User Guide

TMG3992 EVM and TMG3993 EVM

TMG3992/3

Gesture, Color, ALS, and Proximity Sensor Module with mobeam™ Barcode Emulation Evaluation Kit

Version 1.2

Contents

TMG3992/3

The device features advanced Gesture detection, Proximity detection, Ambient Light Sense (ALS), Color Sense (RGBC), and optical pattern generation/transmission for IR broadcast. The modular 2.36mm x 3.95mm x 1.36mm package (TMG3993) is drop-in compatible with existing modular footprints and incorporates an IR LED and factory calibrated LED driver. The slim modular package, 2.0mm x 3.95mm x 1.36mm (TMG3992) also incorporates an IR LED and factory calibrated LED driver and is pin compatible with the larger modular package.

TMG3992/3 will be used to represent TMG3992 and TMG3993. TMG399x will be used to represent TMG3992 or TMG3993 throughout this document.

Gesture detection utilizes four directional photodiodes to sense reflected IR energy (sourced by the integrated LED) to convert physical motion information (i.e. velocity, direction and distance) to a digital information. The architecture of the gesture engine features automatic activation (based on Proximity engine results), ambient light subtraction, cross-talk cancelation, dual 8-bit data converters, power saving inter-conversion delay, 32-dataset FIFO, and interrupt driven I^2C communication.

Initial hardware setup

The TMG3992/3 EVM is USB plug and play friendly. Follow the instructions found in the Quick Start Guide (QSG). This will load the graphical user interface (GUI) onto the target personal computer along with user documentation. The GUI is only Microsoft windows compatible.

The EVM hardware kit consists of the EVM Controller and the TMG399x daughterboard, a USB interface cable and USB Memory Stick.

When the USB cable is connected, the green LED should flash momentarily indicating that power is being received via the USB interface. The amber LEDs should sequence indicating the controller board processor is running. If the green LED does not flash, check the USB cable connections; unplug the USB cable and try again. If the green LED still does not flash, check the PC for USB error messages.

See the Resources section at the end of this document for additional assistance.

1　Establishing basic functionality

The software should be started using the desktop icon or by double clicking the DigitalLightSensor.exe file from the installation directory. The default installation directory, depending on the device and the operating system you are using, is:


C:\Program Files\ams\TMG399xEVM Windows 32 bit operating systems

C:\Program Files (x86)\ams\TMG399xEVM Windows 64 bit operating systems

When started, four windows will open on the PC. The top window is the Parent Window which initializes USB and detects the optical device connected. This window can be placed out of the way. The bottom window, or Child Window, is the main user interface and should be positioned on the screen for easy access. Two other windows open to the right of the parent window. One displays any gesture (E.g. North, South, East, or West) and the other logs information that pertains to each gesture that is processed. Please refer to the figures below.

To close the GUI, click on the "X" in the Parent Window. Closing any of the other windows will not completely terminate the application.

The "Functional" tab on the left and "Gesture" tab on the right side of the child window main display will be selected by default.
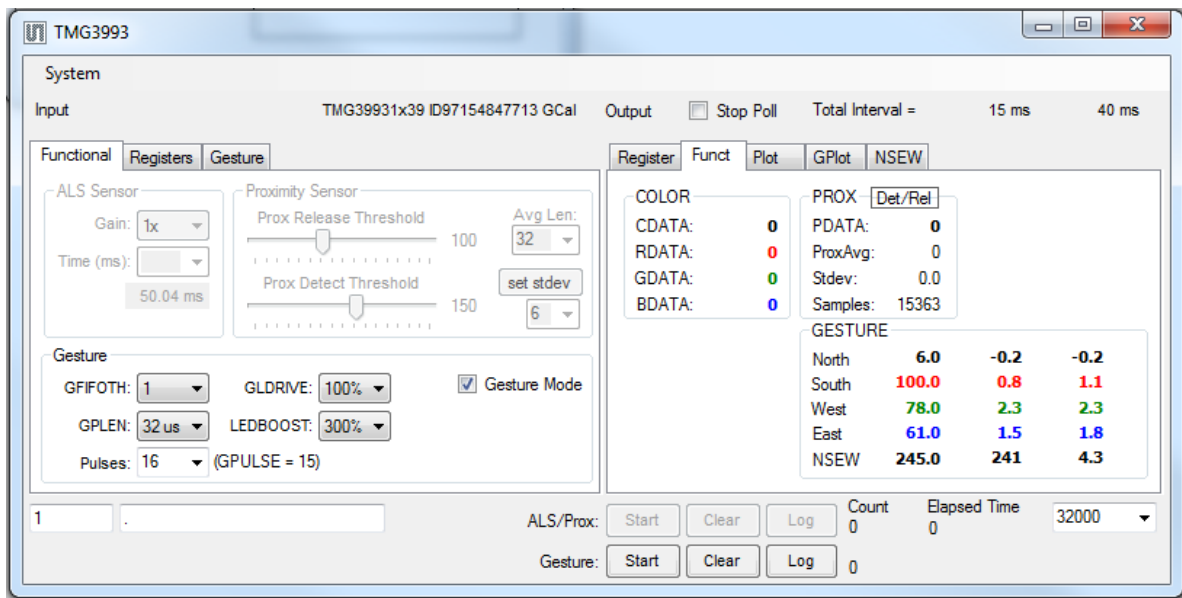
The balance of this document identifies and describes the controls available on the different tabs of the GUI. In combination with the TMG3992/3 datasheet, the quick start guide, and application notes available on the **ams** website, www.**ams**.com, there should be enough information to allow evaluation of the TMG3992/3 device.

