Phoenix Technologies Incorporated

Visualeyez™ III

3D Motion Capture Systems

USER MANUAL

Version 5.2

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NOTICE TO USERS

Printed in Canada.

COMPLIANCE DECLARATIONS

The Visualeyez III motion measurement and tracking systems have been tested and confirmed to comply with certain industry standards, for which the following declarations are made.

U.S. FEDERAL COMMUNICATIONS COMMISSION STATEMENT

Class A Equipment

This equipment has been tested and found to comply with the limits for Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at personal expense.

INDUSTRY CANADA COMPLIANCE STATEMENT

This equipment has been tested and found to comply with the limits for an electronic equipment, pursuant to the Industry Canada regulations.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Visualeyez VZ10K

Tested to Comply with FCC Standards

FOR HOME OR OFFICE USE

FCC #OUK-VSLZ9931
CANADA 35541021806A

EU EMC/ITE/ITU COMPLIANCE DECLARATION

DECLARATION OF CONFORMITY

according to ISO/IEC Guide 22 and EN 45014

Phoenix Technologies Incorporated
201-237 Keefer Street, Burnaby, B. C. Canada

declares that the product (s):
(1)
Product Name: Visualeyez
Model Numbers: VZ3000, VZ4000, VZ4000v, VZ4050, VZ10K,
VZ10K5
Product Options: Sensing units, Target Control Modules, target assemblies

conform to the following Product Specifications:

EMC: EN 50082-1:1997 - All Tests

The product(s) herewith comply with the requirements of the EMC Directive 89/336/EEC. The product(s) were tested in a typical configuration.

(2)
Product Names: Tracker Strober module, Marker Synchronizer module

respectively conform to the following Type Approval Standards:

EN0300-220-1 (1997-11), EN0300-220-2 (1997-11)

in accordance to the
ERC Decision adopting above standard: ERC/DEC/(98)05.

C. C. H. Ma, Ph.D.
President

Contents

WELCOME

Thank you for purchasing the 10,000Hz Visualeyez III 3D motion tracking system. This manual will assist you in learning how to use the Visualeyez system hardware and the VZSoft graphical user interface software. It has been written with the assumptions that the reader has some functional knowledge of the Windows operating system, a basic understanding of the XYZ coordinate system in 3D space, and a fundamental concept of what commercial 3D animation software and popular scientific software can do with the data generated by Visualeyez in real-time.

More specifically, this user manual provides you with the following information:

- Hardware description
- Hardware installation
- *VZSoft* GUI software description & installation instructions
- 3D motion capture operation
- Basic and advanced operation concepts
- Specifications
- System maintenance

To obtain the best possible performance from your tracking system, please read this user manual thoroughly. Be sure to read all the **PRECAUTIONS** and **NOTES** before using Visualeyez.

Please retain this user manual for future reference

Upon receiving a standard single-tracker system, ensure the following contents are enclosed.

Note: Contents may be different for a non-standard system with different/custom marker sets.

Standard Single-Tracker System:

One Visualeyez III 3D motion tracking unit

One custom Tripod (dual purpose stand and protective case) or one steel tripod

One AC power adaptor (power supply for the tracker)

One PCIe bus card with 2 serial ports

One data communication cable

One tracker strober (transmitter) for tetherless operation

One marker synchronizer (receiver) for tetherless operation (for Standard and Octopus markers, not required for SIKMarkers)

One or more Target Control Module (TCM) for Standard markers (not required for SIK or Octopus markers)

One or more rechargeable battery for tetherless operation

One battery charger

One TCM-synchronizer-battery interconnection cable (Standard markers only)

A certain number of active LED markers (Standard, Octopus or SIK type)

One *VZSoft* graphical user interface (operation software)

WARNING - EYE SAFETY

Visualeyez systems are developed using Light Emitting Diodes (LEDs) as markers for sensing the positions and motions of a subject. If the remote (noncontact) digitization option is purchased, the system may also include one or more laser pointers (the VZLaser). Each LED, when powered-up, emits quite powerful light pulses over relatively broad angles for the optical trackers to sense from different directions. Each laser pointer, when powered up, emits highly focused coherent laser light pulses onto one tiny spot for generating reflections for the trackers to sense.

