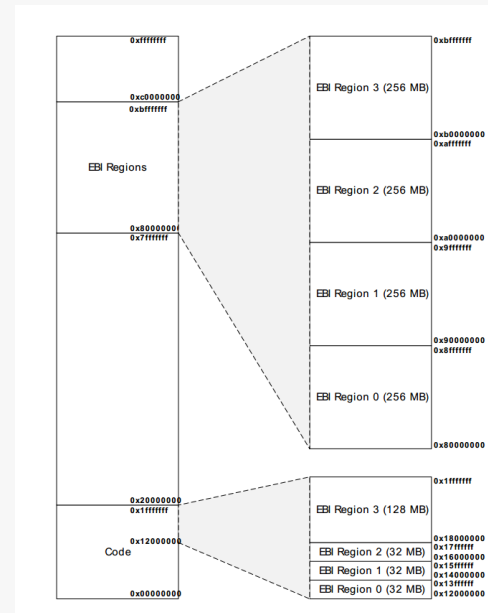
Modes

- Multiplexed 8-bit data, 24-bit address
- Address can be extended with EBI_A lines



EBI Banks

- 4 banks
- Memory mapped access
- Individual chip select lines
- 2 mappings per bank
 - Low region be used for code execution
 - High region can be used by DMA
- Alternative mapping

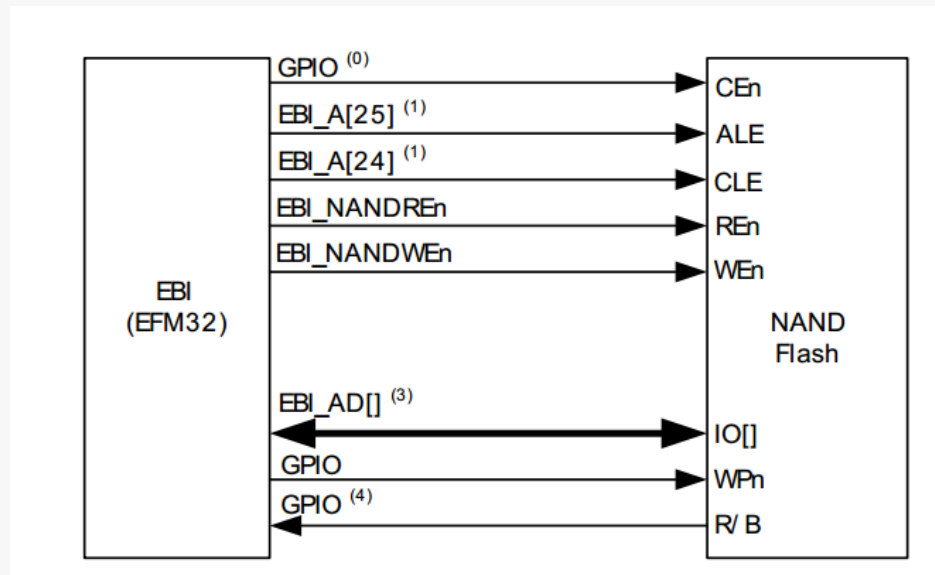


Automatic Data Width Translation

Data Access by Cortex-M3, DMA, or prefetch	8-bit External Device (non-NAND) transaction(s)	16-bit External Device (non-NAND) transaction(s) (with byte lanes)	16-bit External Device (non-NAND) transaction(s) (without byte lanes)	8-bit NAND Flash transaction(s)	16-bit NAND Flash transaction(s)
8-bit read	1 x 8-bit read	1 x 8-bit read (using byte lane)	1 x 16-bit read	1 x 8-bit read	1 x 16-bit read
16-bit read	2 x 8-bit read	1 x 16-bit read	1 x 16-bit read	2 x 8-bit read	1 x 16-bit read
32-bit read	4 x 8-bit read	2 x 16-bit read	2 x 16-bit read	4 x 8-bit read	2 x 16-bit read
8-bit write	1 x 8-bit write	1 x 8-bit write (using byte lane)	1 x 16-bit read; 1 x 16-bit write (read-modify-write)	1 x 8-bit write	- (Hard fault)
16-bit write	2 x 8-bit write	1 x 16-bit write	1 x 16-bit write	2 x 8-bit write	1 x 16-bit write
32-bit write	4 x 8-bit write	2 x 16-bit write	2 x 16-bit write	4 x 8-bit write	2 x 16-bit write

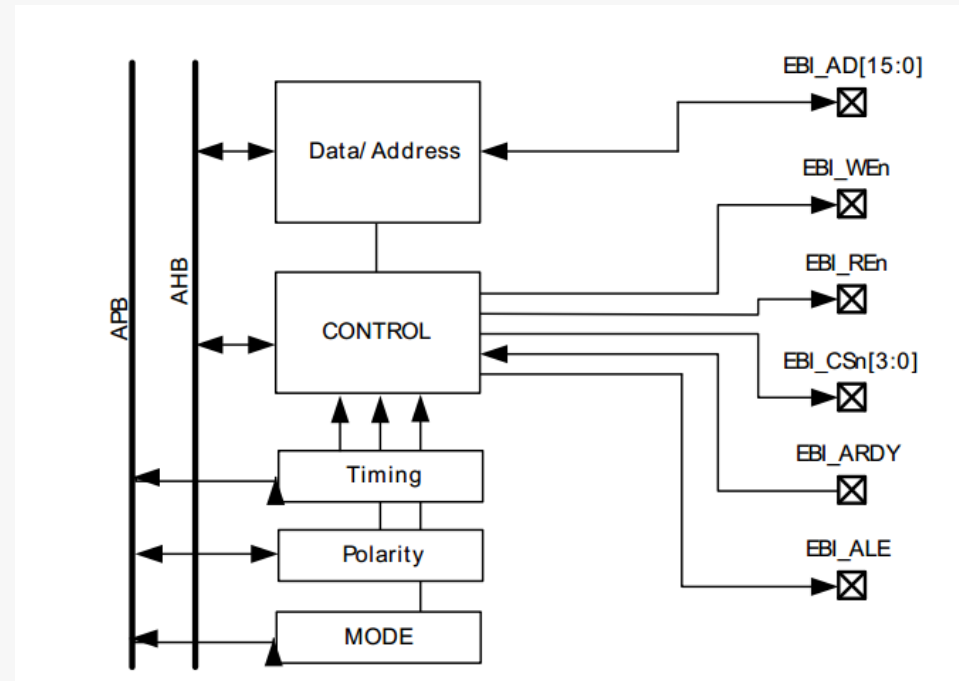
NAND Flash

- NAND Flash timing
- Single bit error correction
- Double bit error detection
- NAND Flash SW driver in example for EFM32GG-STK3700
 - Simple driver. No wear-leveling, bad block allocation etc.

