Application Note AN100

A composite video interface for the ME3203

1 Introduction

The MicroEmissive Displays ME3203 device is an innovative display that uses Polymer OLED technology to provide a high quality micro-display suitable for use in many consumer digital imaging and video products.

The ME3203 has a fully digital video interface allowing it to be directly driven by the highly integrated digital video ASIC's typically found in consumer digital stills cameras and DV products.

In products that are required to support analogue composite video (NTSC or PAL) a video decoder IC is required to convert from the analogue video signal into a digital form suitable for the ME3203 micro-display.

This application note describes a circuit that uses such a video decoder IC. It illustrates the use of several features of the ME3203 micro-display that allow a fully functional circuit to be built using only a minimal number of auxiliary components.

The circuit provides the following features:

- Auto-detection of NTSC/PAL formats.
- Auto power down when video signal not present.
- Image brightness control.
- Low power consumption, up to ten hours of operation from two AAA batteries.

The circuit described below has been built and tested. The full schematic can be found in Section 7 of this document.

It should be noted that the circuit was designed primarily to fulfil a "proof of concept" role. As such, scope exists for further circuit optimisation aimed at cost reduction.

Please contact MicroEmissive Displays Ltd for guidance as to circuit changes that would be appropriate for a production design.

2 Circuit Overview

2.1 System Overview

Three main IC's are used in the circuit, a Texas Instruments TVP5150A video decoder, a ME3203 Polymer OLED micro-display and a Microchip PIC 12F629 microcontroller.

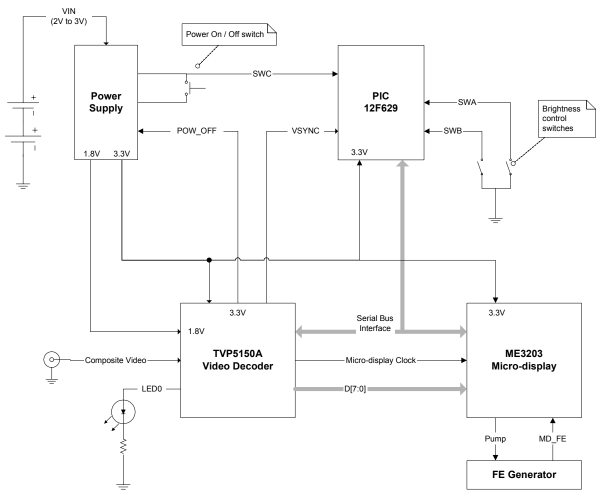
The TVP5150A decodes analogue composite video and generates an ITU Rec. BT.656 standard digital video stream.

The ME3203 micro-display receives the BT.656 format data and drives a full colour image onto its Polymer OLED display surface.

The PIC microcontroller is used to initialise both the TVP5150A and the ME3203. In addition it is used to provide a basic user interface to control the system.

Figure 2-1 shows how these main components are connected.

Figure 2-1 : System Overview



The power supply circuit uses a step-up DC-DC converter to generate 3.3V from the VIN input. A linear LDO 1.8V regulator is used to supply the additional 1.8V voltage required by the TVP5150A device. Both regulators have shutdown inputs that are used to switch off power to the main IC's when the circuit is not operational. A simple latch within the power supply block is used to maintain this shutdown signal when power is removed from the rest of the circuit.

The FE Generator block contains discrete support components required by the ME3203 brightness control circuit.

3 Circuit Operation

The complete schematic for the circuit can be found in Section 7.

3.1 TVP5150A

The support circuit surrounding the TVP5150A device is largely based on recommendations found in the following Texas Instruments documents.

- SLEA021, October 2003 "TVP5150A Frequently Asked Questions – FAQs"
- SLEU044, October 2003 "TVP5150A Quick Start Guide"

Please refer to these documents, together with the TVP5150A Datasheet, for details of these support components.

3.1.1 Configuration

Configuration of the TVP5150A is done by the PIC micro-controller. When the system is switched on it uses the serial bus interface to write to the configuration registers of the TVP5150A.

The TVP5150A is configured to accept analogue composite video on its AIP1A input pin, and deliver BT.656 format digital video on the YOUT0-YOUT7 outputs.

The format of the composite video signal (NTSC or PAL) is automatically detected by the TVP5150A.

The PIC microcontroller periodically interrogates the TVP5150A, via the serial bus, to find out the video format currently in use. The PIC will use this value to ensure the ME3203 micro-display is configured correctly for the current video format.

The *VSYNC/PALI* output is configured to output the VSYNC signal. The PIC microcontroller may use this signal to synchronise its operation with the frame time of the incoming video.

