2006 CMUCam2 Workbook

Table of Sections

Introduction

2006 *FIRST* Robotics Competition Software Overview

This year a variety of software tools are provided to help teams understand, program, and control *FIRST* robots. This overview details the software suite available to 2006 FRC teams.

Background

The robot control system consists of the *Innovation First* (*IFI*) Robot Controller (which is pre-loaded with an installed default program to control the robot) and the *IFI* Operator Interface. *IFI* provides documentation and an overview of the control system at www.ifirobotics.com/frc-robot-control-system-overview.shtml. Details on the system components are located at www.ifirobotics.com/oi.shtml and www.ifirobotics.com/rc.shtml, with the latter site including the *IFI* default program source code and documentation as well as a very useful Programming Reference Guide. Support for the control system is provided at www.ifirobotics.com/forum and teams should monitor the *IFI* website during the season for updates to the default program.

Teams have two options to modify the robot controller code using either a text based programming interface or with a graphical user interface programming tool.

For text based programming, teams start with the default code and make their own alterations to this existing code. The *Microchip Technologies* MPLAB Integrated Development Environment (IDE) is provided as the software interface to write, edit and debug robot controller programs in the ANSI C programming language. MPLAB IDE uses the MPLAB C18 compiler, and both of these pieces of software are supplied in the 2006 FRC Kit of Parts. Compiled code is downloaded to the Robot Controller using the *IFI* Loader software (supplied in the 2006 FRC Kit of Parts and downloadable from www.ifirobotics.com/rc.shtml).

FIRST volunteer and NASA Jet Propulsion Lab engineer Kevin Watson has written a very useful library (supported with full documentation) for programmers working in the MPLAB IDE format. Libraries for most of the sensors provided in the 2006 Kit of Parts, including the CMUCam2 Vision Sensor, gyro, accelerometer, and the Hall-effect sensors, are available at www.kevin.org/frc.

A graphical user interface (GUI) programming tool has been developed by *intelitek* and customized for the 2006 *FIRST* Robotics Competition. easyC™ Robotics Design System is a GUI programming tool that can be downloaded by 2006 FRC teams at www.intelitekdownloads.com/FRC2006. This software, which includes code for sensors contained in the 2006 Kit of Parts, can be used to create, debug, compile and upload code to the FRC Robot Controller. Technical support for this software is available at www.chiefdelphi.com/forums/forumdisplay.php?f=153 and this page should be monitored for updates to the default program during the 2006 FRC season. Intelitek is providing one license of easyC free to all teams with the opportunity to purchase additional seats. Teams will receive an email from intelitek with their license key for downloading the software on Monday January 09, 2006. The software will be available for download at 12:00 EST. that day.

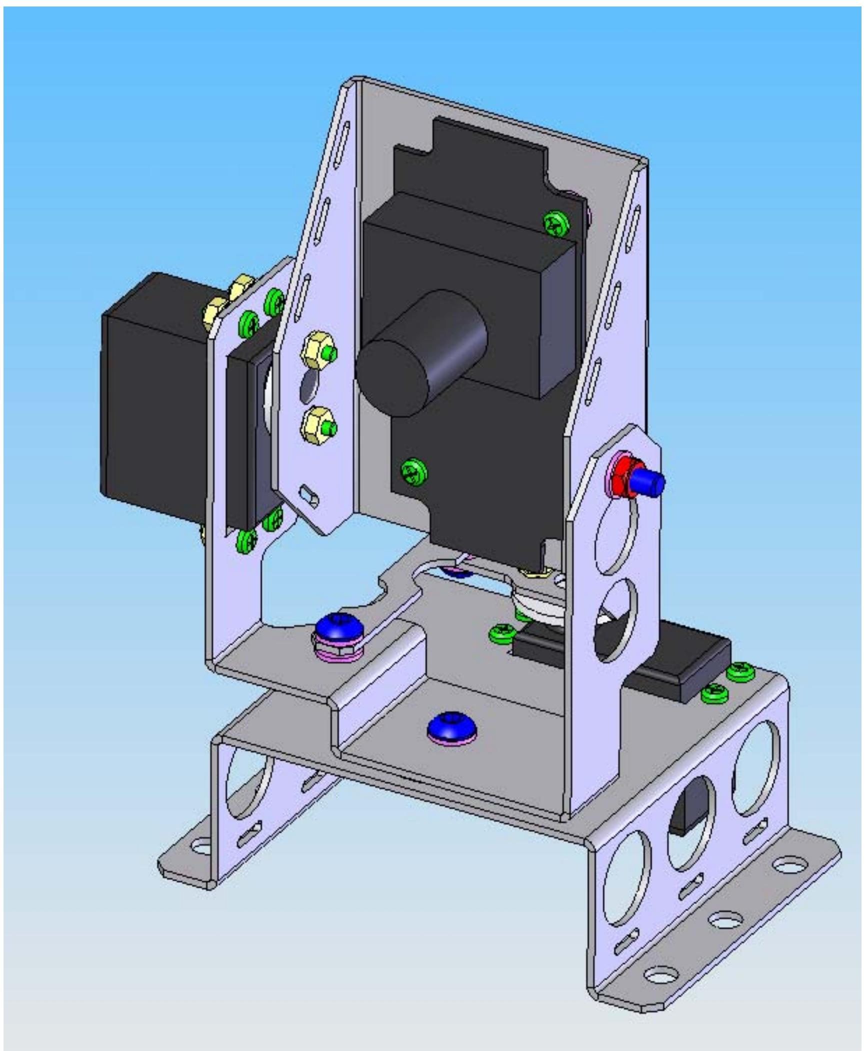
An additional piece of software is provided by *National Instruments*. NI LabVIEW 8 is graphics based software for testing, measurement and control. This software, which is used external to the robot, can help teams learn about sensors, test electronics, and monitor output from the Operator Interface. *NI*'s Danny Diaz and *DEKA*'s Russ Beavis have created sample applications for LabVIEW 8 including:

- CMUcam2 GUI – virtual control panel for the CMUCam2 Vision Sensor
- Motor simulation – Virtual instrument for simulating motor performance
- Dashboard demo - Virtual instrument to process/display data from the Operator Interface dashboard
- Motor tester – virtual instrument for testing motors using the NI USB-6008 Data Acquisition module (available for purchase from *NI*)
- Motor tester – virtual instrument for testing motors without using the NI USB-6008 Data Acquisition module

These applications (and their documentation), technical assistance, and a discussion forum on the LabVIEW 8 software are available at www.chiefdelphi.com/forums/forumdisplay.php?f=149 .

This software suite is a significant advancement in the software provided to teams participating in the 2006 *FIRST* Robotics Competition. Teams are urged to use this software to further their understanding of and control of the components of an FRC robot. A free and open discussion of software developments is encouraged through the use of the listed forums, as well as other forms of team-to-team contact.

CMUCAM – Pan-Tilt Mechanism
Assembly Instructions



Innovation First, Inc
FRC-PANTILT-01, 2006

Drill This hole to 1/8" ∅

Drill This hole to 1/8" ∅

Retainer Screw

Install Rubber Inserts (4x)

For (2x) Servos:

Remove Servo Retainer Screw.
Remove Plastic Servo Horn.
Match Drill Holes to 1/8" ∅ (2x) As Shown.
Install Rubber Inserts (4x)

Printed on 12/7/2005

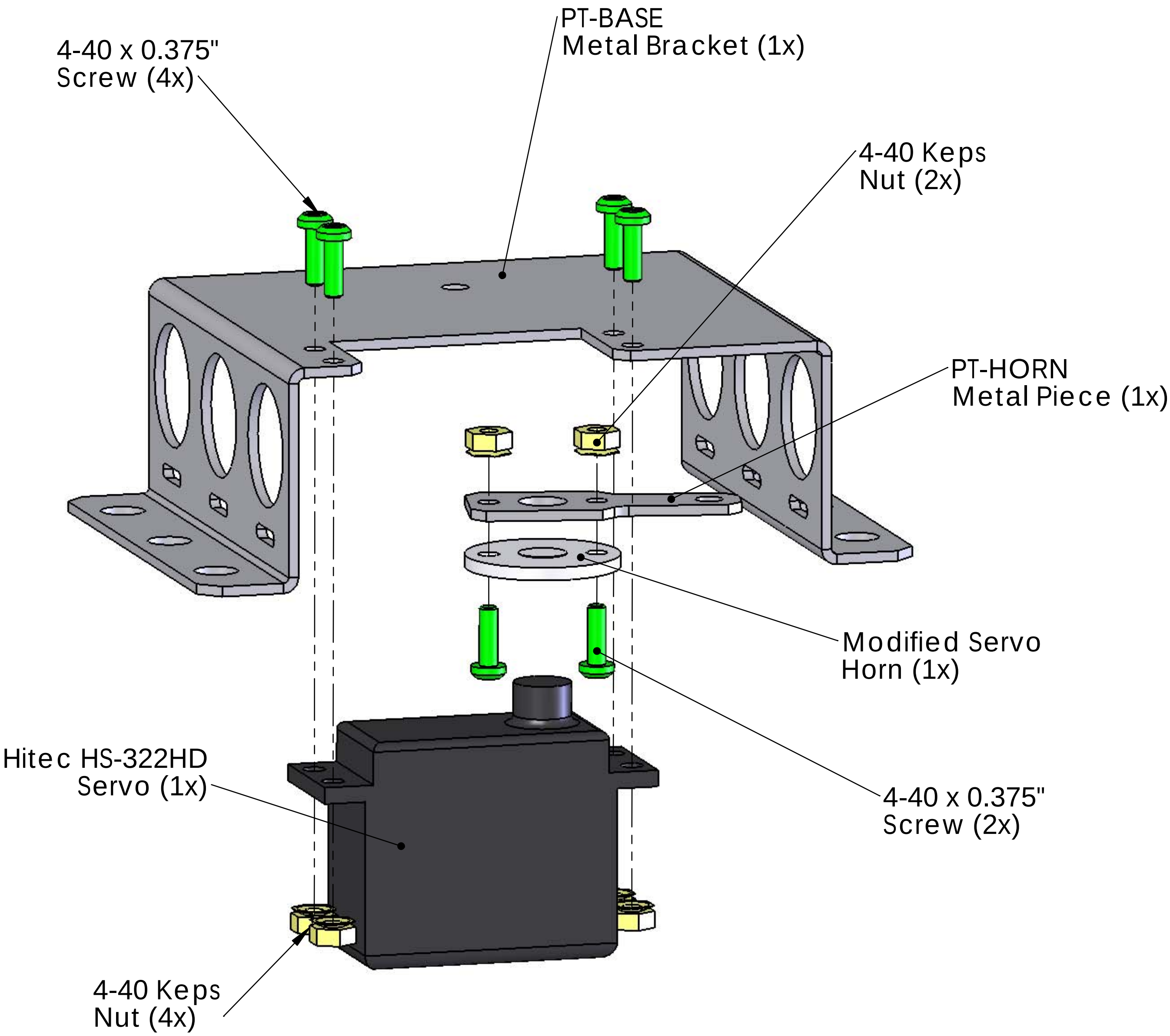
ALL DIMENSIONS ARE IN INCHES.

IFIRobotics.com

Pan Tilt Mechanism

Part Number

FRC-PANTILT-01-ASSY1



Bolt the PT-HORN piece onto the Modified Servo Horn using (2x) 4-40 Screws and Keps Nuts.

Bolt the Servo onto the PT-BASE Metal Bracket using (4x) 4-40 Screws and Keps Nuts.

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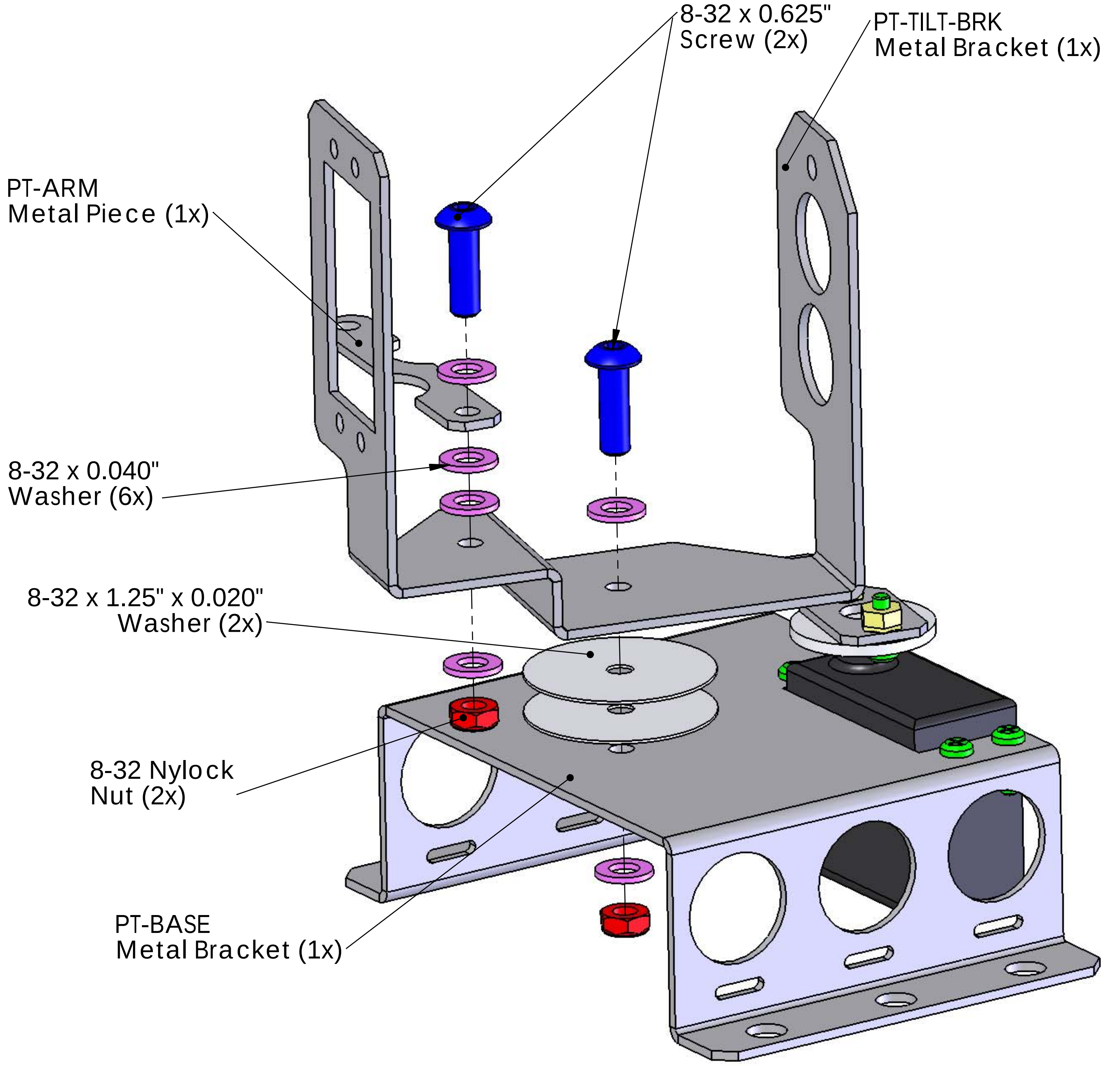
Pan-Tilt Mechanism

Part Number

FRC-PANTILT-01-ASSY2



Form a joint between the PT-ARM and PT-TILT-BRK. Form a joint between the PT-TILT-BRK and PT-BASE.