The full extent of the health effects of these rather powerful pulsed lights on human or other life forms are not yet fully understood. Nevertheless, it is known that these lights can cause injuries to eyes if used improperly.

To ensure safety to eyes,

1. DO NOT look directly into a powered-up LED at closer than 25cm distance for longer than 5 seconds! This applies even to nearly-invisible LEDs!

2. DO NOT allow the LED lights to shine into the capture subject's eyes during a facial capture. This applies even to nearly-invisible LEDs!

3. NEVER look into a laser pointer! Check its operation by finding its light spot reflection.

4. Focus the laser light spot by shining it at a distant object while adjusting focus.

5. NEVER point a laser beam at any eyes!

PRECAUTIONS

HANDLE WITH CARE
Do not bump or apply excessive force to any part of the tracker at any time, during operation or storage.

DO NOT DISASSEMBLE
Visualeyez is a high-precision instrument. Parts and the sensing elements are factory calibrated. There are no serviceable parts inside. Do not open or modify the Visualeyez sensing unit, as this may damage the system and more importantly will void the warranty. Please contact Phoenix Technologies Incorporated to have qualified engineers address any questions or problems.

HANDLE A WIRED/CABLED ASSEMBLY BY ITS WEAKEST POINT(S)
Visualeyez system powers its LED targets through miniature cables to reduce weight and size, hence increase comfort for the motion capture subject. These wire/cable assemblies must always be handled with care in order to prevent damage. Following are some guidelines for handling the target cable assemblies:

- Always pick up both ends of a loose wire/cable assembly first.
- If a target wire/cable must stay connected to a TCM, pick up its loose end before moving the TCM.
- Do not let a long wire/cable assembly dangle without support. The weight of the wire/cable may damage the connection within the end-connectors.

APPROPRIATE OPERATING ENVIRONMENT
To make stable & accurate measurements, Visualeyez should be installed in an area with the following conditions:

- Proper lighting — avoid heat-producing lights (e.g., incandescent). Regular fluorescent office lights are o.k.
- Avoid shining any kind of lights directly into any of the sensing eyes.
- Before operating in tetherless mode, ensure no nearby equipment are sensitive to the radio frequency to be sent by the tracker strober. This is particularly important in a hospital environment.

POWER SUPPLY AND GROUNDING OF THE TRACKING UNIT

- Reversed supply voltage, or over-voltage, may INSTANTLY DAMAGE electronic devices
- Use only the AC/DC power adaptor (see Specifications) supplied by PTI to draw power from a standard (100-240 VAC, 50-60 Hz) grounded wall outlet to the Visualeyez system.

WARNING - DO NOT STARE INTO A POWERED-UP LED FOR MORE THAN 5 SECONDS AT CLOSER THAN 25cm!

WARNING - NEVER LOOK INTO A LASER POINTER!

LIMITED WARRANTY

PhoeniX Technologies Incorporated warrants its hardware product(s) are free from defects in material and workmanship for a period of one year, excluding LED targets, VZSuit wear and tear, battery products, and target cable assemblies, from the date of delivery. LED targets are warranted for three months from the date of delivery, battery products and target cable assemblies are warranted for six months from the date of delivery. These warranties shall not apply to damages or defects resulting from misuse, abuse, accident, improper installation/and care, fire, water, improper site preparation, customer supplied software or hardware, modification or repair not authorized by PhoeniX Technologies Incorporated. In addition, this warranty does not warrant the effective life (length of service) of the battery since the effective life of a battery is primarily determined by the usage patterns and the quality of care given over the battery's lifetime. If any hardware product(s) should fail through no fault of the Buyer during the warranty period, PhoeniX Technologies Incorporated will, at its sole discretion, repair or replace the product(s) free of charge. Other costs associated with the replacement of the product(s) including shipping, customs and insurance etc. shall be paid by the Buyer. The defective product(s) must be returned in proper packaging identical or similar to the original package.

PhoeniX Technologies Incorporated further provides three months' telephone or E-mail technical support for the system and six months of free upgrades on the VZSoft software from the date of delivery. All inquiries must originate from one designated support site or the site to which the products were shipped.