NOTE – the VSYNC signal is provided to easy the implementation of certain advanced firmware features, but its use is not required for the basic operation of the circuit as described in this document.

The *FID/GLCO* output is used to drive an LED indicator. The output is configured to drive high, and light the LED, when the decoder is correctly locked to both the horizontal and vertical timing of the incoming video signal.

The *INTREQ/GPCL/VBLK* output can be used as a user controllable input/output. In this circuit, it is used to drive the POW_OFF input of the power supply block in the following manner: when the system is active it is configured as an input to make it high-impedence; when it required to power down the circuit the output is configured to drive to a high state. Driving the POW_OFF signal momentarily high will cause the power supply block to transition to the power-off state.

Table 3-1 shows the TVP5150A register settings required for the basic operation of the circuit.

Table 3-1 : TVP5150A Register Settings

Register	Data	Notes
MISC_CTRL	0x1D	Enabled output signals. FID is lock output. GPCL is input.
MISC_CTRL	0x7D	Enabled output signals. FID is lock output. GPCL is output driven high.
CONFIG_SHARED	0x42	User defined GPCL H & V lock indicator

3.2 ME3203

3.2.1 SBI

The ME3203 micro-display is configured by the PIC microcontroller via its serial bus interface.

3.2.2 BT.656 Interface

The ITU Rec. BT.656 format data consists a clock that runs at approximate 27MHz (the exact frequency depending on the video standard), plus 8 data signals.

Special embedded timing codes, within the 8 bit data stream, are used for video synchronization.

The pixel data within the BT.656 data stream is coded in YCrCb color-space form. The ME3203 incorporates a color-space converter to transform this YCrCb data into RGB data suitable for display by the Polymer OLED display surface.

3.2.3 Configuration

The ME3203 micro-display is configured by the PIC microcontroller after power-on.

Table 3-2 shows the register values written during the configuration of the ME3203.

As can been seen the MODE register is written to twice during the configuration sequence. Once at the start of the sequence to transition ME3203 from *Power-Down* mode and into *Idle* mode. At the end of the sequence it is then written to again to put the display into *BT656* mode.

NTSC and PAL format require slightly different settings due to their different pixel resolutions. To ensure the ME3203 correctly displays the centre portion of the image the ROW_START register must be altered to match the video format being decoded by the TVP5150A. The PIC microcontroller periodically interrogates the TVP5150A to check the video format and will rewrite the value to the ROW_START register if it has changed.

The value shown for the BRIGHTNESS_DATA register is the default value. The PIC firmware allows the user to adjust this up and down by pressing SWA and SWB.

Table 3-2 : ME3203 Register Settings

Register	Data	Notes
MODE	0x01	Request Idle mode
POLARITY	0x03	Rising edge clock VSYNC high
CLKMAX	0x03	Required for correct operation with a clock of up to 30 MHz.
BT656_CTRL	0x04	Disable line dropping
CONFIGURATION	0x1B	Free-run PCM Split PM5 Progressive scan Inverted Mirrored
DATAPATH	0x20	Enable dither Gamma 2.2
DV_MASK	0x28	Mask out first 40 pixels.
ROW_START	0x10 0x28	PAL operation 0x28 NTSC operation 0x10
PM0	0x01	
PM1	0x02	
PM2	0x04	
PM3	0x08	
PM4	0x10	
PM5	0x10	Split PM5 mode requires this to be half the normal value.
BRIGHTNESS_CTRL	0x93	
BRIGHTNESS_DATA	0x0B	
BRIGHTNESS_FREQ	0x34	
MODE	0x03	Request BT656 mode

3.3 FE Generator

The ME3203 micro-display requires a negative bias voltage on it's Front Electrode(FE) pin. To minimise the system component count a switched mode inverting voltage regulator is integrated on the ME3203. This regulator is referred to as the "FE Generator". The FE Generator requires a small number of discrete external components to operate.

The target voltage of the FE Generator is digitally controlled via the serial bus interface of the ME3203, thus providing an overall brightness control for the micro-display.

Please see the *MED Application Note AN101 – "Brightness control of ME3203"* for further details of the operation of the FE Generator block.

3.4 Power Supply

The power supply circuit uses separate voltage regulators to provide 3.3V and 1.8V outputs. Two CMOS NAND gates are connected into a flip-flop configuration and used to latch enable, or disable, signals to the regulators.

The circuit has been designed to operate from a battery supply of between 2V and 3.3V. This could be provided by a pair of alkaline, NiMh or NiCd batteries.

