APPLICATION NOTES

4D SYSTEMS
TURNING TECHNOLOGY INTO ART

Serial Arduino Displaying Images from the uSD Card FAT16

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Description

This application note explores the possibilities provided by the Serial environment in Workshop for a 4D display module to work with an Arduino host. In this example, the host is an Arduino Uno board. The host can also be an Arduino Mega 2560 or Due. Ideally, the application described in this document should work with any Arduino board that supports software serial or with at least one UART serial port. See specifications of Aduino boards here.

Before getting started, the following are required:

- Any Picaso or Diablo16 display module. Visit www.4dsystems.com.au to see the latest products using any of these graphics processors.
- 4D Programming Cable or µUSB-PA5
- micro-SD (µSD) memory card
- Workshop 4 IDE (installed according to the installation document)
- Any Arduino board with a UART serial port
- 4D Arduino Adaptor Shield (optional) or connecting wires
- Arduino IDE
- When downloading an application note, a list of recommended application notes is shown. It is assumed that the user has read or has a working knowledge of the topics presented in these recommended application notes.

Content

Application Overview

This application note shows how an Arduino host is programmed to control a 4D display module (slave device) and make it display images. The images are contained in a graphics file saved on a µSD card mounted on the µSD card slot of the display. The Arduino host sends serial commands to the 4D display slave to access the graphics file and display the images. The graphics file is of a format that is readable by 4D-LAB's processors. This graphics file is generated using the Workshop 4 IDE.

Setup Procedure

The following are the steps involved in doing this project:

1. **Generate the graphics file** using Workshop 4 ViSi. Copy the generated graphics file to the uSD card and mount the uSD card to the display module.
2. Configure the display module as a serial slave device by **loading it with the SPE application**.
3. **Program the Arduino host.** The Arduino board will be the master. By communicating with the slave display module, it will be able to access and display the images stored inside the graphics file on the uSD card of the display module.

Generate the Graphics File

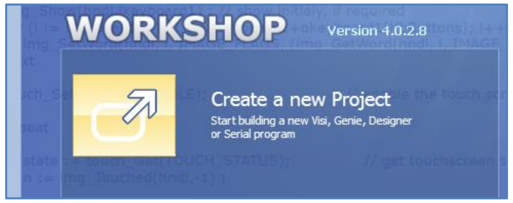
This application note, although written for Serial, requires the use of the ViSi environment to generate the necessary files which will be copied to the uSD card. The procedure for creating a ViSi project will be shown. Users who want to learn more about the ViSi environment may consult the application note

ViSi Getting Started - First Project for Picaso and Diablo16

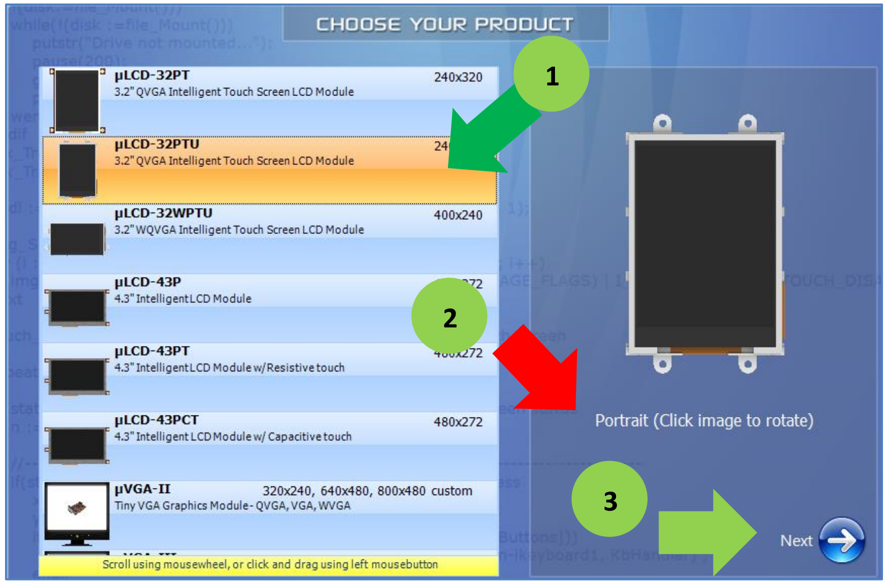
Topics discussed in that application note include instructions on how to launch Workshop 4, how to open a ViSi project, how to change the target display, how to create a new ViSi project, how to save a ViSi project, how to connect the target display to the PC, how to copy the graphics file to the uSD card, and how to compile and upload a program.

Launch Workshop 4

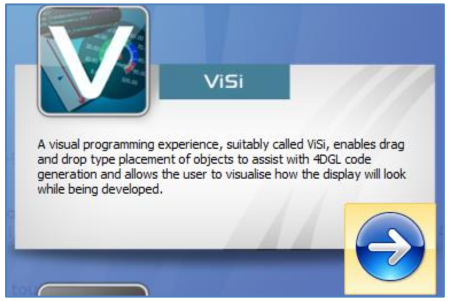
Open the Workshop 4 (WS4) IDE and click "Create a new project".


WORKSHOP
Version 4.0.2.8
Create a new Project
Start building a new Visi, Genie, Designer or Serial program

Choose your target device. For this example we select the **uLCD-32PTU**. Orientation is portrait. Click **Next**.

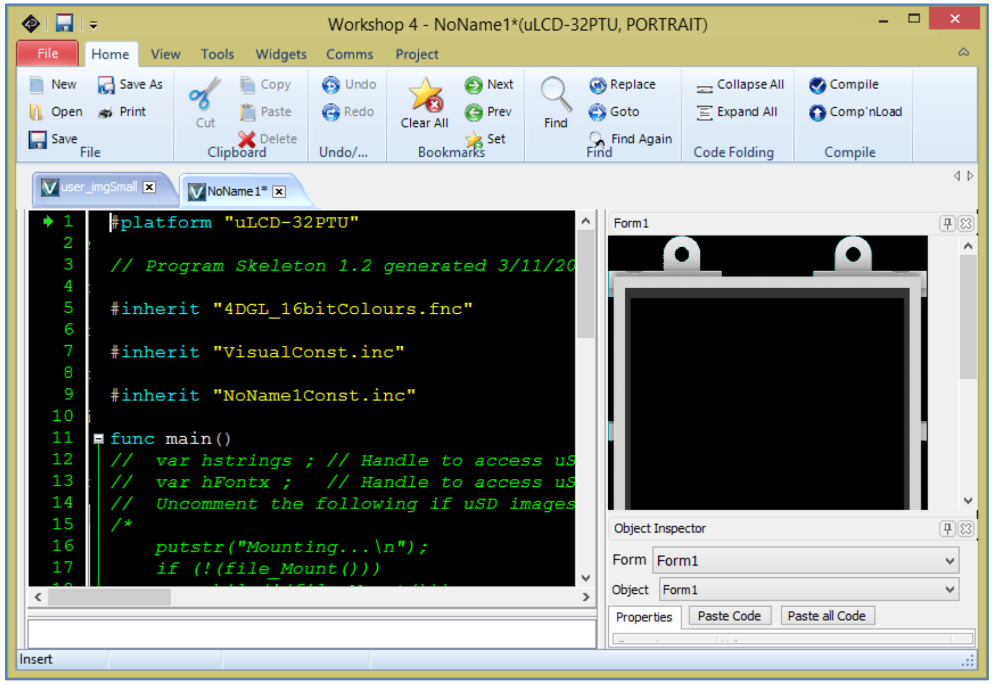

CHOOSE YOUR PRODUCT
1
2
3
µLCD-32PT 3.2" QVGA Intelligent Touch Screen LCD Module 240x320
µLCD-32PTU 3.2" QVGA Intelligent Touch Screen LCD Module
µLCD-32WPTU 3.2" WQVGA Intelligent Touch Screen LCD Module 400x240
µLCD-43P 4.3" Intelligent LCD Module
µLCD-43PT 4.3" Intelligent LCD Module w/ Resistive touch
µLCD-43PCT 4.3" Intelligent LCD Module w/ Capacitive touch 480x272
µVGA-II 320x240, 640x480, 800x480 custom Tiny VGA Graphics Module - QVGA, VGA, WVGA
Scroll using mousewheel, or click and drag using left mousebutton
Portrait (Click image to rotate)
Next

Select the **ViSi** environment.