This warranty is "exclusive". There is no other implied or expressed warranty other than indicated on this agreement.

The software product(s) are licensed and provided "as is" without warranty of any kind. PhoeniX Technologies Incorporated makes no warranties, express or implied, that the functions contained in the software product(s) will meet the Buyer's requirements or that the operation of the programs contained therein will be error free.

WARRANTY RETURN POLICY

In the event that an item must be returned, please follow these steps:

1. Obtain a RMA (Return Merchandise Authorization) number by contacting Customer Services of PhoeniX Technologies Inc. with the following information:
   - Customer name
   - Order number and purchase date
   - Item description(s) and/or number(s)
   - Description of the problem

   Note: No return of any kind will be accepted without a RMA number.

2. Send the item(s) being returned to:
   Phoenix Technologies Incorporated
   Attn: Returns Dept.
   201-237 Keefer Street, Vancouver, BC, Canada 6A 1X6

In your shipment, please note your RMA number and include a copy of the sales order.

LIMITED LIABILITY

All statements, technical advice and recommendations contained on our documents are based on tests believed to be reliable, but the accuracy thereof is not guaranteed, and the following is made in lieu of all warranties, express or implied:

> Seller's and manufacturer's only obligation shall be to repair or to replace the defective product(s) within the stated warranty period. Neither seller nor manufacturer shall be liable for any injury, loss or damage, direct or consequential, arising from the use of or the inability to use the product. Before using, user shall determine the suitability of the product for his intended use, and user assumes all risk and liability whatsoever in connection therewith. PhoeniX Technologies Incorporated expressly disclaims any warranties of merchantability and fitness to or for a particular purpose.

NOTES:

- **Misuse of the high-intensity LEDs and/or the VZLaser laser pointer may cause eye injury. This is stated in the WARNING and PRECAUTIONS sections of the User Manual. Please request a copy should you require such information.**

- **This system has not been approved for medical use.**

CONTACT INFORMATION

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Phoenix Technologies Incorporated welcomes any comments, suggestions, and feedback. We take pride in listening and attending to our customers' needs and believe that our success comes from their acknowledgement and opinions about our products. Please contact us by telephone, visit our website at http://www.ptiphoenix.com, or send an email to info@ptiphoenix.com.

I. INTRODUCTION

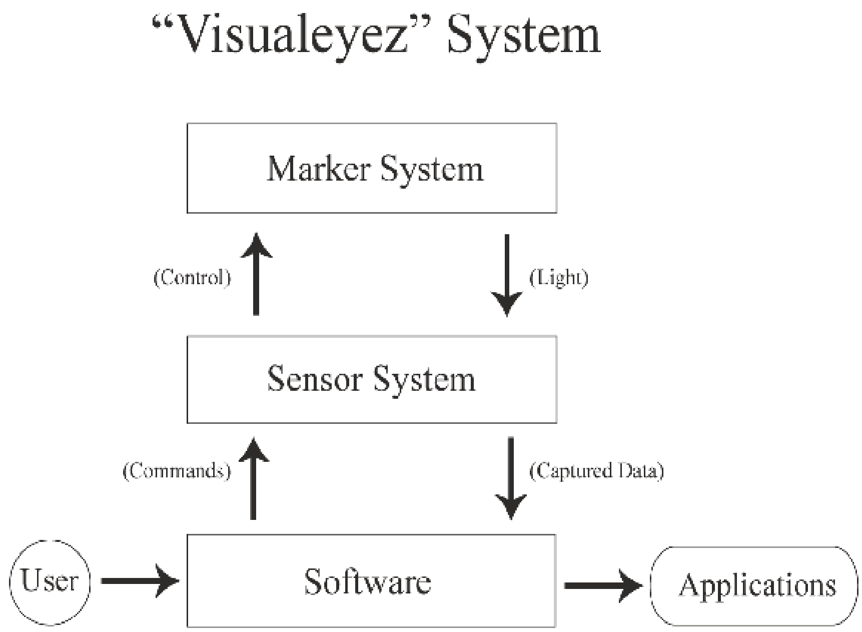
Visualeyez is a family of 3D motion measurement and tracking systems created to meet demands of the CG motion capture, scientific motion analysis and control industries for a cost-effective compact product with high data throughput, high accuracy and large operating space. A single-tracker Visualeyez system consists of only a few separate essential parts: a tracking unit with tripod, target control module(s), light emitting diode (LED) targets, and a graphical user interface (VZSoft). The tracking unit detects the lights from an LED target, calculates its 3D position, then transmits the computed position coordinates to the host computer immediately. This is carried out for each LED target in sequence, one at a time, and repeat at very high speed.