## 2   TMG3992/3 EVM graphical user interface (GUI)

2.1   Software Overview

On initialization the software displays three windows – a smaller "Digital Light Sensor" window (the Parent Window), a larger window (the Child Window) containing controls pertinent to the device connected and a third window (the Gesture Window) showing any gesture vectors detected.

If "No Devices" appears, verify that the daughterboard is connected to the motherboard properly. If "No_HID" appears, verify the USB cable is connected. A green LED on the EVM Controller 2.1a will flash to indicate that the USB cable is connected and providing power to the system. The "Reset" button in this window can be pressed, or the software can be restarted, to reinitialize the system.
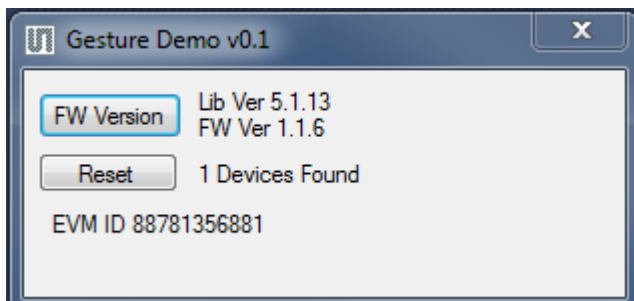

The larger window, Child Window (CW), contains the user interface with control buttons, fields, selection boxes and output values for the device connected. Tabs are used to make control and evaluation of specific device functions easy. For the TMG3992/3 sensor the initial display screen is shown:
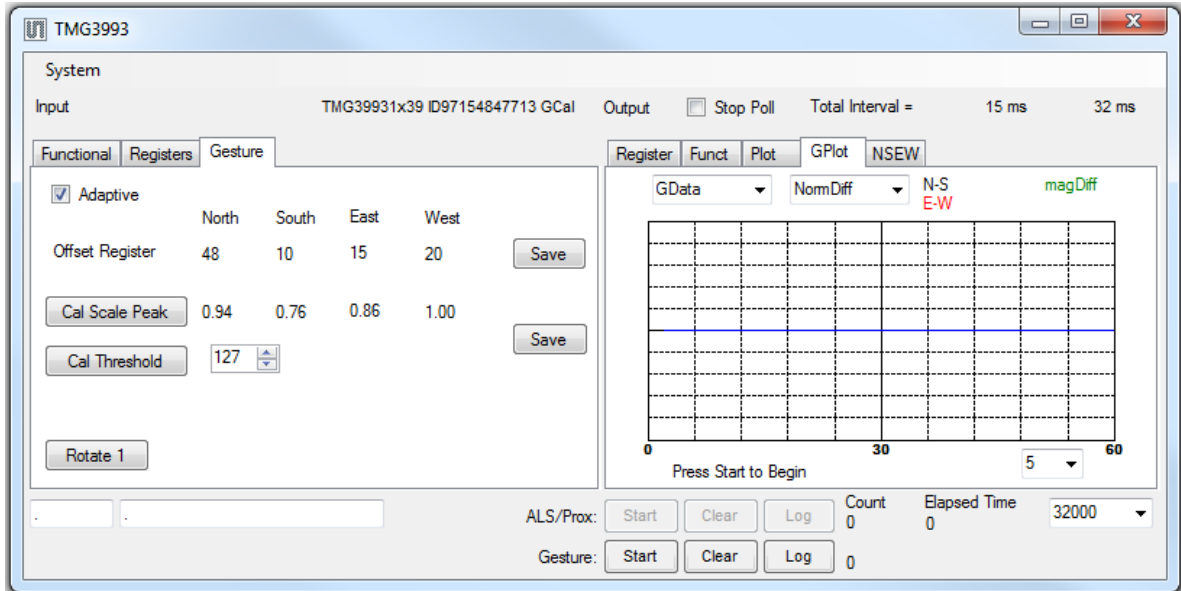
This window has inputs organized on the left, and outputs organized on the right. Values for register variables may be set using multiple techniques. The Functional tab is commonly used to quickly evaluate the device with nominal settings. The Input Register tab allows the register settings to be changed, and the Output Register tab allows registers to be viewed. Other tabs provide additional demonstration and test features for evaluation.

The tabs that are displayed correspond to the different functional parts of the device. Since the TMG3992/3 IRBeam and Gesture functionality are controlled by a common address space, it is necessary for the GUI to keep track of which functional mode is currently being evaluated.
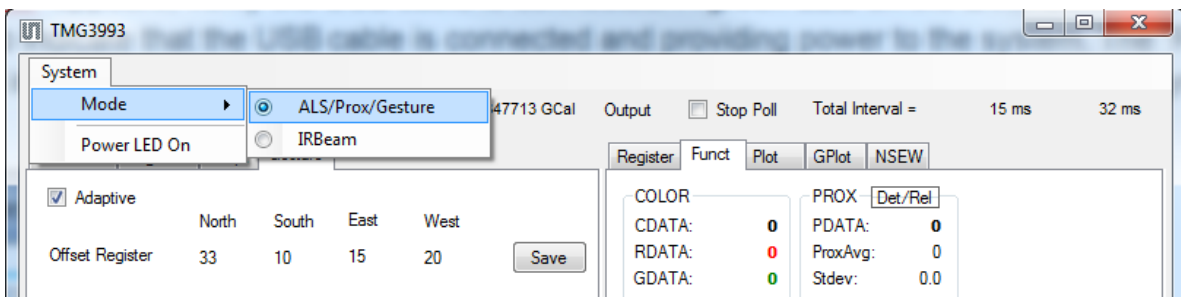
By default, the GUI is set for ALS/PROX/Gesture memory space/mode. While in this mode, IRBeam cannot be evaluated because the shared device memory space is controlling gesture functions. If IRBeam is to be evaluated, then the user must select IRBeam from the "System" menu as shown above. It is possible to switch between IRBeam and ALS/Prox/Gesture, but care must be taken to manually set (reset) the "Enable" bits (address 0x80) each time a switch is made.
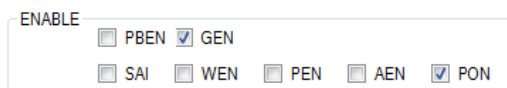
Always visible along the bottom are the following controls:

- A section containing logging controls and sampling status information:

1. Text entered here is appended to the default file name and stored in the log file. The file name contains the Part Name and address shown in the large "Digital Light Sensor" window, the child window, an underscore "_" and the text entered. The default if nothing is entered is a period (".").

2. Secondary comment box. Text entered here is also appended to the log file name and stored in the log. The default if nothing is entered is a period (".").

Sample:

TMG39931Bx39 _ A-B-C _ 1-2-3 _ Log.csv

—————— From DigitalLightSensor.exe
—————— From User Input

3. The start button tells the program to start logging. The fields entered in #2 and #3 will be used as field names in the output. If you change the values in #2 or #3, the corresponding field names will change in the output beginning at the time of the change. The default log file name will be based on the values in #2 and #3 at the time the log file is written.

4. Clear –The Clear button will flush the previous optical sample readings and reset the elapsed time indicator (see #7).

5. Log – Creates a comma-separated values file containing the log data. The name will be assigned as explained in #3. This will cause the system to write out any data currently in the log buffer.

6. Count of samples in the log buffer. When that number reaches the limit selected in #9, the system will show a file dialog to save the log in a named file.

7. The elapsed time since the beginning of logging data.

8. The number of log samples collected before log entry is written to the log file.

2.1.1 Input side, "Functional" tab

Simple commonly used controls exist for the ALS functionality, the proximity detection functionality, the wait time between samples, and the proximity threshold level.
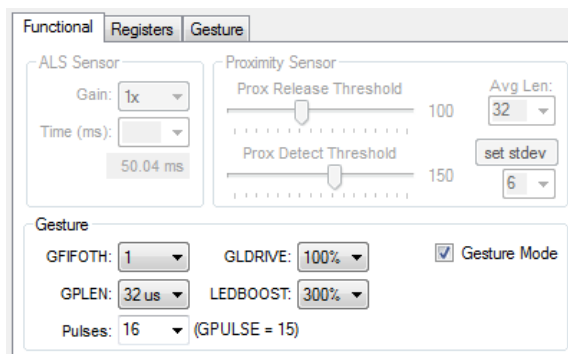

The Input Functional Tab is enabled with the Gesture Mode checked by default. This allows the user to adjust several key Gesture parameters.

- Gesture FIFO length to 1, 4, 8, or 16
- Gesture LED Drive to 12.5%, 25%, 50% and 100%
- Gesture Pulse Length to 4µs, 8µs, 16µs, or 32µs.
- LED Boost of 100%, 150%, 200% and 300%

- Number of Gesture Pulses of 1, 2, 4, 8, 16, 32 or 64 pulses.

If the Gesture Mode box is not checked, the upper half of the box is made visible to that the ALS Sensor and Proximity Sensor controls may be accessed. These allow optimization of ALS and Proximity sensing.
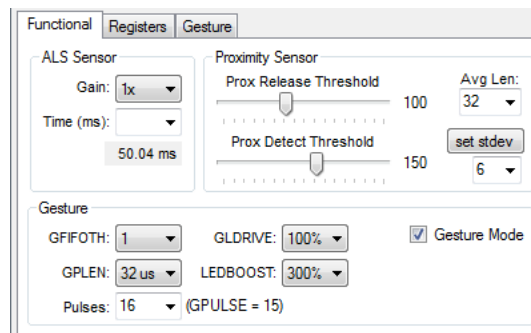
ALS Sensor

Gain - The gain control allows the user access to the GAIN settings of the ADC signal to increase sensitivity. The gain options include 1x, 4x, 16x and 64x and are selected from the list box when the down arrow is depressed

Time (mS) – This list box has numerous preselected values for the integration time from 2.78mS to 712mS with a default of 50.04mS. If a value other than what is shown in the list box is desired it must be entered manually using the Register Tab, ALS Sub Tab (documented later). Manually entering a value will NOT work in this location. The actual integration time is shown on the line below.

Proximity Sensor

The control fields to vary the proximity sensor threshold settings are found in this section. These controls allow setting the release and detect threshold for Proximity detection. Both controls allow register settings from 00 to 255.