A visual programming experience, suitably called ViSi, enables drag and drop type placement of objects to assist with 4DGL code generation and allows the user to visualise how the display will look while being developed.

This will open the ViSi development environment window within the WS4 IDE as shown below.

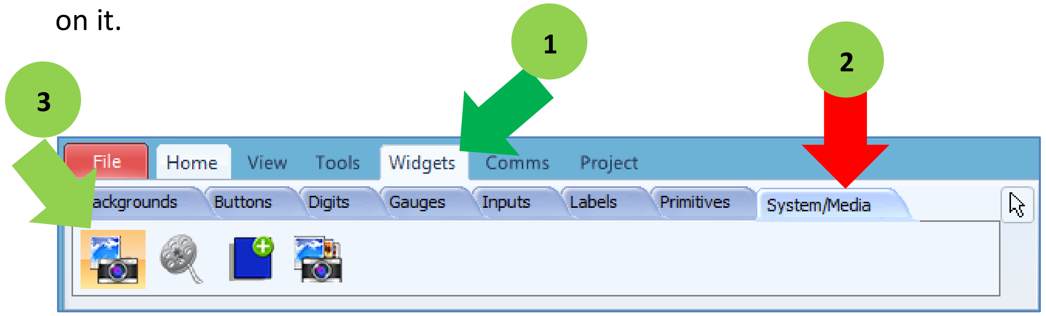


```
#platform "uLCD-32PTU"

// Program Skeleton 1.2 generated 3/11/20

#inherit "4DGL_16bitColours.fnc"

#inherit "VisualConst.inc"

#inherit "NoName1Const.inc"

func main()
//   var hstrings ; // Handle to access uS
//   var hFontx ;   // Handle to access uS
//   Uncomment the following if uSD images
/*
     putstr("Mounting...\n");
     if (!(file_Mount()))
```

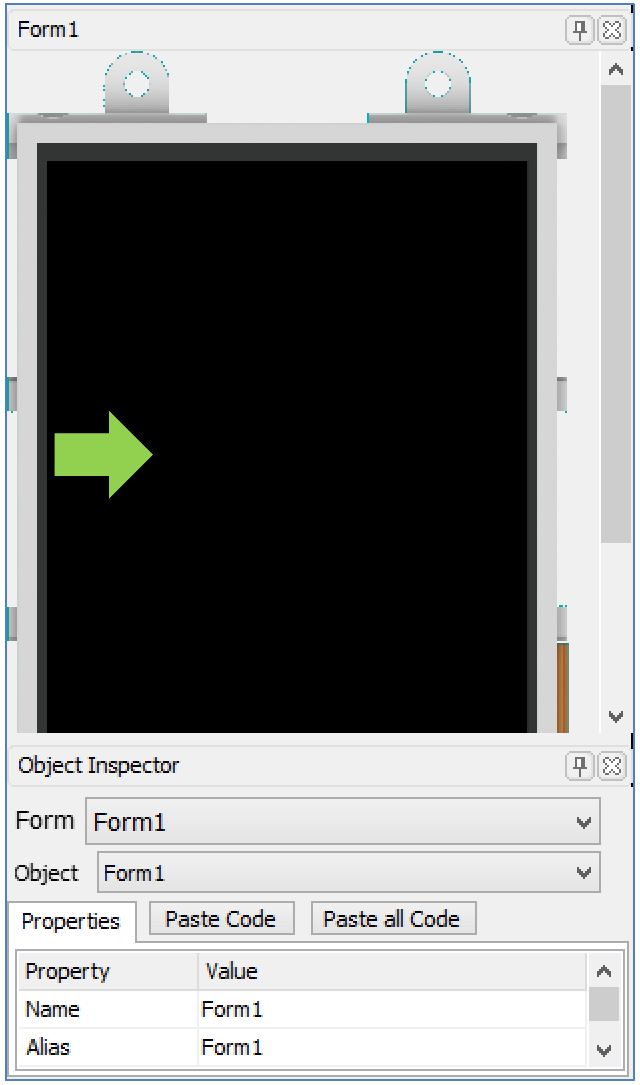
Form: Form1
Object: Form1

Add an Image Object

We will add the image for the face of the penguin. The icon for the image object is found under the **Systems/Media** pane of the **Widgets** menu. Click on it.



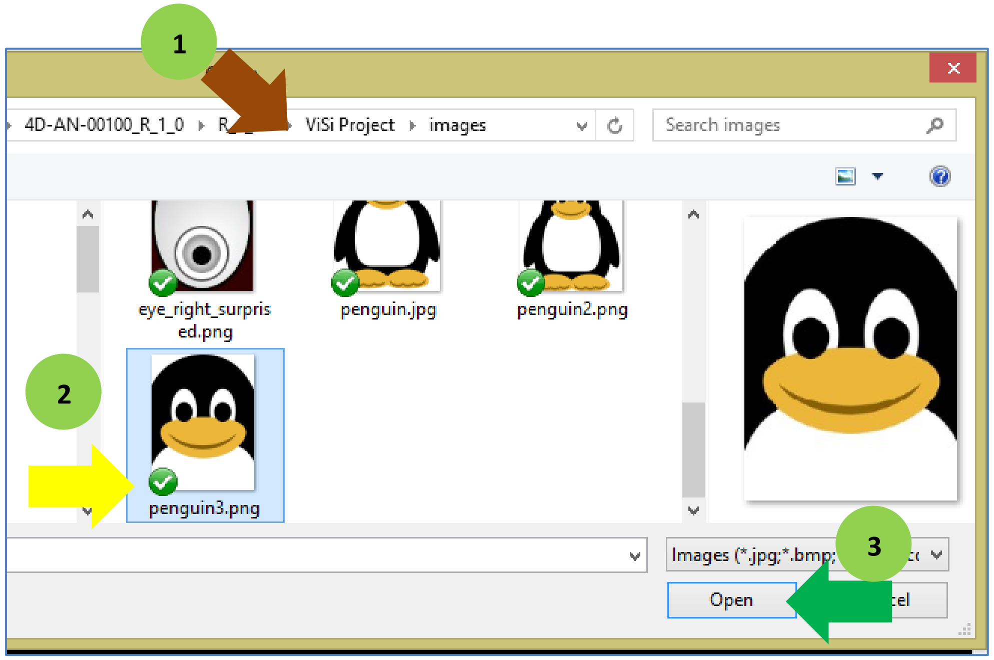
Click on the WYSIWYG (What-You-See-Is-What-You-Get) screen to place an image object.



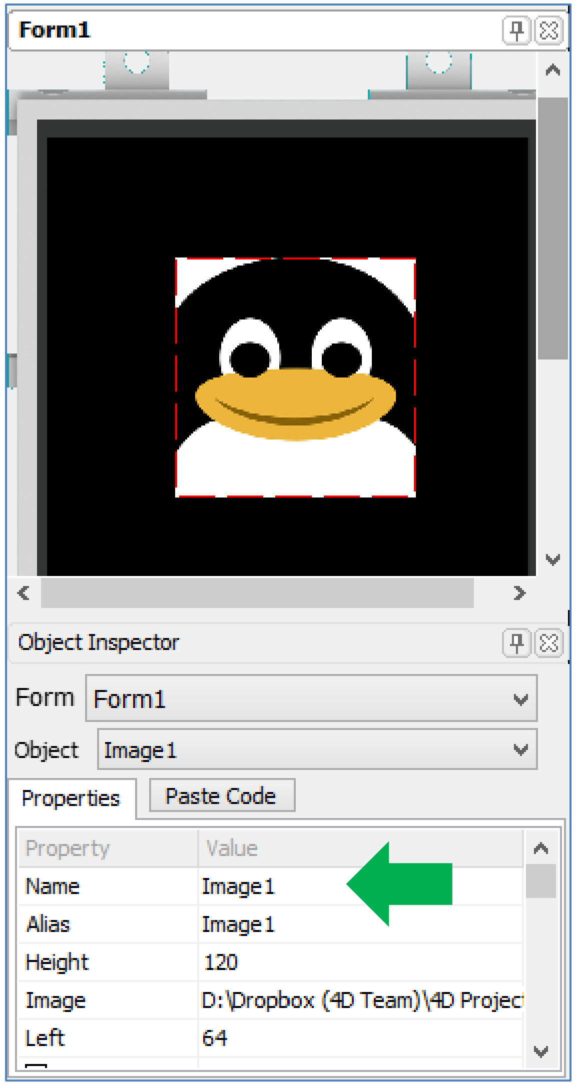
Form: Form1
Object: Form1

Property	Value
Name	Form1
Alias	Form1

Workshop will then ask for an image file. Here the file "**penguin3.png**" is selected. This file was resized to proportionally fit into the WYSIWYG screen. Look for this image file inside the folder "ViSi Project".



