Display Initialization Setup Personality (DISP) Software Tool User Guide

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Abstract

This User guide explains the display initialization setup in detail. The software used for the reference here is DISP (Display Initialization Setup Personality). DISP will empower the user to setup display initialization of any display of the choice within a certain set of parametric range. DISP is used for initialization of displays used with the Goldelox-SGC and Picaso-SGC.

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INTRODUCTION

Display Initialization Setup Personality is a utility that can provide you the flexibility to accommodate any relevant resolution display of your own choice on the 4D boards. You would have to extract the parametric information from the display datasheet. You can set the splash screen, from DISP, which appears on the display module startup. You can also set Fonts of your own choice for the display module. These fonts can be designed manually or can be imported in the form of a font file. A utility called 'FontTool' is specially designed by 4D Systems to produce raw font file using windows range of fonts.

Once you have completed putting the information for each parameter you can save the data in the form of a header file by clicking "Save to file" button. Display settings can also be loaded from the display module itself, if it contains the appropriate PmmC and the header file.

The header files for standard display modules such as µOLED 96 G1, µOLED 128 G1, uOLED 3202X P1 etc. are available. User can modify these files to suit their requirements. User can also use these for help and reference before developing initialization setup for any other display. The module needs to be loaded with the appropriate PmmC file which is a blank serial PmmC. The display would need the initialization setup before it can display anything.

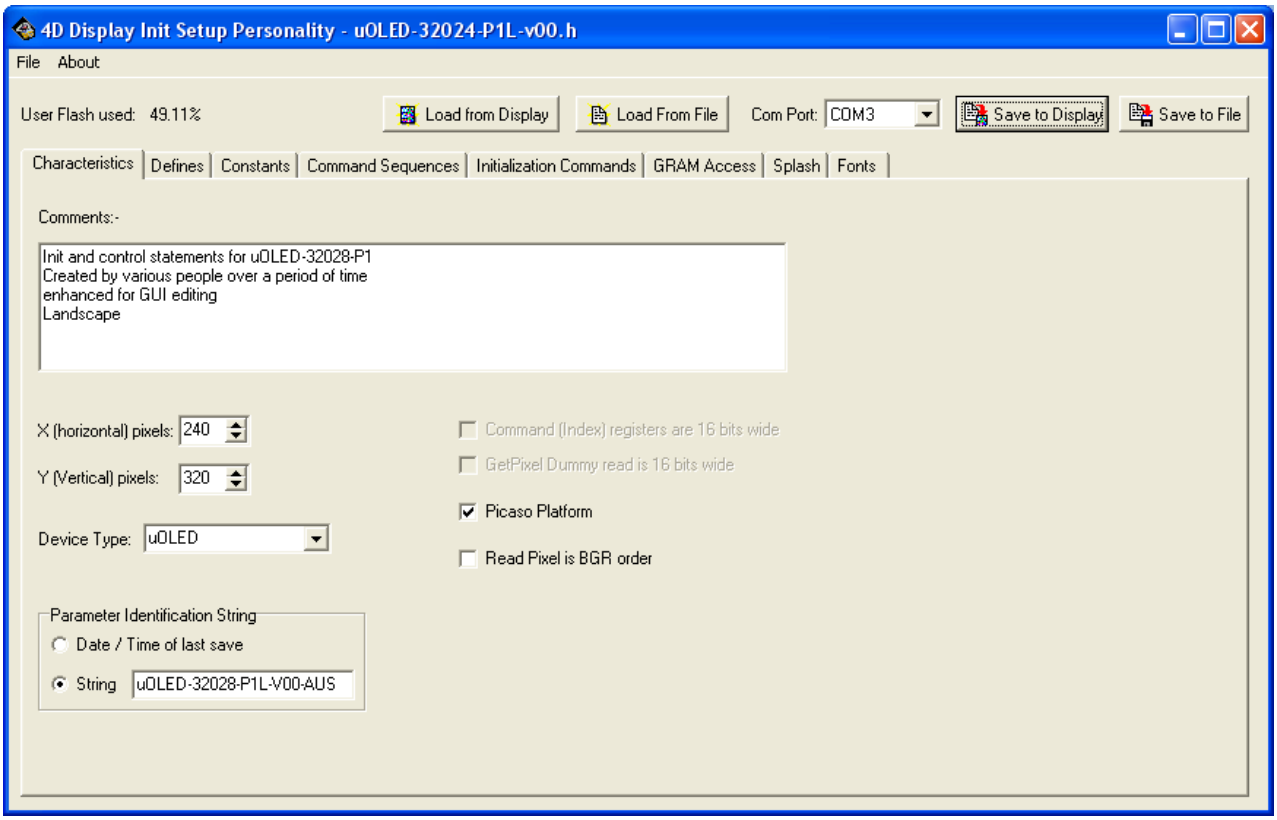

Figure 1: Setting display characteristics

Prerequisites to the Initialization setup

There are certain things that need to be done before developing anything on DISP.

- Install the display independent serial PmmC to the module.
- Make sure the connection between the screen and the board can be established. In other words the connectors match.
- Make sure the screen is connected to the board before you download the DISP output file to the module.
- Get the datasheet of the driver IC for the display.
- Check the datasheet, if the command (index) register addresses are 8 bit or 16 bit wide.
- Check the datasheet to see if the getpixel dummy read requires 8 bit or 16 bit value.

Startup

- You can load a header file by clicking 'Open' in the file menu. You can also load from the display by clicking "Load from Display" command button.
- You can save the file in the form of a header file with a filename.h format. The file initialization settings can be downloaded directly to the display. It is always a good practice to save the file in the form of a header file which can be edited or used any time in future.
- 'Load from Display', 'Load from File', 'Save to Display' and 'Save to File' are the same options available in the file menu. 'Save as' is only available from the file menu.
- You can get the status of the current display attached by clicking the "Get status" in the file menu.
    - The correct com port must be selected.
    - The display module must be connected through the (uUSB CE5 or uUSB MB5 or Real serial port with appropriate level conversion etc.)
    - The driver for the interface (uUSB CE 5 etc.) is installed.
- "User Flash used" label provides the percentage of user flash used with the current display settings and fonts. The file cannot be saved if it exceeds 100%.

Saving

When saving your file checks are made to ensure it is valid. If it is not valid, you may receive a simple message alerting you to the error, or another tab, entitled 'Errors' may appear with a list of the errors encountered. If the 'Errors' tab is shown you can double click on any entry to show the tab containing the error. The error field will be displayed with a red background.

INITIALIZATION SETTINGS

All the initialization settings are explained using SSD1339 as an example

Characteristics

- Set the pixel resolution. This is the total number of pixels in each direction. For example if you have a 128x128 resolution board, it must be set to X pixels: 128 and Y pixels: 128.
- The device type must be selected. This is simply used for reporting information in the V (Version) command.
- Parameter identification string is a way of 'tagging' a personality module, it displays before you overwrite an existing module as confirmation. It is also displayed by clicking “get status” in the file menu to confirm, the device has the display independent PmmC.
- The ‘date/time of last save’ is the parameter which can be changed by saving the file. The text box will show up the date and time of save. So, the module will be loaded with whatever appears in the text box as an identification tag.
- If the command (index) register addresses are 16 bit wide, make sure you check the “Reads and Writes are 16 bits wide” checkbox. Also ensure that the GRAM access setup has extra control and data writes as required.
- If the getpixel dummy read requires 16 bit value, make sure you check the “GetPixel Dummy read is 16 bits wide” checkbox.
- Check the “Picaso Platform” check box only when initializing a display with the Picaso SGC.
- Checking the “Picaso Platform” will enable “Read pixel is BGR order”. By default read pixel returns in RGB order. Check “Read pixel is BGR order” check box to read the pixel in BGR order.

Defines

DISP has a separate tabbed window “Defines” for defining the command-IDs/command-registers as constants. Constants can be defined with any name. See the following screen shot of DISP, setting the command IDs with specific names just like constants. These names are case sensitive. They are used in the settings under other tabs. Not all the commands need to be sent for initialization therefore not all the IDs are required to be defined in the ‘Defines’ section. You can also define any other constants if you need to. Any unused constants are not saved.