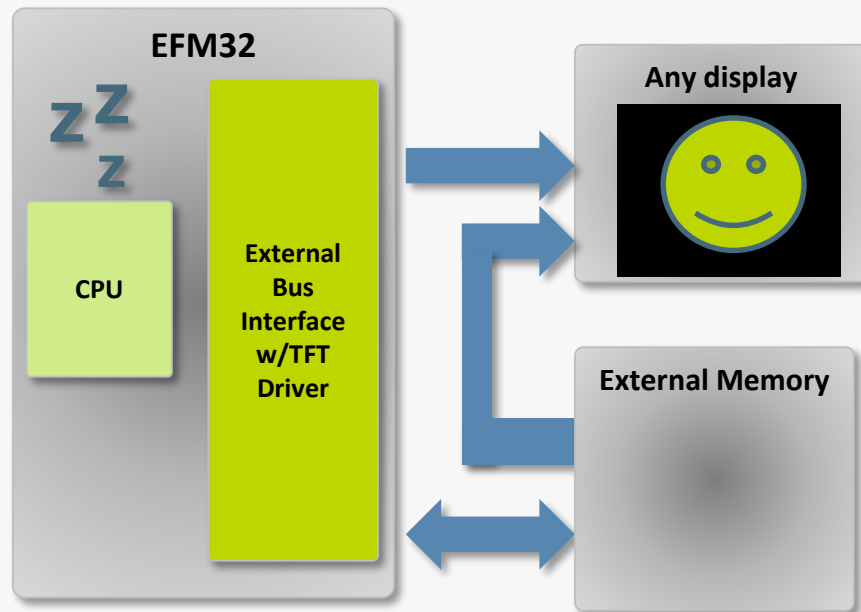


Gecko EBI

- EFM32G parts have a limited version of EBI
- No NAND flash support
- No TFT Direct Drive
- No individual bank timing
- No EBI_A lines
- No byte lane support
- No prefetch unit or write buffer
- No data width translation