The 3.3V output is provide by a Maxim MAX1796 Step-Up DC-DC converter which will function for an input voltage as low as 1V. It should be noted that this Maxim regulator is capable of sourcing far more current than is required for this circuit. It has been included in this circuit purely due to historical reasons.

The 1.8V supply is provided by a Torex XC6204B18 LDO regulator. This part requires an input voltage in the range 2 to 10V for correct regulation of the supply.

Both regulators have inputs that allow them to be put into a shutdown state in which they generate no output and draw minimal current. The flip-flop and the associated components on its inputs are used to provide the following functionality:

- When power is first applied to the circuit the regulators are put into shutdown state.
- When switch SWC is momentarily pressed the regulators are enabled.
- When POW_OFF is briefly driven high the regulators are put into shutdown state.

The NAND gates are powered directly off the battery input and so keep their state independent of the 3.3V and 1.8V supply state.

3.5 PIC 12F629

The PIC 12F629 is a highly integrated microcontroller that includes on-chip all the support components normally required by microcontrollers, e.g. oscillator, POR, brown-out detect.

3.5.1 Configuration Bits

The following PIC configuration bits are set when the 12F629 firmware is programmed.

- BODEN = 1, Brown-out Detect is Enabled
- MCLRE = 0, GP3/MCLR is user I/O.
- PWRTE = 0, Power-up Timer is Enabled
- FOSC[2:0] = 100b, Internal Oscillator, GP4/5 is user I/O.

3.5.2 Start-up delay

After power-on the PIC firmware executes a software delay of 200ms before it attempts to configure the TVP5150A device. This is to allow the RC reset circuit connected to the TVP5150A to release it from reset.

3.5.3 Power Supply Control

SWC is the On / Off switch for the system. The power supply block handles the system *Shutdown* to *Active* transition internally, but the *Active* to *Shutdown* transition is controlled by the microcontroller.

When the system is active the microcontroller monitors the SWC state. When it detects a switch press it will request that the TVP5150A drive the POW_OFF signal high, thus putting the system to shutdown state.

The microcontroller also periodically checks whether the TVP5150A has is currently locked to the incoming video signal or not. If lock has been lost for more than a pre-determined time then the microcontroller will also put the system into shutdown state.

3.5.4 Brightness Control SWA / SWB

SWA and SWB are used as Up / Down controls for the overall brightness of the display.

The microcontroller monitors these switches and then uses the serial bus interface of the ME3203 to adjust the value in the BRIGHTNESS_DATA register. This register adjusts the target voltage for the on-chip switch mode regulator circuit, and thus modifies the bias voltage applied to the FE pin of the ME3203.

3.5.5 In-Circuit Serial Programming

Because of the careful choice of GPIO function allocation the PIC microcontroller may be programmed while in situ within the circuit. Care should be taken to remove the supply to the VIN input before connecting the circuit to a programmer. Also care must be taken not to press switches SWA or SWB while programming!

3.5.6 Tasks

Initialise the TVP5150A device.

Initialise the ME3203 micro-display.

Detect NTSC/PAL type by monitoring the TVP5150A registers.

Write correct value into ME32030 ROW_START register to match the detected video format.

Detect “lost lock” condition(no video present) condition by reading the TVP5150A registers.

Switch off supply when video not detected for more than 15 seconds.

Monitor switches SWA and SWB to detect user requests to modify display brightness.

Modify the ME3203 BRIGHTNESS_DATA register to adjust brightness as requested by user.

Switch of power supply if SWC pressed.

3.5.7 Future Development

Further features could be added to the system by additions to the firmware. For example:

- Control of contrast, saturation and hue. Via TVP51050A registers.
- Image mirroring and inversion. Via ME3203 registers.

Selection of an advanced setup mode to modify these settings could be done by using a “both SWA and SWB pressed” trigger. The rocker switch used on the prototype board was of a “jog dial” type that allowed the user to easily simultaneously press both switches.

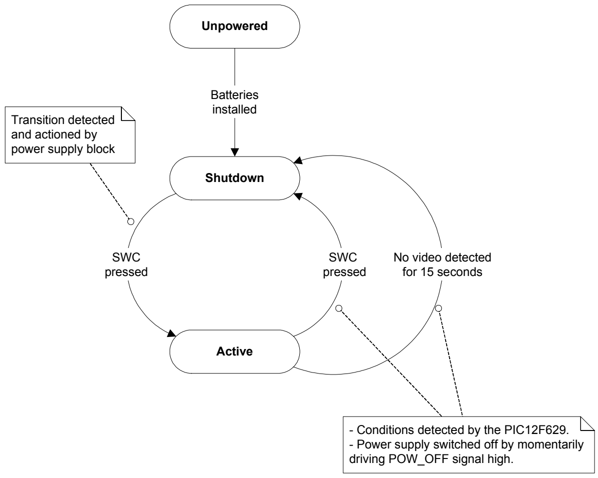
If a PIC microcontroller with more available GPIO pins was used in the design it would be possible to add textual menus to the user interface. In such a system the ME3203’s Random Row Access (RRA) mode could be used to allow the PIC to display menu options on the ME3203.