The system takes advantage of PTI's patented wide-angle sensing methodology to create a very small 'blind' region and very large operating space without compromising position sensing resolution. Advanced pipelined parallel digital signal processing (DSP) electronic technology delivers 3D coordinates in real-time, without requiring any external processing, at the highest rate available in any real-time motion capture system. Innovative compact mechanical design further makes the system very mobile and deployable even in limited spaces without any special setup. All these merits combine to yield tremendous utility at very significant cost-savings for the users.

1.1 SYSTEM OPERATION OVERVIEW

A standard Visualeyez™ system repeatedly senses and computes the 3D positions of markers attached to motion capture subjects. The subjects can be people, animals, objects, machines, or a combination of them. After capturing, the data are displayed on the VZSoft graphical user interface (GUI), and passed on to user application(s).

The system operates first with the user specifying the desired motion capture operation modes and parameters (e.g., marker names, sampling period, intermission period between frames, coordinate reference frame, sensor exposure, data storage directory, occlusion handling, etc.) according to his/her application requirements through the VZSoft™, which is further described in details later in this manual. Upon capture initiation, VZSoft passes the mode settings and parameters to the trackers. The trackers in turn set up the LED-based ('active') marker system either via a tetherless (radio) link, or via a thin tether cable. Subsequently, the LED markers light up and the tracker(s) sense the LED lights to triangulate their 3D positions. Then the trackers stream the captured marker position data back to VZSoft, thus completing the 3D motion capture operation. This is shown in the following drawing.



A system can consist of one or more trackers. When more than one tracker is used, their relative positions and orientations to each other (the 'system configuration') must be calibrated in order for the multiple trackers to operate as one larger coordinated unit. To accomplish this, VZAutoCal™ software is required. The user must also assign one of the trackers to be the 'master', so that the captured marker position data can be referenced to it. As long as the configuration is not changed, the system should continue to operate with high accuracy. In case a tracker within a multi-tracker system is bumped or moved, or the ambient temperature has changed significantly, the system must be re-calibrated in order to recover its accuracy. If the VZAutoCal™ is used and enabled, this re-calibration will be done automatically without user intervention. A single-tracker system never needs to be calibrated at all.

1.2 MARKERS & MARKER IDENTIFICATION

A Visualeyez™ system can capture the 3D positions of up to 512 LED markers (also interchangeably called 'targets'). These markers may be controlled and powered by Target Control Modules ('TCMs') and be referred to as 'standard markers', or they may come in the form of 'self-identified markers' (see SIMarker or SIKMarker) powered by individual tiny batteries, or in the form of 'semi-wireless markers' (see Octopus Markers, or 'OctMarker' for short) powered by one battery for several markers. Thus at least three major types of LED markers are available for a Visualeyez system.

As of now the self-identified markers can also be equipped with vibrators to provide tactile feedback to the capture subject. This feedback mechanism may also be customized to provide other forms of distributed feedback if desired. Please consult PTI for the possibility.

The TCMs are distinguished from one another by up to eight different identification numbers referred to as 'TCM_ID's (or simply 'TCMID's for short). More than one TCMs can have the same TCMID. The system treats them as one single unit (with multiple bodies).

A fundamental optical condition for proper capture of the LED marker motions by a Visualeyez system is that only one single point-light source (an LED is such a source) is present within the system's capture space at any time. To ensure this is the case, the master tracker actively controls which and when a LED target can turn on or off.