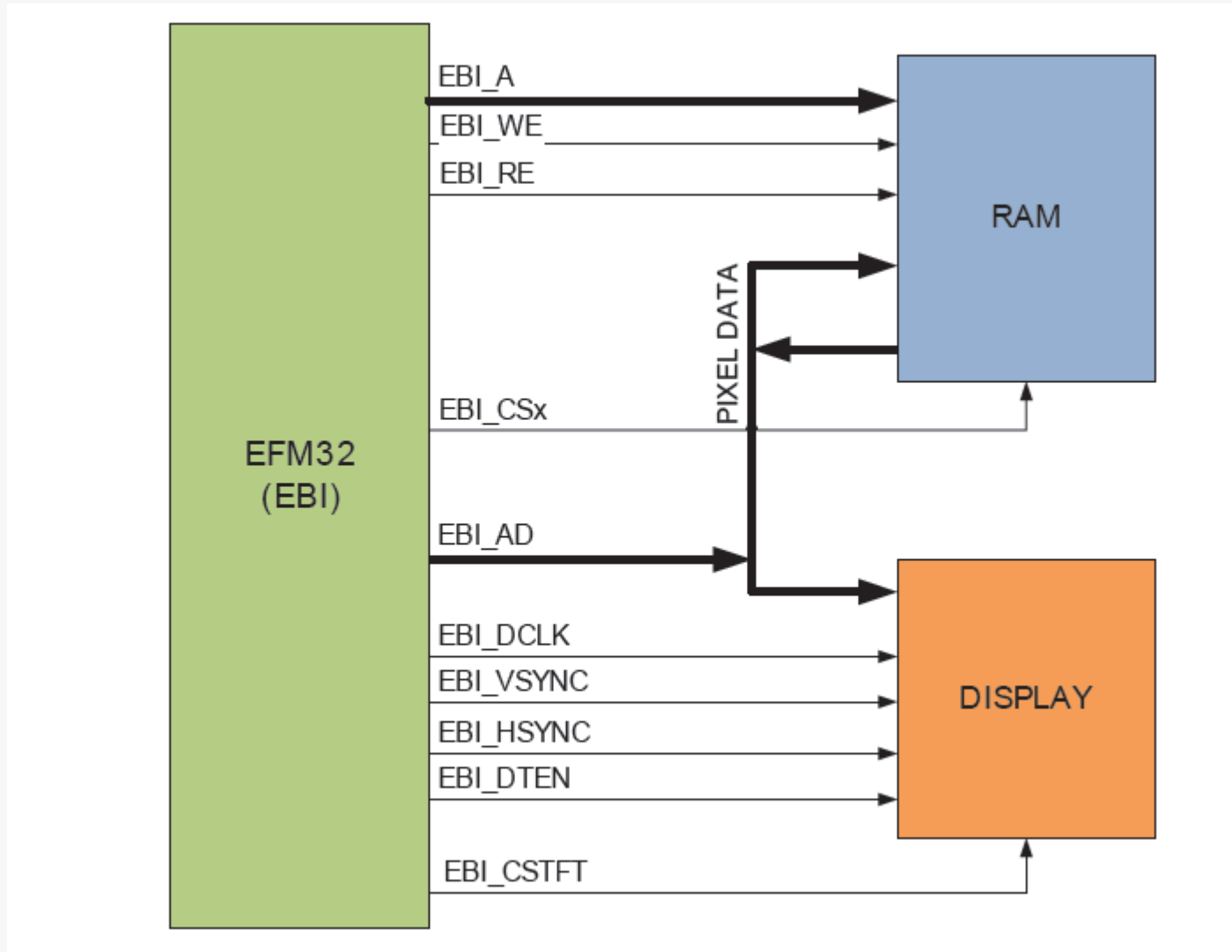


TFT Direct Drive

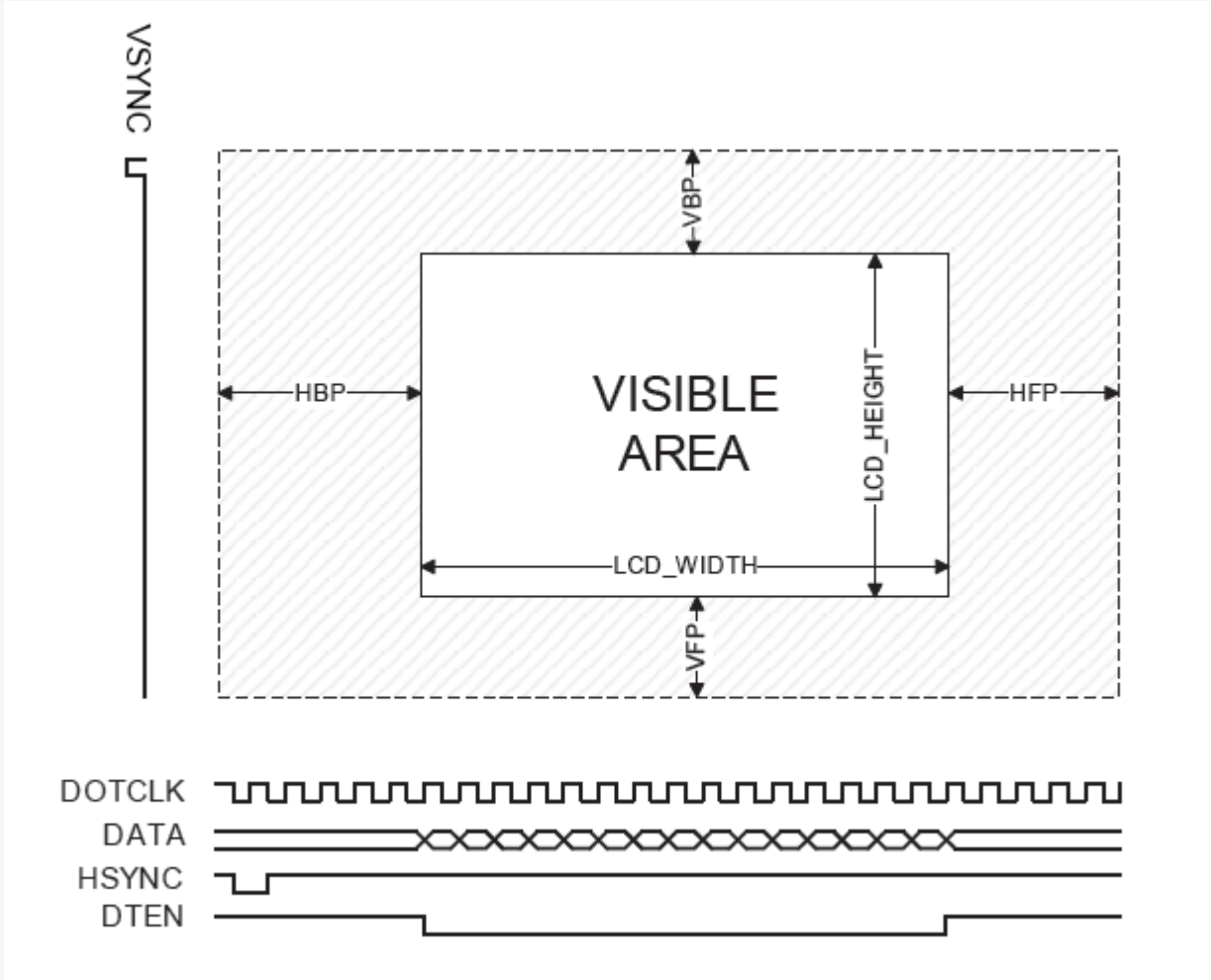


- Specially designed HW-TFT-driver solution.
- CPU fully in offloaded when static image is displayed.
- blending/scrolling/masking features in hardware.
- CPU-accesses can be interleaved with TFT-accesses.
- Configurable timing

Connection Diagram



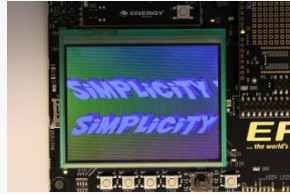
TFT Timing



Direct Drive Configuration

- Display width/height (in pixels)
- Pixel size (8 or 16 bit)
- Control signal polarity
- Timing for VSYNC, HSYNC and DLCK
- Size of porch intervals
- Address and EBI bank of frame buffer
- Interleaved CPU access