4 Power Consumption

4.1 Power States

Figure 4-1 is a state diagram that shows the possible power states that the circuit may be in, and the events that trigger transitions between these states.

Figure 4-1 : Power state diagram



4.1.1 Unpowered

No batteries in the system.

- VIN = 0V
- VD3_3 = 0V
- VD1_8 = 0V

4.1.2 Shutdown

Batteries in the system. Power supply block powered, TVP5150A, ME3203 and PIC not power.

- VIN = 2V to 3V
- VD3_3 = 0V
- VD1_8 = 0V

4.1.3 Active

All components powered.

- VIN = 2V to 3V
- VD3_3 = 3.3V
- VD1_8 = 1.8V

4.2 Power Consumption

4.2.1 Shutdown State

The MAX1796 is put into *Shutdown* mode. In this mode no power will be passed to the TVP5150A, ME3203 and the 12F629. The MAX1796 itself typically only draws 2uA in this mode.

The Torex XC6204B18 LDO regulator is also disabled in *Shutdown* mode, in which state it will typically only draw 0.3uA.

Therefore the total current consumption in Shutdown state is 2.3uA.

Power consumption in Shutdown state is, assuming a VIN of 3V, approximately 6.9uW.

4.2.2 Active State

The table below shows the current taken by the various components.

Device	Voltage	Typical Current	Total & Notes
PIC	2V to 3V	<1mA	3mW
Serial Bus Pull-ups	2V to 3V	2 x 0.5mA	3mW – Assumes 2K pull-ups.
TVP5150	3.3V 1.8V	5mA 25mA digital 30mA analogue	115mW total - Values taken from TVP5150A datasheet.
ME3203	3.3V	15mA	50mW - Includes FE generator circuit. Typical image scene.

The DC-DC Converter has an efficiency of over 85% supplying a 20mA load from a 2.4V supply.

The LDO regulator will drop 0.6V and be supplying a 55mA load.

Thus total power consumption for the circuit can be estimated as:

3 + 3 + (17 + 50) / 85% + 132 = 217mW

Current required on the 3.3V supply is:

2 + 5 + 15 = 22mA

Current required on the 1.8V supply is:

25 + 30 = 55mA

Total current required from the battery:

VIN @ 2.4V = 217 / 2.4 = 90mA

VIN @ 2.0V = 217 / 2.0 = 109mA

4.2.3 Battery Lifetime

The power supply block requires an input voltage of between 2V and 3V for correct operation. This could be provided by two battery cells of various types, e.g. alkaline, NiCd or NiHh. Alternatively a single lithium cell could be used.

When calculating battery lifetimes the following assumptions have been made:

Current required in Shutdown mode 2.3uA

Current required in Active mode 100mA

Based on these assumptions Table 6-1 in Section 6 gives the projected battery life for a number of different battery types.

5 Conclusion

This application note has described a low cost, low power interface circuit that can be used to display an analogue composite video signal on the all-digital ME3203 micro-display.

The circuit illustrates a number of features of the ME3203 micro-display:

- Direct, glue-less, connection to BT.656 compatible digital video sources.
- Display brightness control using the integrated voltage regulator (FE Generator).
- Configuration and control of ME3203 using a low cost micro-controller.
- Low power operation suitable for battery powered mobile applications.

6 Projected battery lifetime

Table 6-1 : Projected battery life

Battery Type	Size	Chemistry	Nominal Capacity (mAh)	Capacity @ 100mA (mAh)	Active Lifetime (hours)	Shutdown Lifetime (months)
DuraCell Ultra MX2400	AAA	Alkaline-Manganese Dioxide	not specified	>600	10	400
DuraCell Ultra MX1500	AA	Alkaline-Manganese Dioxide	not specified	>2000	20	1200
Sanyo NiMh	AAA	NiMh	750	700	7	400 (note 1)
Sanyo NiMh	AA	NiMh	1850	>1750	17	1200 (note 1)
Duracell Ultra Ultra123	123	Lithium / Manganese Dioxide	not specified	not specified	10	not specified

1. NiMh batteries tend to have a fairly fast “self discharge” rate, typically 1% per day, thus after 50 days they could be expected to have less than 50% of capacity left.

7 Schematic Diagram