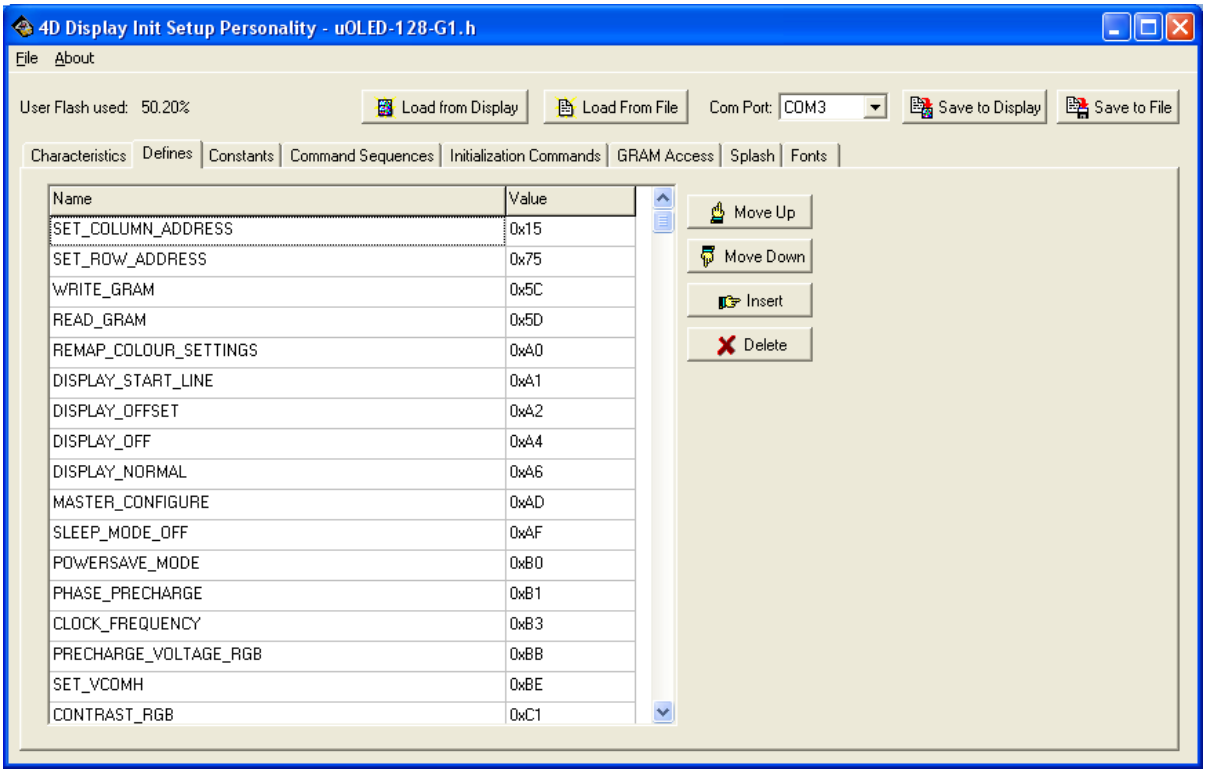

Figure 2: Setting display command IDs or command registers

These command IDs are used as identification hex values that are needed to set the initialization parameters of the display. The command IDs with the illustration of their functions can be obtained from the display datasheet. An extract from the SSD1339 datasheet is shown in the figure 3. For example command ID (register) for 'setting column addresses is 15 hex. Similarly, command ID for 'setting row addresses is 75 hex. Refer to appendix for complete command table for SSD1339.

8. COMMAND TABLE

Table 3 – Command table

(**D/C** = 0, **R/W** (**WR**) = 0, E(**RD**) = 1) unless specific setting is stated
Single byte command (D/C = 0), Multiple byte command (D/C = 0 for first byte, D/C = 1 for other bytes)

Command ID

Command ID

D/C	Hex	D7	D6	D5	D4	D3	D2	D2	D0	Command	Description
0	15	0	0	0	1	0	1	0	1	Set Column Address	A[7:0]: Start Address, reset=0d
1	A[7:0]	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0		B[7:0]: End Address, reset=131d
1	B[7:0]	B_7	B_6	B_5	B_4	B_3	B_2	B_1	B_0		Range from 0d to 131d
0	75	0	1	1	1	0	1	0	1	Set Row Address	A[7:0]: Start Address, reset=0d
1	A[7:0]	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0		B[7:0]: End Address, reset=131d
1	B[7:0]	B_7	B_6	B_5	B_4	B_3	B_2	B_1	B_0		Range from 0d to 131d

Figure 3: Command table for setting the display with SSD1339 driver IC

Constants

Constants are predefined values that need to be set as part of the display initialization setting. 'SetColoumnAddress', 'SetRowAddress', 'WriteGram' and 'ReadGram' are the only relevant parameters here therefore the rest are set to zero. Note the command IDs were defined with certain constant names in the 'Defines' section hence the constant names can be used instead of numeric register hex values. All values must be set, so use 0 for unused constants.

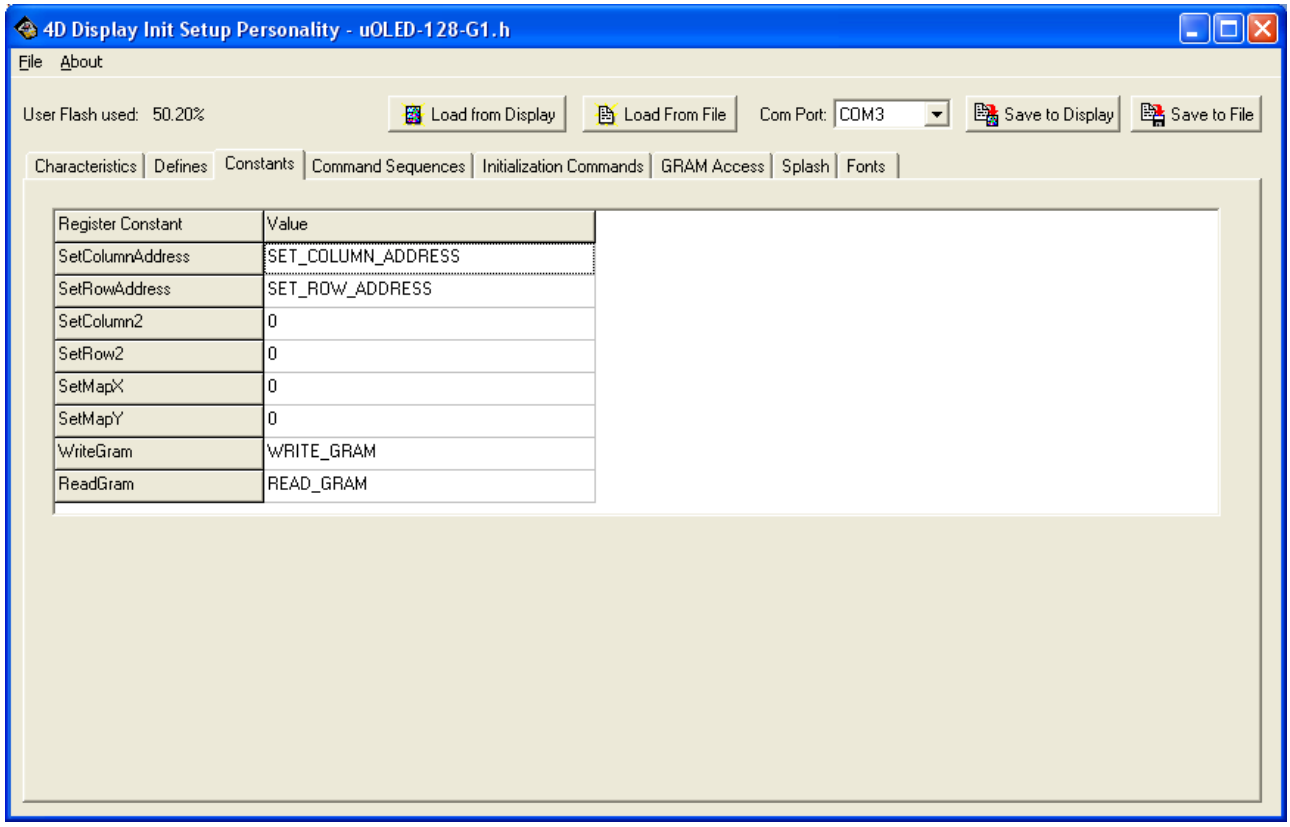

Figure 4: Setting up constants

Command Sequences

There are certain command sequences that are required to be invoked time to time while using different serial command set. The command IDs need to be set for those command sequences. Given on Figure-6 is a screenshot of the DISP showing the command sequences setting for the SSD1339. Horizontal Scroll is a command that can be directly executed via the display driver IC. The processor just needs to provide certain arguments. Some of those parameters passed for Driver built-in command sequences are predefined. These parameters are passed automatically as soon as these commands are invoked. One such command is Horizontal Scroll. Provide the horizontal spacing you need for the successive move. The next byte is the start row address which is set to "1" as shown in the DISP snapshot. Number of rows to be Horizontal scroll is set to "0", Reserved is set to "1" and the final parameter is passed through from the serial command, e.g.

```
Syntax : spCmd, cmd, register, data

Where,
Command Register        Data Value
0x02 Scroll Speed       1 = fast, 2 = normal, 3 = slow
```

0	96	1	0	0	1	0	1	1	0	Horizontal Scroll
1	A[7:0]	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0	
1	B[7:0]	B_7	B_6	B_5	B_4	B_3	B_2	B_1	B_0	
1	C[7:0]	C_7	C_6	C_5	C_4	C_3	C_2	C_1	C_0	
1	D[7:0]	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	
1	E[1:0]	*	*	*	*	*	*	E_1	E_0	

A[7:0] : 1~124 horizontal offset in number of Column
Invalid entry for value larger than 124
0 no horizontal scroll

B[7:0] : start row address

C[7:0] : number of rows to be H-scrolled
B+C <= 132

D[7:0] : Reserved

E[1:0] : scrolling time interval
0 test mode
1 normal
2 slow
3 slowest

Note : operates during display on.