- Avg Len – Specifies the number of samples that are averaged together to determine that a proximity event was detected.
- Set stdev allows the user to set the number of standard deviations after which the proximity detection will occur when a value is outside the threshold limits. This provides hysteresis or "persistence" of the reading.
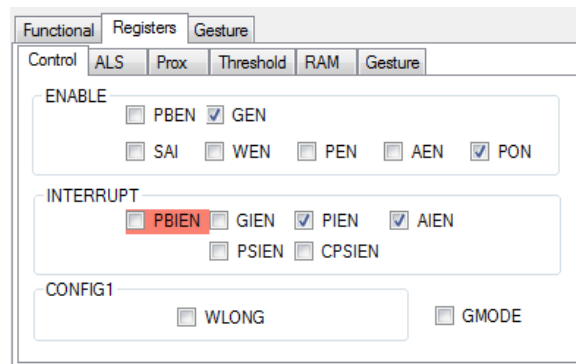
2.1.2 Input Side "Register" Tab

The input "Register" Tab has six sub tabs that allow setting values for most functions of the TMG3992/3.

Control Sub Tab

The Control has 15 check boxes which enable/disable individual bits to control operation of the TMG3992/3 in various operating modes.

- **ENABLE**
    1. PBEN – Enables the IRBeam™ functionality. IRBeam allows the user's phone to be used by barcode scanners as if it was a paper barcode
    2. GEN – Gesture Detection Enable. Checking the GEN box enables detection of a Gesture movement and generating an interrupt if GEIN is enabled.
    3. SAI – Stop After Interrupt. Writing a one (0x01) causes the device to power down at the end of the ALS cycle when an interrupt has been generated.
    4. WEN – Wait Enable. Writing a one (1) activates the wait timer.
    5. PEN – Proximity Enable. Writing a one (1) enables the proximity detection.
    6. AEN – ALS Enable. Writing a one (1) enables the ALS
    7. PON – Power on. Activates internal oscillator. When PON=0 device is in standby.

- **INTERRUPT**
    1. PBEN – IR Beam Interrupt Enable. Enables interrupt generation when an IR Beam Event occurs. Setting this check box enables this interrupt.
    2. GEIN – Gesture Interrupt Enable. Checking this box allows an interrupt to be generated when a Gesture movement occurs.
    3. PIEN – Proximity Interrupt Enable. Writing a one (0x01) enables the Proximity interrupt.
    4. AIEN – ALS Interrupt Enable. Writing a one (0x01) enables the ALS interrupt.

5. CPSIEN – Color Photodiode Saturation Interrupt Enable being checked will cause an interrupt when the Color Photodiode saturates.

- **CONFIG1**
    1. WLONG – Wait Long Enable causes the wait time to be multiplied by 12x when checked.
    2. GMODE – Gesture State Machine Active will enable Gesture processing when checked.

"ALS" Sub Tab

The ALS tab shows the registers associated with ambient light sensing control. Register values in hex are shown on the left, preselected values are available in list boxes in the middle, and actual values are shown on the right.
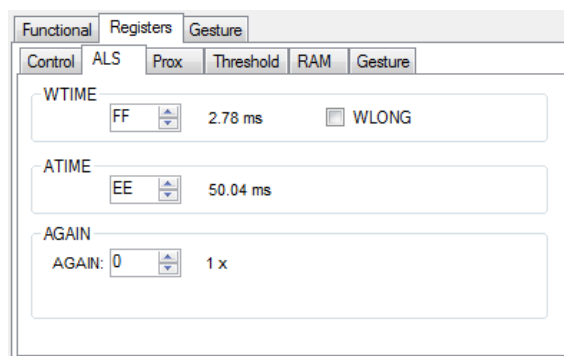
- WTIME Register (0x83) sets the time between PROX and ALS cycles. This value, shown to the right of the box, varies from 2.72mS to 711.68mS by setting a value from 0xFF to 0x00.

- ATIME Register (0x81) controls the ALS integration time. The actual time is:

    (256-ATIME) * 2.72 mS

    Note: The column on the right is the computed value for ATIME and is always correct. Sometimes the value shown in the list box will be one of the preselected values but it has not been selected. If this happens the number will not be the same as the computed number for WTIME on the Control Sub-Tab. The computed value is the one that is correct. This can be fixed by selecting a preselected value from the list box or by cycling the register value UP/DOWN or DOWN/UP. This will set the list box value or clear the value from the list box so the screen is correct.

- AGAIN Register (0x8F) adjusts the ALS input gain. Valid values are 1x, 4x, 16x, and 64x.

"Prox" Sub Tab

The Prox Sub tab shows registers associated with proximity sensing control. Counts and length are shown on the left, the middle section contains controls for offset, and the column on the right displays the gain values. Two drop-down controls allow adjustment of the sink current and number of LED pulses, and selection of the photodiode mask are used to detect the reflected energy. The first list box allows rapid selection of LED sink current and the number of LED pulses. Clicking the down arrow brings up a list box with several predefined combinations:
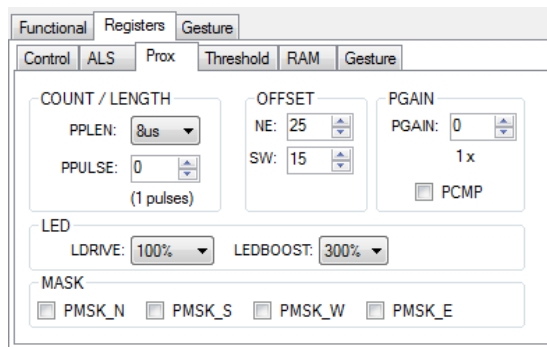
Note: Due to the automatic nature of the gesture algorithm, values entered in the registers and list boxes may not automatically update each other, so the values displayed may not match. The computed values on the right are always correct and show the values currently in use.