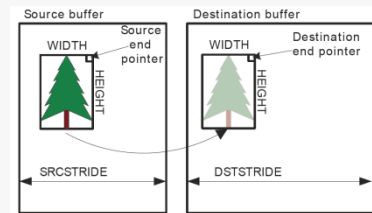
Direct Drive HW Accelerated Features



➤ Scrolling



➤ Alpha blending



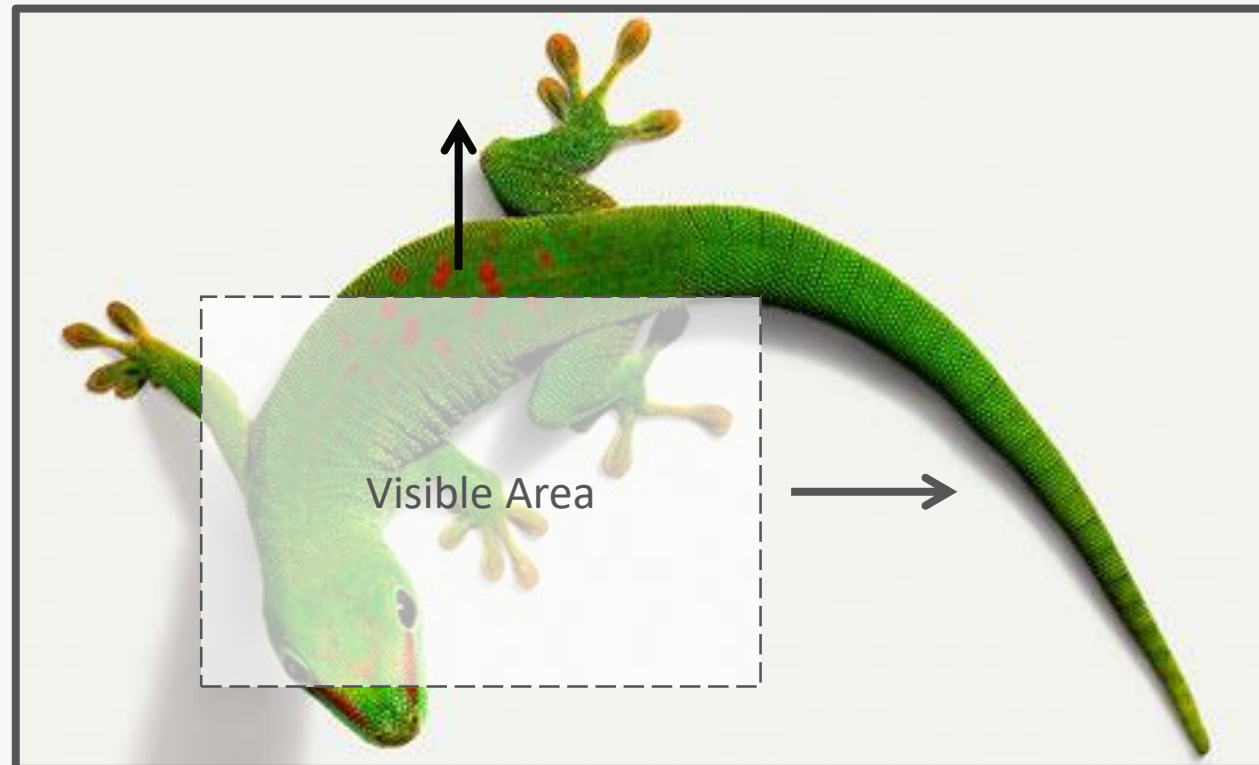
➤ Rectangular copy



➤ Masking

Scrolling

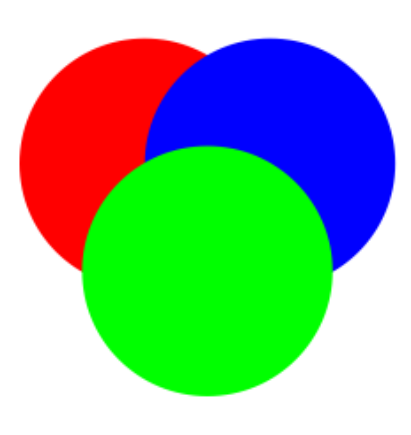
- Frame buffer larger than display size
- Programmable HSTRIDE
- Scroll by reprogramming EBI_TFTFRAMEBASE



Alpha Blending

EBI Alpha Blending Equation

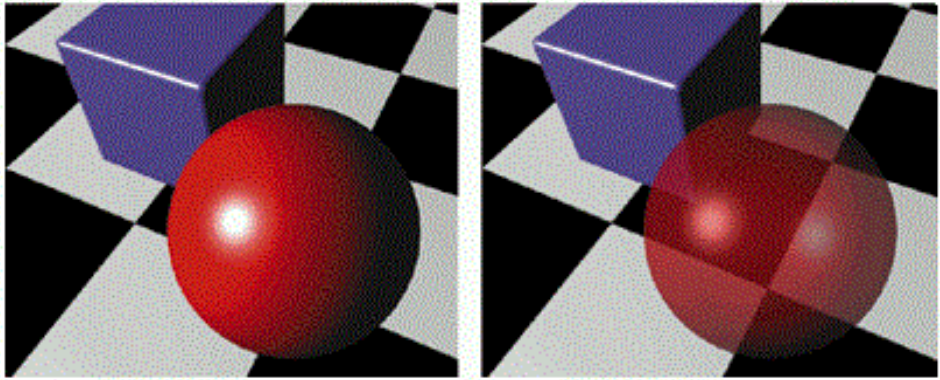
$$\text{AlphaBlend}(\text{Color0}, \text{Color1}) = ((\{R0, G0, B0\} \times \text{EBI_TFTALPHA}) + (\{R1, G1, B1\} \times (256 - \text{EBI_TFTALPHA}))) / 256$$