To control multiple markers individually, each LED target is assigned a uniquely identifiable number. Since two LED targets connected to two TCMs with two TCMIDs are already distinguishable by their different TCMIDs, only those targets with the same TCMID still need to be further distinguished from one another. This is done with a second identification number referred to as the 'LED_ID' (or simply 'LEDID' for short). The combination of a TCMID and a LEDID is also called a Marker ID (or 'MarkerID' for short).

Both the TCMID and LEDID are automatically assigned when a standard marker is connected to a TCM. A wireless self-identified SIMarker is assigned a MarkerID by an internal microprocessor at the factory. A semi-wireless marker is also assigned a MarkerID internally by a microprocessor at the factory. A semi-wireless marker differs from a wireless marker mainly in the absence of an individual battery. Thus each physical LED marker connected to a Visualeyez motion capture system is labeled with a distinct MarkerID. To turn on/off a particular LED marker, the system simply addresses this unique ID number.

1.3 THE CAPTURE PROCESS

A Visualeyez system captures the positions of the LED markers one by one, in the order of the user-specified 'target flashing sequence' (TFS), and in the sampling interval ('sampling period') specified by the user. For the 'standard markers', the order in which the markers are captured can be arbitrarily arranged. However, this is not possible for the 'wireless markers' or 'semi-wireless markers'.

Before a LED marker with a different TCMID is captured, the system will first command all markers with that new TCMID to wake up and be ready to flash their LEDs, and command the rest of the markers to sleep. This process takes some time. As a result, a capture may be skipped (a 'capture-skip') if the specified sampling period is too short for the relevant markers to wake up and one of them to be captured within the same sampling period. Similarly, after all markers in the target flashing sequence have been captured once (i.e., one motion 'frame' is captured, or one 'capture cycle' is completed), the system will command all markers to re-synchronize in case noise caused one or more of them to go out of sync with the others. This may also cause a capture-skip if the sampling period is too short. Then the target flashing sequence will be repeated either immediately or after an 'Intermission Period' depending on the user settings.

After a capture, the 3D marker position data is output to a common memory location within a very short time delay ('latency'). Along with the position data, the MarkerID, the precise (microsecond) relative timestamp at which the marker was captured, and the status of the data itself, are also output to the same common memory location for user applications (normally software) to make use of. More details on these subjects are within the texts of this manual. Thus the Visualeyez system can be applied in innumerable areas, including 3D animation, games, entertainment, as well as in demanding scientific motions research, sports analysis, real-time feedback control, virtual reality (VR), physical rehabilitation, industrial measurement, human factor analysis, and many other areas.

1.4 HOW TO USE THIS MANUAL

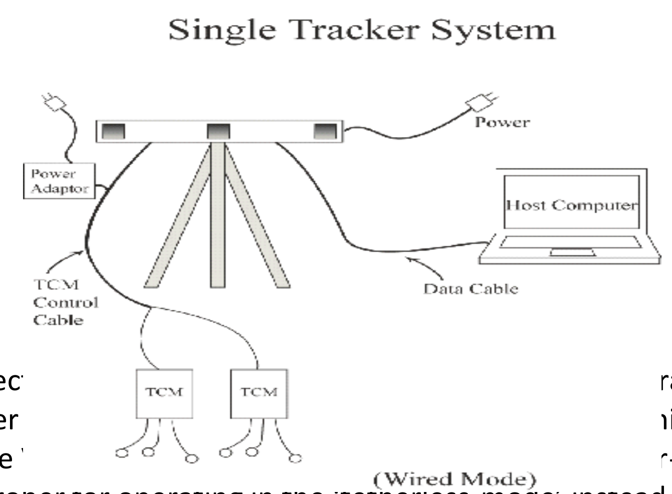
This manual has been written in order of importance for the proper setup and use of a Visualeyez system. It is recommended that the user at least read the sections

- WARNING
- PRECAUTIONS
- WARRANTY
- CAUTIONS on Approximate Frame Rate Chart (FPS)
- SINGLE-TRACKER SYSTEM CONNECTION
- TRYING IT OUT (next subsection)

To facilitate learning about the system on a need-to-know basis, an Index has been constructed and is available at the end of this manual. This is a highly useful table for searching for helpful information regarding a specific subject. Please use it any time you have a question.