COUNT/LENGTH

- PPLEN (0x8E:7,,6) define the length of the Proximity IR LED Pulses. These can be set to 4µS, 8µS, 16µS or 32µS.

- PPULSE (0x8E:5..0) - This control allows the user to select the number of LED pulses for proximity detection. These may be set from zero (0x00) to 64 (0x3F) pulses.

OFFSET

- OFFSET – shifts the data positive in a North East direction (NE) or a South West direction (SW) from 0 to 127 (0x00 to 0xFF) counts.

PGAIN

- PGAIN – Sets the gain of the Proximity sensors to 1x, 2x, 4x or 8x.

- PCMP – sets Prox Gain Compression to 2x when only one diode is in use.

LED

- LDRIVE – sets the sink LED drive current to 12.5%, 25%, 50% and 100%.

- LEDBOOST – boosts LED drive current 100%, 150%, 200% or 300%.

MASK

- PMSK_N – Prox Mask North enables and disables the North diode.

- PMSK_S– Prox Mask South enables and disables the South diode.

- PMSK_W– Prox Mask West enables and disables the West diode.

- PMSK_E– Prox Mask East enables and disables the East diode

"Threshold" Sub Tab

This tab contains the settings for controlling the generation of ALS and Prox interrupts to a control processor.
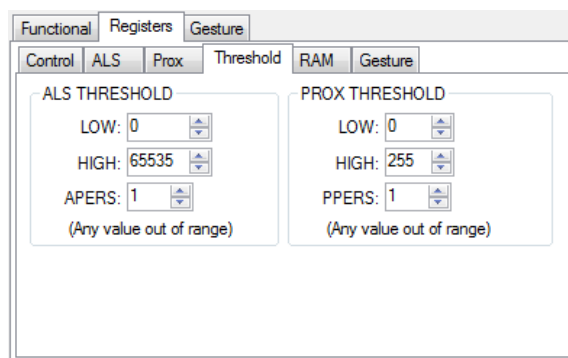
- ALS Threshold

The LOW and HIGH values are 16 bit thresholds for the upper and lower trigger points. Each is set using 1 16-bit control. Another control APERS establishes the required persistence of the interrupt signal. APERS values control from zero to 60 samples for a persistence value.
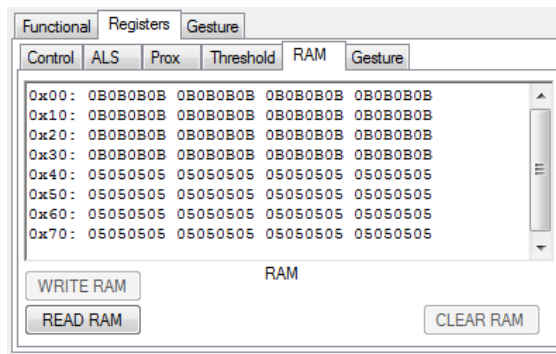
- Prox Threshold

The LOW and HIGH values are 8-bit thresholds for the upper and lower trigger points. Each is set using one 8-bit register. Another control PPERS establishes the required persistence of the interrupt signal. PPERS values range from 0 to 15 samples for a persistence value.

"RAM" Sub Tab

The RAM Sub Tab allows reading of the internal RAM Memory of the TMG3992/3 for test and debug. Clicking the "READ RAM" button performs the memory read. Clicking the "WRITE RAM" button performs the memory write. Clicking the "CLEAR RAM" button sets all RAM to zero.

"Gesture"Tab

The Gesture Tab allows the user to set various timings and parameters to optimize gesture sensing in the user's environment.
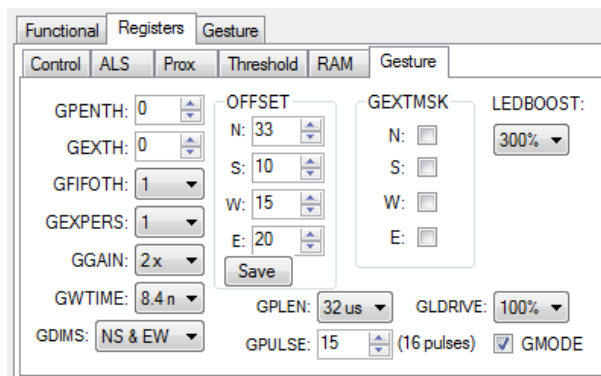
- GPENTH – Gesture Prox Entry Threshold sets the PDATA value which starts the Gesture State Machine. GPENTH can be set from 0 through 255.
- GEXTH – Gesture Exit Threshold sets the sum of the photodiodes which trigger exit of the Gesture State Machine.   GEXTH can be set from 0 through 255.

- GFIFOTH – Gesture FIFO Threshold sets the number of times the gesture is detected before GINT is triggered. GFIFOTH can be set to 1, 4, 8 or 16.

- GEXPERS – Gesture Exit Persistence sets the number of Gesture Exits required before the gesture will exit. GEXPERS can be set to 1, 2, 4, or 7 counts.

- GGAIN – Gesture Gain Control allows setting of the gain of the gesture detection. GGAIN can be set to 1, 2, 4 or 8.

- GWTIME – Gesture Wait Time controls how long to wait before a gesture can be detected. GWTIME can be set from 000 through 111 in 2.8mS increments up to a total of 39.2mS.

- GDMS – Gesture Dimension Select sets which or how many of the four or eight dimensions are being used to detect that a gesture has occurred.