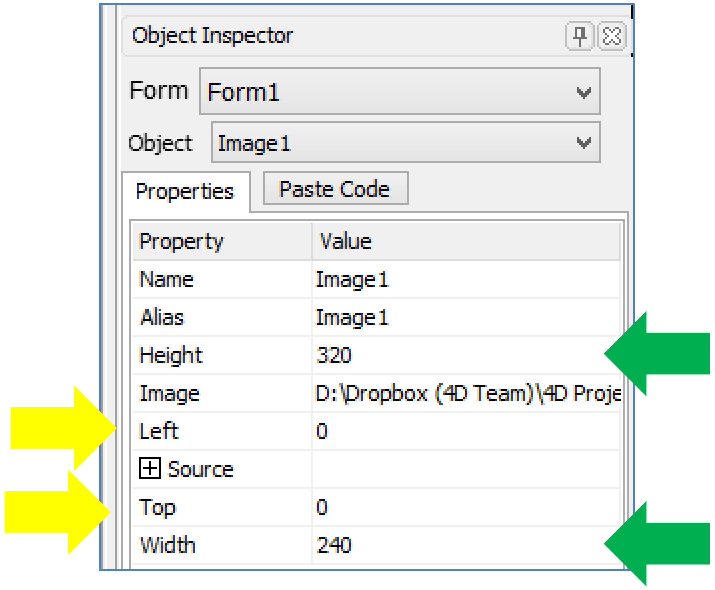
The WYSIWYG screen is updated accordingly with the image. This image object is Image1.



Form: Form1
Object: Image1

Property	Value
Name	Image1
Alias	Image1
Height	120
Image	D:\Dropbox (4D Team)\4D Projec
Left	64

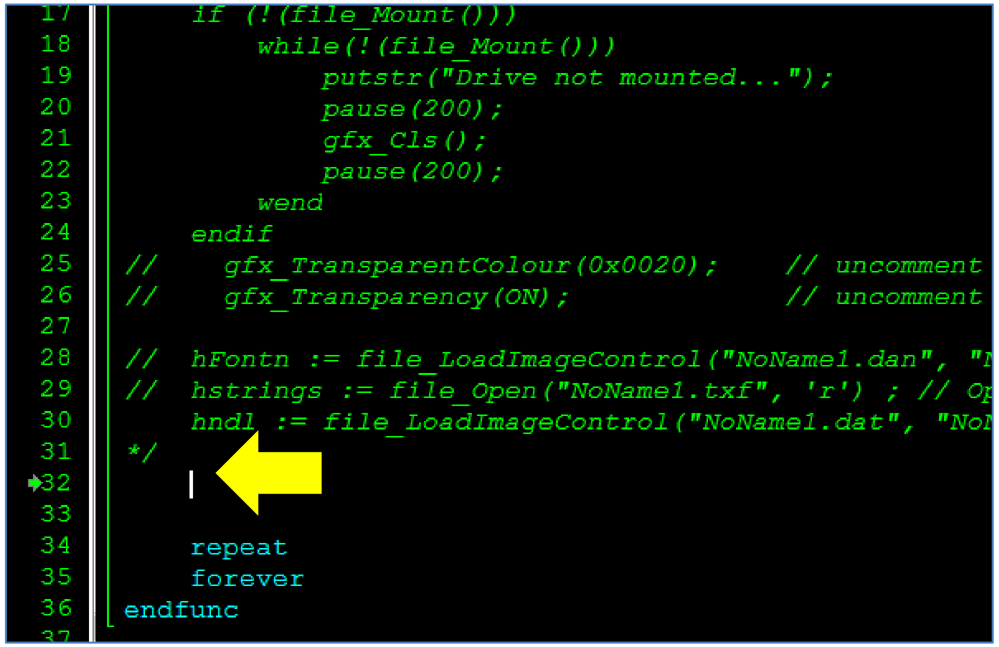
You can drag the edges of the object "Image1" to resize it. You can also input the width and height values directly to the Object Inspector. To make the penguin image fill the entire WYSIWYG screen, input the width and height parameters below. Also, take note of the parameters “Left” and “Top”.


Object Inspector

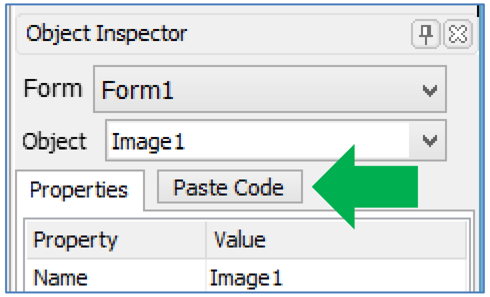
Form: Form1
Object: Image1

Property	Value
Name	Image1
Alias	Image1
Height	320
Image	D:\Dropbox (4D Team)\4D Proje
Left	0
⊞ Source	
Top	0
Width	240

The 4DGL commands for displaying Image1 can be seen by pasting the code for it on the code area. Place the cursor on line 32 of the code area, as indicated below.

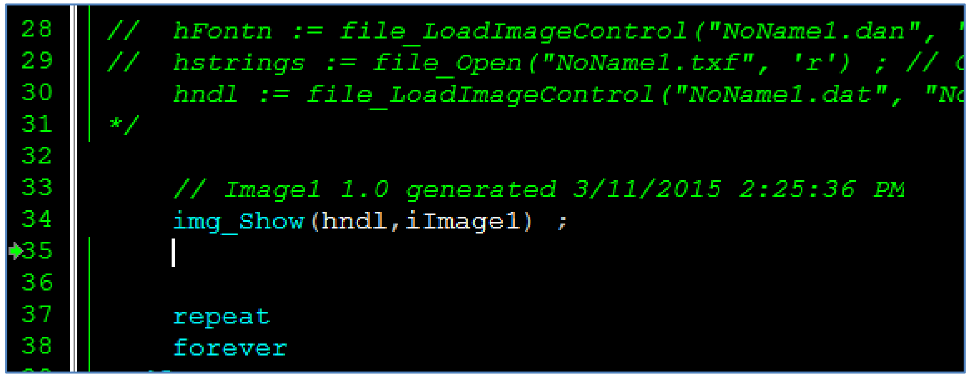

```
17        if (!(file_Mount()))
18            while(!(file_Mount()))
19                putstr("Drive not mounted...");
20                pause(200);
21                gfx_Cls();
22                pause(200);
23            wend
24        endif
25    //    gfx_TransparentColour(0x0020);    // uncomment
26    //    gfx_Transparency(ON);             // uncomment
27
28    //  hFontn := file_LoadImageControl("NoName1.dan", "N
29    //  hstrings := file_Open("NoName1.txf", 'r') ; // Op
30        hndl := file_LoadImageControl("NoName1.dat", "NoN
31    */
32        |
33
34        repeat
35        forever
36    endfunc
37
```

In the object inspector for Image1, click on the “Paste Code” button.



Property	Value
Name	Image1

The code area is updated accordingly.