Figure 5: Command and Setting for horizontal scroll

There are other command sequences that are called by other commands. Some commands may not be available for your display, in this case just set the command to N/A, or click on the row containing the command and then click the 'Set not available' button.

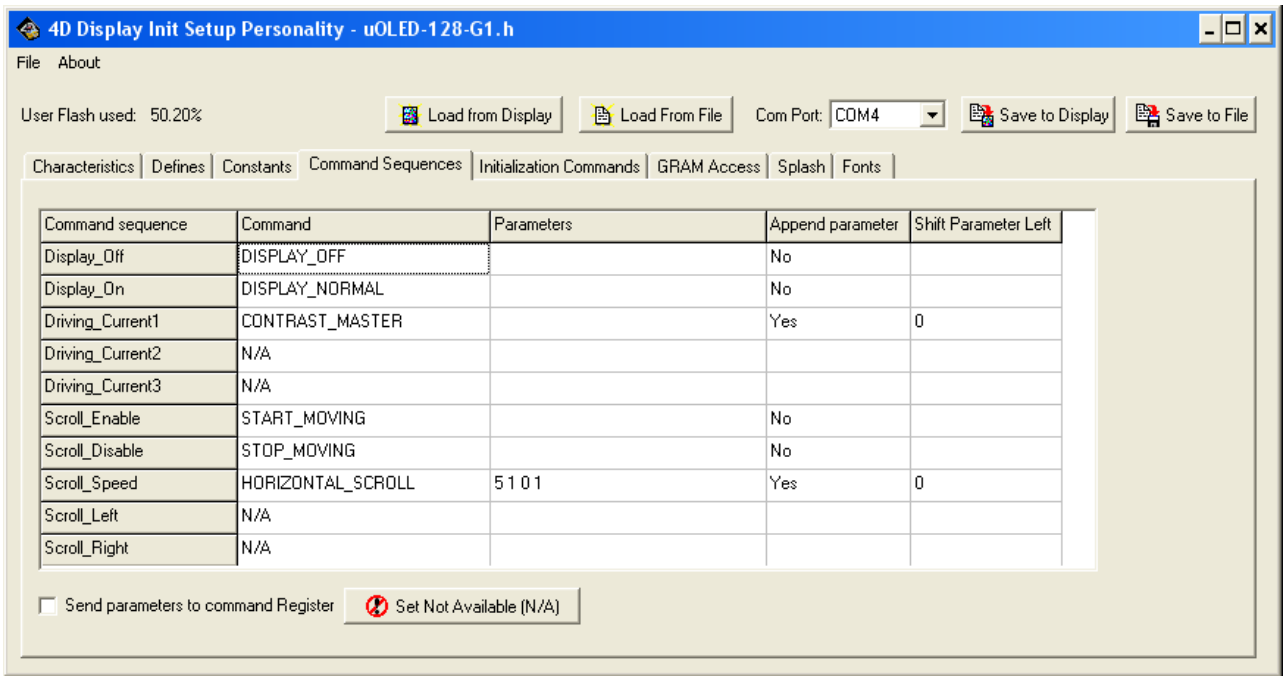

Figure 6: Command sequences setting while "Goldelox Platform" selected

If you set 'Append Parameter' to yes the parameter, if required, used in the serial command will be appended appropriately before passed to the call. Shift left is to shift the parameter left a number of times (i.e. * 2, *4, etc), as sometimes the parameters say 0-4 need to converted to 0,4,8,12,16. etc.

Extra Command features on Picaso Platform

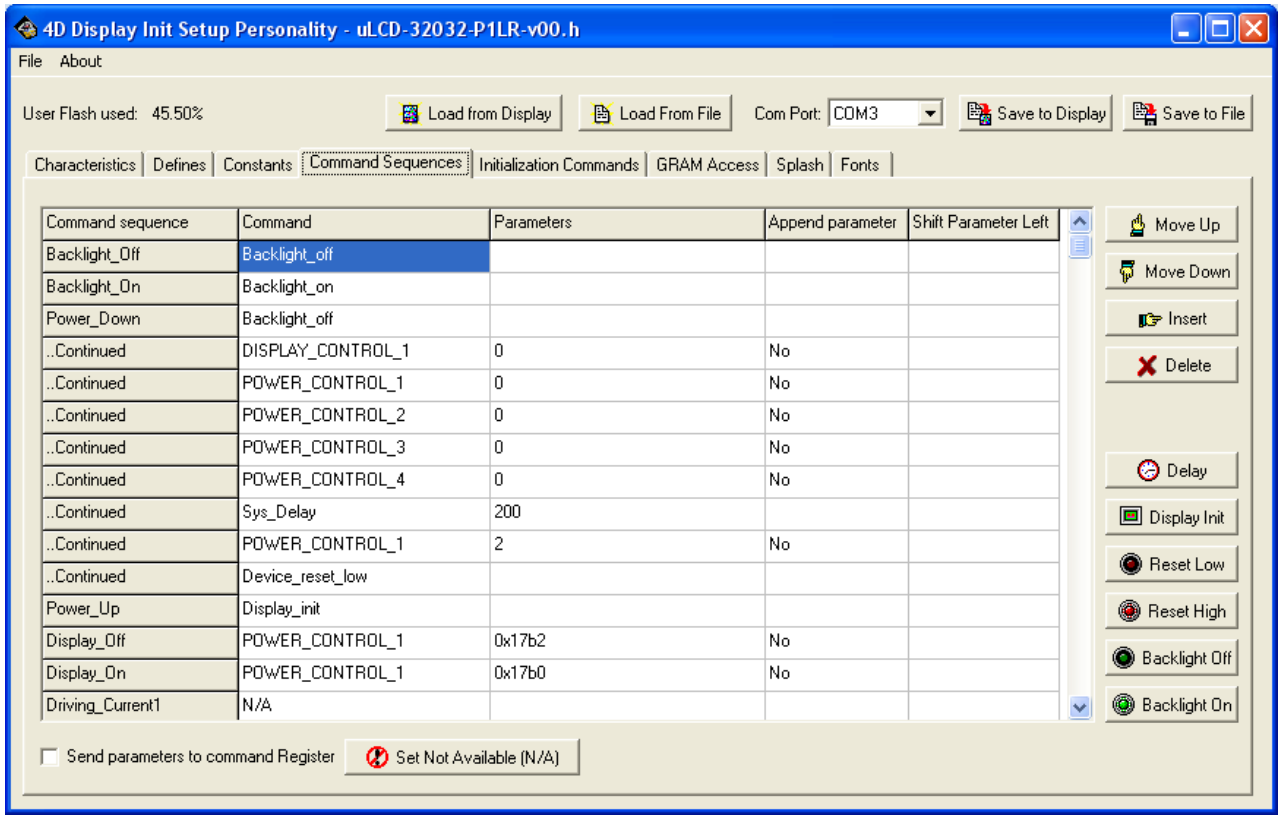

Figure 7: Command Sequence setting with "Picaso Platform" selected

Under the Picaso platform there are a number of built-in commands which user can incorporate in the display initialization commands sequence such as, *Delay, Display Init, Reset Low, Reset High, Backlight off* and *Backlight on*.
Set your cursor to a row and click insert to insert a new row under the selected row. Select a row and click on any of the command button to apply the command. You can always delete, insert or move a row up or down using the relevant buttons.

Initialization Commands

Under the 'Initialization Commands' tab, the values that follow the command ID are set. Figure 7 is an extract of the command table from the SSD1339 datasheet. It shows the values that could be set for the column range and row range. On 12x128 resolution there will be 128 columns which mean the column would start from 0 or 0x00 and end at 127 or 0x7F. Similarly there will be 128 rows which mean the rows will range from 0 or 0x00 to 127 or 0x7F.
Note: This driver IC (SSD1339) can support screens of maximum 132x132 resolution. Since we are developing the initialization for a display which is 128x128, the column range should not exceed 128x128.

D/C	Hex	D7	D6	D5	D4	D3	D2	D2	D0	Command	Description	
0	15	0	0	0	1	0	1	0	1	Set Column Address	A[7:0]: Start Address, reset=0d	0 or 0x00
1	A[7:0]	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0		B[7:0]: End Address, reset=131d	127 or 0x7F
1	B[7:0]	B_7	B_6	B_5	B_4	B_3	B_2	B_1	B_0		Range from 0d to 131d	
0	75	0	1	1	1	0	1	0	1	Set Row Address	A[7:0]: Start Address, reset=0d	0 or 0x00
1	A[7:0]	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0		B[7:0]: End Address, reset=131d	127 or 0x7F
1	B[7:0]	B_7	B_6	B_5	B_4	B_3	B_2	B_1	B_0		Range from 0d to 131d	

Figure 8: Initializing Coloumns and Rows with SSD1339 driver IC

DISP snap shot underneath explains how the values are set. Multi byte values can be written with a space between. See (CONTRAST_RGB 0xFF 0xFF 0xFF). You can also put constant names, as defined in the 'Defines' section, such as '_65K_COLOURS'. There are certain command names that were set with the command IDs are not initialized here with any values. These commands are not required to set with any value here; they are used internally once the initialization setup is downloaded to the device. For example 'SLEEP_MODE_OFF', it is loaded with the command ID 0xAF in the 'Defines' section (See pg 5) but does not require any parameter. Similarly, the 'DISPLAY_NORMAL' and 'DISPLAY_OFF' commands. To insert a delay during initialization select the line you wish to insert a delay after and then click 'Insert Delay', each delay can be from 1 to 255 msecs.