- **OFFSET**
    1. N: North Offset in 0 to 127 counts
    2. S: South Offset in 0 to 127 counts
    3. W: West Offset in 0 to 127 counts
    4. E: East Offset in 0 to 127 counts
- Save will store the offsets previously entered into memory.

- **GEXTMSK**
    - N: Masks the North Photodiode out of the exit sum for exiting the gesture state machine.
    - S: Masks the South Photodiode out of the exit sum for exiting the gesture state machine.
    - W: Masks the West Photodiode out of the exit sum for exiting the gesture state machine.
    - E: Masks the East Photodiode out of the exit sum for exiting the gesture state machine.

- LEDBOOST will increase the LED Current 100%, 150%, 200% or 300%.
- GPLEN sets the Gesture Pulse Length to 4µS, 8µS, 16µS or 32µS.
- GLDRIVE sets the Gesture LED Drive current to 12.5mA, 25mA, 50mA or 100mA.
- GPULSE sets Gesture Pulse Count from 1 to 16 pulses (0x00 to 0x0F).
- GMODE enables the Gesture State Machine when checked.

2.1.3 Output side, "Register" tab

The value of internal registers are displayed on this tab. Register values cannot be set here. To set registers use the Register tab on the input side of the screen. The CDATA, RDATA, GDATA and BDATA values are the ADC values for the photodiodes and the proximity detection value. Each is read via 8-bit registers.

FLAGS

- [ ] CPSAT
- [ ] PSAT
- [ ] PINT
- [ ] AINT

- [ ] GINT
- [ ] PVALID
- [ ] AVALID

- [ ] PBINT
- [ ] PBUSY
- [x] GVALID

- [ ] GFOV

PROX

PDATA:

0

COLOR

CDATA: [0] [0]   **0**
RDATA: [0] [0]   **0**
GDATA: [0] [0]   **0**
BDATA: [0] [0]   **0**

CLEAR INTERRUPTS

IIClear	CIClear
PIClear	GIClear
AIClear	IForce

Tabs: Register | Funct | Plot | GPlot | NSEW

Flags

These boxes show the state of various interrupts, flags and other bits.

CPSAT – Clear Photodiode Saturated

PSAT – Proximity Saturated

PINT – Proximity Interrupt

AINT – ALS Interrupt

GINT – Gesture Interrupt

PVALID – Proximity Valid

AVALID – ALS Valid

PBINT – IR Beam Interrupt

PBUSY – Interrupt Busy

GFOV – Gesture FIFO Over Flow

GVALID – Gesture Valid

PROX

PDATA – Shows the current Prox Count

Color

- CDATA
    1. CDATA – Clear photodiode ADC data, 8-bit value.
- RDATA
    1. RDATA – Red photodiode ADC data, 8-bit value.
- GDATA
    2. GDATA – Green photodiode ADC data, 8-bit value.
- BDATA
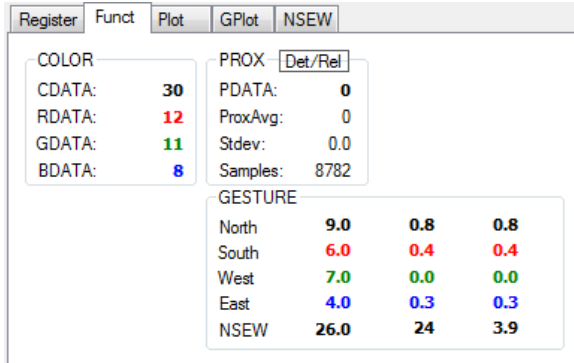   3. BDATAL – Blue photodiode ADC data, 8-bit value.

Clear Interrupts

These buttons clear or set an interrupt.

1. IIClear – Clears the IRBeam Interrupt
2. IForce – Forces an IRBeam Interrupt
3. PIClear – Clears a Packet Interrupt
4. CIClear – Clears a Symbol Interrupt
5. AIClear –Clears all Interrupts
6. GIClear – Clears a Gesture Interrupt

2.1.4 Output side, "Functional" tab

The Proximity indication shows the current reading (Raw Prox Count), a rolling average (ProxAvg), and the standard deviation of the rolling samples. The number of samples is specified on the Input Side, "Functional" tab.

The "Prox Detect" box is a visual indicator of proximity detection, based on the Release and Detect settings on the Input Side "Functional" tab.

The Clear and Color photodiodes output values are shown, and their ratio is shown below.

When in the Gesture Mode, the GESTURE box will show values for the RGB and Clear for each direction photodiode and the sum NSEW value.