Alpha blending



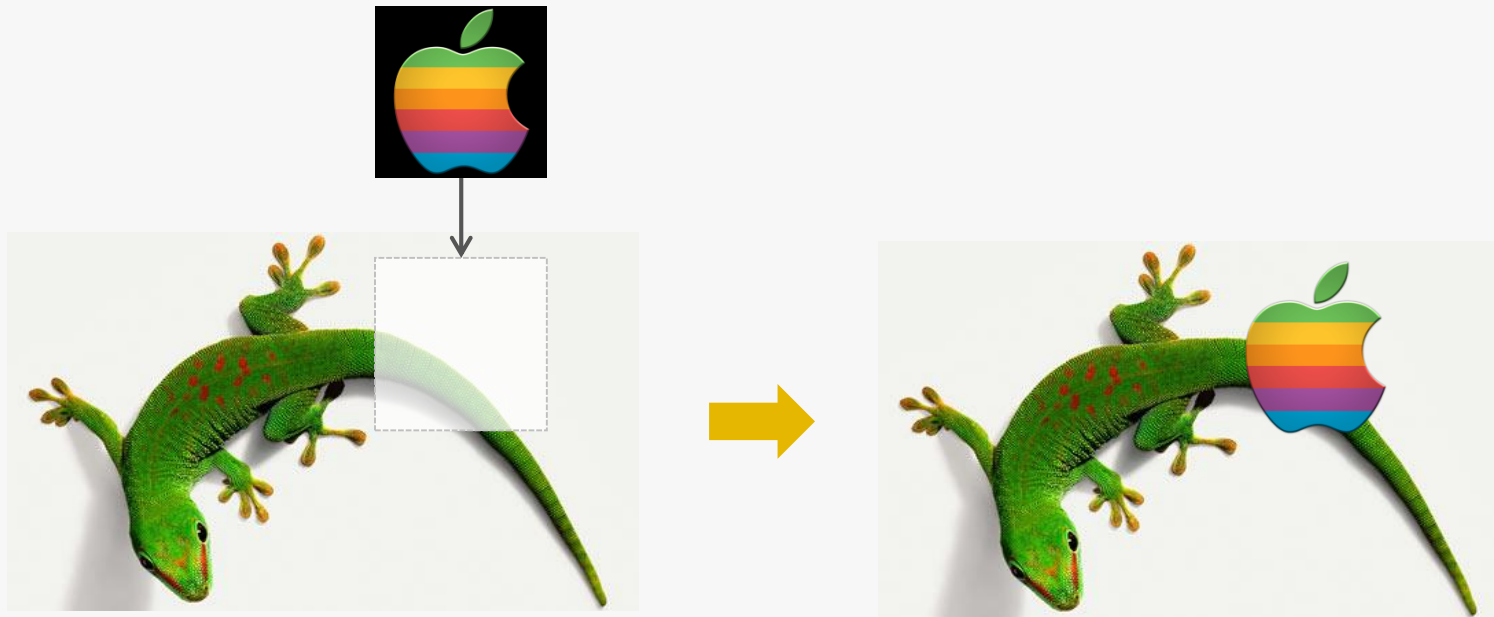
Alpha blended



Application example

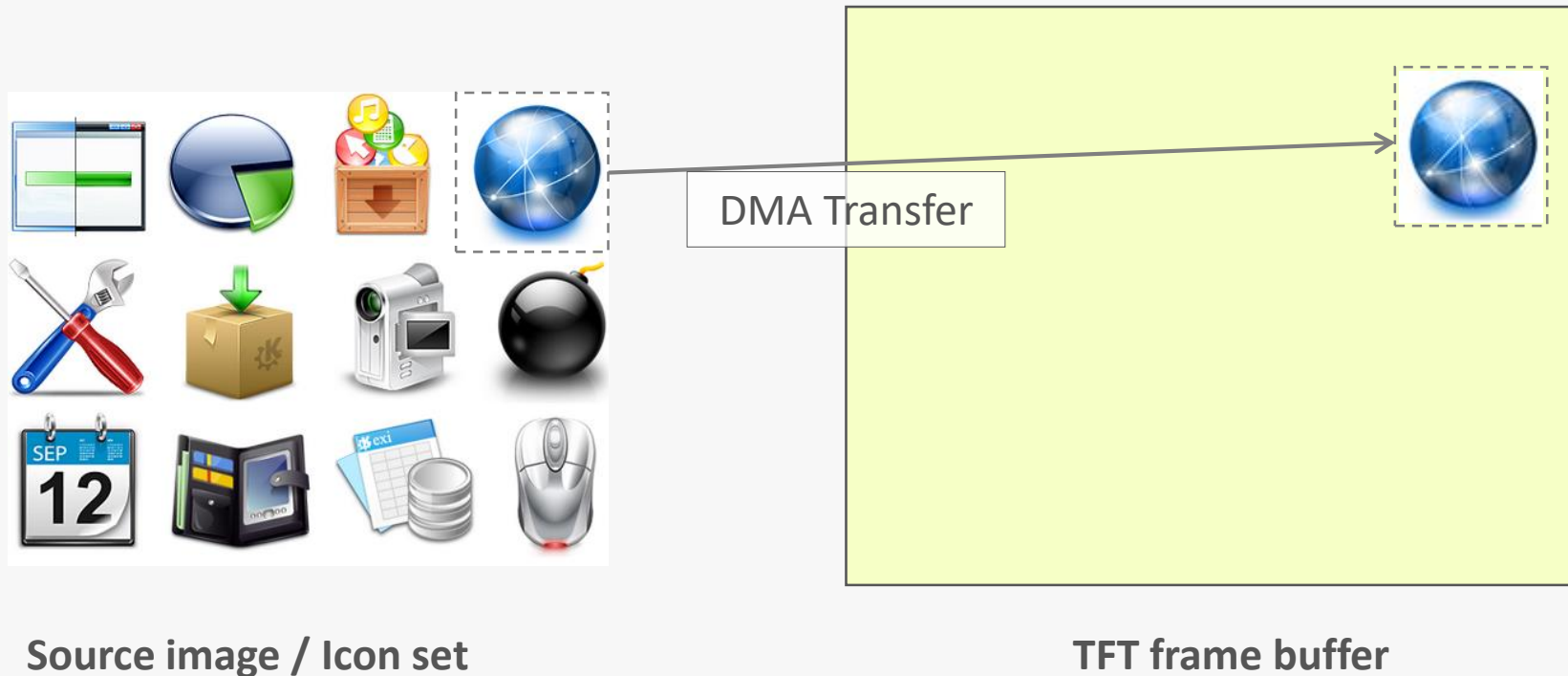
Masking

- Suppress pixel writes that match EBI_TFTMASK
- Useful for drawing overlays, icons etc.



2D Copy

- DMA can transfer arbitrary rectangle between two frame buffers
- All dimension are configurable
 - Source frame buffer, dest frame buffer, rectangle dimensions
- Can be used together with masking or alpha blending



SEGGER emWin Graphical Library

- Free in Simplicity Studio!
- Examples for DK3750 / DK3650
 - Reversi
 - Guidemo
 - Graphxy
- Application note
 - AN0047 Interfacing Graphical Displays
- Tools
 - GUI Builder
 - Font converter
 - Bitmap Converter