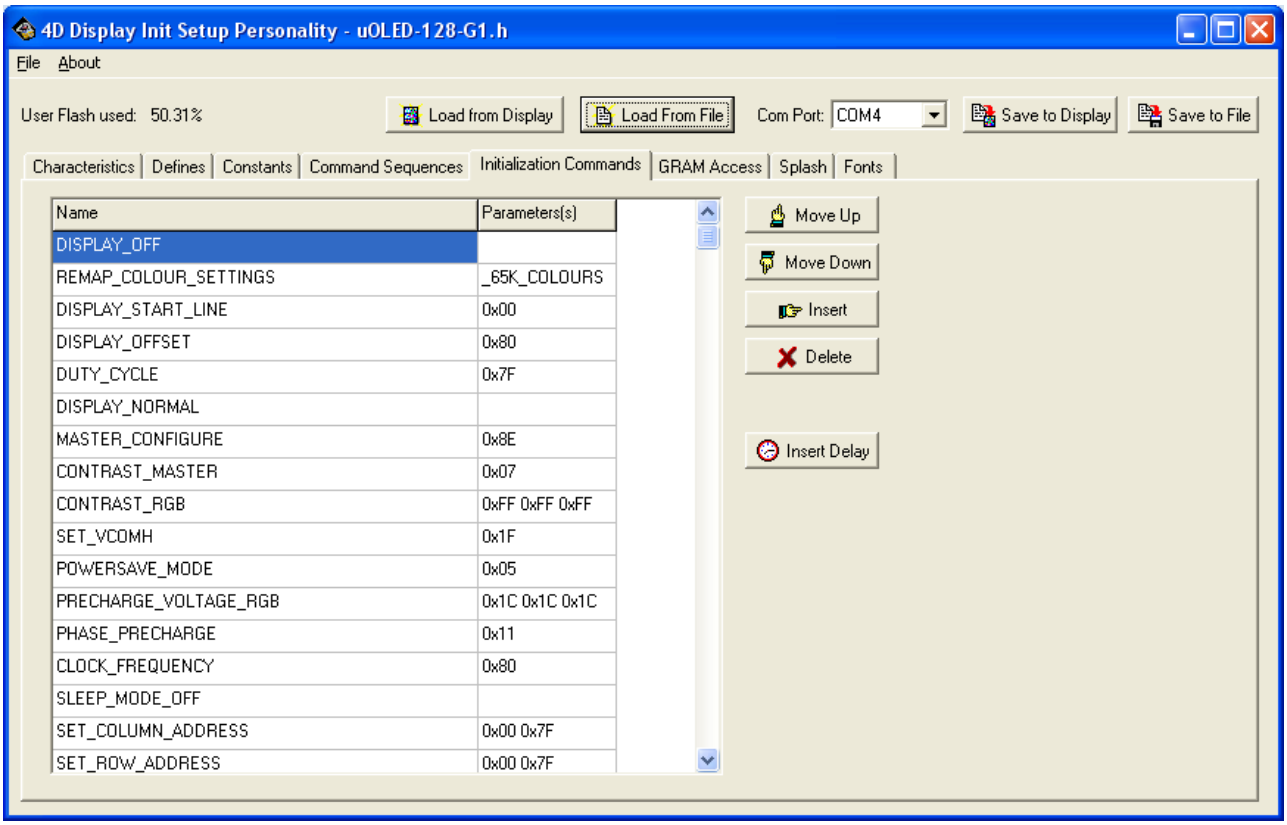

Figure 9: Display initialization with the "Goldelox Platform" selected

Orientation and Calibration settings on Picaso Platform

When you choose the Picaso platform you will get two extra options,

- Orientation Settings
- Calibration Settings

You can set the default orientation of the display by checking the relevant check box in the "Orientation Set in Hardware" settings. The registers also need to be set appropriately to set the display in the certain orientation.

For calibration settings you need to set calibration values for the MinX, MaxX, MinY and MaxY. If you wish to set default values for the set of 4D modules, you can click the button that represents your display module, relevant values will be loaded in the combo boxes. If you need custom calibration follow the steps below

Connect the Picaso display module loaded with the SGC PmmC file.

- Select the com port from the com port combo box.
- Click "Calibrate Now" command button. A "Touch Calibration" window will pop up. See the figure below.
- Click start and you will be prompted with a message "Please touch the line with a stylus in 3 evenly spaced spots. Color will change when the reading is acceptable. Pause for a few seconds between each touch".
- You will see a line at the border on the display, just touch that line thrice as mentioned in the message.
- After each touch the colour of line will change.
- After touching the line three times successfully, the line would appear on another border, this will repeat for all the four borders.
- Later you will see the "Copy to values" command button enabled, click the button to load your customized calibration values to the MinX, MaxX, MinY and MaxY combo boxes.
- After completing the initialization setup on DISP, when you will burn the header file to the module, the values in the combo boxes will be incorporated in the chip level configuration.

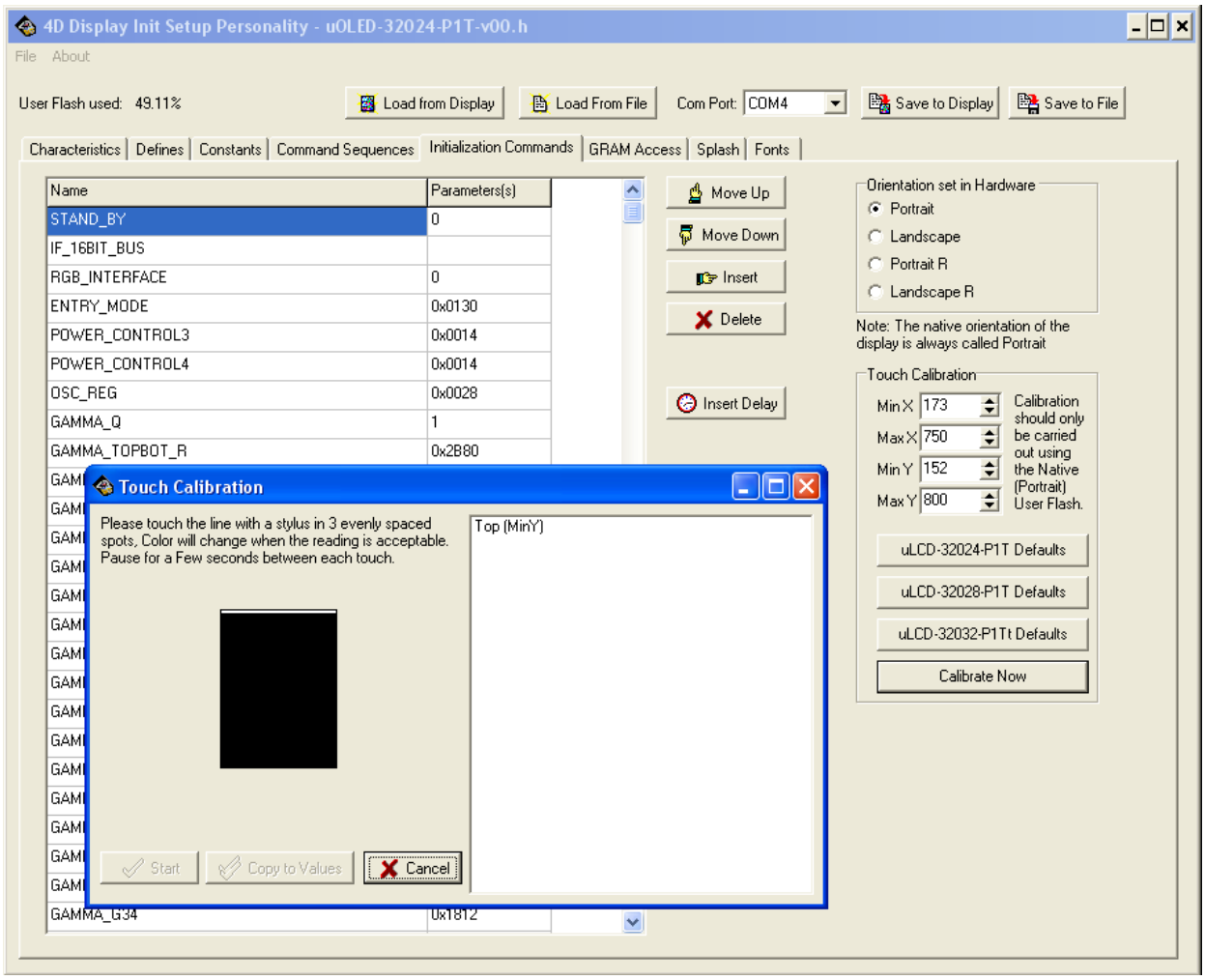

Figure 10: Display Orientation and Calibration on the Picaso platform

GRAM Access

Given in figure 9 is an extract from SSD1339 Driver IC datasheet from page 34. It explains how the columns and rows are addressed by the driver IC. The area of operation or the window is selected first which in this case is from Col2, Row1 to Col129, Row130.