2.1.5 Output side, "PLOT" tab

The Clear and RGB photodiodes and the Prox reading can be displayed vs. time on the graph. The plot shows proximity events happening and all outputs for a static system. Multipliers (selected from the list boxes) may be used to scale the display accordingly.
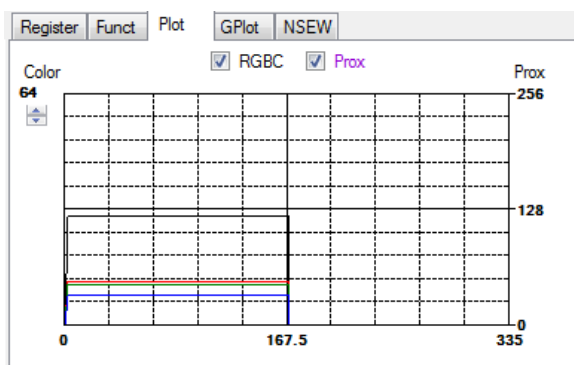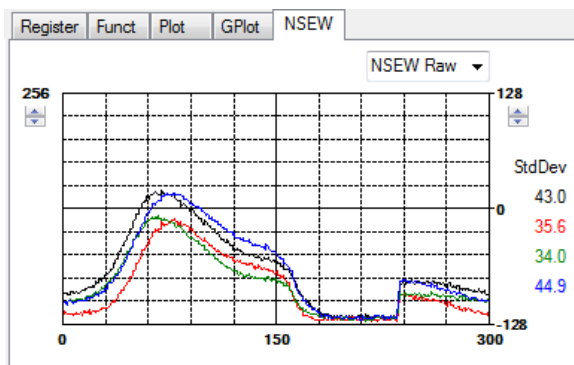
2.1.6 Output "GPlot" Tab

The GPlot is a graphical display of the Gesture diodes along with their magnitude and differences.
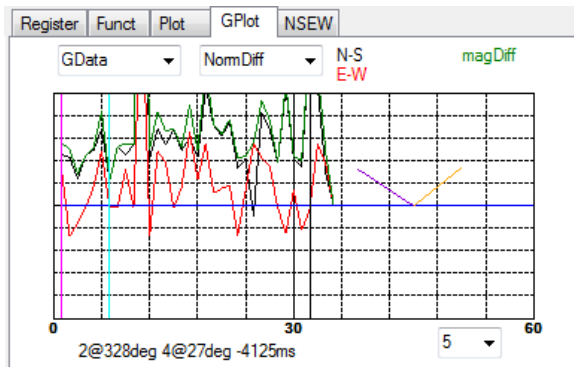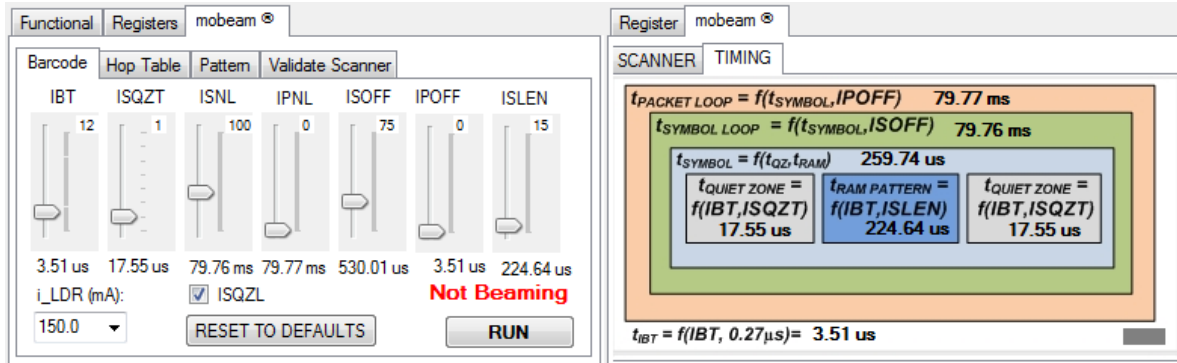

2.1.7 Output "NSEW" Tab

The Output NSEW tab shows the raw NSEW data from the photodiodes as well as the Standard Deviation of the various diode readings.


2.1.8 IRBeam (mobeam) Operation

Once IRBeam operation is selected in the "System" menu, two new tabs become visible on the Input and Output sides of the GUI as shown below.

The Barcode tab allows direct control of IRBeam registers in one convenient location. As the trackbars are modified, the register values are displayed in the upper right corner. Below the trackbars, the parameter timing is displayed. The Timing tab (right side) depicts a graphical representation of IRBeam timing associated with the barcode transmission. The "Reset to Defaults" button preloads the IRBeam registers with values known to work with many barcode scanners, including the Symbol LS2208. The "RUN" button initiates a barcode pattern burst. The barcode pattern is generated and displayed in the Pattern tab.

The GUI can also receive data from two types of barcode scanners: the Symbol LS2208 (Serial emulation) or a generic "HID Keyboard" scanner.
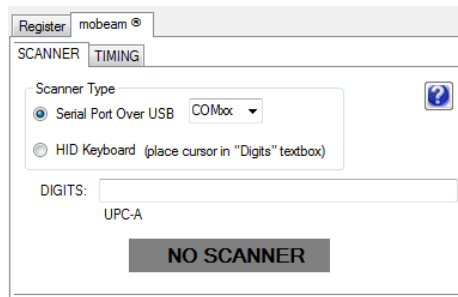

If an LS2208 (Serial emulation) scanner is used, then "Serial Port Over USB" must be selected and the appropriate COM port must also be selected in the "COMxx" dropdown box. Note that a USB driver must be installed for Windows OS to recognize the scanner.

Any barcode that is received by the scanner will be displayed I the "DIGITS" textbox. Note that if a HID keyboard scanner is used, then the textbox must be in focus (I.e. mouse clicked, cursor blinking in the "Digits" textbox). On startup, the success indicator displays "NO SCANNER" and is grey in color. If the received barcode matches the barcode that was generated by the software, in the pattern tab, then the success indicator will change color from grey to green, otherwise it will change color to red.