Segment LCD Controller

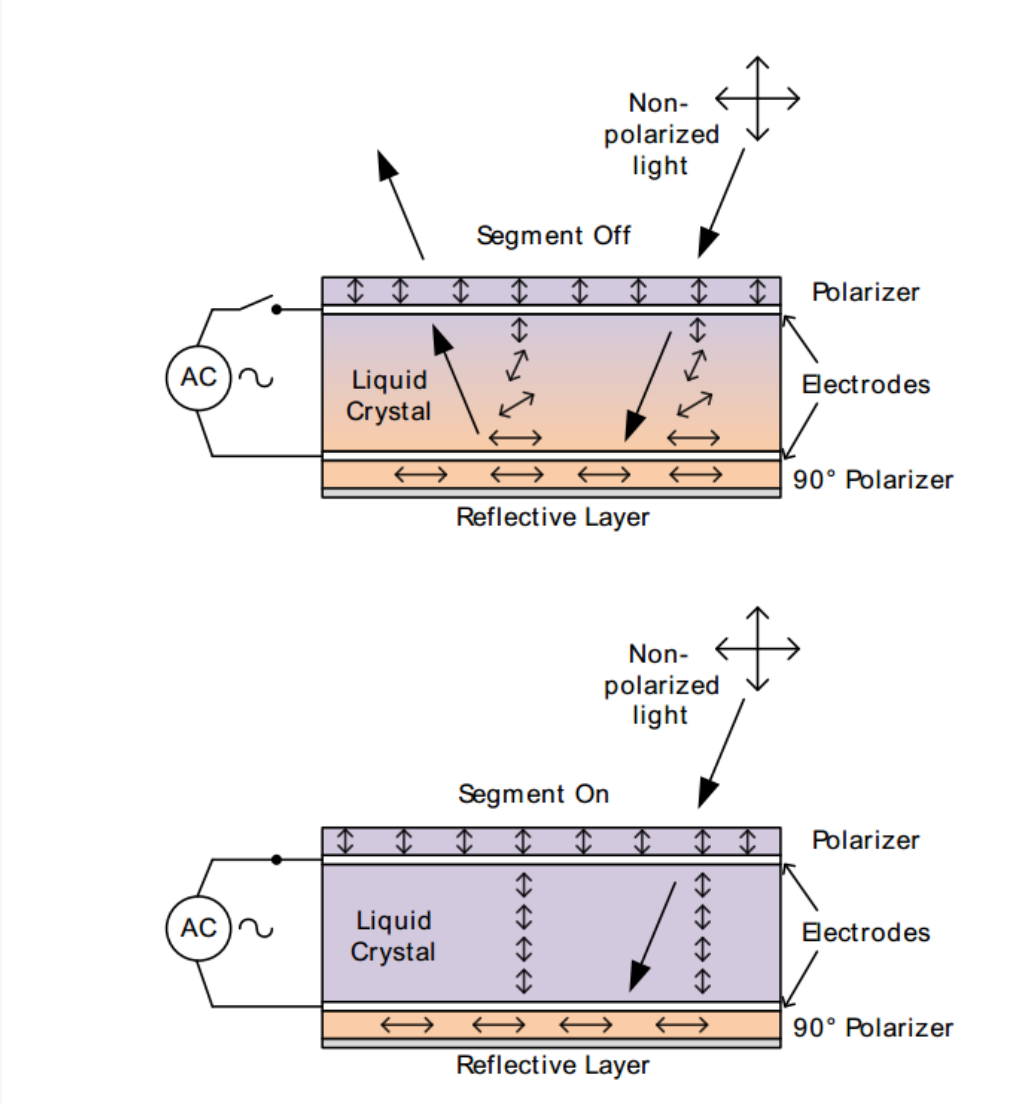


Segment LCD Controller

- Up to 8x36 segments
- Configurable multiplexing
- Configurable bias / voltage levels
- Configurable frame rate
- Autonomous operation in EM2
 - Animation
 - Running off low frequency clock (LFRCO or LFXO)
- Low power waveforms
- Voltage booster