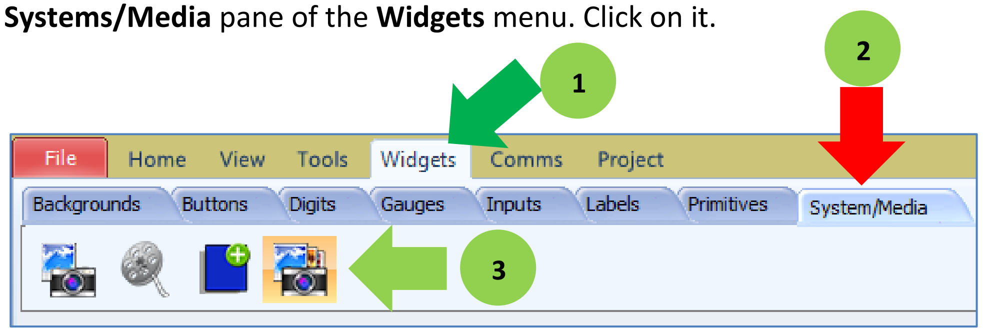


```
//  hFontn := file_LoadImageControl("NoName1.dan", "
//  hstrings := file_Open("NoName1.txf", 'r') ; // C
    hndl := file_LoadImageControl("NoName1.dat", "No
*/

    // Image1 1.0 generated 3/11/2015 2:25:36 PM
    img_Show(hndl,iImage1) ;


    repeat
    forever
```

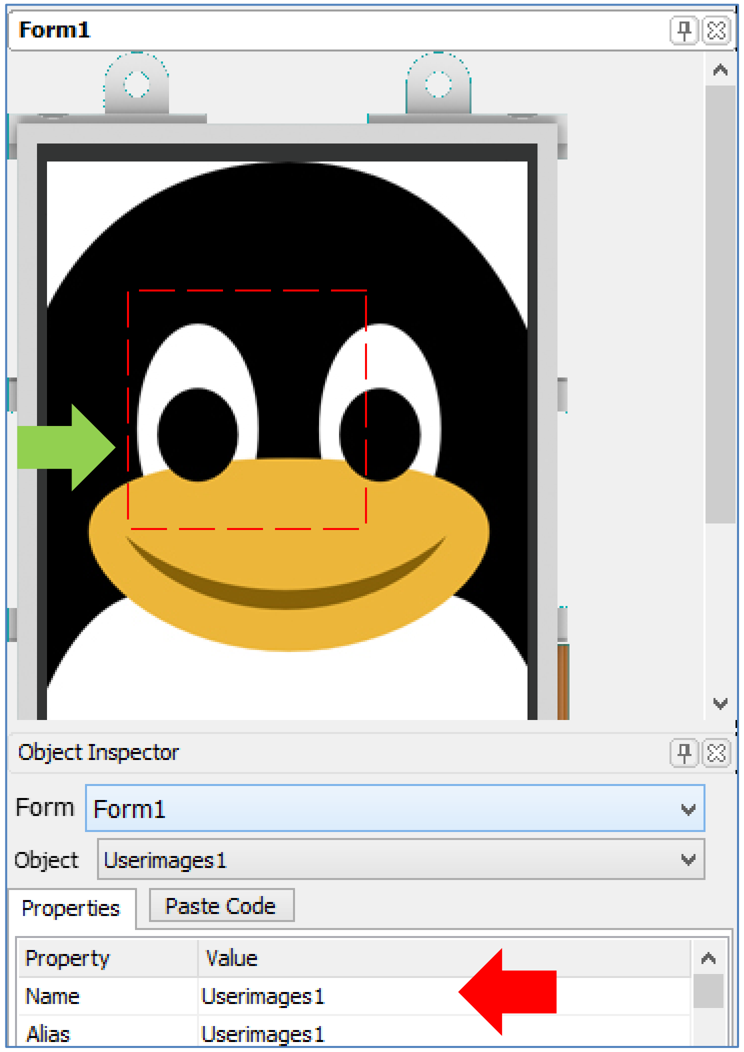
The 4DGL code is not needed in this application note. When writing the sketch for the Arduino host controller however, it is often useful to refer to the 4DGL code and functions.

Add a User Images Object

A user images object is an object composed of several frames of images. With the correct serial command, the desired frame of a user images object can be displayed. For the eyes of the penguin, we will use two user images objects. The icon for the user images object is found under the **Systems/Media** pane of the **Widgets** menu. Click on it.



Click on the WYSIWYG screen to place a new user images object. Shown below is an empty user images object. This is Userimages1, which will be the left eye of the penguin.

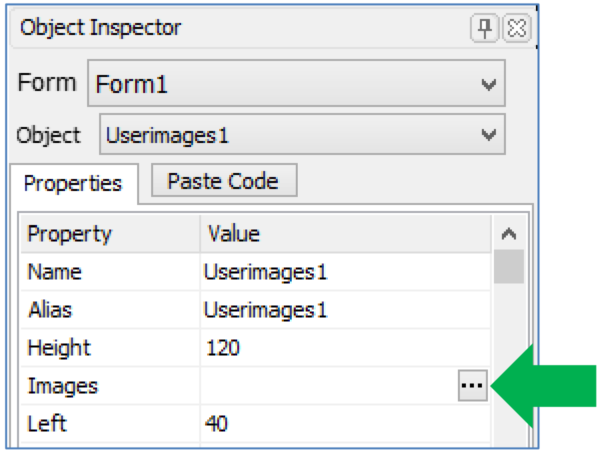


Form: Form1

Object: Userimages1

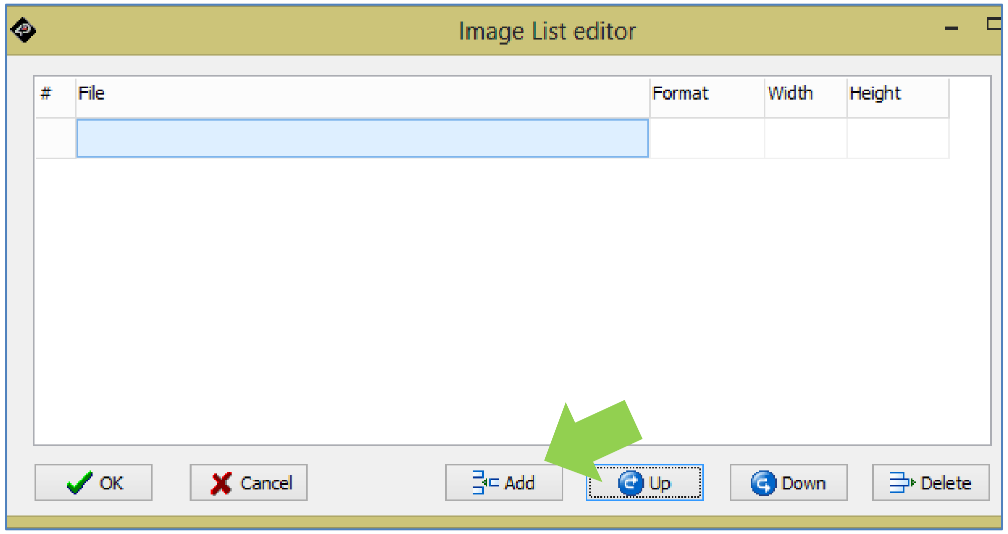
Property	Value
Name	Userimages1
Alias	Userimages1

To populate Userimages1, click on the ellipsis symbol of the property "Images" of the Object Inspector.