Set Column Address (15h)

This command specifies column start address and end address of the display data RAM. This command also sets the column address pointer to column start address. This pointer is used to define the current read/write column address in graphic display data RAM. If horizontal address increment mode is enabled by command A0h, after finishing read/write one column data, it is incremented automatically to the next column address. Whenever the column address pointer finishes accessing the end column address, it is reset back to start column address.

Set Row Address (75h)

This command specifies row start address and end address of the display data RAM. This command also sets the row address pointer to row start address. This pointer is used to define the current read/write row address in graphic display data RAM. If vertical address increment mode is enabled by command A0h, after finishing read/write one row data, it is incremented automatically to the next row address. Whenever the row address pointer finishes accessing the end row address, it is reset back to start row address.

For example, column start address is set to 2 and column end address is set to 129, row start address is set to 1 and row end address is set to 130. Horizontal address increment mode is enabled by command A0h. In this case, the graphic display data RAM column accessible range is from column 2 to column 129 and from row 1 to row 130 only. In addition, the column address pointer is set to 2 and row address pointer is set to 1. After finishing read/write one pixel of data, the column address is increased automatically by 1 to access the next RAM location for next read/write operation. Whenever the column address pointer finishes accessing the end column 129, it is reset back to column 2 and row address is automatically increased by 1. While the end row 130 and end column 129 RAM location is accessed, the row address is reset back to 1. The diagram below shows the way of column and row address pointer movement for this example.

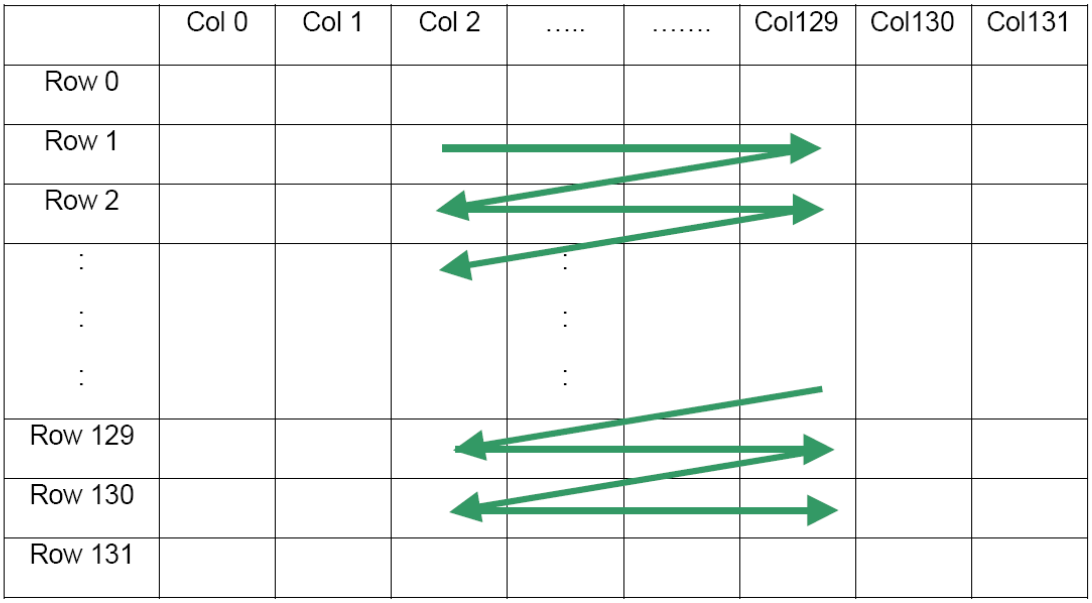

Figure 11: GRAM accessing process inside the Driver IC

The Goldelox processor needs to know how to access the GRAM on your display. You set this up from the 'GRAM Access' Tab. 'Control Code' tells what is to be written (a variable or a constant) and where to write it (to the control or data register). Data options available for constant writes are the six 'set register constants' from the 'constants' tab. Data options available for variable writes are VX1, VX2, XY1 and VY2. VX1 and VY1 define the upper left corner of the GRAM access rectangle and VX2 and VY2 define the lower right of the GRAM access rectangle.

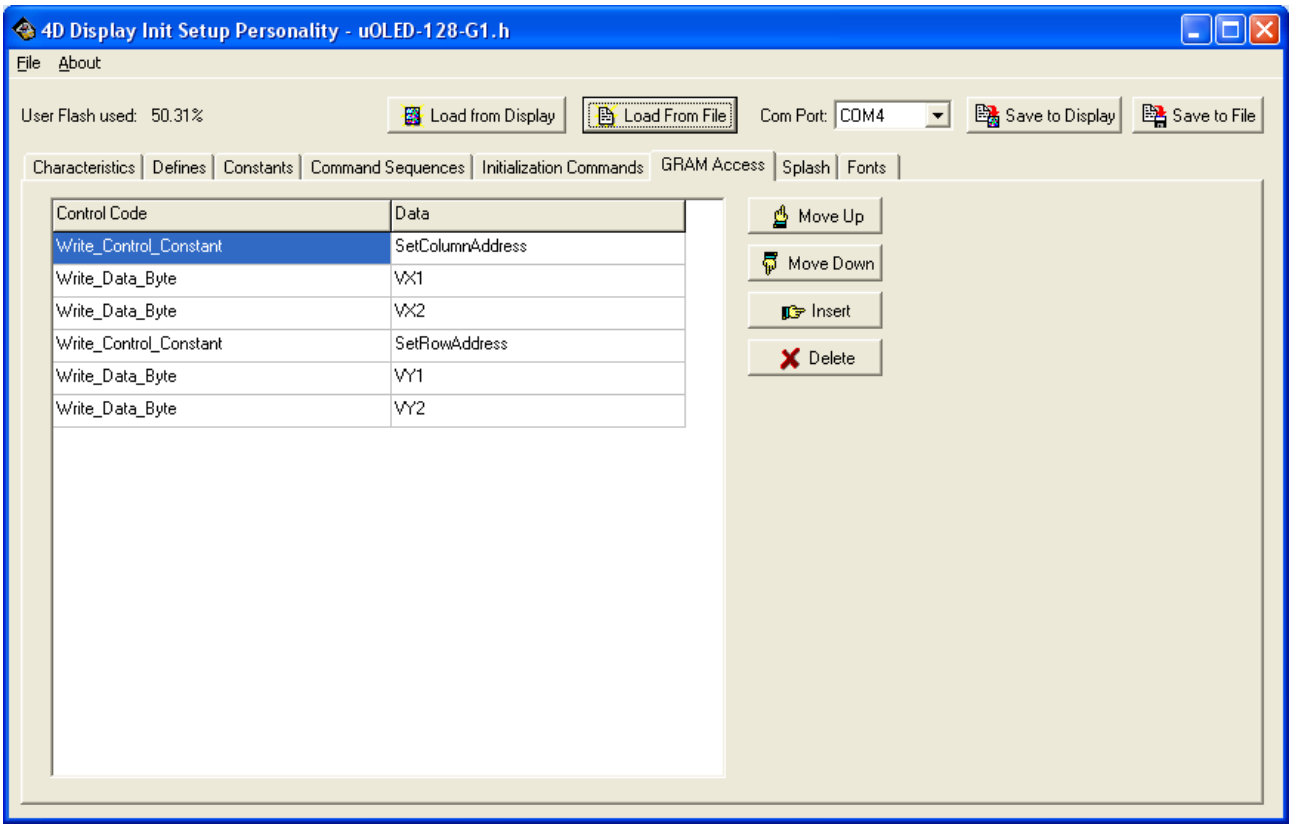

Figure 12: GRAM Access settings

Following the above GRAM Access Setting and the example shown in Figure 9, The GRAM would be accessed as shown below,

VX1 = Col2
VX2 = Col129
VY1 = Row1
VY2 = Row130

Splash

DISP is a great tool to customize the splash screen. It can be used by the customers for advertizing. If you are developing your own product with GOLDELOX-SGC or PICASO-SGC processors, it is ideal to set a personalized splash screen with the help of DISP.

Certain restrictions apply to the writing of splash screens (in order to minimize the use of the user flash memory):-

- Only 'formatted' text can be written (i.e. positioned by line and column)
- Only 8 colors are available
- Text is written as opaque

To set up a line of text:-

- Set the x and y location of the first character of the text where you want them on screen.
- You can set the text color ranging from 0 to 7.
- Set the font type. Remember, you can only set the font number that is included in the fonts initialization under the 'Fonts' tab. By default the 96 G1, 128 G1 and 160 G1 will have three fonts. Any font imported to DISP will have an identification number starting from zero to 15. Select 'Fonts' tab, click the 'Font' combo box to find what fonts are available.