The "HOP Table" tab functions to sequentially transmit the same barcode pattern with different settings for timing. This functions similarly to the mobeam driver implementation of barcode transmission. This is done to improve the likelihood that a barcode will be received successfully by most any scanner, independent of its scan rate. The values in the hop table are editable, and the barcode pattern can be sourced by the RAM tab or the barcode loaded in the Pattern tab. The

"HOPS" textbox sets the number of iterations that the entire hop table will be burst. If HOPS = 0 and RUN button is clicked, then barcode transmission is immediately terminated. If HOPS = 255, and the RUN button is clicked, then the hop table will continuously burst. Any number of HOPS between 1 and 254 will cause that number of hop table iterations.
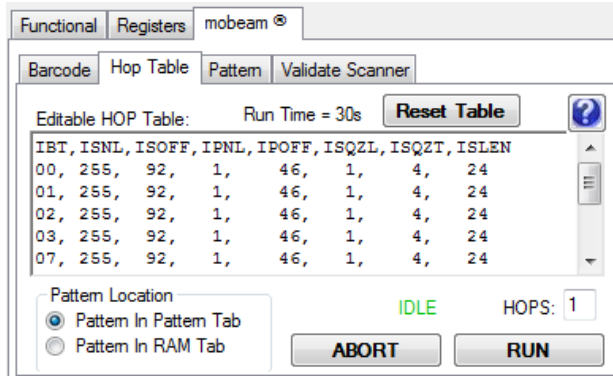

The Pattern tab specifies the barcode to be burst. Two barcode protocols are available: UPC-A and CODE-39. UPC-A is always 12 digits long, but CODE-39 can be any length up to 55 characters. The code length is selectable. Users can uncheck the Auto-generate checkbox and manually input a barcode into the DIGITS textbox, or, left checked, the GUI will automatically generate a new barcode and display in before transmission by the device. The "RUN" button initiates the barcode transmission.
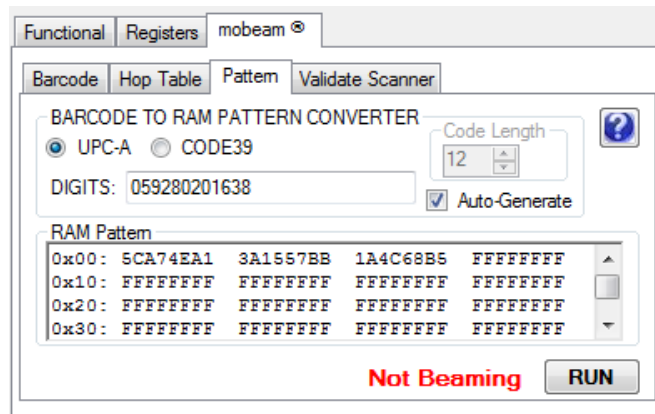
The Validate Scanner tab provides another device interface similar to the Hop table tab, except that the hop table setting have been preselected by mobeam and are hardcoded into the GUI. Control of LED intensity and number of hop table iterations textbox function as previously described in the Hop Table tab.

IRBeam tabs also contain a blue question mark button on most tabs. These buttons open an informational window that briefly explains how to use the functions on the tab. Also, users may hover the mouse pointer over a control causing a tool-tip to appear which describes the control/and the associated device function.
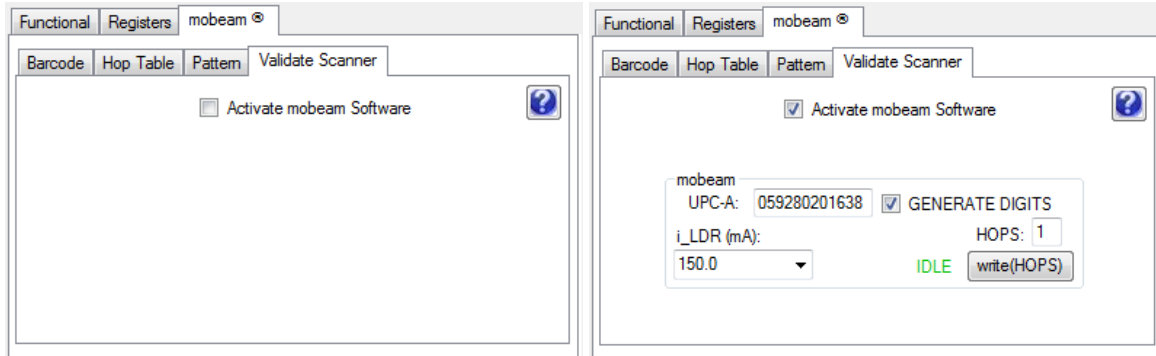
Conclusion

The inclusion of IRBeam into mobile applications provides System Designers an easy and cost effective solution to meet expectations set by consumers of electronics devices, cell phones in particular. IRBeam technology works reliably to "beam" barcode data to the multitude of the world's GS1 standard point-of-sale scanners.

References

1. Roger C. Palmer, The Bar Code Book, Trafford Publishing, 2007
2. Symbol LS2208 Product Reference Guide, April 2012
3. TCS3390 Datasheet, ams AG

Resources

TMG3992/3 datasheet

TMG3992/3 EVM Quick Start Guide (QSG)

Designer's Notebooks

For additional information regarding the TMG3992 and TMG3993, please refer to the datasheet. For information regarding the installation of the Gesture EVM host application software please refer to the TMG3992/3 EVM Quick Start Guide.

Designer's Notebooks dealing with various aspects of optical measurement and optical measurement applications are available. All content is available on the ams website www.**ams**.com.