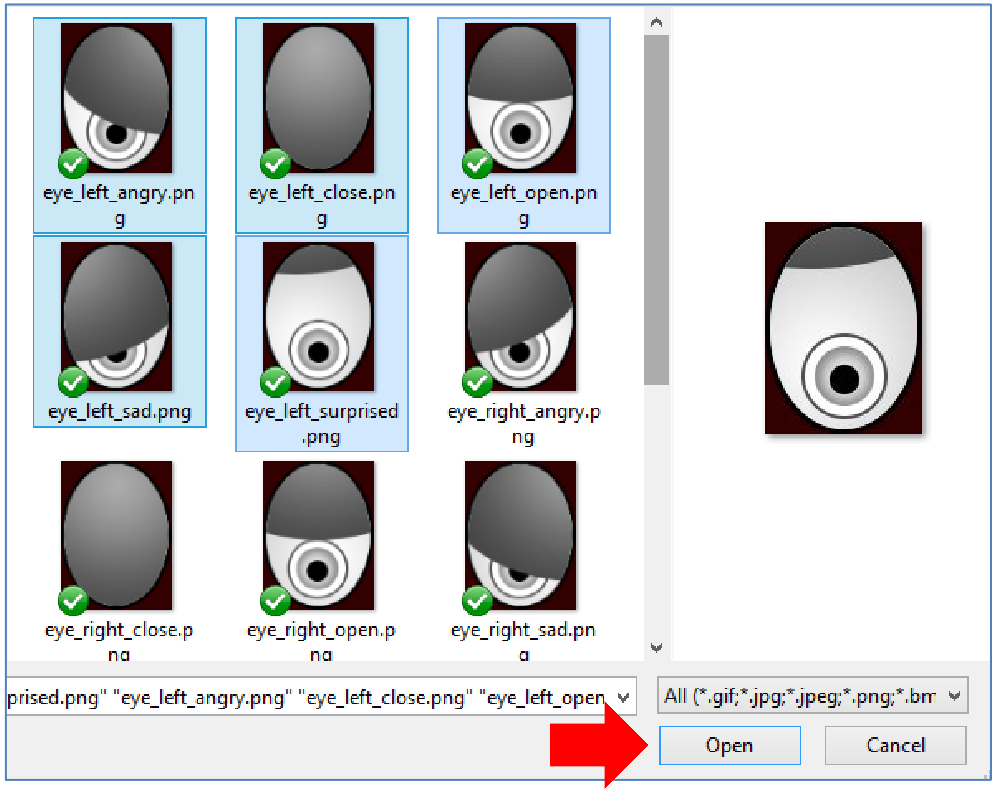


Property	Value
Name	Userimages1
Alias	Userimages1
Height	120
Images	...
Left	40

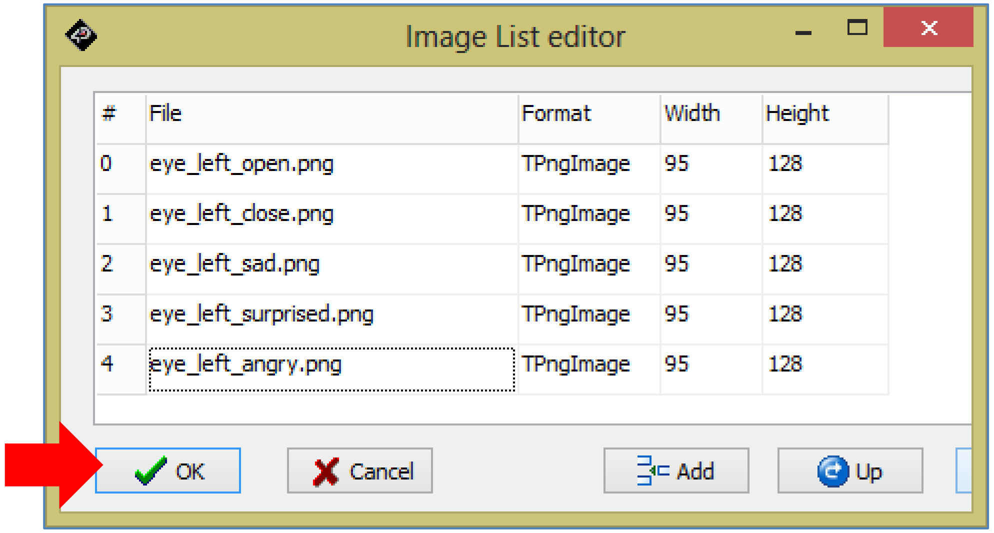
The image list editor window appears. Click on the "Add" button.



A standard open window appears. Use "Ctrl + Click" to select multiple files. Select all those for the left eye. The files are found inside the zip file attached to this application note. Then click on the open button.

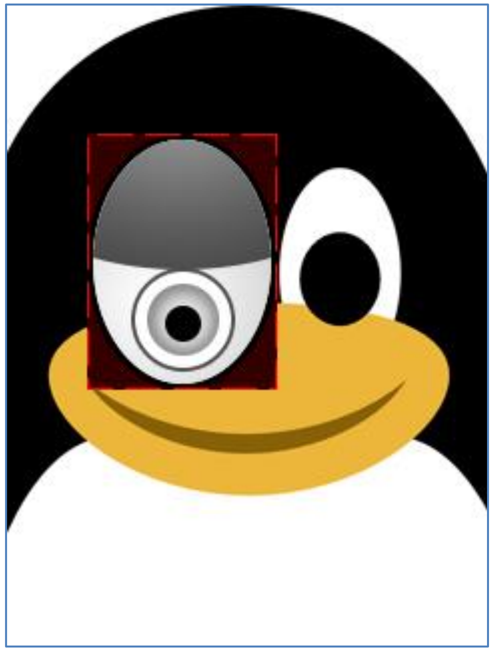


The image list editor is updated.

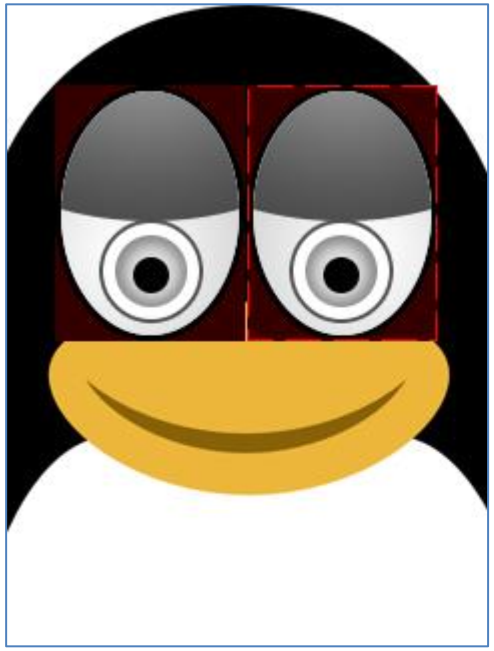


#	File	Format	Width	Height
0	eye_left_open.png	TPngImage	95	128
1	eye_left_close.png	TPngImage	95	128
2	eye_left_sad.png	TPngImage	95	128
3	eye_left_surprised.png	TPngImage	95	128
4	eye_left_angry.png	TPngImage	95	128

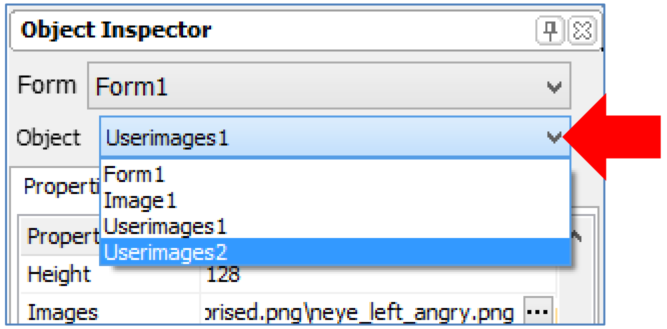
The arrangement above is important as each image frame is indexed. Use the “Up” and “Down” buttons to rearrange your images if necessary. Then click OK. The WYSIWYG screen is updated.



Repeat the same procedure for the right eye. The right eye object will be Userimages2.



Position the left and right eyes on the WYSIWYG screen such that they don't overlap. When objects disappear on the WYSIWYG screen, use the Object Inspector to navigate between different objects.