- Prop is also a font setting. Setting it to ‘yes’ will use width of the individual characters (Proportional spacing). Setting it to ‘No’ will use the font width as the character width (Fixed spacing).
- Set the text.
- IF uSD is set to ‘Yes’ this line will only be displayed if there is a uSD card inserted into the display. Because the text is written opaquely it will overwrite any previous line in the same location. E.g. ‘Please insert uSD card’ could be overwritten by ‘uSD card present’’.

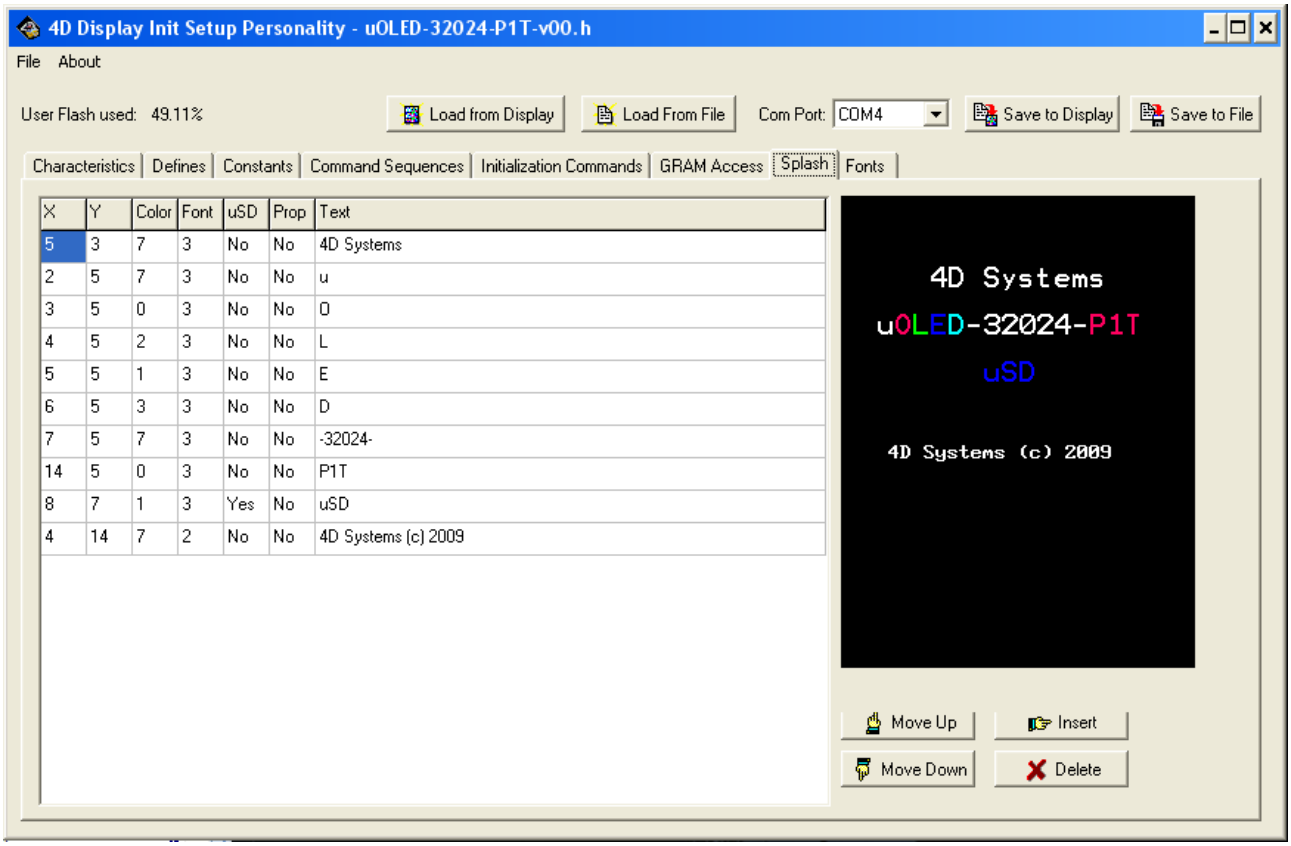

Figure 13: Setting Splash screen

You can preview the splash to the right to see if you like the look and feel of the splash before you commit it to the display.

- Select any cell and click the ‘Move Up’ or ‘Move Down’ button to move up or down the whole row.
- Select a cell and click ’Insert’ to insert a new row under the selected cell.
- Select a cell and click ‘Delete’ to delete the whole row.

Fonts

By default the G1 header files will have three fonts. You can add more fonts. User Flash must not exceed 100% when you save the file.

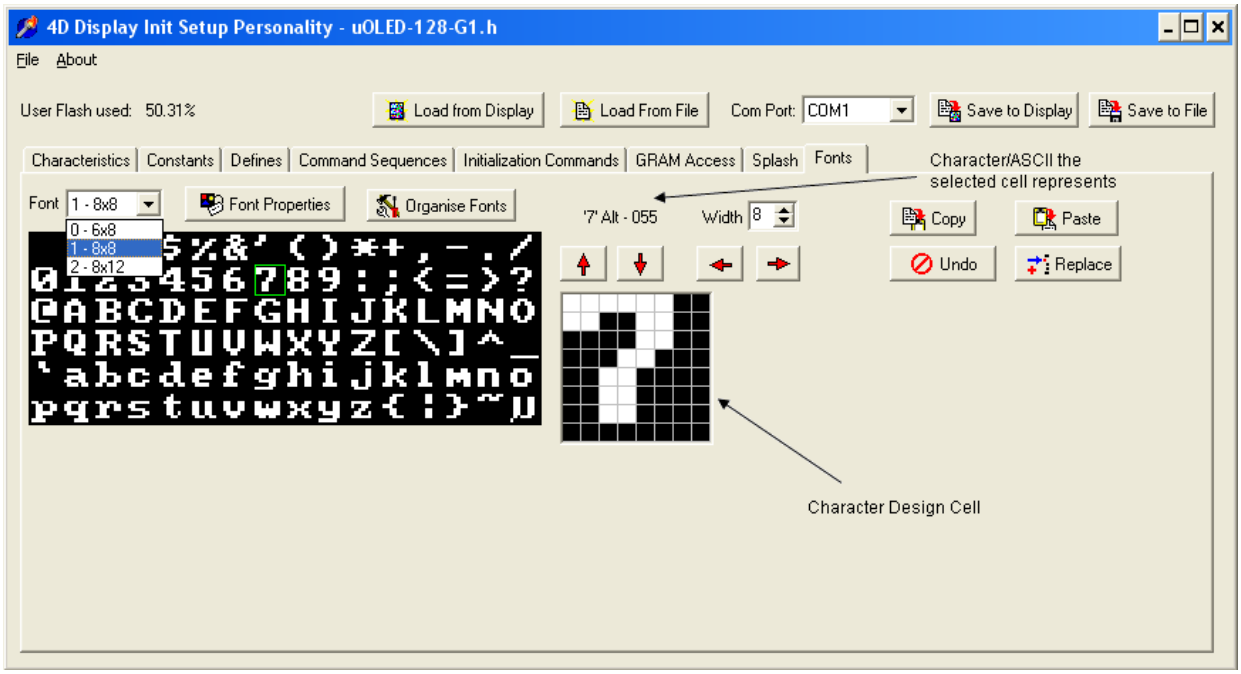

Figure 14: Font Settings

Setting the font Manually

- Select the font type (number) to get all the characters displayed. Select the character and you will see it in another cell in a matrix.
- The character selected is internally represented by an ASCII displayed on the window, as shown in figure 12.
- The white squares form a character and the rest remains empty. Click the white square and it will vanish. Click a black square and it will become white again as part of the character.
- You can also move the whole character up, down, right or left within a cell by using arrow keys.
- Click 'Undo' to undo the changes before replacing the character.
- After completing the character design click replace. The selected character, in the main window, will be replaced by edited character.
- You can also copy one character to another. Just select the character you want to copy and click 'Copy' select the character where you want to put the copied character and click 'Paste'. Then press 'Replace' to complete the replacement.
- The width of the selected character is displayed on the 'Width' combo box.
    - When the character is 'displayed' as 'fixed' width it will be displayed occupying the maximum width of the font.
    - When the character is 'displayed' as 'proportional' it will be displayed occupying the character width.
    - When the character width is less than the maximum width of the font and it is displayed as fixed it will be 'centered' within the maximum width, as opposed to being 'left justified'.

Organize Fonts

- Click 'Organize Fonts' button and a window will popup.
- Select the font and you can change the font type (number) by moving it up or down. Say if you select "1 – 6x8" and click "Move Up" button, 6x8 size font will be represented by "0" (0 – 6x8) now. Similarly you can select any other font and change its representative type (number).
- Select a font and click "Delete" to remove the font.
- You can make your own set of fonts by clicking "New". A window "Font Properties" will pop up. See 'Font Properties' below.
    - Select the first character you want to set for the font. Click up or down to select.
    - Set the number of characters you want.
    - Set the width and height of the standard cell and press "OK".
    - You will get a blank set of cells. Now you can design your own fonts on the cells.