Use washers as shown above to reduce joint friction.

Tighten screws as much as possible, while still allowing for smooth joint movement.

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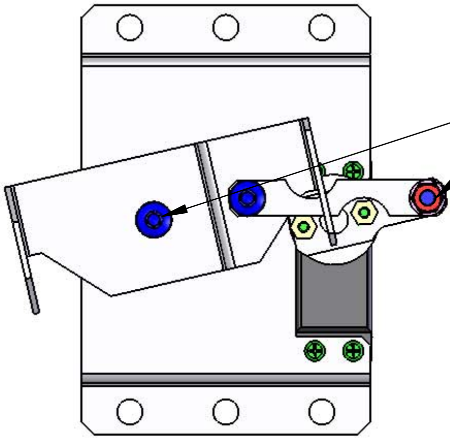
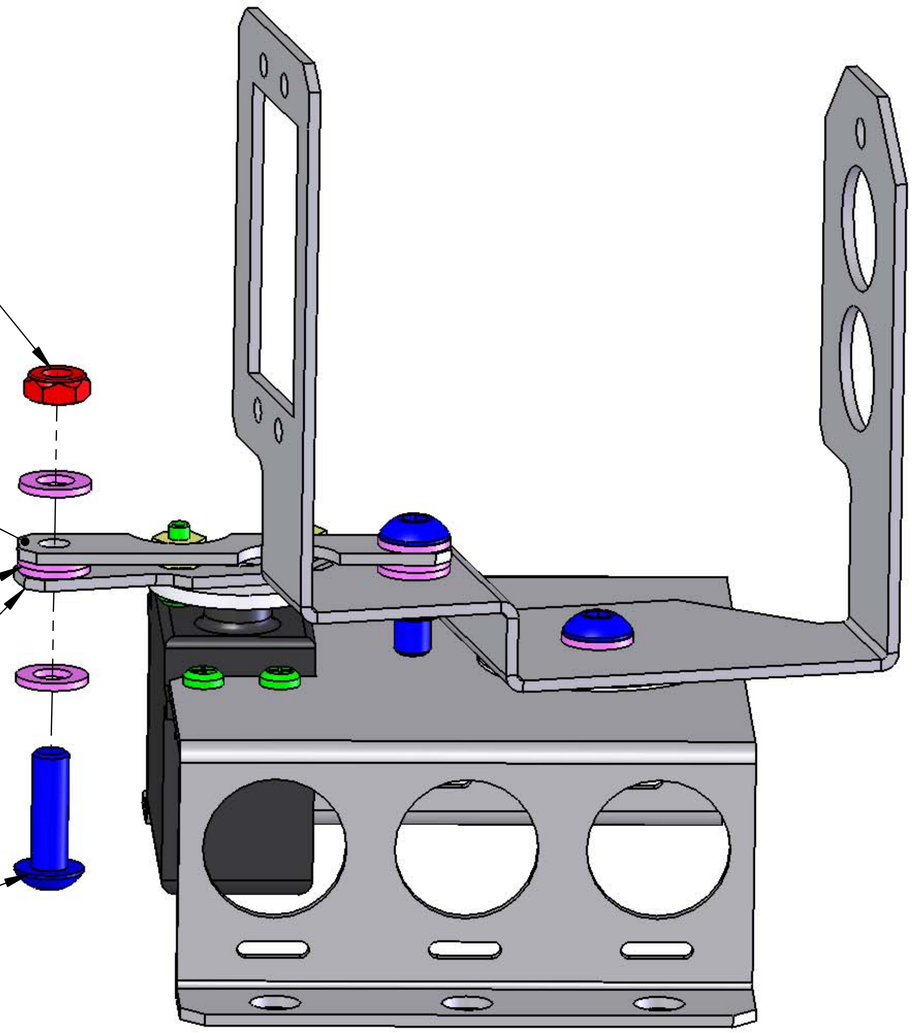
Pan-Tilt Mechanism

Part Number

FRC-PANTILT-01-ASSY3





Form a joint between the PT-ARM and PT-HORN Metal Pieces.

Use an 8-32 bolt and nylock nut, with small nylon washers to reduce joint friction.

Tighten screws as much as possible, while still allowing for smooth joint movement.

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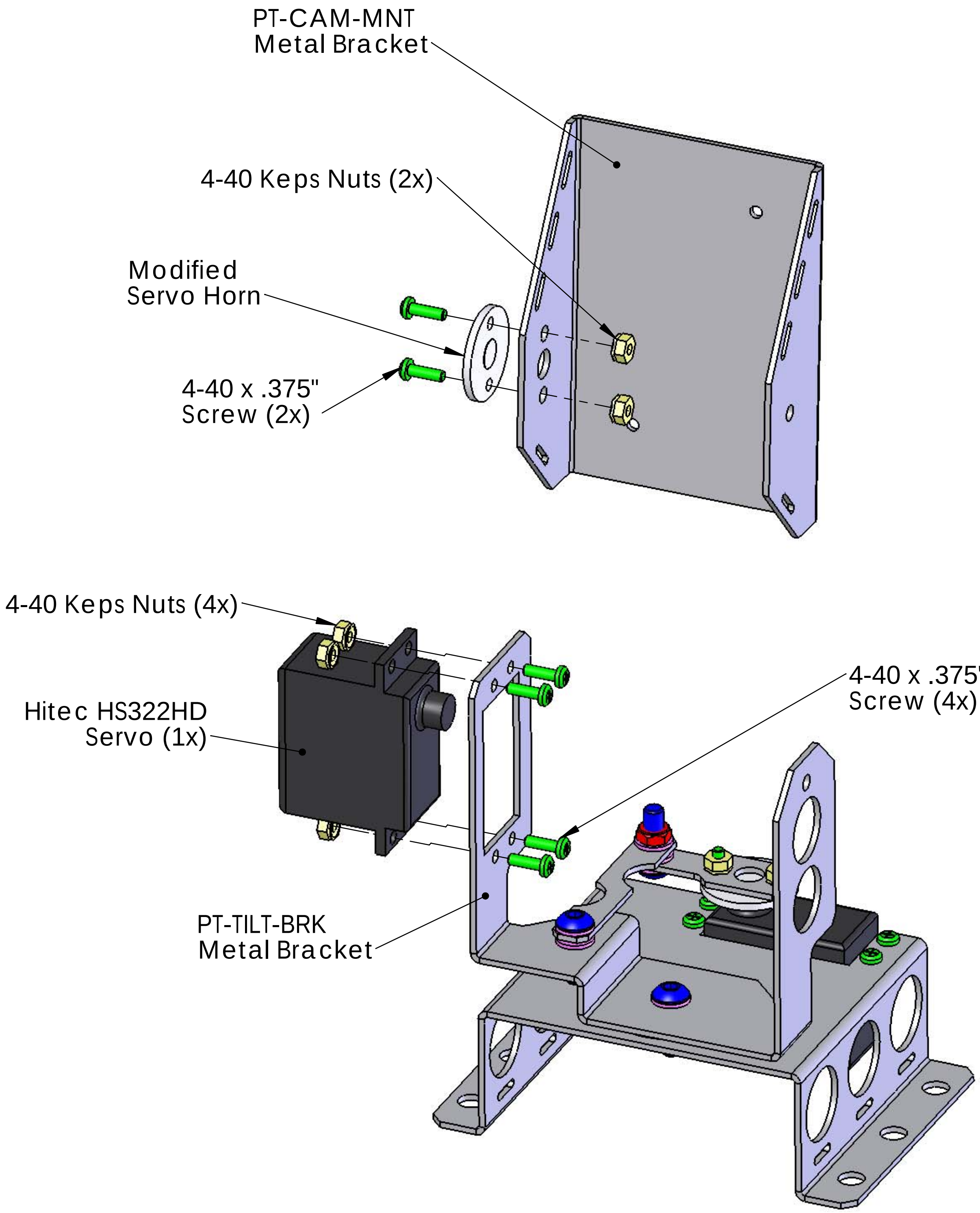
Pan-Tilt Mechanism

Part Number

FRC-PANTILT-01-ASSY4



Bolt the Modified Servo Horn onto the PT-CAM-MNT Metal Bracket using (2x) 4-40 Screws and Keps Nuts. As Shown.

Bolt the Servo onto the PT-TILT-BRK using (4x) 4-40 Screws and Keps Nuts. As Shown.

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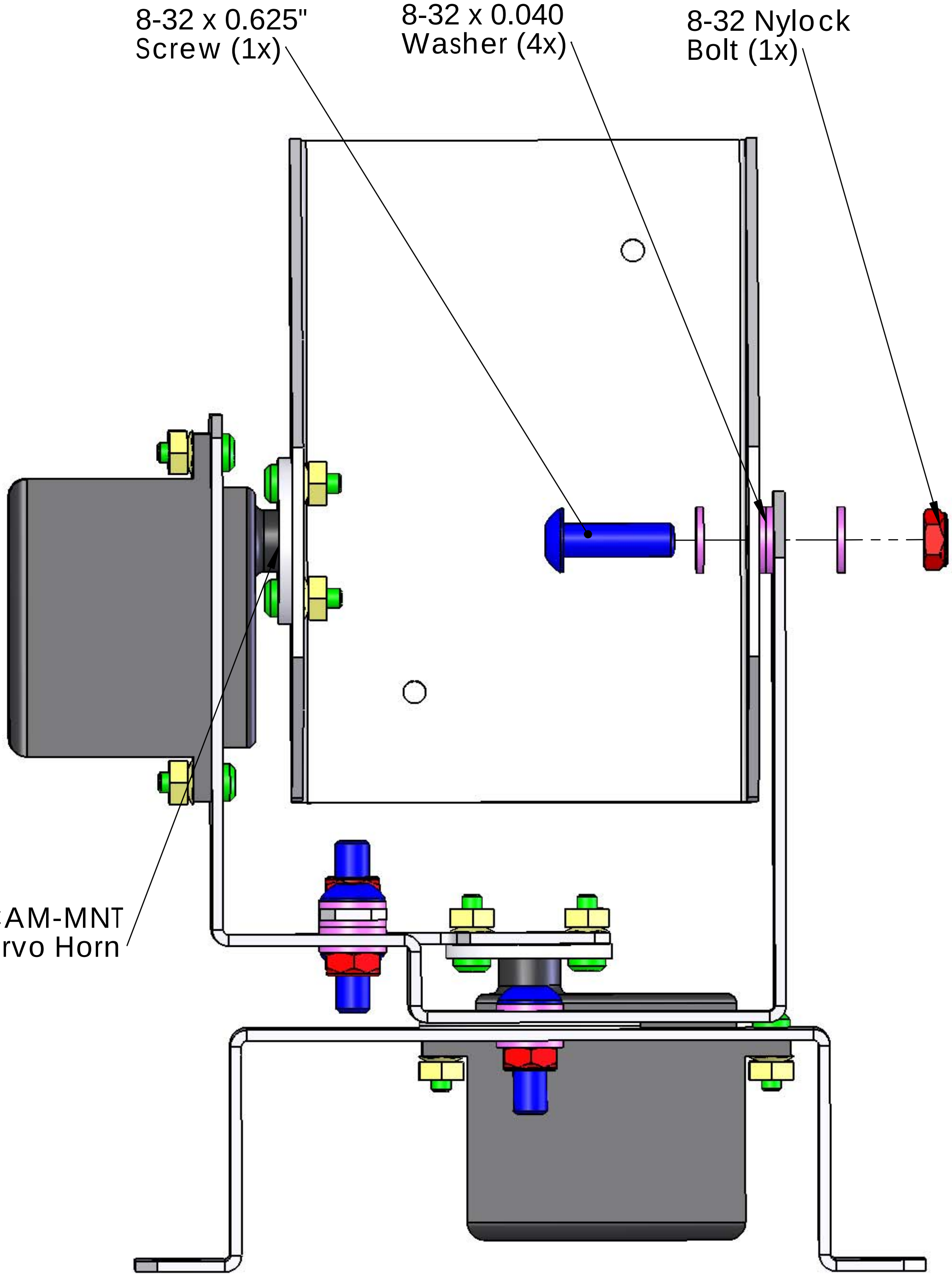
Pan-Tilt Mechanism

Part Number

FRC-PANTILT-01-ASSY5



Center the Servo into neutral position then install the CAM-MNT Bracket as shown.

Form a joint between the PT-CAM-MNT and the PT-TILT-BRK.

Bolt through with (1x) 8-32 Bolt, and Nylock Nut. Use (4x) Washers as shown to reduce joint friction.

Tighten screws as much as possible, while still allowing for smooth joint movement.