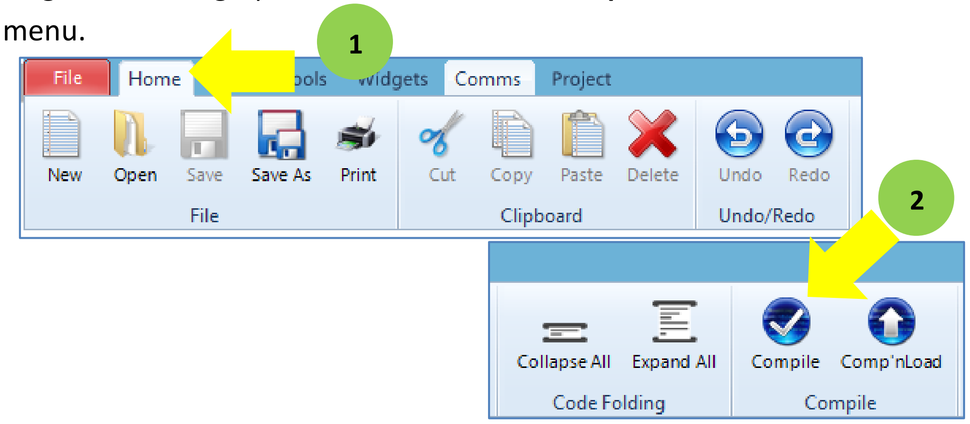
The 4DGL code for a user images object is:

```
// Userimages1 1.0 generated 3/11/2015 3:54:47 PM
img_SetWord(hndl, iUserimages1, IMAGE_INDEX, frame) ;
img_Show(hndl,iUserimages1) ;
```

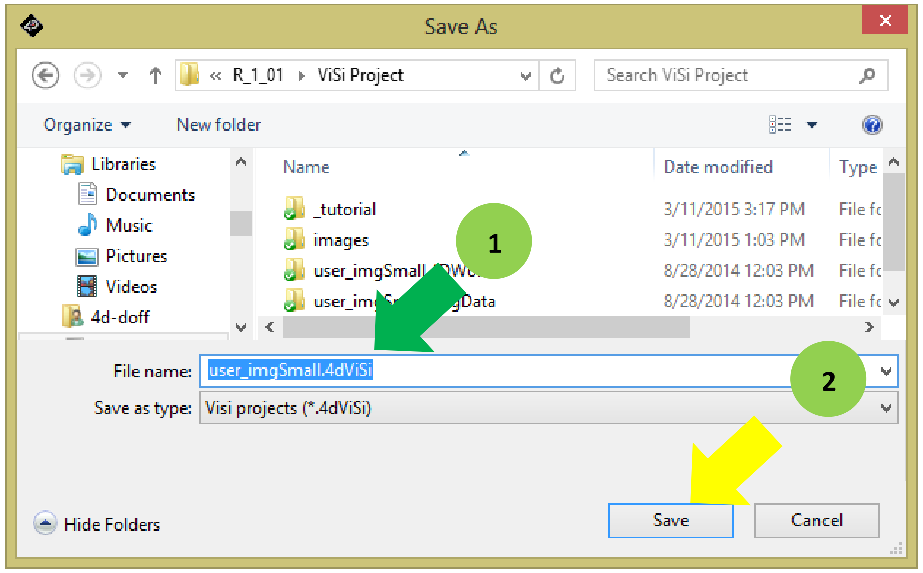
The last parameter, "***frame***", of the function "***img_SetWord()***" is the index of the frame to be shown. In this case, frame can be any value between 0 and 4, inclusive.

Save and Compile

To generate the graphics file, click on the "**Compile**" button under the **Home** menu.



Workshop will ask for a filename for the project. Enter a name then click on the Save button. Here the filename is "***user_imgSmall***".

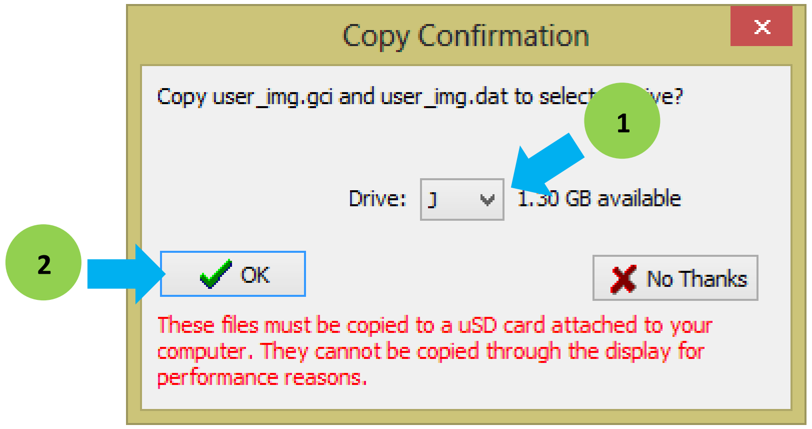


Name	Date modified	Type
_tutorial	3/11/2015 3:17 PM	File fo
images	3/11/2015 1:03 PM	File fo
user_imgSmall4DWork	8/28/2014 12:03 PM	File fo
user_imgSmallgData	8/28/2014 12:03 PM	File fo

File name: user_imgSmall.4dViSi

Save as type: Visi projects (*.4dViSi)

Workshop now builds the graphics file and copies it to the uSD card. The Copy Confirmation window appears. Make sure that your uSD card is properly mounted to your PC. You will be prompted to choose the correct drive for the memory card. Choose the correct drive by clicking on the drop down arrow. Then click OK.



Copy user_img.gci and user_img.dat to selected drive?

Drive: J 1.30 GB available

These files must be copied to a uSD card attached to your computer. They cannot be copied through the display for performance reasons.

Workshop now copies the graphics file to the µSD card. Properly unmount the uSD card from your PC then mount it to the display module. Note that the filename of the graphics file is derived from that of the project filename. Check the contents of the uSD card for the exact filename of the generated files. There are two files actually – the GCI file and the DAT file. The GCI file contains the actual graphics. The DAT file contains a list of the images inside the GCI file.

Load the SPE Application

The display must be configured as a slave device before it can be controlled by a host. For instructions on how to launch Workshop 4, how to connect the display module to the PC, and how to configure the display as a slave device, kindly refer to the section "**Setup Procedure**" of any of the application notes below. Choose according to your display module's processor.

Serial Picaso Getting Started - The SPE Application

Serial Diablo16 Getting Started - The SPE Application

These application notes also introduce the user to the Serial Protocol thru the use of the Serial Commander.

Program the Arduino Host

A thorough understanding of the application note **Serial Connection to an Arduino Host** is required before attempting to proceed further beyond this point. **Serial Connection to an Arduino Host** provides all the basic information that a user needs to be able to get started with the Serial Environment and Arduino. The following is a list of the topics discussed in **Serial Connection to an Arduino Host**.

- How to download and install the Serial-Arduino library (choose a library according to your display module's processor)
- How to modify the library for Arduino Due (due to a Due bug reported by a forum user)
- How to define the serial port to be used for talking to the display
- How to set the baud rate
- The Error Handling Routine
- How to set the Timeout Limit
- How to reset the Arduino Host and the Display
- How to let the Display Start Up
- How to set the Screen Orientation
- How to Clear the Screen
- The uSD Card Mount Routine
- How to enable message logging to the Serial Monitor of the Arduino IDE

Discussion of any of these topics is avoided in other Serial-Arduino application notes unless necessary. Users are encouraged to read **Serial Connection to an Arduino Host** first.

Load Image Control

When compiling a project in the ViSi environment, Workshop uses the Graphics Composer Software tool to build the graphics file. This graphics file contains all the objects added to the project by the programmer with the use of the WYSIWYG screen. The graphics file has an extension of ".gci", which stands for "Graphics Composer image". Another file (with an extension of ".dat") is generated along with the graphics file. This file contains a list of all the objects contained in the ".gci" file. These two files are copied to the uSD card, which is then mounted to the display module.

To access the objects, we now need to load these files, using the Load Image Control function.

```
//load the graphics files
hndl = Display.file_LoadImageControl("user_img.dat", "user_img.gci", 1) ;
```

The Load Image Control function reads a control file to create an image list. This function returns a handle (pointer to the memory allocation), to the image control list that has been created. This handle can then be used for accessing and showing the desired object.