Figure 15: Organise Fonts

- You can also import fonts from a 4D systems' dedicated font file with an extension of "4dfont".
    - Click "Import" on the "Organise Fonts" window and a File-Open dialogue box will pop up.
    - Select the appropriate font file you wish to import and click "Open". The fonts will be loaded into the DISP.
    - "FontTool" is the tool that can use windows font and generate a font file which can be later imported to DISP.

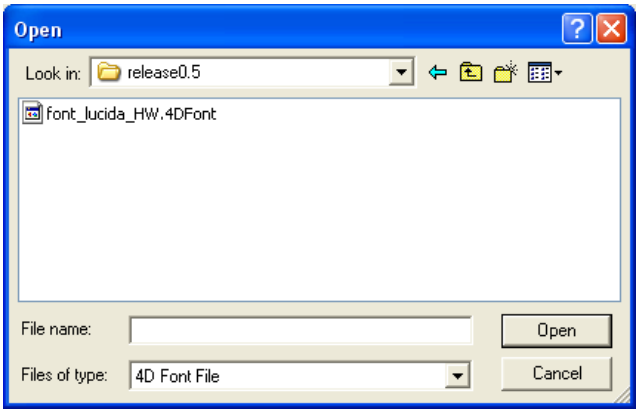

Figure 16: Open a 4D font file

Font Properties

- You can manage the fonts by using "Font Properties". Click the "Font Properties" button to get the pop up window.
    - If you set the first character without checking the "Move chars to First Character" check box the ASCII values behind each cell will be moved while the character designs representing each cell will stay. This should not be tried by a non expert user because you would end up changing the ASCII representation of every designed character.
    - If you set the first character with the "Move chars to First Character" check box checked the ASCII values combined with the design character will completely move to the first character.
    - Set the number of characters you want in the font set. Use those characters that you need. There are a number of special characters included in the imported fonts which may lead to the shortage of user flash space. It is a good practice to get rid of all those characters by shrinking the number of characters if you don't need them.
    - Set the width and height of the characters as per your requirement and click "OK".

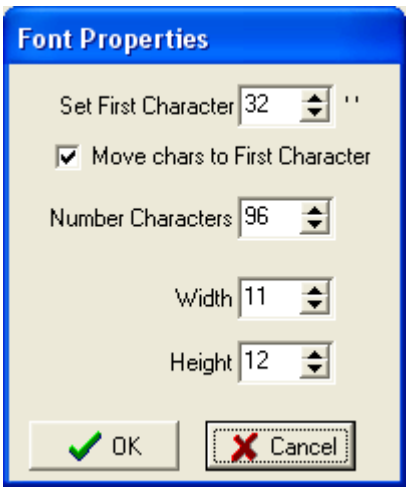

Figure 17: Setting Font Properties

APPENDIX

SSD1339 Command Table

4D Systems www.4dsystems.com.au

8. COMMAND TABLE

Table 3 – Command table

(**D/$\overline{C}$** = 0, **R/$\overline{W}$** (**$\overline{WR}$**) = 0, E(**$\overline{RD}$**) = 1) unless specific setting is stated
Single byte command (D/$\overline{C}$ = 0), Multiple byte command (D/$\overline{C}$ = 0 for first byte, D/$\overline{C}$ = 1 for other bytes)

D/C	Hex	D7	D6	D5	D4	D3	D2	D2	D0	Command	Description
0	15	0	0	0	1	0	1	0	1	Set Column Address	A[7:0]: Start Address, reset=0d
1	A[7:0]	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0		B[7:0]: End Address, reset=131d
1	B[7:0]	B_7	B_6	B_5	B_4	B_3	B_2	B_1	B_0		Range from 0d to 131d
0	75	0	1	1	1	0	1	0	1	Set Row Address	A[7:0]: Start Address, reset=0d
1	A[7:0]	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0		B[7:0]: End Address, reset=131d
1	B[7:0]	B_7	B_6	B_5	B_4	B_3	B_2	B_1	B_0		Range from 0d to 131d
0	5C	0	1	0	1	1	1	0	0	Write RAM Command	Enable MCU to write Data into RAM
0	5D	0	1	0	1	1	1	0	1	Read RAM Command	Enable MCU to read Data from RAM
0	A0	1	0	1	0	0	0	0	0	Set Re-map / Color Depth(Display RAM to Panel)	A[0]=0, Horizontal address increment (POR) A[0]=1, Vertical address increment A[1]=0, Column address 0 is mapped to SEG0 (POR) A[1]=1, Column address 131 is mapped to SEG0 A[2]=0, Color sequence: A → B → C (POR) A[2]=1, Color sequence is swapped: C → B → A A[3]=0, Disable 9/18-bit bus interface (POR) A[3]=1, Enable 9/18-bit bus interface A[4]=0, Scan from COM 0 to COM [N –1] (POR) A[4]=1, Scan from COM [N-1] to COM0. Where N is the Multiplex ratio. A[5]=0, Disable COM Split Odd Even (POR) A[5]=1, Enable COM Split Odd Even A[7:6] Set Color Depth, 00 256 color 01 65K color, (POR) 10 262k color, 8/9/18-bit,16 bit (1st option) MCU interface 11 262k color, 16 - bit MCU interface (2nd option)
1	A[7:0]	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0		
0	A1	1	0	1	0	0	0	0	1	Set Display Start Line	Set vertical scroll by RAM from 0~131
1	A[7:0]	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0		[reset=00d]

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D/C	Hex	D7	D6	D5	D4	D3	D2	D2	D0	Command	Description
0	A2	1	0	1	0	0	0	1	0	Set Display Offset	Set vertical scroll by Row from 0-131. [reset=00b]
1	A[7:0]	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0		
0	A4~A7	1	0	1	0	0	1	X_1	X_0	Set Display Mode	A4: All Off A5: All On (All pixels have GS15) A6 : Reset to normal display (POR) A7: Inverse Display (GS0 -> GS63, GS1 -> GS62, ...)
0	AD	1	0	1	0	1	1	0	1	Master Configuration	A[7:0] should be set as 100011A[1]A[0]b
1	A[7:0]	1	0	0	0	1	A_2	A_1	A_0		A[0]= 0 Select external VCC supply at master ON A[0] = 1 Select internal booster at master ON [reset] A[1]= 0 Select external VCOMH voltage supply at master ON A[1] = 1 Select internal VCOMH regulator at master ON [reset] A[2] = 0 Select external pre-charge voltage source A[2] = 1 Select internal pre-charge voltage source [reset]
0	AE~AF	1	0	1	0	1	1	1	X_0	Set Sleep mode On/Off	AE = Sleep mode On (Display off) AF = Sleep mode Off (Display on)
0	B0	1	0	1	1	0	0	0	0	Power Saving Mode	A[4:0]: 00000b = Normal 10010b = Power Saving 00101b = External VSL
		0	0	0	A_4	A_3	A_2	A_1	A_0		
0	B1	1	0	1	1	0	0	0	1	Set Reset (Phase 1) /Pre-charge (Phase 2) period	A[3:0] Phase 1 period of 1~16 dclk clocks [reset=4h]
1	A[7:0]	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0		A[7:4] Phase 2 period of 1~16 dclk clocks [reset=7h]
0	B3	1	0	1	1	0	0	1	1	Front Clock Divider (DivSet)/ Oscillator Frequency	A[3:0] [reset=0], divide by DIVSET+1 (i.e. 1 to 16)
1	A[7:0]	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0		A[7:4] Osc frequency, frequency increase as level increase [reset=1001b]
										Look Up Table for Gray Scale Pulse width	The next 32 bytes of command set the current drive pulse width of gray scale level GS1, GS3, GS5 …GS63 as below in unit of DCLK.
0	B8	1	0	1	1	1	0	0	0		A[7:0] : PW1, POR =1 DCLK
1	A[7:0]	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0		B[7:0] : PW3, POR = 5 DCLK
1	B[7:0]	B_7	B_6	B_5	B_4	B_3	B_2	B_1	B_0		C[7:0] : PW5, POR = 9 DCLK
1	.	.	.	.	.	.	.	.	.		.
1	.	.	.	.	.	.	.	.	.		.
1	.	.	.	.	.	.	.	.	.		AE[7:0] : PW61, POR = 121 DCLK
1	.AE[7:0]	AE_7	AE_6	AE_5	AE_4	AE_3	AE_2	AE_1	AE_0		AF[7:0] : PW63, POR = 123 DCLK
1	AF[7:0]	AF_7	AF_6	AF_5	AF_4	AF_3	AF_2	AF_1	AF_0		where PW1 must > 0 PW3 must > PW1+1