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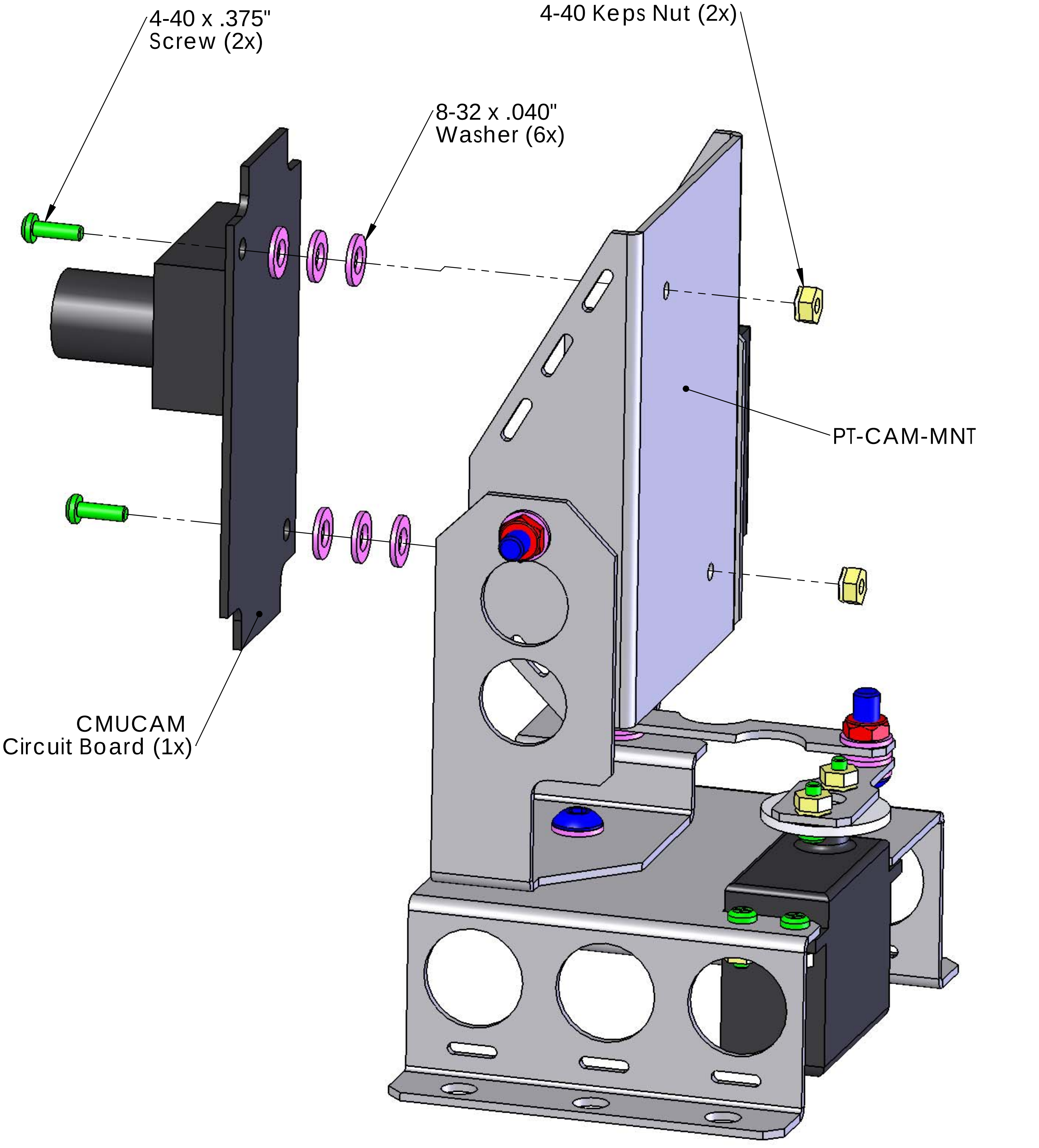
Pan-Tilt Mechanism

Part Number

FRC-PANTILT-01-ASSY6



Install the CMUCAM ontothe PT-CAM-MNT Metal Bracket by screwing (2x) 4-40 Screws into 4-40 Keps Nuts. Offset the Board off the Metal Bracket using (6x) of the small washers.

If CMUCAM is mounted in RadioShack Project box. Use Velcro to attach Box to PT-CAM-MNT Metal Bracket in position shown.

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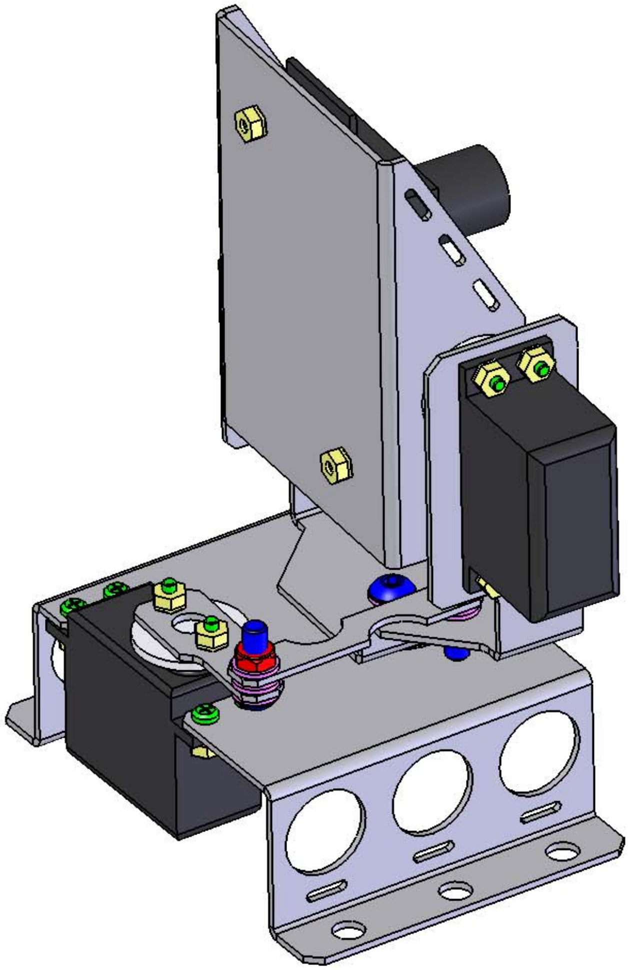
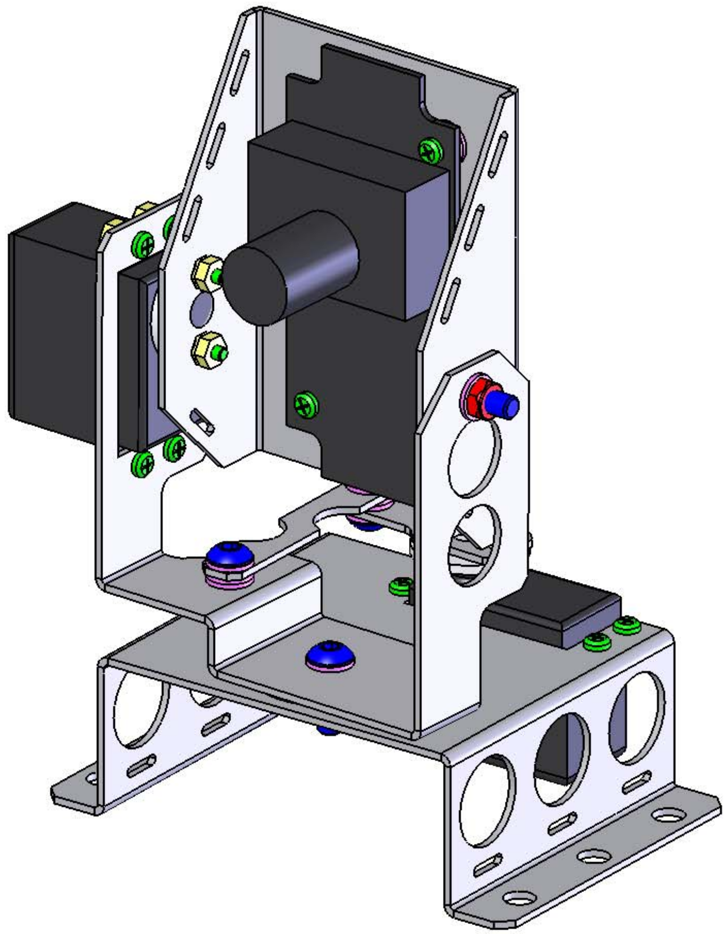
Pan-Tilt Mechanism

Part Number

FRC-PANTILT-01-ASSY7





To complete assembly, install Retainer Screws back into Modified Servo Horns.

Tighten all Joint bolts as much as possible, but allow free movement.

Ziptie all cables in provided slots.

Printed on 1/10/2006	ALL DIMENSIONS ARE IN INCHES.
IFIRobotics.com	
Pan-Tilt Mechanism	
Part Number FRC-PANTILT-01-ASSY8	

Section

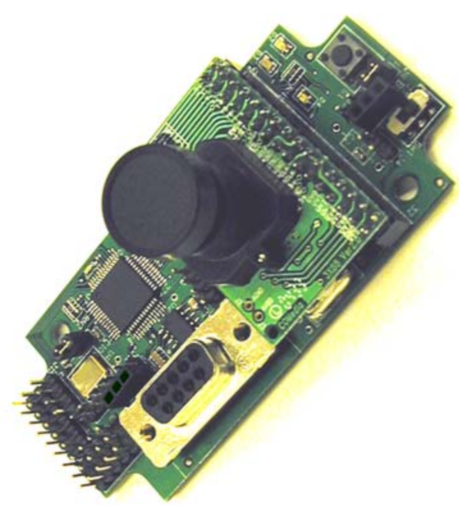
2

CMUCam2 Setup and Initialization

CMUCAM2 SETUP AND INITIALIZATION

This section describes the items required, connections, and initial setup of the Vision Sensor assembly and prepares the sensor for calibration.

2.1 ITEMS REQUIRED

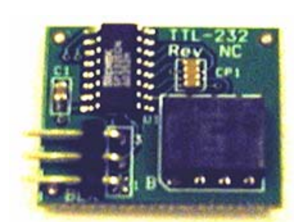


1. Vision Sensor assembly from kit.
Camera Module on Sensor Control Board TTL-232 Adapter

2. Vision Sensor pan and tilt mounting assembly with servos.

3. Computer with the following items:
    a. LabVIEW 8 Student Edition installed.
    b. LabVIEW CMUCam2 demo.llb Application.
    c. DB9 male to female cable (from the kit of parts).

4. Robot wired and "ready to go" **<u>or</u>** the following items from the kit for " bench testing".
    - Charged 7.2 vdc NiCad Battery pack.
    - Vision Sensor power adapter cable.



2.2 VISION SENSOR SETUP

2.2.1 The Sensor Mount and Servo assembly

1. Assemble the Vision Sensor Pan and Tilt mount assembly per the instructions.

2.2.1.1 <u>On the Robot</u>

2. Mount the Sensor Mount and Servo Assembly to the robot. The sensor may be mounted at any height on your Robot with an unobstructed view of the area in front of the Robot. The Sensor Mount and Servo assembly may be mounted using the six holes, three on either side, in the flanges of the base plate of the assembly. Be sure to mount the base plate on a surface parallel to the floor or shim the base plate as necessary.

3. Run the PWM cables from the sensor assembly to the Robot Controller (RC). Be sure to avoid running the cables where they are at risk of being damaged by moving components of your robot. Leave enough cable at the Sensor Assembly to allow the Sensor Mount Assembly to pan and tilt without interference from the cables. Since the sensor can be sensitive to voltage fluctuations it is recommended to extend PWM cables by splicing and soldering two PWM cables together. Be sure to properly insulate the spliced wires.

4. With the robot power off:
    - Connect the PWM cable attached to the POWER connection of the Sensor board to an unused PWM OUT port observing the position of the black wire of the PWM cable in relation to the label on the RC.
    - Connect the PWM cable connected to the RS232 PORT, (3-pin) connection of the Sensor to the TTL-232 Adapter observing the position of the black wire of the PWM cable in relation to the label on the TTL-232 Adapter printed circuit board. <u>Lay the adapter on top of the RC for now</u>. *This will connect to the TTL data port on the RC after initial sensor testing is complete.*
    - Connect the two servo motor cables to two PWM OUT ports on the RC noting which port is used for 'panning' the sensor and which port is used for 'tilting' the sensor. *If using pre written sensor code, be sure to connect the servos to the PWM OUT ports specified in that code*.

2.2.1.2 <u>On the Bench</u>

2. Secure the Sensor Mount and Servo Assembly to the bench keeping an unobstructed view of the area where the target will be placed.

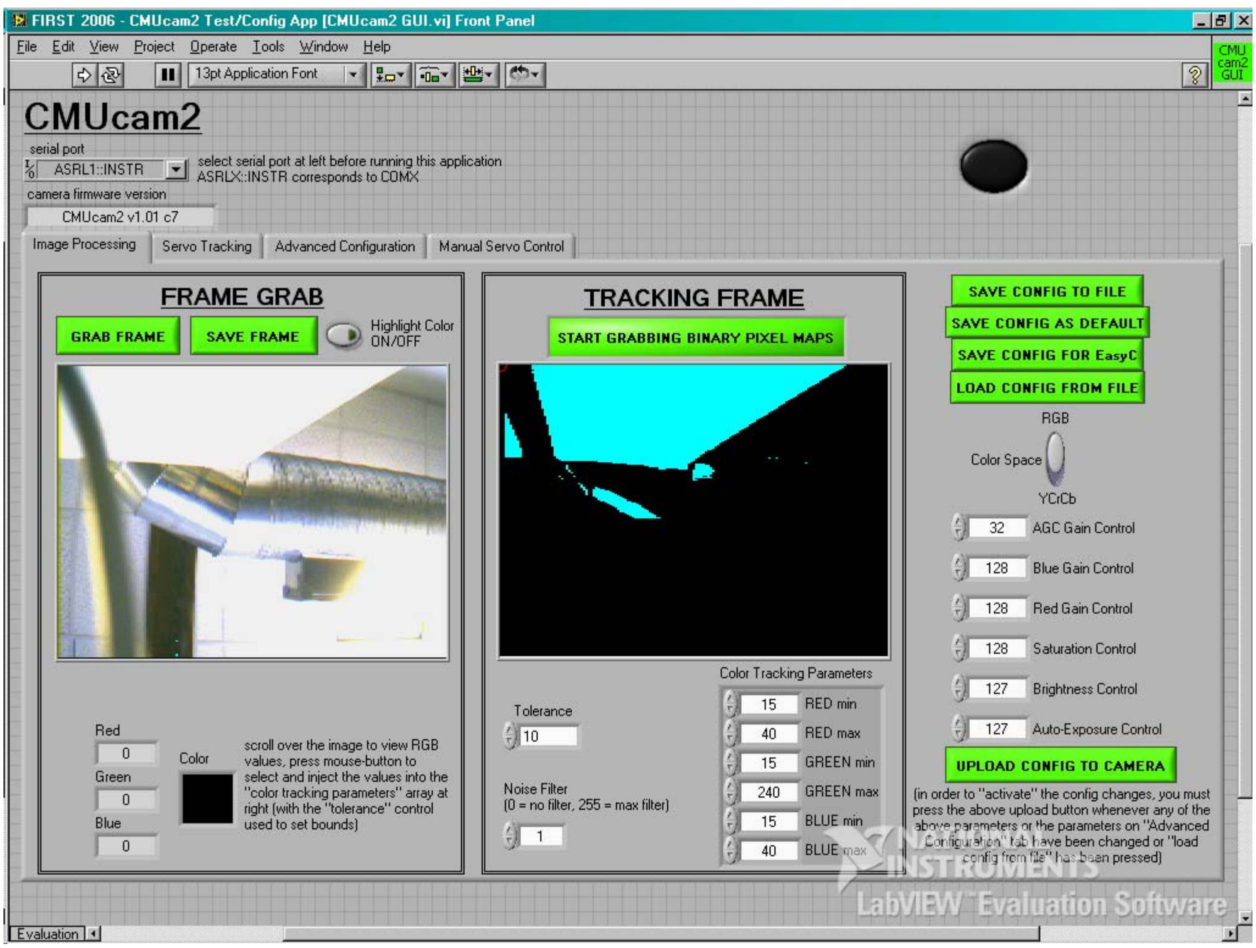
3. Run the DB9 cable from the sensor to the computer providing enough slack to allow the mount to be manually rotated and tilted.