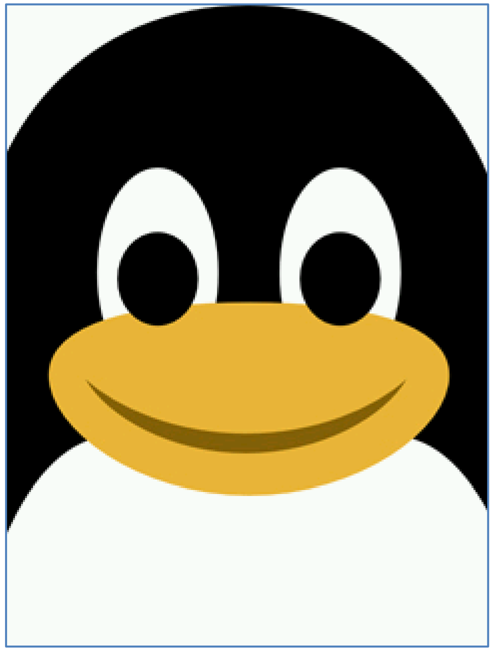
Image Show

```
Display.img_Show(hndl,iImage1) ;                    //show the penguin
```

The Show Image command requires that an image control has been created with the “Load Image Control” command. This enables the displaying of the image entry in the image control and returns a non-zero value if successful. The return value is usually ignored.

iImage1 is the index for Image1 (the image for the penguin). Since Image1 is the third object added to the project, its index, iImage1, has a value of 2. Userimages1 (left eye of the penguin), the first object added to the project, has an index value of 0. Userimages2 (right eye of the penguin), the second object added to the project, has an index value of 1. Workshop automatically creates a constant for each image index and generates the value.

The object **Image1.**



Setting Image Parameters

This function requires that an image control has been created with the “Load Image Control” command. It is used to set image parameters in an image entry.

The function

Img_SetWord(handle,index,offset,value)

requires four parameters. The **handle** parameter is a pointer to the Image List. The **index** parameter is the index of the images in the list. The **offset** parameter is the offset of the required word in the image entry.

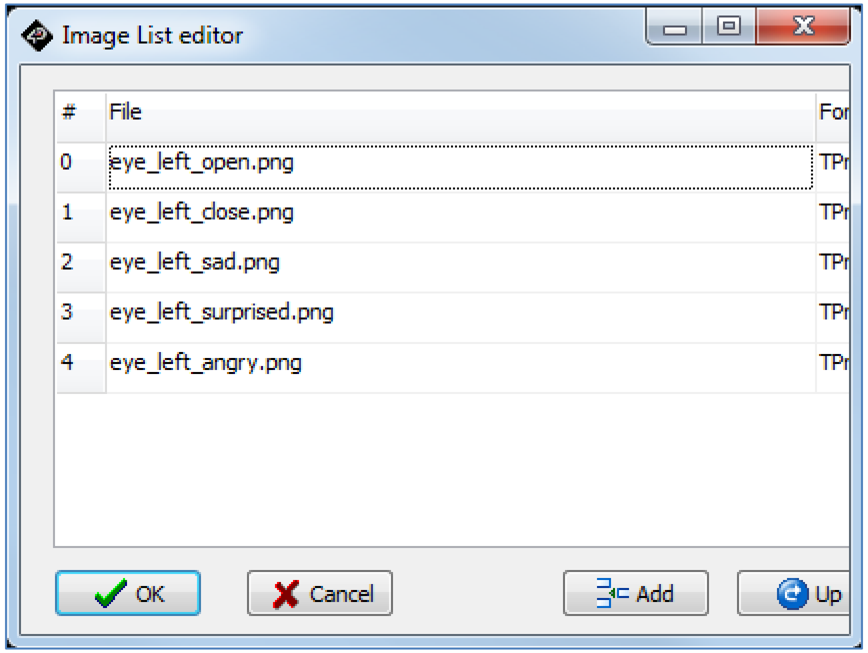
Offset	Constant name	Description
2	IMAGE_XPOS	// WORD image location X
3	IMAGE_YPOS	// WORD image location Y
6	IMAGE_FLAGS	// WORD image flags
7	IMAGE_DELAY	// WORD inter frame delay
9	IMAGE_INDEX	// WORD current frame

The **value** parameter is the word to be written to the entry.

Note: The "Show Image" command will show an error box for out of range frame values (IMAGE_INDEX). Also, if the frame is set to -1, a rectangle will be drawn in background colour to blank an image.

Set the IMAGE_INDEX Parameter

We will now discuss how to set the value of the IMAGE_INDEX word. Modifying the value of this word will enable us to show the desired frame of a multi-frame object. User images and video objects are some examples of multi-frame objects. Going back to the attached ViSi project, the image below shows the Image List editor.



#	File	For
0	eye_left_open.png	TPr
1	eye_left_close.png	TPr
2	eye_left_sad.png	TPr
3	eye_left_surprised.png	TPr
4	eye_left_angry.png	TPr

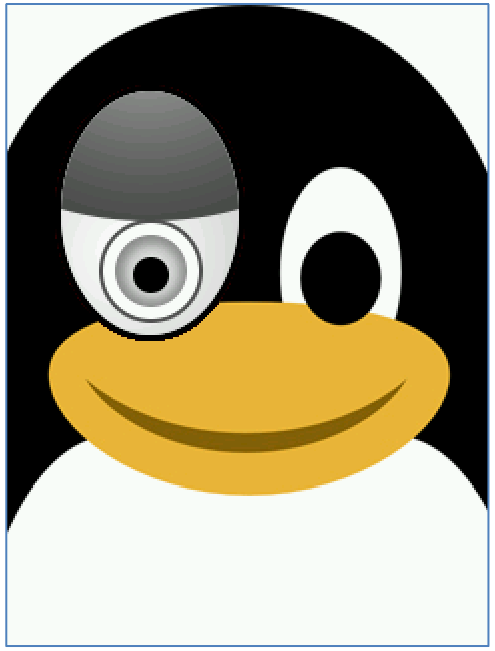
The Image List editor enumerates the images inside a user images object. Here, the images inside Userimages1 are shown. Userimages1 contains the images for the left eye while iUserimages2 contains the images for the right eye. This list can be used as a reference when showing a particular frame (IMAGE_INDEX) using the function img_SetWord.

To illustrate,

```
frame = 0;    //eyes open
```

```
Display.img_SetWord(hndl, iUserimages1, IMAGE_INDEX, frame) ;
Display.img_Show(hndl,iUserimages1) ;
```

This code will show frame 0 of the left eye of the penguin. The image below shows the actual output.

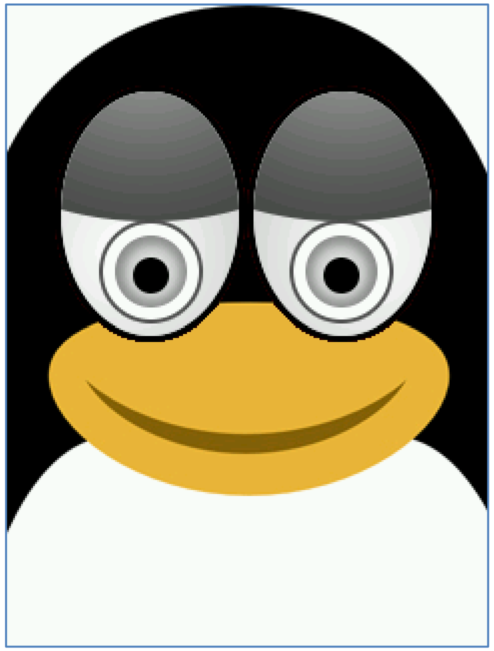


Now, to display frame 0 of the right eye, write

```
frame = 0;    //eyes open
```

```
Display.img_SetWord(hndl, iUserimages2, IMAGE_INDEX, frame) ;
Display.img_Show(hndl,iUserimages2) ;
```

The image below shows the actual output.



Note that frame 0 of the left eye is also shown as a result of the previous commands.