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D/C	Hex	D7	D6	D5	D4	D3	D2	D2	D0	Command	Description
											PW5 must > PW3+1 Note: GS0 has no pre-charge and current drive stages. For GS2 GS4…GS62, they are derived by driver itself with: PWn = (PW_{n-1}+PW_{n+1})/2 Max pulse width is 125
0	B9	1	0	1	1	1	0	0	1	Use Built-in Linear LUT (reset= linear)	Reset to default Look Up Table: PW1 = 1 PW2 = 3 PW3 = 5 PW4 = 7 ... PW62 = 123 PW63 = 125
0 1 1 1	BB A[7:0] B[7:0] C[7:0]	1 A_7	0 A_6	1 A_5	1 A_4	1 A_3	0 A_2	1 A_1	1 A_0	Set Pre-charge voltage of Color A B C	A[7:0] Pre-charge Color A [reset = 00011100] B[7:0] Pre-charge Color B [reset = 00011100] C[7:0] Pre-charge Color C [reset = 00011100] 00000000 0.51*Vref ..... 00011111 0.84*Vref 1xxxxxxx connects to VCOMH
0 1	BE A[6:0]	1 *	0 A_6	1 A_5	1 A_4	1 A_3	1 A_2	1 A_1	0 A_0	Set VCOMH	A[6:0] 0000000 0.51*Vref ..... 0011111 0.84*Vref [VCOMHSET, reset]
0 1 1 1	C1 A[7:0] B[7:0] C[7:0]	1 A_7 B_7 C_7	1 A_6 B_6 C_6	0 A_5 B_5 C_5	0 A_4 B_4 C_4	0 A_3 B_3 C_3	0 A_2 B_2 C_2	0 A_1 B_1 C_1	1 A_0 B_0 C_0	Contrast Current for Color A,B,C	A[7:0] Contrast Value Color A [reset=1000000b] B[7:0] Contrast Value Color B [reset=1000000b] C[7:0] Contrast Value Color C [reset=1000000b]
0 1	C7 A[3:0]	1 *	1 *	0 *	0 *	0 A_3	1 A_2	1 A_1	1 A_0	Master Contrast Current Control	A[3:0] : 0000 reduce output currents for all colors to 1/16 0001 reduce output currents for all colors to 2/16 .... 1110 reduce output currents for all colors to 15/16 1111 no change [reset = 1111b]

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D/C	Hex	D7	D6	D5	D4	D3	D2	D2	D0	Command	Description
0	CA	1	1	0	0	1	0	1	0	Set Mux Ratio	A[7:0] mux ratio 16MUX ~ 132MUX, [reset=131d], (Ran
1	A[7:0]	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0		from 15d to 131d)
0	E3	1	1	1	0	0	0	1	1	NOP	Command for No Operation

Table 4 – Graphic acceleration command

Set (GAC) (**D/$\overline{C}$** = 0, **R/$\overline{W}$** (**$\overline{WR}$**) = 0, E(**$\overline{RD}$**) = 1) unless specific setting is stated
Single byte command (D/$\overline{C}$ = 0), Multiple byte command (D/$\overline{C}$ = 0 for first byte, D/$\overline{C}$ = 1 for other bytes)

D/C	Hex	D7	D6	D5	D4	D3	D2	D2	D0	Command	Description
0	83	1	0	0	0	0	0	1	1	Draw Line	A[7:0] : Column Address of Start
1	A[7:0]	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0		B[7:0] : Row Address of Start
1	B[7:0]	B_7	B_6	B_5	B_4	B_3	B_2	B_1	B_0		C[7:0] : Column Address of End
1	C[7:0]	C_7	C_6	C_5	C_4	C_3	C_2	C_1	C_0		D[7:0] : Row Address of End
1	D[7:0]	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0		E[7:0] : Line Color - CCCCCBBB
1	E[7:0]	E_7	E_6	E_5	E_4	E_3	E_2	E_1	E_0		F[7:0] : Line Color - BBBAAAAA
1	F[7:0]	F_7	F_6	F_5	F_4	F_3	F_2	F_1	F_0		* A < C < 132
											* B < D < 132
0	84	1	0	0	0	0	1	0	0	Draw Rectangle	A[7:0] : Column Address of Start
1	A[7:0]	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0		B[7:0] : Row Address of Start
1	B[7:0]	B_7	B_6	B_5	B_4	B_3	B_2	B_1	B_0		C[7:0] : Column Address of End
1	C[7:0]	C_7	C_6	C_5	C_4	C_3	C_2	C_1	C_0		D[7:0] : Row Address of End
1	D[7:0]	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0		E[7:0] : Line Color - CCCCCBBB
1	E[7:0]	E_7	E_6	E_5	E_4	E_3	E_2	E_1	E_0		F[7:0] : Line Color - BBBAAAAA
1	F[7:0]	F_7	F_6	F_5	F_4	F_3	F_2	F_1	F_0		G[7:0] : Fill Color - CCCCCBBB
1	G[7:0]	G_7	G_6	G_5	G_4	G_3	G_2	G_1	G_0		H[7:0] : Fill Color - BBBAAAAA
1	H[7:0]	H_7	H_6	H_5	H_4	H_3	H_2	H_1	H_0		
											* A < C < 132
											* B < D < 132
0	86	1	0	0	0	0	1	1	0	Draw Circle	A[7:0] : Column Address of Centre
1	A[7:0]	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0		B[7:0] : Row Address of Centre
1	B[7:0]	B_7	B_6	B_5	B_4	B_3	B_2	B_1	B_0		C[7:0] : Radius
1	C[7:0]	C_7	C_6	C_5	C_4	C_3	C_2	C_1	C_0		D[7:0] : Line Color - CCCCCBBB
1	D[7:0]	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0		E[7:0] : Line Color - BBBAAAAA
1	E[7:0]	E_7	E_6	E_5	E_4	E_3	E_2	E_1	E_0		F[7:0] : Fill Color - CCCCCBBB
1	F[7:0]	F_7	F_6	F_5	F_4	F_3	F_2	F_1	F_0		G[7:0] : Fill Color – BBBAAAAA
1	G[7:0]	G_7	G_6	G_5	G_4	G_3	G_2	G_1	G_0		
0	8A	1	0	0	0	1	0	1	0	Copy	A[7:0] : Column Address of Start
1	A[7:0]	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0		B[7:0] : Row Address of Start
1	B[7:0]	B_7	B_6	B_5	B_4	B_3	B_2	B_1	B_0		C[7:0] : Column Address of End
1	C[7:0]	C_7	C_6	C_5	C_4	C_3	C_2	C_1	C_0		D[7:0] : Row Address of End
1	D[7:0]	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0		E[7:0] : Column Address of New Start

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D/C	Hex	D7	D6	D5	D4	D3	D2	D2	D0	Command	Description
1	E[7:0]	E_7	E_6	E_5	E_4	E_3	E_2	E_1	E_0		F[7:0] : Row Address of New Start
1	F[7:0]	F_7	F_6	F_5	F_4	F_3	F_2	F_1	F_0		* A < C < 132 * B < D < 132
0	8C	1	0	0	0	1	1	0	0	Dim Window	A[7:0] : Column Address of Start
1	A[7:0]	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0		B[7:0] : Row Address of Start
1	B[7:0]	B_7	B_6	B_5	B_4	B_3	B_2	B_1	B_0		C[7:0] : Column Address of End
1	C[7:0]	C_7	C_6	C_5	C_4	C_3	C_2	C_1	C_0		D[7:0] : Row Address of End
1	D[7:0]	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0		* A < C < 132 * B < D < 132
0	8E	1	0	0	0	1	1	1	0	Clear Window	A[7:0] : Column Address of Start
1	A[7:0]	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0		B[7:0] : Row Address of Start
1	B[7:0]	B_7	B_6	B_5	B_4	B_3	B_2	B_1	B_0		C[7:0] : Column Address of End
1	C[7:0]	C_7	C_6	C_5	C_4	C_3	C_2	C_1	C_0		D[7:0] : Row Address of End
1	D[7:0]	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0		* A < C < 132 * B < D < 132
0	92	1	0	0	1	0	0	1	0	Fill Enable / Disable	A0 0 : Disable Fill for Draw Rectangle/Circle Command [reset] 1 : Enable Fill for Draw Rectangle/Circle Command A4 0 : Disable reverse copy, reset] 1 : Enable reverse during copying. A5 0 : Disable x-wrap, [reset] 1 : Enable wrap around in x-direction during copying
1	A[5:0]	*	*	A_5	A_4	A_3	A_2	A_1	A_0		
0	96	1	0	0	1	0	1	1	0	Horizontal Scroll	A[7:0] : 1~124 horizontal offset in number of Column Invalid entry for value larger than 124 0 no horizontal scroll B[7:0] : start row address C[7:0] : number of rows to be H-scrolled B+C <= 132 D[7:0] : Reserved E[1:0] : scrolling time interval 0 test mode 1 normal 2 slow 3 slowest Note : operates during display on.
1	A[7:0]	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0		
1	B[7:0]	B_7	B_6	B_5	B_4	B_3	B_2	B_1	B_0		
1	C[7:0]	C_7	C_6	C_5	C_4	C_3	C_2	C_1	C_0		
1	D[7:0]	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0		
1	E[1:0]	*	*	*	*	*	*	E_1	E_0		
0	9E	1	0	0	1	1	1	1	0	Stop Moving	
0	9F	1	0	0	1	1	1	1	1	Start Moving	

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