4. With the Sensor power off:

a. Connect the power adapter cable from the POWER connection of the Sensor board to the 7.2 vdc NiCad Battery pack.

5. With the computer (see Page 1, Item 3) booted up and ready to go:
   a. Connect the RC programming cable to the Serial Communication Port, (com port), of the computer and the RS232 PORT, (DB9) of the Vision Sensor Assembly. The settings for the computer's com port should be:
      - *Baud Rate:* *115200*
      - *Data Bits:* *8*
      - *Parity:* *none*
      - *Stop Bits:* *1*
      - *Flow Control:* *none*
   b. Place the power switch on the Sensor assembly into the on position (the switch position closest to the Camera lens.). The RED and GREEN LEDs on the Sensor control board should light.

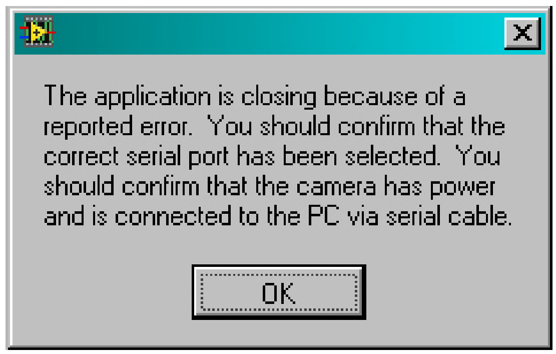
2.2.2 Start the CMUCam2 demo Application in LabVIEW.



1. At the upper left corner of the screen, under the CMUCam2 title, select the COM port the sensor is attached to from the list in the Serial Port drop down menu.

2. Start the application by selecting the white arrow at the upper left corner of the screen above the CMUCam2 title.

- CMUcam2 v1.01 c7 should appear in the Camera Firmware Version text box, below the Serial Port drop down menu. If there is an error with the sensor then the following message will appear.



Correct the error and try again.

3. Once the application is running remove the lens cap from the Vision Sensors camera module. Acquire an image from the sensor by select the Grab Frame button above the Frame Grab Image Display. *The RED LED on the sensor control board will flash rapidly flash as the image is transferred to the computer.*

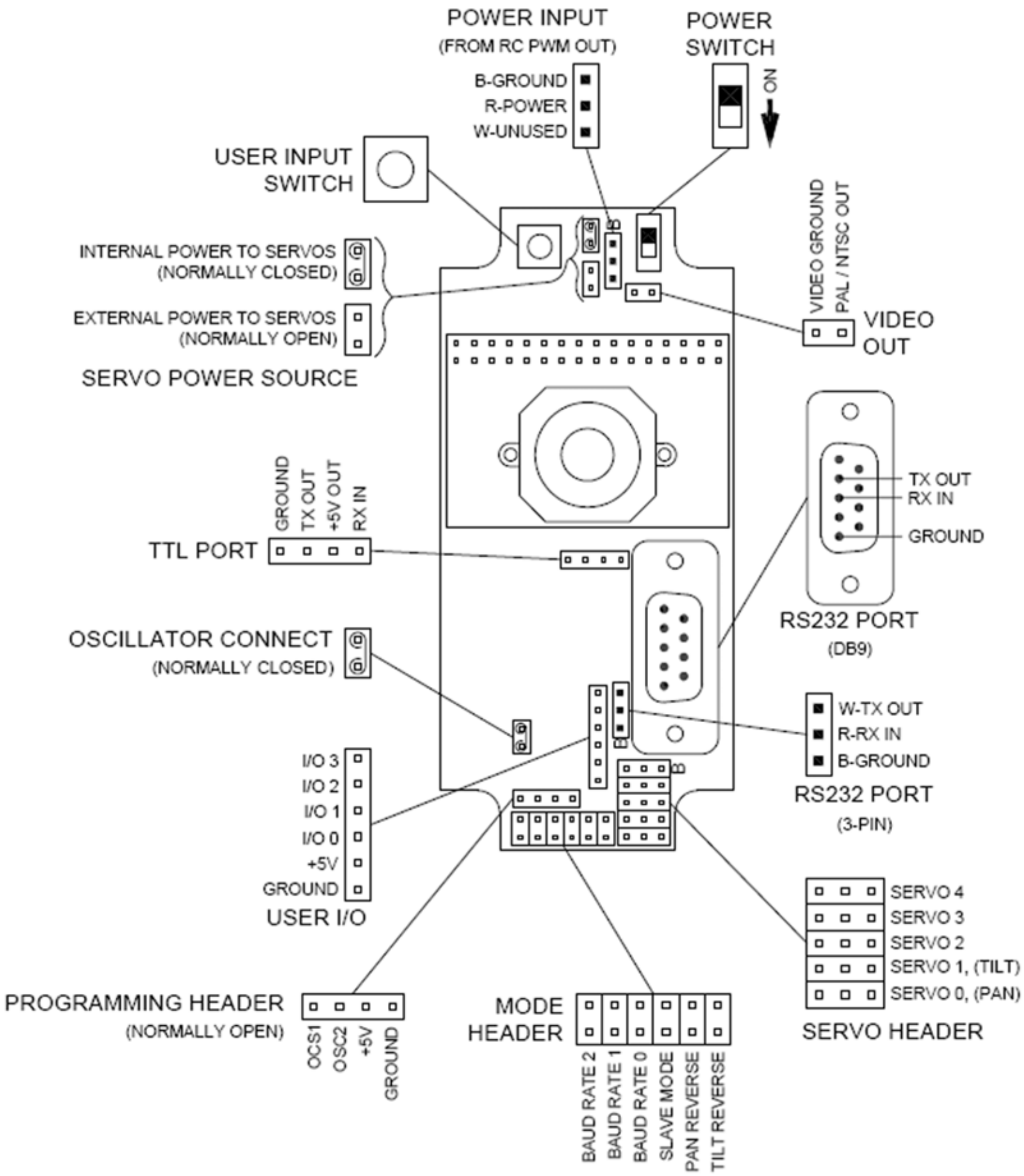
When the image appears in the Grab Frame image display examine it closely for focus. If all but the closest objects to the sensor are in focus then there is no need to refocus the lens.

4. If the image is not in focus then repeat the following four steps until all but the closest objects to the sensor are in focus.

- Turn the end and outer most part of the lens up to one-half turn in either direction (clockwise, counter-clockwise) noting the direction.
- Acquire a new image using the ‘Grab Frame’ button.
- Inspect the image on the screen.
- If the image is less focused reverse the direction in which the lens is turned.

If the target chosen is the 2006 FRC Vision target then perform the calibration for that target. If another target is being used then perform either the calibration procedure for RGB or YCrCb color space.

2.2.3 Vision Sensor Connection Diagram (Reference)



2.2.3.1 <u>Connections:</u>

- The <u>POWER INPUT</u> connection connects to an unused PWM OUT port of the Robot Controller.
- The <u>RS232 PORT, (DB9)</u> data connection connects to the COM port of the computer using the DB9 Male to Female cable.
- The <u>RS232 PORT, (3-PIN)</u> data connection connects to the TTL-232 Adapter which connects to the TTL data connection of the Robot Controller.

Note: The 'B' on the printed circuit board, at one end of each connection denotes the end of the connector the Black wire of the cable is attached.

Section

3

CMUCam2 Calibration Procedures

3.1 THE 2006 FRC VISION SENSOR TARGET

The calibration parameters for the 2006 FRC Vision Sensor Target are included with the distribution of the LabVIEW CMUcam2 demo application. This procedure is for use when there are distractions to the Vision Sensor in the area it will be used.

3.1.1 The Test Area

The area where the configuration is to take place should mimic the setting where the sensor will actually be used. If a non-self illuminated target is to be used then the lighting should be of the same type, brightness, and position relative to the target as where the sensor will be used. The hardware (sensor and target) placement should be as close to the mean positioning of where the sensor will be used but allow movement of the sensor relative to the target to test for adverse lighting effects such as shadows and glare.

Place the powered FRC Vision Sensor Target in somewhere in front of the sensor.
Supply power to the sensor and turn the power switch on.
Connect the sensor to COM port of the computer with LabVIEW 8 and the CMUCam2 demo.llb installed.

Start LabVIEW and load the CMUCam2 Graphical User Interface (GUI).
Using the Serial Port drop-down menu, below the CMUCam2 title at the upper left of the screen; select the port where the sensor is connected.
Start the CMUCam2 GUI by selecting the white run arrow, on the toolbar above the CMUCam2 title at the top left of the screen.

To load the parameters for the 2006 Vision Sensor target select the Load Config From File button to the right of the Track Frame display area.

In the pop-up window select the file named 2006 ‘Target.cfg’, select Load Config Params then OK in the lower right corner of the pop-up window.
Once the pop-up window closes select the Upload Config to Camera button to the lower right of the Tracking Frame display image. A pop-up window will appear verifying the parameters have been uploaded to the sensor. Select OK to close this window.

To allow the sensor to fully realize the effects of the change in parameters select the Start Grabbing Binary Pixel Maps button above the Tracking Frame image display.
Let it run for five seconds then select the Stop button above the Tracking Frame image display.

Acquire an image by selecting the Grab Frame button above the Frame Grab image display.
Drag the cursor over the target portion of the Frame Grab image slowly and select (click on) the image, highlighting the target color as it now appears to the sensor.
Select the Load Config from File button to the right of the Track Frame display area.
In the pop-up window select the file named 2006 Target.cfg then select Load Config Params then OK in the lower right corner of the pop-up window.

Note: As OK is selected the target color in the Frame Grab display image becomes highlighted with cyan color. This is a tool to assist in the calibration process.

Also, the odd coloring of the background is due to YCrCb color space being used and the image being darkened to filter other background lighting. There may also be visible in this display image some fragments of local lighting, light reflections, etcetera- these may be ignored since these are not the color of the target.

If there are no areas of highlighting other than the target in the image then there is no need to adjust the parameters/settings.

If there are only the target and a few stray dots or areas of highlighting then attempt to determine what is causing the dots. The most common cause of stray color dots is fluorescent lighting.
If the source can be found then determine if it is necessary in the area you will be using the sensor. If not then remove the cause and try again. If the cause is necessary in the area you will be using the sensor then continue with this procedure.

If there are only the target and a few stray dots or areas of highlighting then perform the next three steps up to 3 times.

1. Reduce the Red max value 1.
2. Select the Start Grabbing Binary Pixel Maps button above the Tracking Frame image display.
3. Inspect the streaming in the Track Frame display image for the target color highlighted with no stray dots highlighted.

If there are still the target and a few stray dots or areas of highlighting then perform the next three steps up to two times.

1. Stop the Binary Pixel Map stream from the sensor using the Stop button above the Tracking Frame image display.
2. Increase the Noise Filter setting below the Track Frame image display by 1.
3. Select the Start Grabbing Binary Pixel Maps button above the Tracking Frame image display.

Inspect the streaming Binary Pixel Map image in the Tracking Frame display for the target color highlighted with no stray dots highlighted.

If there are still the target and a few stray dots or areas of highlighting then return the Noise Filter setting to 1.
Perform the next five steps repeatedly until either the stray dots are gone or the setting changes do not appear to improve the image.

1. Stop the Binary Pixel Map stream from the sensor using the Stop button above the Tracking Frame image display.
2. Decrease the Saturation Control setting by 2.
3. Select the Upload Config to Camera button to the lower right of the Tracking Frame display image.
4. A pop-up window will appear verifying that the parameters have been uploaded to the sensor. Select OK to close this window.
5. Select the Start Grabbing Binary Pixel Maps button above the Tracking Frame image display.

If there are no stray areas or dots of target color then the calibration is complete.
Save the image and the configuration parameters.**

If there are still the target and a few stray dots or areas of highlighting then perform the Calibration Procedure for YCrCb color space.

** If easyC is to be used as a programming environment then export the Vision Sensor parameters for use with easyC by:

- Selecting the Save Config for easyC button to the right of the Tracking Frame display. *A Dialog box will open.*
- Locate the default easyC directory (C:\Program Files\intelitek\easyC for FRC\Camera)
- Provide a name for the new file or accept the default name.
- Select the Save Config for easyC button in the lower right corner.

3.2 CALIBRATING THE CMUCAM2 VISION SENSOR IN RGB COLOR SPACE

The process of calibrating the CMUCam2 vision sensor to a specific target is a multi-phase process. The first phase of the process is the target selection itself.

3.2.1 The Target

The target should be of a color and intensity to boldly stand out in the environment where the sensor is to be used. Due to the nature of the effects lighting has on color as seen through the sensor, a self-illuminated target is a more reliable choice. Be aware that a self-illuminated target can be an issue if it is too bright. This document assumes a target color other than white.