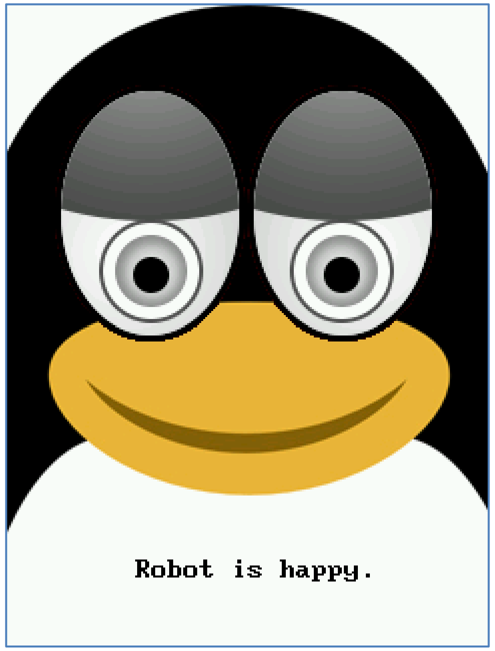
Main Loop

With the foregoing discussions on how to set the value of the IMAGE_INDEX word, we can now proceed to writing codes for displaying the different frames of objects.

Display Frame 0

```
frame = 0;    //eyes open
Display.img_SetWord(hndl, iUserimages1, IMAGE_INDEX, frame) ;
Display.img_Show(hndl,iUserimages1) ;
Display.img_SetWord(hndl, iUserimages2, IMAGE_INDEX, frame) ;
Display.img_Show(hndl,iUserimages2) ;
Display.putstr("  Robot is happy.   \r");
```

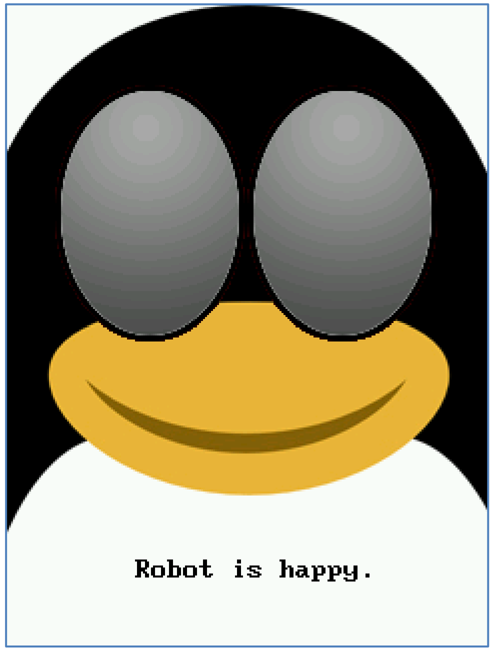
This code will show frame 0 of both the left and right eyes and will print the string “Robot is happy.”


Robot is happy.

Display Frame 1

```
frame = 1;    //eyes closed
Display.img_SetWord(hndl, iUserimages1, IMAGE_INDEX, frame) ;
Display.img_Show(hndl,iUserimages1) ;
Display.img_SetWord(hndl, iUserimages2, IMAGE_INDEX, frame) ;
Display.img_Show(hndl,iUserimages2) ;
```

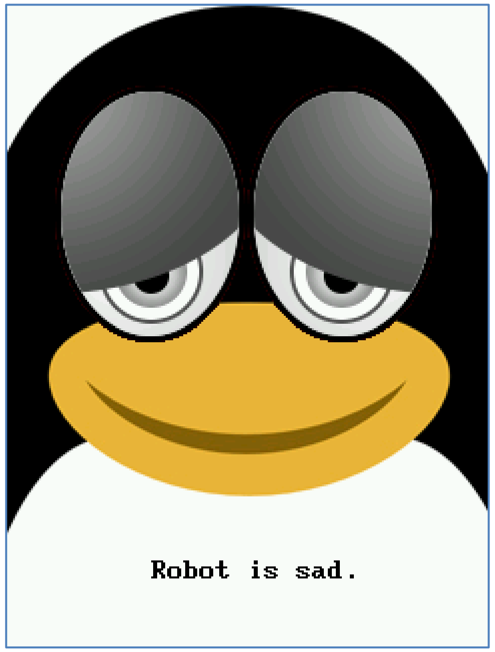
This code will show frame 1 of both the left and right eyes.


Robot is happy.

Display Frame 2

```
frame = 2;    //eyes sad
Display.img_SetWord(hndl, iUserimages1, IMAGE_INDEX, frame) ;
Display.img_Show(hndl,iUserimages1) ;
Display.img_SetWord(hndl, iUserimages2, IMAGE_INDEX, frame) ;
Display.img_Show(hndl,iUserimages2) ;
Display.putstr("    Robot is sad.    \r");
```

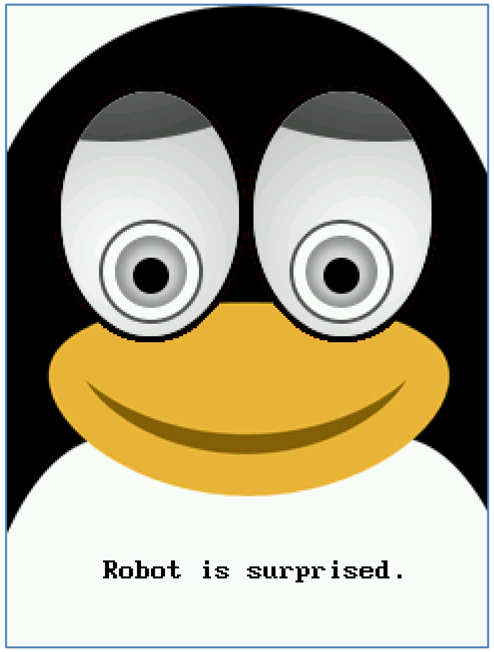
This code will show frame 2 of both the left and right eyes and will print the string “Robot is sad.”.



Display Frame 3

```
frame = 3;    //eyes surprised
Display.img_SetWord(hndl, iUserimages1, IMAGE_INDEX, frame) ;
Display.img_Show(hndl,iUserimages1) ;
Display.img_SetWord(hndl, iUserimages2, IMAGE_INDEX, frame) ;
Display.img_Show(hndl,iUserimages2) ;
Display.putstr("Robot is surprised.\r");
```

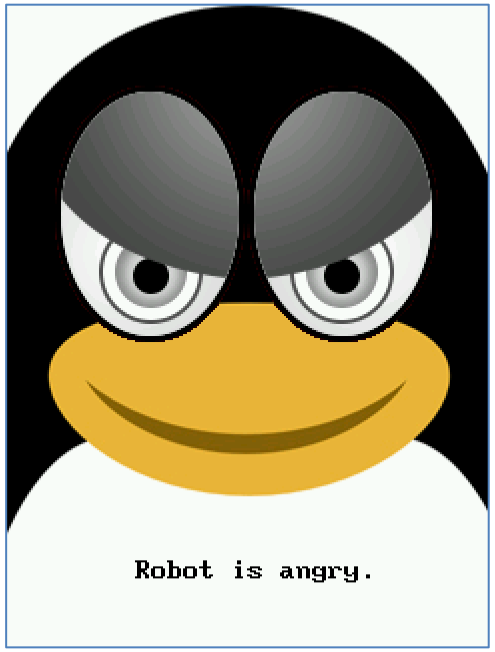
This code will show frame 3 of both the left and right eyes and will print the string “Robot is surprised.”.



Display Frame 4

```
frame = 4;   //eyes angry
Display.img_SetWord(hndl, iUserimages1, IMAGE_INDEX, frame) ;
Display.img_Show(hndl,iUserimages1) ;
Display.img_SetWord(hndl, iUserimages2, IMAGE_INDEX, frame) ;
Display.img_Show(hndl,iUserimages2) ;
Display.putstr("  Robot is angry.  \r");
```

This code will show frame 4 of both the left and right eyes and will print the string “Robot is angry.”.



Connect the 4D Display Module to the Arduino Host

Refer to the section **“Connect the Display Module to the Arduino Host”** of the application note **Serial Connection to an Arduino Host** for the following topics:

- Using the New 4D Arduino Adaptor Shield (Rev 2.00)
  - Definition of Jumpers and Headers
  - Default Jumper Settings
  - Change the Arduino Host Serial Port
  - Power the Arduino Host and the Display Separately
- Using the Old 4D Arduino Adaptor Shield (Rev 1)
- Connection Using Jumper Wires

Proprietary Information

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