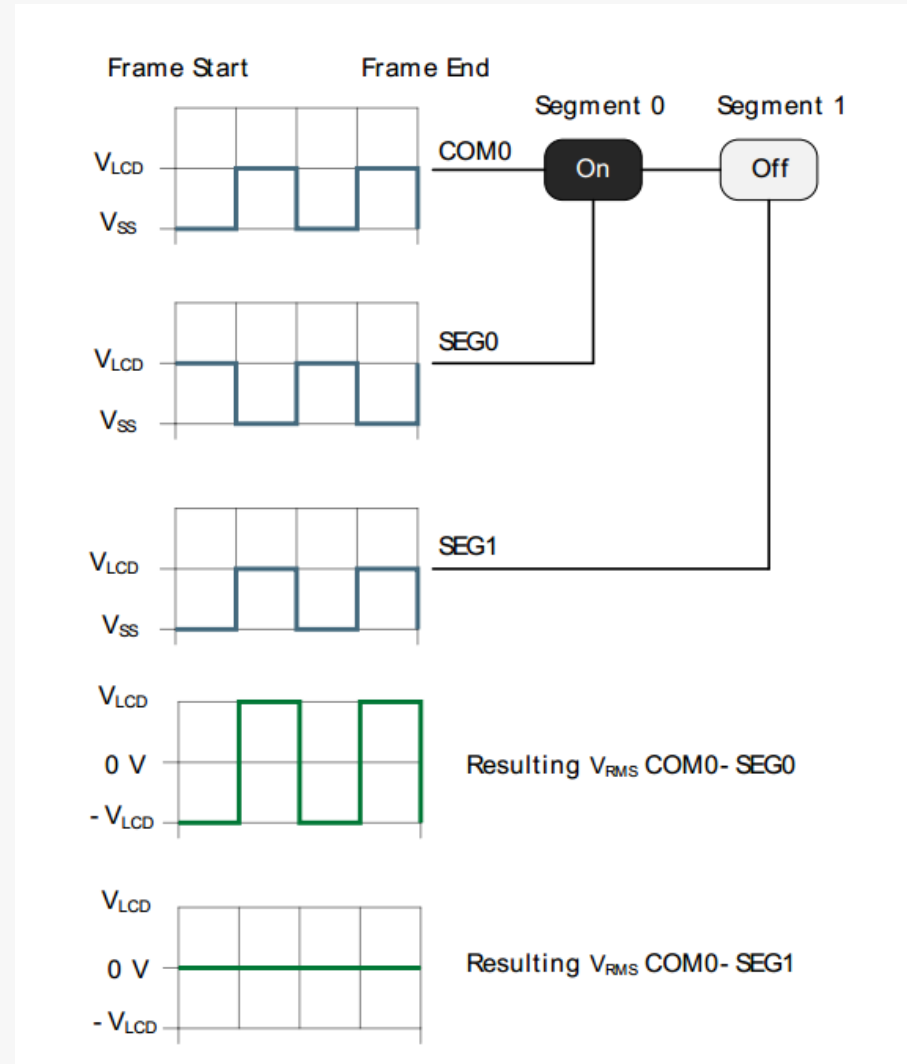


Liquid Crystal Displays



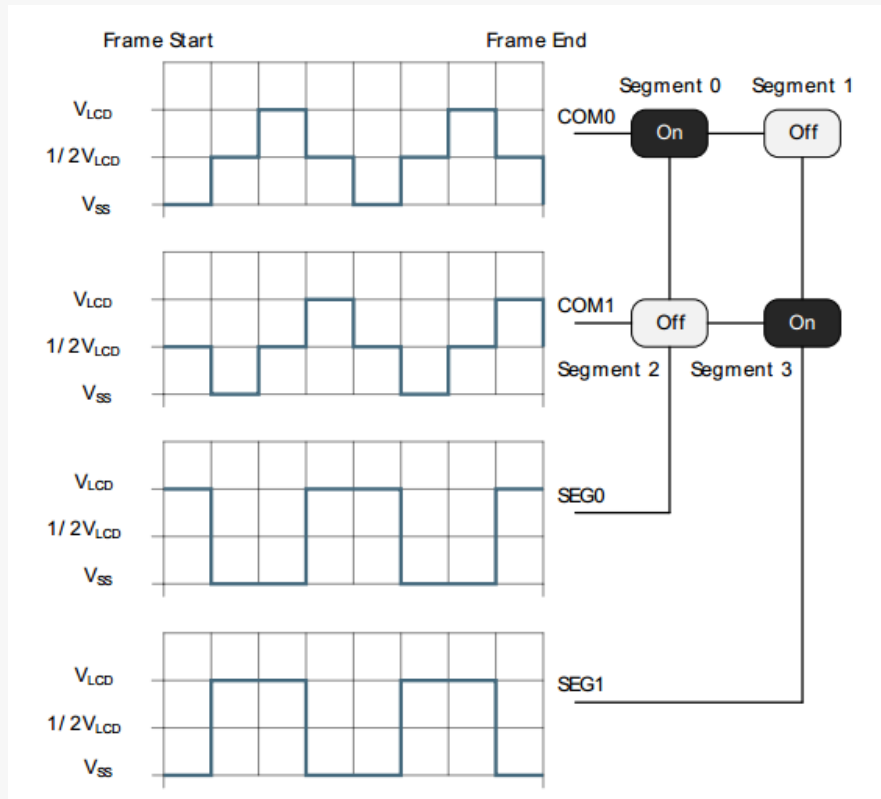
Waveforms

- LCDs will degrade if DC voltage is applied over time
- Segments are connected to common (COM) and segment (SEG) lines
- Same waveforms on COM and SEG => segment OFF
- Opposite waveforms on COM and SEG => segment ON



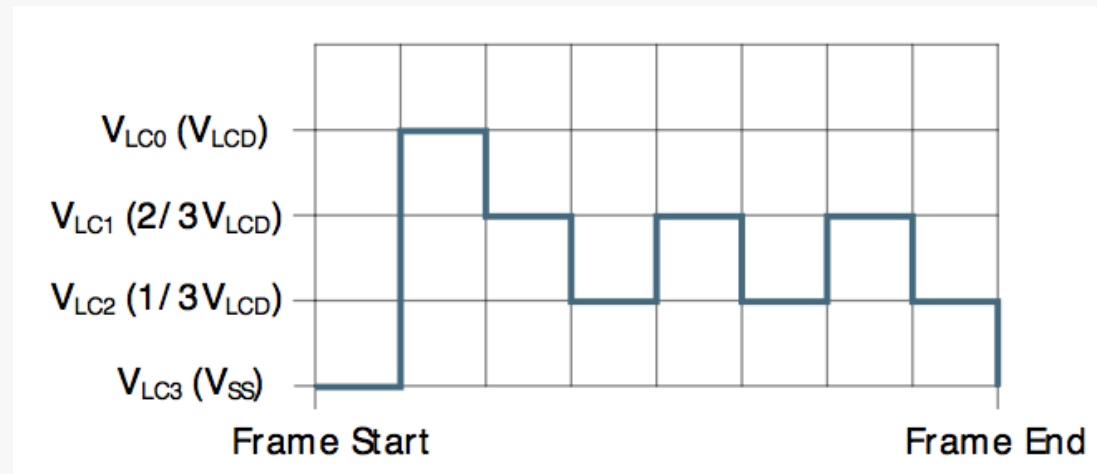
Multiplexing

- Multiplexing controls more segments with fewer pins
- Possible configurations
 - 1x40, 2x40, 3x40, 4x40, 6x38, 8x36