The target should be of sufficient size to be “tracked” by the vision sensor to a distance greater than the distance required for the normal operation of the sensor. Since the sensor “tracks” to the center of the color mass of the target, the maximum size is the only constraint, meaning do not make the target so large that it fills the entire imaging area of the sensor.

3.2.2 The Test Area

The next phase of the process is the environment (test area) where the configuration is to take place.

The area where the configuration is to take place should mimic the setting where the sensor will actually be used. If a non-self-illuminated target is to be used then the lighting should be of the same type, brightness, and position relative to the target as where the sensor will be used. If a self-illuminated target is used then the lighting of the environment becomes a minor issue.

The hardware (sensor and target) placement should be as close to the mean positioning of where the sensor will be used but allow movement of the sensor, relative to the target, to test for adverse lighting effects such as shadows and glare.

3.2.3 General Testing

This phase is where general testing and data collection begin for the target Color Tracking Parameters.

Note: The sensor may take up to three frames for the full effect of any parameter / register changes to be realized. For this reason it is important to grab three frames each time a parameter / register change is sent to the sensor. This may be skipped when using the “Start Grabbing Binary Pixel Maps” button is used immediately after a parameter / register change.

To begin the testing process, acquire an image from the sensor using the "Grab Frame" button above the Frame Grab display image. When the image is displayed, inspect it for focus.

To focus the sensor repeat the following four steps until the image is in focus.

1. Turn the end and outer most part of the lens up to one-half turn in either direction, (clockwise, counter-clockwise), noting the direction.
2. Acquire a new image using the 'Grab Frame' button, (three times).
3. Inspect the image on the screen.
4. If the image is less focused reverse the direction in which the lens is turned.

Note: Although the image is low resolution, good focus can be identified by examining sharp edges in the image, except for objects very close to the lens.

Next, drag the cursor over the target portion of the Frame Grab image, slowly taking note of the range (low to high) of numbers displayed in the Red, Green, and Blue display boxes below the image. Use the lowest of the three ranges to set the tolerance.

Example:

Red range	*85 to 173*	*= Range of 88*	*Mid-point = 129*
Green range	*42 to 72*	*= Range of 30*	*Mid-point = 57*
Blue range	*144 to 203*	*= Range of 63*	*Mid-point = 175*
Tolerance		*30*	

Once you have determined the tolerance setting, select the number in the Tolerance text box below the Tracking Frame image.
Enter the tolerance setting and press enter on the keyboard.
Return the cursor to the target portion of the Frame Grab image. Locate a position where the number in the display box of the color used for the tolerance (Red, Green, or Blue) is at the mid-point of the values noted in order to determine the range, and select with a mouse click.

Two things happen at the click of the mouse.

1. The Color Tracking Parameter text boxes below the Tracking Frame image are filled in with the minimum and maximum color levels, based on the tolerance setting, to use in tracking the target.
2. All portions of the Frame Grab image which fall within the range of color represented by the values in the min / max Color Tracking Parameters are highlighted in cyan color.

The amount of the image highlighted offers a clue as to how unique the target color is in the setting the calibration is taking place. The less scattered the cyan is from the actual target image, the more unique the targeted color. Save the image and the configuration parameters.

Note: To keep things organized it would be helpful to create a folder labeled ‘Test Parameters’ where the image and configuration files will be stored. Additionally it will be easier to identify which image file goes with each configuration file if they have the same first name.

Example:
Step_1_1 010706.bmp
Step_1_1 010706.cfg

The next phase in the process is to fine-tune the Color Tracking Parameters and register settings for the target color to determine its validity in the current Color Space, (RGB).

3.2.4 Fine Tuning for RGB Color Space

At this point there is an image in the Frame Grab image display with some portions highlighted in cyan color and a set of numbers for the targeted color in the Color Tracking Parameter text boxes below the Tracking Frame image display. There may also be a cyan bitmap image in the Tracking Frame image display, either from the default start-up image or from those who like to play with buttons.

3.2.5 Target Brightness

The first step is to determine if the target is too bright for the current camera settings. This is done by turning OFF the Highlight Color option using the Highlight Color ON/OFF switch next to the Save Frame button and above the Frame Grab display.

The image of the target should either be the color of the target or white/mostly white, possibly with hints of the target color around the edges

If the target color in the image is white, possibly with hints of the target color around the edges, then perform the following six steps to darken the image:

1. Reduce the Auto-Exposure Control setting, (*in a text box to the right of the Track Frame image display*), to 0.
2. Reduce the AGC Gain Control setting, (*in a text box to the right of the Track Frame image display*), to 0.
3. Reduce the Brightness Control setting, (*in a text box to the right of the Track Frame image display*), to 1.
4. Upload the setting to the sensor using the Upload Config to Camera button.
5. Acquire a new image from the sensor using the “Grab Frame” button, (three times).
6. Inspect the image in the Grab Frame display.

If the target image is still white then the target is too bright and either the light intensity needs to be reduced or another target needs to be chosen.

If the target image is not visible in the Grab Frame display image then perform the next four steps repeatedly until the target image is visible in the image in the color of the target.

1. In the text boxes to the right of the Frame Tracking display, increase the Auto-Exposure Control setting by 1.
2. Upload the setting to the sensor using the Upload Config to Camera button.
3. Acquire a new image using the “Grab Frame” button (three times).
4. Inspect the image in the Grab Frame display.

At this point there should be an image of the target color with a very dark background in the Grab Frame image display. There may also be visible in this display image some fragments of local lighting, light reflections, etcetera- these may be ignored since these are not the color of the target.
Turn ON the Highlight Color option using the Highlight Color ON/OFF switch next to the Save Frame button above the Frame Grab display.

1. Drag the cursor slowly over the target portion of the image, taking note of the range (low to high) of numbers displayed in the Red, Green, and Blue display boxes below the image.
   - Determine the mean of the lowest of the three ranges.
   - Select a point on the target image where the mean value chosen is displayed in the appropriate Red, Green, or Blue display box. The target color as it now appears to the sensor will be highlighted.
2. Save the image and the configuration parameters.

Inspect the entire image in the Grab Frame image display.

If the target is highlighted and there are areas other than the target that are highlighted then perform the following four steps.

1. Decrease the Auto-Exposure Control setting by 1.
2. Upload the setting to the sensor using the Upload Config to Camera button.
3. Acquire a new image using the “Grab Frame” button (three times).
4. Inspect the entire image in the Grab Frame image display.
5. If the target image is not visible in the Grab Frame display then return the Auto-Exposure Control setting to its previous setting.
   a. Upload the setting to the sensor using the Upload Config to Camera button.
   b. Acquire a new image using the “Grab Frame” button (three times).

If the target shape is still visible in the image as the color of the target then perform the following two steps.

1. Drag the cursor slowly over the target portion of the image, taking note of the range (low to high) of numbers displayed in the Red, Green, and Blue display boxes below the image.
   - Determine the mean of the lowest of the three ranges.

- Select a point on the target image where the mean value chosen is displayed in the appropriate Red, Green, or Blue display box. The target color as it now appears to the sensor will be highlighted.

2. Save the image and the configuration parameters.

3.2.6 RED Gain Control and BLUE Gain Control

Attempt to reduce the stray highlighted areas of the image by systematically increasing/decreasing the RED Gain Control values then the BLUE Gain control values (*in a text box to the right of the Track Frame image display*) repeatedly per the following five steps.

1. Manually adjust the value by 30 (until the limit of either 0 or 255 has been reached).
2. Upload the setting to the sensor using the Upload Config to Camera button.
3. Acquire a new image using the “Grab Frame” button (three times).
4. Inspect the entire image in the Grab Frame image display.
5. Repeat the process until the most effective value has been reached.

At this point there is an extremely darkened image with the target color portion highlighted along with some other areas of the image as well. To attempt to remove or at least reduce those other areas to usable levels requires fine-tuning the Color Tracking Parameters min/max levels. This is done by manually adjusting one parameter at a time, repeatedly until finished with the adjustment for that parameter then moving on to the next parameter.

Note: The objective of this fine-tuning is to end up with a solidly highlighted image that represents the target, as seen through the sensor, with as few stray dots (specs) of highlighting as possible while finishing each color adjustment with the broadest range between the min/max color values.

Working in the order of the text boxes, RED min, RED max, GREEN min, GREEN max, BLUE min, BLUE max, adjust the parameters using the adjustment methods below. Note: The range of numbers for these settings is from 15 to 240. The sensor will ignore any number outside of this range.

3.2.6.1 <u>min Value adjustment</u>

If the current value is greater than 15 then perform the following three steps until there is either no change in the image, the image is less refined, or a value of 15 is reached.

1. Select the current value in the text box and manually decrease this value by 10 but to a value no less than 15.
2. Observe the image in the Grab Frame display as you press the enter key on the keyboard.
3. If the image became less refined or there was no change in the image then return the value to its previous setting.

If on the first attempt of the previous steps, the image became less refined or there was no change in the image then perform the following three steps until there is either no change in the image, the image is less refined, or a value no greater than (max value – 1) is reached.

1. Select the current value in the text box and manually increase the value in the text box by 10.
2. Observe the image in the Grab Frame display as you press the enter key on the keyboard.
3. If the image became less refined or there was no change in the image then return the value to its previous setting.

3.2.6.2 max Value adjustment

If the current value is less than 240 then perform the following three steps until there is either no change in the image, the image is less refined, or a value of 240 is reached.

1. Select the current value in the text box and manually increase the value by 10.
2. Observe the image in the Grab Frame display as you press the enter key on the keyboard.
3. If the image became less refined or there was no change in the image then return the value to its previous setting.

If , on the first attempt of the previous steps, the image became less refined or there was no change in the image then perform the following three steps until there is either no change in the image, the image is less refined, or a value no less than (min value + 1) is reached.

1. *Select the current value in the text box and manually decrease this value by 10.*
2. Observe the image in the Grab Frame display as you press the enter key on the keyboard.
3. If the image became less refined or there was no change in the image then return the value to its previous setting.

Once all of the Tracking Color Parameters have been fine-tuned per the above method then save the image and the configuration parameters.
Acquire a new image using the “Grab Frame” button (three times).
Inspect the entire image in the Grab Frame image display.

If at this point there is still areas highlighted target color in the image that are not just stray dots or the target then it is time to start over and calibrate the sensor using the procedure for YCrCb color space.

If the highlighted portion of the image consists of a solid target shaped blob of color with possibly a few dots of highlight scattered about the image then it is time to view the Binary Pixel Map.
Start the Binary Pixel Map stream from the sensor using the Start Grabbing Binary Pixel Maps button above the Tracking Frame image display.

Note: *Once started this display continuously receives a stream of bit-mapped data from the sensor until the process is stopped. The "shifting" of the highlighted image is the result of the image being refreshed with new data.*

Observe the Track Frame image display. Notice that the image consists of the highlighted portion of the Grab Frame image including any stray dots of highlighted target color. In this image also note the red circle, which may or may not be shifting about as the image is refreshed. The red circle is placed where at the perceived center of the color blob, (target), is. The more stable the position of the circle, on the target color mass, the more reliable the tracking.

Note: The method used in the sensor to determine the center of the color blob includes any stray areas or dots of target color as the color blob. To be able to effectively use the sensor for tracking, it is essential that all erroneous areas and dots of target color be eliminated from the image.

If there are stray dots of highlighted target color in the Track Frame image then perform the following four steps repeatedly, but no more than three times.

1. Stop the Binary Pixel Map stream from the sensor using the Stop button above the Tracking Frame image display.
2. Increase the Noise Filter setting below the Track Frame image display by 1.
3. Start the Binary Pixel Map stream from the sensor using the Start Grabbing Binary Pixel Maps button.
4. Observe the Track Frame image display.

Note: *It is normal for the actual target color mass of this image to be reduced in size as the noise filter increases. The noise filter setting filters out the number of pixels it is set for from the perimeter of all incidences of target color in the display image.*

If all stray dots of highlighted target color have been eliminated from the image and the Noise Filter setting is less than 3 then the calibration procedure for this target is complete. Save the image and the configuration parameters.**

If the stray dots of highlighted target color have been eliminated from the image and the Noise Filter setting is greater than 2 then it must be determined whether the tracked target image is large enough to be tracked by the sensor at the maximum required distance. This is done by moving the target to the required distance while monitoring the Track Frame image display.

If the target reliably tracks to the maximum required distance then the calibration procedure for this target is complete.
Save the image and the configuration parameters.**

If the target does not track to the maximum required distance then it is time to start over and calibrate the sensor using the procedure for YCrCb color space.

** If easyC is to be used as a programming environment then export the Vision Sensor parameters for use with easyC by:

- Selecting the Save Config for easyC button to the right of the Tracking Frame display. *A Dialog box will open.*
- Locate the default easyC directory (C:\Program Files\intelitek\easyC for FRC\Camera)
- Provide a name for the new file or accept the default name.
- Select the Save Config for easyC button in the lower right corner.

3.3 CALIBRATING THE CMUCAM2 VISION SENSOR IN YCRCB COLOR SPACE

The process of calibrating the CMUCam2 vision sensor to a specific target in YCrCb color space is only slightly different than calibrating the sensor in RGB color space. The first phase of the process is the target selection itself.

3.3.1 The Target

The target should be of a color and intensity to boldly stand out in the environment the sensor is to be used in. Due to the nature of the effects lighting has on color as seen through the sensor, a self-illuminated target is a more reliable choice. Be aware that the use of a self-illuminated target can be an issue if it is too bright. This document assumes a target color other than white. Color tracking using digital imaging can be more reliable for some colors in YCrCb color space due to the tolerance of changes in lighting.
The target should be of sufficient size to be "tracked" by the vision sensor to a distance greater than the distance required for the normal operation of the sensor. Since the sensor "tracks" to the center of the color mass of the target, then the maximum size is the only constraint, meaning do not make the target so large that it fills the entire imaging area of the sensor.

The next phase of the process is the environment (setting), where the configuration is to take place.

3.3.2 The Test Area

The area where the configuration is to take place should mimic the setting where the sensor will actually be used. If a non-self illuminated target is to be used then the lighting should be of the same type, brightness, and position (relative to the target) as where the sensor will be used. If a self-illuminated target is used then the lighting of the environment becomes a minor issue.
The hardware (sensor and target) placement should be as close to the mean positioning of where the sensor will be used but allow movement of the sensor relative to the target to test for adverse lighting effects such as shadows and glare.

This phase is where general testing and data collection begin for the target Color Tracking Parameters.

Note: *The sensor may take up to three frames for the full effect of any parameter/register changes to be realized. For this reason it is important to grab three frames each time a parameter/register change is sent to the sensor. This may be skipped when the "Start Grabbing Binary Pixel Maps" button is used immediately after a parameter/register change.*

3.3.3 General Testing

To begin the testing process:
Acquire an image from the sensor using the “Grab Frame” button at the top of the Frame Grab image display.
Inspect the image in the Frame Grab image display for focus.

If the image is out of focus (blurry) then perform the following four steps repeatedly until the image is in focus.

1. Turn the outer-most part of the lens up to one-half turn in either direction, (clockwise, counter-clockwise), noting the direction.
2. Acquire a new image using the ‘Grab Frame’ button, (three times).
3. Inspect the image on the screen.
4. If the image is less focused reverse the direction in which the lens is turned.

Note: Although the image is low resolution, good focus can be identified by examining the sharp edges, except for objects very close to the lens.

Click on the Color Space switch to the right of the Tracking Frame display. The switch will “slide” down to the YCrCb end of the switch.
Select the Upload to Camera button to the lower right off the Frame Grab display.
Acquire a new image using the ‘Grab Frame’ button (three times).

Note: The image display will have a deep magenta hue to it and the colors of the objects in the image will appear different than the actual color of the objects. This is normal in YCrCb color space for this sensor at the default settings being used.

Select the number in the Tolerance text box below the Tracking Frame image.
Enter a value of 10 and press enter on the keyboard.
Select the number in the Noise Filter text box below the Tracking Frame image.
Enter 0 and press enter on the keyboard.

Observing the Color box below the Frame Grab image, drag the cursor over the target shape in the Frame Grab image to locate a position on the target shape that displays the greatest noticeable difference in color from the area around the target shape.
Select with a mouse click.
Two things happen at the click of the mouse.

3. The Color Tracking Parameter text boxes below the Tracking Frame image are filled in with the minimum and maximum color levels, based on the tolerance setting, to use in tracking the target.
4. All portions of the Frame Grab image which fall within the range of color represented by the values in the min / max Color Tracking Parameters, are highlighted in cyan color.

The amount of the image highlighted offers a clue as to how unique the target color is in the environment the calibration is taking place. The less scattered the cyan is from the actual target image, the more unique the targeted color.
Save the image and the configuration parameters.

Note: To keep things organized it would be helpful to create a folder labeled 'Test Parameters' where the image and configuration files will be stored. Additionally it will be easier to identify which image file goes with each configuration file if they have the same first name.

Example:
Step_1_1 010706.bmp
Step_1_1 010706.cfg

The next phase in the process is to fine-tune the Color Tracking Parameters and register settings for the target color to determine its validity in the current Color Space, (YCrCb).

3.3.4 Fine Tuning for YCrCb Color Space

At this point there is an image in the Frame Grab image display with some portions highlighted in cyan color and a set of values for the targeted color in the Color Tracking Parameter text boxes below the Tracking Frame image display. There may also be a cyan bitmap image in the Tracking Frame image display either from the default start-up image or from those who like to play with buttons.

3.3.5 Target Brightness

To determine if the target is too bright for the current camera settings:

- Turn OFF the Highlight Color option using the Highlight Color ON/OFF switch next to the Save Frame button above the Frame Grab display.

If the target color in the image is white, possibly with some hints of color around the edges, then to darken the image perform the following six steps.

1. Reduce the Auto-Exposure Control setting (*in a text box to the right of the Track Frame image display*) to 1.
2. Reduce the AGC Gain Control setting (*in a text box to the right of the Track Frame image display*) to 0.
3. Reduce the Brightness Control setting (*in a text box to the right of the Track Frame image display*) to 1.
4. Upload the setting to the sensor using the Upload Config to Camera button.
5. Acquire a new image from the sensor using the "Grab Frame" button, (three times).
6. Inspect the image in the Grab Frame display.

If the target image is still white then the target is too bright and either the light intensity needs to be reduced or another target needs to be chosen.

If the target image is not visible in the Grab Frame display image then perform the next four steps repeatedly until the target shape is visible in the image as some color in the mostly magenta background.

1. In the text boxes to the right of the Frame Tracking display, increase the Auto-Exposure Control setting by 1.
2. Upload the setting to the sensor using the Upload Config to Camera button.
3. Acquire a new image using the “Grab Frame” button (three times).
4. Inspect the image in the Grab Frame display.

At this point there should be an image of the target shape of some color in a mostly magenta background in the Grab Frame image display. There may also be visible, in this display image, some fragments of color the shape of local lighting, light reflections, etcetera- these may be ignored since these are not the color of the target.

Turn ON the Highlight Color option using the Highlight Color ON/OFF switch next to the Save Frame button above the Frame Grab display.

Observing the Color box below the Frame Grab image, drag the cursor over the target shape in the Frame Grab image to locate a position on the target shape that displays the greatest noticeable difference in color from the area around the target shape.
Select with a mouse click.
Save the image and the configuration parameters.

Inspect the entire image in the Grab Frame image display.

If the target is highlighted and there are areas other than the target that are highlighted then perform the following four steps.

1. Decrease the Auto-Exposure Control setting by 1.
2. Upload the setting to the sensor using the Upload Config to Camera button.
3. Acquire a new image using the “Grab Frame” button (three times).
4. Inspect the entire image in the Grab Frame image display.
5. If the target image is not visible in the Grab Frame display then return the Auto-Exposure Control setting to its previous setting.
    c. Upload the setting to the sensor using the Upload Config to Camera button.
    d. Acquire a new image using the “Grab Frame” button, (three times).

If the target shape is still visible in the image as the color of the target then perform the following two steps.

1. Observing the Color box below the Frame Grab image, drag the cursor over the target shape in the Frame Grab image to locate a position on the target shape that displays the greatest noticeable difference in color from the area around the target shape. Select with a mouse click.
2. Save the image and the configuration parameters.

3.3.6 Color Parameter Adjustment

At this point there is an extremely darkened image with the target shape highlighted along with some other areas of the image as well. To attempt to remove or at least reduce those other areas to usable levels requires fine-tuning the Color Tracking Parameters' min/max levels. This is done by manually adjusting one parameter at a time, repeatedly until finished with the adjustment for that parameter then moving on to the next parameter.

***Note**: The objective of this fine-tuning is to end up with a solidly highlighted image that represents the target as seen through the sensor with as few stray dots (specs) of highlighting as possible.*

Working in the following order of the text boxes, GREEN min, GREEN max, RED min, RED max, BLUE min, BLUE max, adjust the parameters using the adjustment methods below.

The resulting GREEN min / max range will be very small while the resulting range RED and BLUE min / max range will be much broader.

***Note:** The range of numbers for these settings is from 15 to 240. The sensor will ignore any number outside of this range*.

3.3.6.1 <u>min Value adjustment for GREEN</u>

If the current value is less than (max value – 1) then perform the following three steps until there is either no change in the image, the image is less refined, or a value no greater than (max value – 1) is reached.

1. Select the current value in the text box and manually increase the value in the text box by 1.
2. Observe the image in the Grab Frame display as you press the enter key on the keyboard.
3. If the image became less refined or there was no change in the image then return the value to its previous setting.

3.3.6.2 <u>min Value adjustment for RED and BLUE</u>

If the current value is greater than 15 then perform the following three steps until there is either no change in the image, the image is less refined, or a value of 15 is reached.

1. Select the current value in the text box and manually decrease this value by 10 but to a value no less than 15.
2. Observe the image in the Grab Frame display as you press the enter key on the keyboard.
3. If the image became less refined or there was no change in the image then return the value to its previous setting.

If , on the first attempt of the previous steps, the image became less refined or there was no change in the image then perform the following three steps until there is either no change in the image, the image is less refined, or a value no greater than (max value – 1) is reached.

1. Select the current value in the text box and manually increase the value in the text box by 10.
2. Observe the image in the Grab Frame display as you press the enter key on the keyboard.
3. If the image became less refined or there was no change in the image then return the value to its previous setting.

3.3.6.3 <u>max Value adjustment for GREEN</u>

If the current value is greater than (min value + 1) then perform the following three steps until there is either no change in the image, the image is less refined, or a value no less than (min value + 1) is reached.

1. *Select the current value in the text box and manually decrease this value by 1.*
2. Observe the image in the Grab Frame display as you press the enter key on the keyboard.
3. If the image became less refined or there was no change in the image then return the value to its previous setting.

3.3.6.4 <u>max Value adjustment for RED and BLUE</u>

If the current value is less than 240 then perform the following three steps until there is either no change in the image, the image is less refined, or a value of 15 is reached.

1. Select the current value in the text box and manually increase the value by 10.
2. Observe the image in the Grab Frame display as you press the enter key on the keyboard.
3. If the image became less refined or there was no change in the image then return the value to its previous setting.

If , on the first attempt of the previous steps, the image became less refined or there was no change in the image then perform the following three steps until there is either no change in the image, the image is less refined, or a value no less than *min value + 1* is reached.

1. *Select the current value in the text box and manually decrease this value by 10.*
2. Observe the image in the Grab Frame display as you press the enter key on the keyboard.
3. If the image became less refined or there was no change in the image then return the value to its previous setting.

Once all of the Tracking Color Parameters have been fine tuned per the above method save the image and the configuration parameters.
Acquire a new image using the “Grab Frame” button (three times).
Inspect the entire image in the Grab Frame image display.

If the highlighted portion of the image consists of a solid target-shaped blob of cyan with possibly a few dots of highlight scattered about the image then it is time to view the Binary Pixel Map.

Start the Binary Pixel Map stream from the sensor using the Start Grabbing Binary Pixel Maps button above the Tracking Frame image display.

***Note**: Once started this display continuously receives a stream of bit-mapped data from the sensor until the process is stopped. The "shifting" of the highlighted image is the result of the image being refreshed with new data.*

Observe the Track Frame image display. Notice that the image consists of the highlighted portion of the Grab Frame image including any stray dots of highlight. In this image also note the red circle, which may or may not be shifting about as the image is refreshed. The red circle is placed where at the perceived center of the color blob (target) is. The more stable the position of the circle on the target color mass, the more reliable the tracking.

Note: *The method used in the sensor to determine the center of the color blob includes any stray areas or dots of target color as the color blob. To be able to effectively use the sensor for tracking, it is essential that all erroneous areas and dots of target color be eliminated from the image.*

If there are stray dots of highlighted target color in the Track Frame image then perform the following four steps repeatedly, but no more than three times.

1. Stop the Binary Pixel Map stream from the sensor using the Stop button above the Tracking Frame image display.
2. Increase the Noise Filter setting below the Track Frame image display by 1.
3. Start the Binary Pixel Map stream from the sensor using the Start Grabbing Binary Pixel Maps button.
4. Observe the Track Frame image display.

Note: It is normal for the actual target color mass of this image to be reduced in size as the noise filter increases. The noise filter setting filters out the number of pixels it is set for from the perimeter of all incidences of target color in the display image.

If all stray dots of highlighted target color have been eliminated from the image and the Noise Filter setting is less than 3 then the calibration procedure for this target is complete. Save the image and the configuration parameters. **

If the stray dots of highlighted target color have been eliminated from the image and the Noise Filter setting is greater than 2 then it must be determined whether the tracked target image is large enough to be tracked by the sensor at the maximum required distance. This is done by moving the target to the required distance while monitoring the Track Frame image display.

If the target reliably tracks to the maximum required distance then the calibration procedure for this target is complete.

Save the image and the configuration parameters. **

If there are only the target and a few stray dots or areas of highlighting then attempt to determine what is causing the dots. The most common cause of stray color dots are fluorescent lights.

If the source can be found then determine if it is necessary in the area you will be using the sensor. If not then remove the cause and try again. If the cause is necessary in the area you will be using the sensor then continue with this procedure.

3.3.7 RED Gain Control and BLUE Gain Control

Attempt to eliminate the remaining stray highlighted areas of the image by systematically increasing/decreasing the RED Gain Control then the BLUE Gain control values (*in text boxes to the right of the Track Frame image display*) repeatedly per the following six steps.

1. Stop the Binary Pixel Map stream from the sensor using the Stop button above the Tracking Frame image display.
2. Manually adjust the value of the Gain Control being adjusted by 3 (until the limit of either 0 or 255 has been reached).
3. Upload the setting to the sensor using the Upload Config to Camera button.
4. Start the Binary Pixel Map stream from the sensor using the Start Grabbing Binary Pixel Maps button.
5. Observe the Track Frame image display.
6. Repeat the process until the most effective value has been reached.

If there are still a few remaining dots of stray highlighted target color about the image then return to the Color Parameter Adjustment phase. Perform the adjustments for RED and BLUE min/max values substituting a value of 1 for the value of 10 used in the steps.

If removal of the stray dots of highlighted target color has failed and the calibration procedure for RGB color space has not been attempted for this target then perform the calibration using the procedure for calibrating in RGB color space.

If the procedure for calibrating in RGB color space has been attempted then either remove the cause for the stray highlighted target color, move to a new test location, or choose a new target color.

** If easyC is to be used as a programming environment then export the Vision Sensor parameters for use with easyC by:

- Selecting the Save Config for easyC button to the right of the Tracking Frame display. *A Dialog box will open.*
- Locate the default easyC directory (C:\Program Files\intelitek\easyC for FRC\Camera)
- Provide a name for the new file or accept the default name.
- Select the Save Config for easyC button in the lower right corner.

Section 4

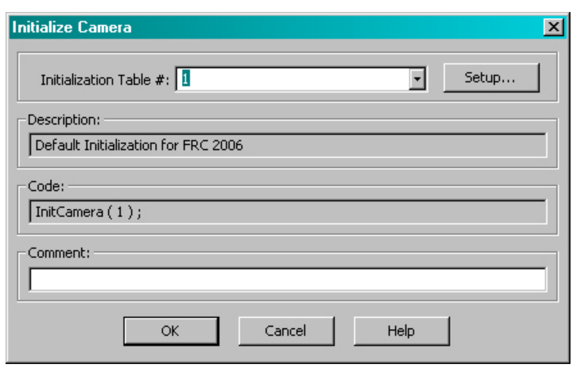
CONFIGURING THE CMUCAM2 VISION SENSOR WITH EASYC

This section outlines configuring the Vision Sensor when using the easyC programming environment. If using a target other than the 2006 Vision Target or the Default Configuration Parameters for the 2006 Vision target require revision then perform the following procedure.