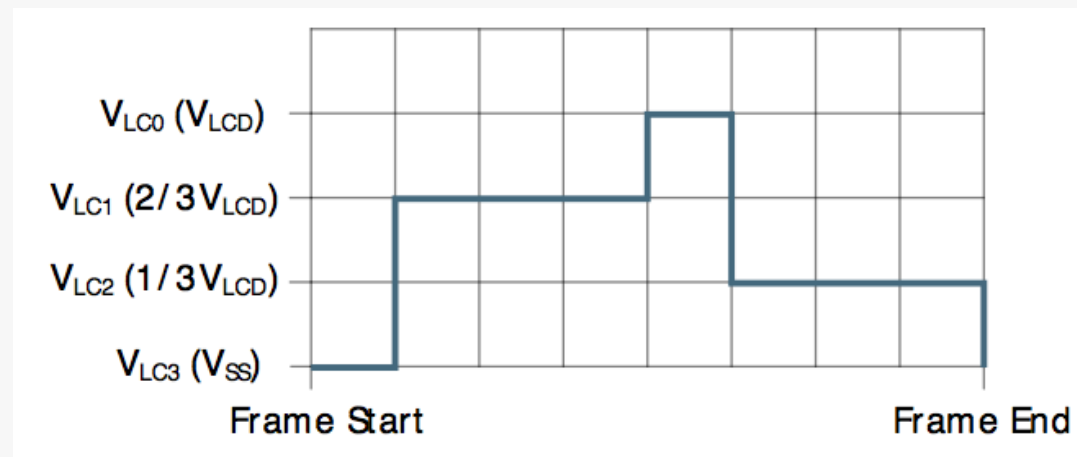


Low Power Waveforms

Normal waveform

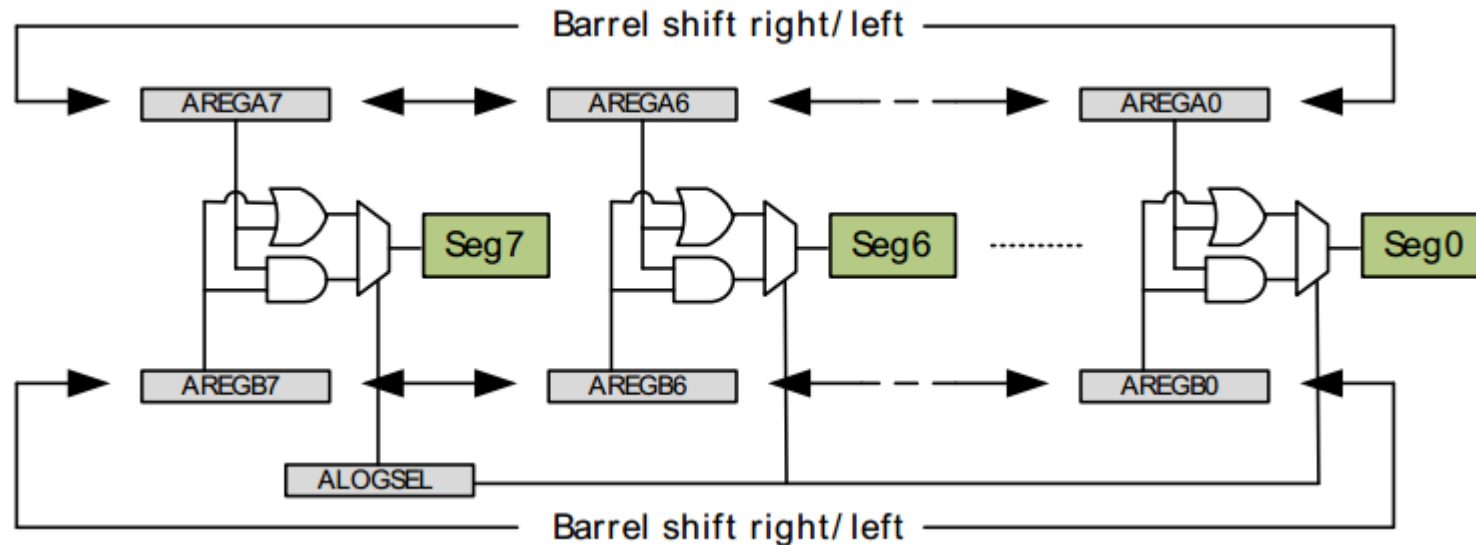


Low power waveform



Animation and Blinking

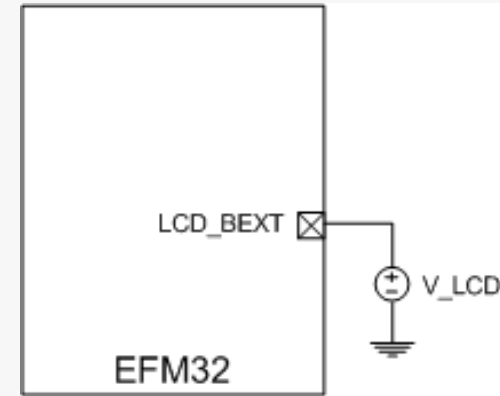
- Segments 0 to 7 multiplexed with COM0
- 2 programmable 8 bit animation registers: AREGA, AREGB
- Animation registers shifts left/right on frame counter event
- OR/AND of animation registers give segment status
- Total 16 states possible



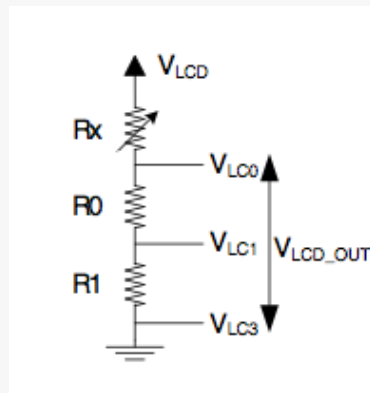
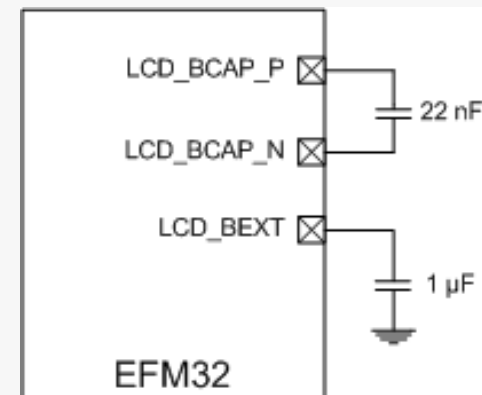
Contrast Control

- EFM32 can run down to ~2 V
- Segment LCDs loose contrast as voltage drops
- Segment LCD driver includes voltage booster
- LCD can also be driven from external supply up to 3.6 V independent on VMCU
- Contrast ratio can be set with CONLEV

External LCD supply



Voltage booster



$$V_{LCD_OUT} = V_{LCD} \times 0.5(1 + CONLEV/31)$$



Low Power Graphical Displays
E-paper and Memory LCDs



E-paper

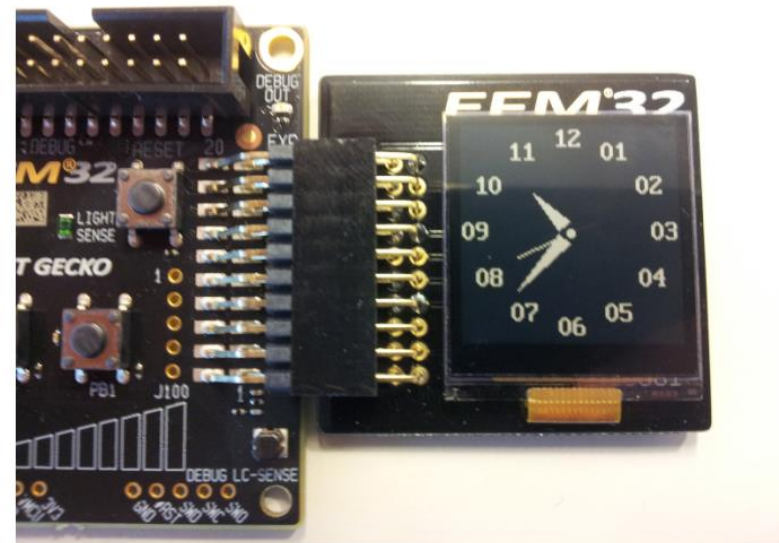
- Draws *no* power when showing static image
- Excellent contrast in ambient light
- High voltage needed for update
- Long update time (1 – 2 seconds)
- Applications
 - Electronic shelf labels
 - Industrial signage
 - E-readers
- Application note AN0063
 - EPD Kit from PDI

http://www.pervasivedisplays.com/kits/ext_kit



Memory LCD

- Draws very little power with both static and dynamic content
- Simple SPI protocol
 - DMA possible
- 3.3 V operation
- Good contrast ratio
- Applications
 - Smart watch
 - Pulse watch
 - ZG STK
- Application note AN0048
 - Module not in sale, but schematics are included



Hands-on

1. Open AN0047
2. Set TFT in 'EFM' mode
3. Compile and upload
4. Create a new image
 1. Open emWin bitmap converter: `reptile/emwin/exe/bmpconv.exe`
 2. Open a image in the bitmap converter. PNG or BMP, not JPG
5. Save image as .c file
6. Include image in project
7. Edit code to use the new image