When at the stage in programming where the Vision Sensor is initialized and you have saved configuration parameters for easyC from the LabVIEW CMUCam2 demo application, perform the following.

Under the ‘camera’ directory in the project explorer drag the ‘Initialize’ block to the appropriate point in the code.

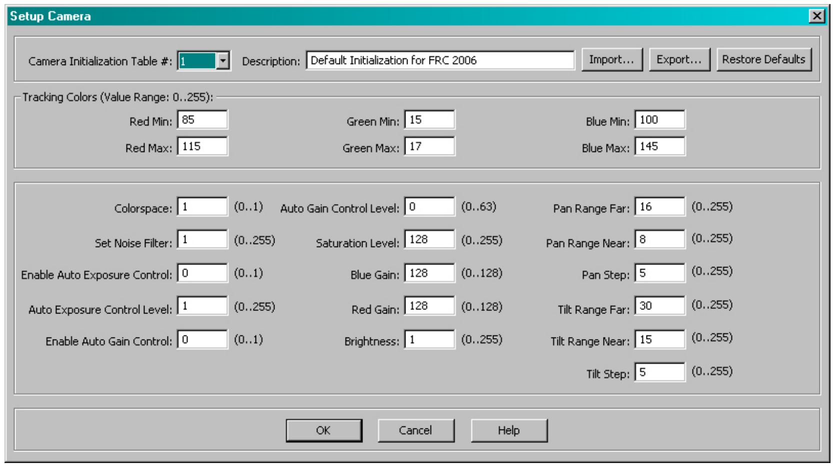
When released the ‘Initialize Camera’ text window will open.



- Select an Initialization Table number from the drop down menu provided.

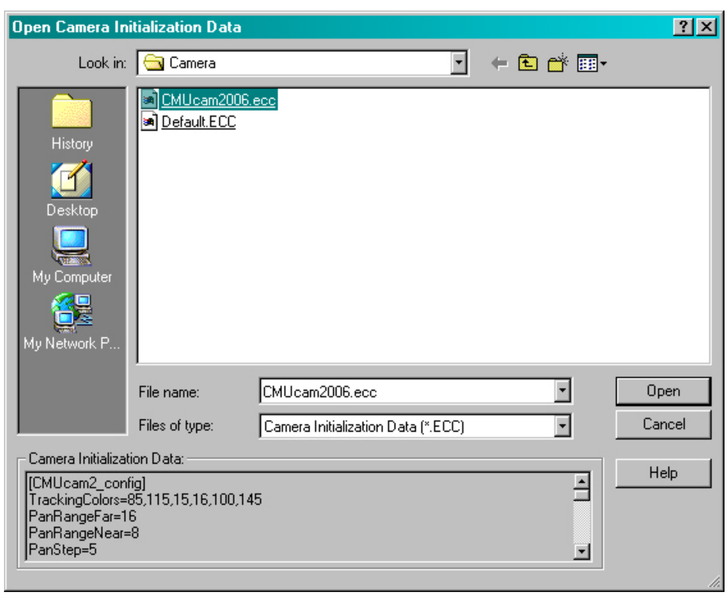
Note: easyC can store up to 10 sets of calibration data with each project. Each set of parameters is assigned to a 'Camera Initialization Table #' and can be given a description for identification.

1. To open the Setup Camera window Select the ‘Setup button’ at the upper right of the window.



- Select the Camera Initialization Table # you wish to modify from the drop down menu in the upper left corner.
- Change the description in the description field if appropriate.
- Select the 'Import' button at the upper right of the window the 'Open Camera Initialization Data' window will open.

2. Select the name of the configuration file to be opened. Once selected the data from the file will be displayed in the text display at the bottom of the window for verification.



- Select ‘Open’ at the lower right of the window to load the file and close the 'Open Camera Initialization Data' window.

Note: The table in the Camera Setup window will automatically update. All of the fields should now reflect the settings from the imported file.

3. Select ‘OK’ at the bottom of the Camera Setup window to save your work.
4. Select ‘OK’ at the bottom of the Initialize Camera window to return to programming in easyC

Section

5

CONFIGURING THE CMUCAM2 VISION SENSOR CODE FOR MPLAB

Available at http://kevin.org/frc are two offerings of Vision Sensor Code: a 'Bells and Whistles' version and a 'Streamlined' version.

5.1 THE BELLS AND WHISTLES VERSION

This program is the 2006 Default Code supplemented with Vision Sensor code.
It has built-in configuration menus for both the Vision Sensor and the Servo Tracking parameters plus a Servo/Sensor search routine and the ability to store all of the parameters in the onboard EEPROM of the Robot Controller.
The Default Configuration Parameters are for the 2006 Vision Target and use the 2006 Vision Sensor Mount. The parameters are pre-loaded in the code in the files camera.h for the Vision Sensor parameters and tracking.h for the Servo Tracking parameters.

5.2 THE STREAMLINED VERSION

This program is the 2006 Default Code supplemented with the Vision Sensor code.
It provides the tracking ability of the "bells and whistles" version without the configuration menus and EEPROM routines.
The Default Configuration Parameters are for the 2006 Vision Target and use the 2006 Vision Sensor Mount. The parameters are pre-loaded in the code in the files camera.h for the Vision Sensor parameters and tracking.h for the Servo Tracking parameters.

Required Items

A computer with the following software installed and ready to go.

1. The MPLAB IDE and C18 compiler, (supplied in the Innovation First Control system box).
   a. Specifically you will need to know how to:
      - Open Projects.
      - Open files within the project.

- Edit a file.
- Compile a program.

2. The Bells and Whistles version of 2006 Default / Vision Sensor code, ('frc_camera1.zip') or The Streamlined version of 2006 Default / Vision Sensor code, ('frc_camera_s.zip'). Both of these are available at http://kevin.org/frc.

3. The Innovation First IFI_Loader v1.0.20 (Available at http://www.innovationfirst.com/).
   a. Specifically you will need to:
   - Connect the computer to the Robot Controller.
   - Locate the .hex file in the project directory.
   - Download the file to the Robot Controller.

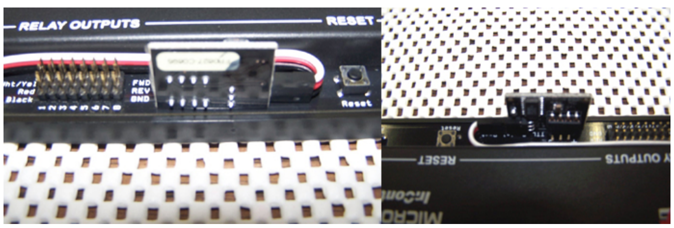
5.2.1 Loading the MPLAB Vision Sensor code into the Robot Controller

The Bells and Whistles Version

Note: This process assumes the following:

- The Robot with Vision Sensor is wired and ready to go.
- The computer is up and running with the required software installed.
- A Vision Sensor Calibration Procedure has been performed.
- The Robot power is 'ON'.

1. Connect the TTL-232 adapter to the RC 4-pin TTL port. The TTL-232 adapter has 'BLK' printed on the printed circuit board. This is the end of the connector where the black wire of the power PWM cable is oriented. The TTL-232 adapter plugs directly into TTL port of the Robot Controller.



2. This program requires that the servos be attached to the RC as follows
   a. The Pan Servo connected to PWM OUT 1.
   b. The Tilt Servo Connected to PWM OUT 2.
3. Connect the DB9 programming cable from the computer COM Port to the Programming Port of the RC.
4. Start MPLAB IDE and open the project 'camera.mcp' in the folder 'frc_camera'.
5. Start the Innovation First IFI Loader program and:
   a. Select Browse in the IFI Loader window
   b. Navigate to the folder 'frc_camera' where the Vision Sensor code is stored.

c. Select the appropriate '.hex' file.
d. Select 'Open' at the lower right corner of the dialog box.
e. Depress the 'PROG' (Programming button) on the RC until the Program State and RC Mode LEDs light solid Orange.
f. Select the 'DOWNLOAD' button in the IFI Loader window.

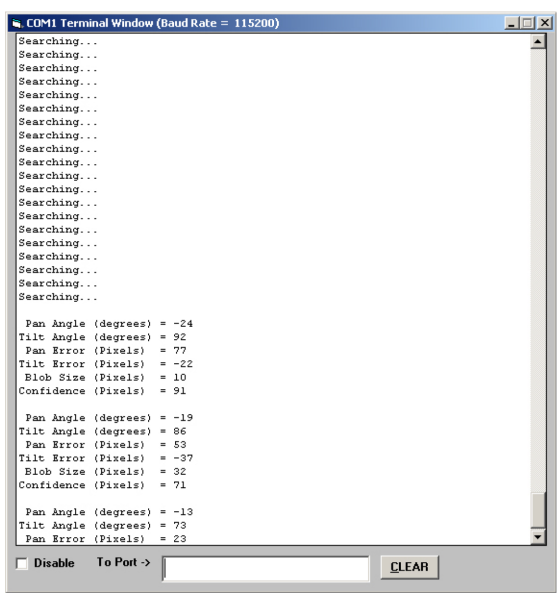
As the code downloads to the RC a status bar will appear across the lower portion of the IFI Loader window. When the download is complete the status bar is removed and the Terminal Window will open.

Note: There are no drive control algorithms in this code for the Vision Sensor. These must be provided by the user.

5.2.1.1 <u>Testing and Configuring the Vision Sensor</u>

If everything is wired and working correctly then the following will be happening:

1. The Vision Sensor will be performing a search for the Default Target by sweeping across its range in steps.
    a. After completing each sweep the Sensor will:
        - Return to the 'Home' position
        - Increase its tilt position
        - Begin another sweep.
2. Until the target is acquired this will repeat until the maximum tilt position is achieved then begin again.
3. Until the target is acquired the text "Searching…" is written to the Terminal window for each sweep of the search pattern.
4. If the Sensor acquires the target then the following status text will be written to the Terminal window. *Note: the values may differ.*



This block of information is constantly updated and will continue to be written to the Terminal window while the sensor is active.

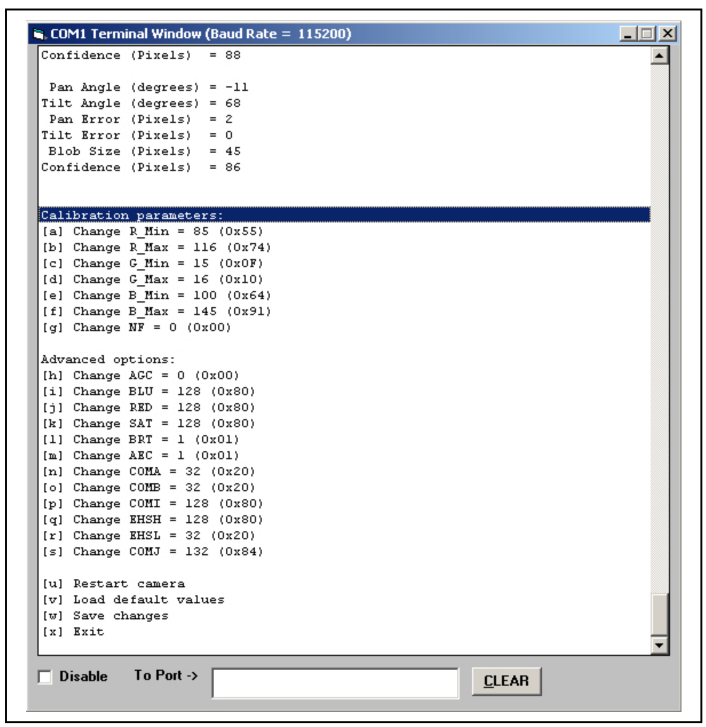
The Block of text reports the following information:

1. Pan Angle (degrees):
   - The position of the Pan Servo relative to center (127) represented in degrees.
2. Tilt Angle (degrees):
   - The position of the Tilt Servo relative to center (127) represented in degrees.
3. Pan Error (Pixels):
   - How far off (in Pixels) from the vertical center of the color blob the sensor is aimed.
4. Tilt Error (Pixels):
   - How far off (in Pixels) from the horizontal center of the color blob the sensor is aimed.
5. Blob Size (Pixels):
   - The size of the color blob (in Pixels) reported from the Sensor.
6. Confidence:
   - The (# of pixels being tracked / area of the bounded rectangle)*256 and capped at 255.

The Vision Sensor and Servo Tracking configuration parameters may be changed in this version of code through the use of the Terminal window.

5.2.1.2 Changing the Vision Sensor Parameters

Place the cursor in the To Port-> text box at the bottom of the Terminal window.
To bring up the Vision Sensor parameters type ‘c’ in the text box then press Enter on the keyboard. The following menu will be diplayed in the Terminal window.



To change any one of the parameters listed:

1. Enter the letter of the parameter in the To Port -> text box.
2. Press Enter on the keyboard.
3. Enter the new value for that parameter in the To Port -> text box.
4. Press Enter on the keyboard.

To Return the parameters to the default values (in camera.h):

1. Enter the letter ‘v’ in the To Port -> text box.

2. Press Enter on the keyboard.

To save all of the parameters to the onboard EEPROM:

1. Enter the letter ‘w’ in the To Port -> text box.
2. Press Enter on the keyboard.

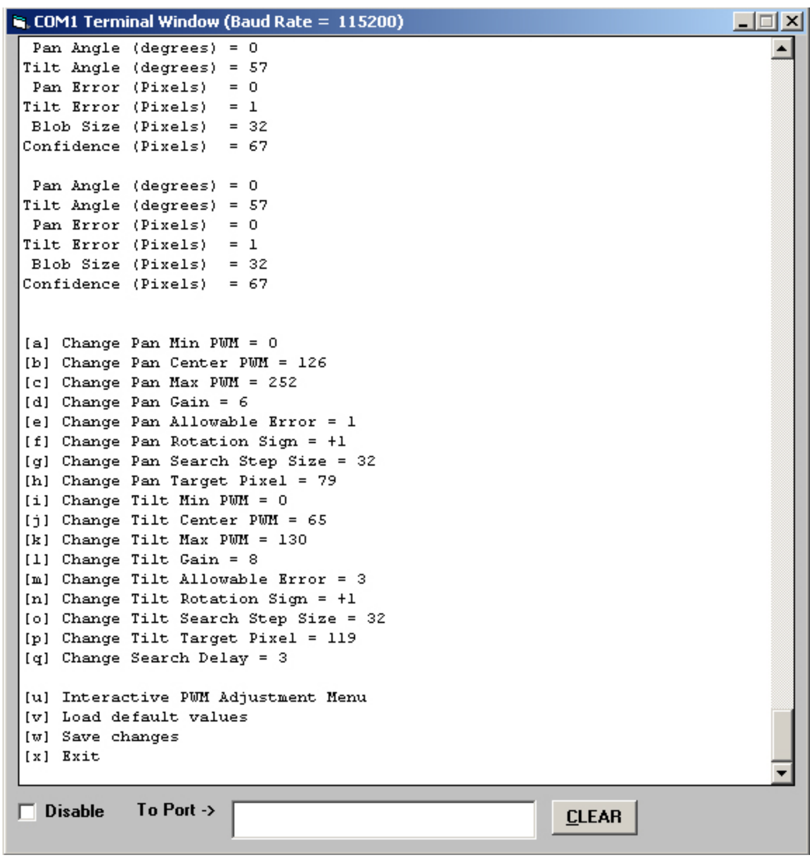
To Restart the Vision Sensor with the new parameter(s):

3. Enter the letter ‘u’ in the To Port -> text box.
4. Press Enter on the keyboard.

To Exit the Vision Sensor menu and resume receiving status text:

5. Enter the letter ‘x’ in the To Port -> text box.
6. Press Enter on the keyboard.
7. Changing the Servo Tracking Parameters

Place the cursor in the To Port-> text box at the bottom of the Terminal window.
To bring up the Servo Tracking parameters type ‘t’ in the text box then press Enter on the keyboard. The following menu will be displayed in the Terminal window.



To change any one of the parameters listed:

5. Enter the letter of the parameter in the To Port -> text box.
6. Press Enter on the keyboard.
7. Enter the new value for that parameter in the To Port -> text box.

8. Press Enter on the keyboard.

To Return the parameters to the default values (in camera.h):

8. Enter the letter ‘v’ in the To Port -> text box.
9. Press Enter on the keyboard.

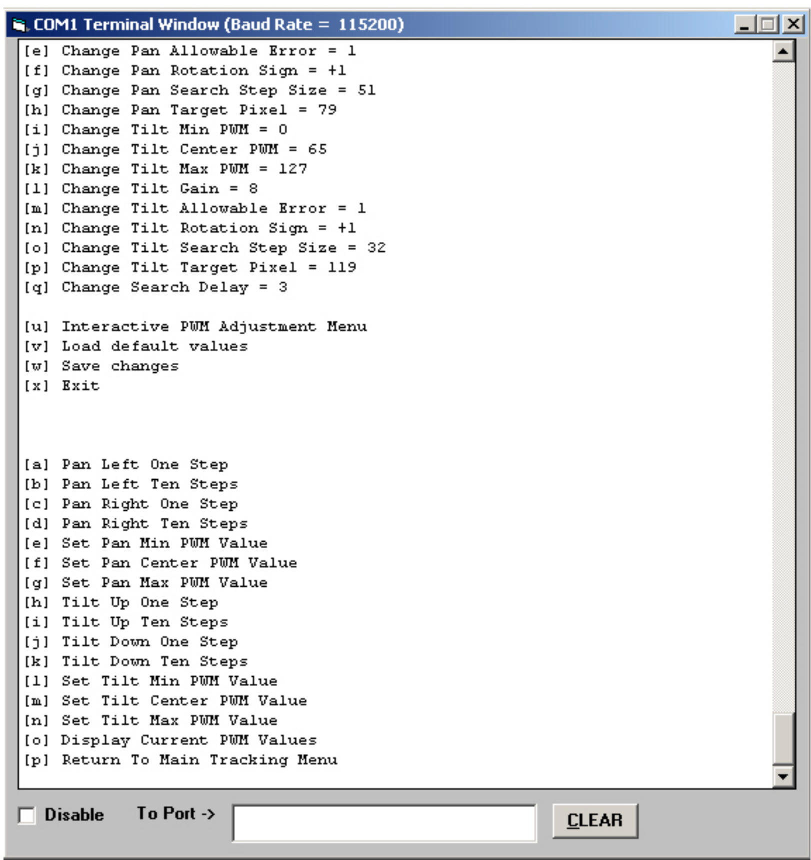
To save all of the parameters to the onboard EEPROM:

3. Enter the letter ‘w’ in the To Port -> text box.
4. Press Enter on the keyboard.

To Exit the Servo menu and resume searching / tracking:

1. Enter the letter ‘x’ in the To Port -> text box.
2. Press Enter on the keyboard.

Notice the menu item ‘u’, the Interactive PWM Adjustment Menu. This menu is used to help define the pan and tilt center values and the pan and tilt min/max limits.
To bring up the Interactive PWM Adjustment Menu type ‘u’ in the text box then press Enter on the keyboard. The following menu will be displayed in the Terminal window.



To determine a limit for a servo:

1. Check the current position of the servos using the Display Current PWM Values option (letter ‘o’).

2. If the value for the servo to be adjusted is greater than 0 or less than 255 then enter the letter for the servo direction and step value in the To Port -> text box.
3. Press Enter on the keyboard while observing the Sensor Mount for movement.
4. Repeat the steps above until there is either no movement of the Sensor Mount or the min/max value is reached for the direction of movement.

Once a limit is determined it can be set in the code using the appropriate menu option (‘e’, ’f’, ’g’ for Pan & ‘l’, ‘m’, ‘n’ for Tilt). When all intended settings are completed return to the main tracking menu (Option ‘p’), save the changes (Option ‘w’), and exit the Servo Tracking menu to resume searching / Tracking (Option ‘x’).

5.2.2 Loading the MPLAB Vision Sensor code into the Robot Controller

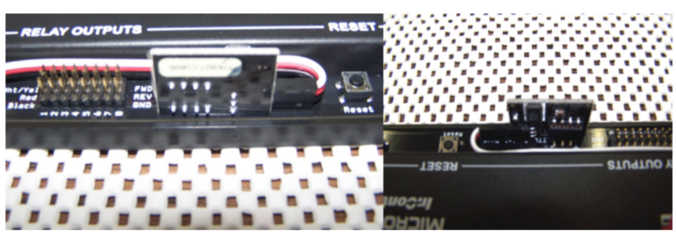
5.2.2.1 <u>The Streamlined Version</u>

This program is the 2006 Default Code supplemented with Vision Sensor code.
It provides the tracking ability of the “bells and whistles” version without the configuration menus and EEPROM routines. The Default Configuration Parameters are for the 2006 Vision Target and use the 2006 Vision Sensor Mount. These parameters are pre-loaded in the files camera.h for the Vision Sensor parameters and tracking.h for the Servo Tracking parameters.

Note: This process assumes the following:

- The Robot with Vision Sensor is wired and ready to go.
- The computer is up and running with the required software installed.
- A Vision Sensor Calibration Procedure has been performed.
- The Robot power is ‘ON’.

6. Connect the TTL-232 adapter to the RC 4-pin TTL port. The TTL-232 adapter has ‘BLK’ printed on the printed circuit board. This is the end of the connector where the black wire of the power PWM cable is oriented. The TTL-232 adapter plugs directly to TTL port of the Robot Controller.

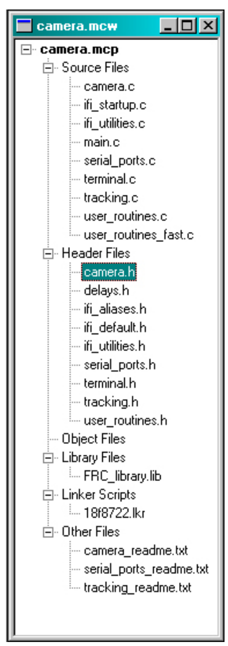


7. This program requires that the servos be attached to the RC as follows
    a. The Pan Servo connected to PWM OUT 1.
    b. The Tilt Servo Connected to PWM OUT 2.
8. Connect the DB9 programming cable from the computer COM Port to the Programming Port of the RC.

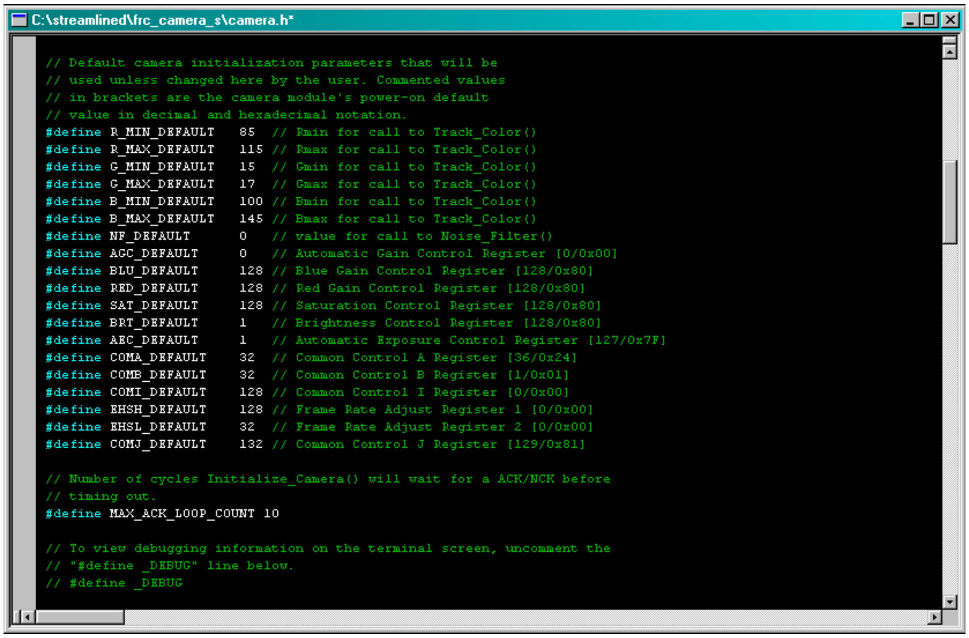
9. Start MPLAB IDE and open the project 'camera.mcp' in the folder 'frc_camera_s'.
10. Start the Innovation First IFI Loader program and:
    a. Select Browse in the IFI Loader window
    b. Navigate to the folder 'frc_camera_s' where the Vision Sensor code is stored.
    c. Select the appropriate '.hex' file.
    d. Select 'Open' at the lower right corner of the dialog box.
    e. Depress the 'PROG' (Programming button) on the RC until the Program State and RC Mode LEDs light solid Orange.
    f. Select the 'DOWNLOAD' button in the IFI Loader window.

As the code downloads to the RC a status bar will appear across the lower portion of the IFI Loader window. When the download is complete the status bar is removed and the Terminal Window will open.
Note: There are no drive control algorithms in this code for the Vision Sensor. These must be provided by the user.

The Streamlined version is supplied with the 2006 Vision Target default settings for the Vision Sensor already entered into the code. To change these settings open the file 'camera.h' in the Project Window by double-clicking on the filename.

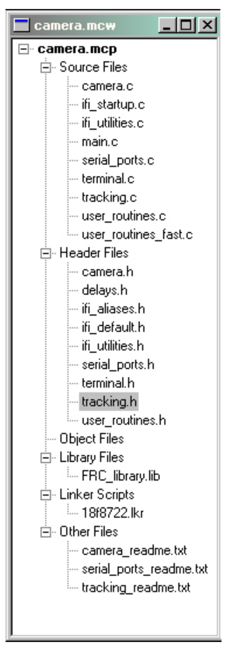


Scroll to the Default Camera Initialization Parameters as shown below.

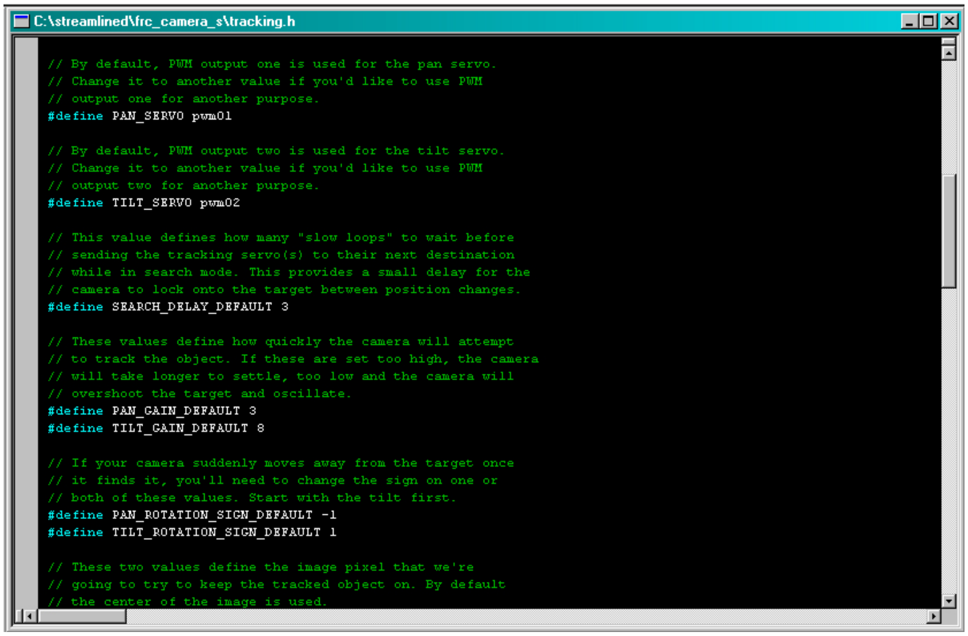


Find the parameter in the list to be changed and replace the value with the new value. Re-compile the code and download the code to the RC using the IFI Loader.

The Streamlined version is also supplied with the Servo Tracking default settings already entered into the code. To change these settings open the file ‘tracking.h’ in the Project Window by double-clicking on the filename.



Scroll to the Default Servo Tracking Parameters as shown below.



Find the parameter in the list to be changed and replace the value with the new value. Note: The comments preceding each of these parameters explain the use of the parameter in the code. Read these comments carefully to reduce the risk of undesired results.

When all changes to these parameters have been made, re-compile the code and download the code to the RC using the IFI Loader.