1.5 TRYING IT OUT

Operating a Visualeyez system via the VZSoft is relatively easy, especially for a single-tracker system. However, due to the possibility of permanently damaging the supplied LED markers, the user MUST READ the CAUTIONS on Approximate Frame Rate Chart (FPS) before trying out a capture. Following are drawings and the typical procedures for quickly starting a motion capture session with a single-tracker system:



1. Properly connec… racker power. (The three cables are the power … high-speed COM port on a computer where the … -mode' control cable to a TCM or a tracker strober for operating in the 'tetherless-mode' instead.)

2. Attach markers to the points of interest on your motion capture subject and turn on the power. (If you use 'standard markers', you need to plug the other ends of the marker wires to a

TCM and turn the TCM power on. If you further want to capture in tetherless-mode, you need to connect a marker synchronizer and a battery pack together with the TCM.)

3. From the VZSoft program window, go to the Settings / Data Communication / Data Source Selection panel, click 'Auto Detect' and wait a little while for VZSoft to detect and connect with the tracker.

4. Go to the Targets / Auto Target Detection panel, press the Start button and wait for the progress bar to turn blue. You should see the markers flashing at about once per second as the tracker try to detect their presence. After a few flashes, press Stop and you should see the detected markers showing up on the eight target selection panels.

5. Set up other parameters on the System Settings / Operation panels if desired. (Normally just the Sampling Period and Frame Rate on the Sampling Timing panel for most applications.)

6. Press 'Record' (the round button, when at least one marker is enabled) on the Motion Capture and Playback Control bar to start capturing 3D motions of the subject.

II. HARDWARE DESCRIPTION

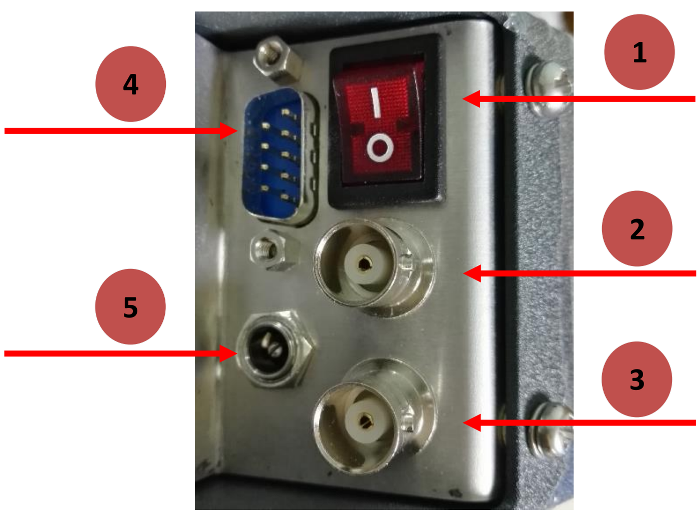
A basic Visualeyez system hardware consists of a tracking unit, a tripod, and some LED (Light Emitting Diode) markers. This chapter provides a detailed description of each of these hardware components.

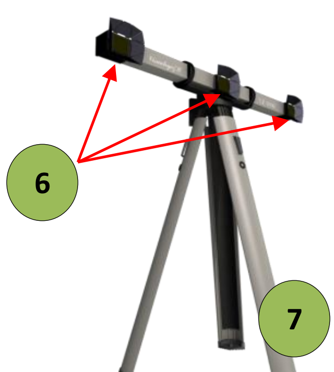
2.1 THE TRACKING UNIT

The tracking unit (also ‘sensor’ or ‘tracker’) captures and computes the 3D positions (hence motion) of one or more LED targets and passes the XYZ coordinates to the host computer. It performs four functions:

1. Receive and execute user commands;
2. Program and activate the markers (via TCMs if standard markers are used);
3. Sense marker lights and calculate the marker’s XYZ position coordinates;
4. Output the sensing status, MarkerID, XYZ coordinates, and timestamp to the host.

CAUTION: The tracking unit is precision calibrated. Do not subject it to hard contact and/or undue stress as these may permanently de-calibrate or damage the unit.





1 – ON/OFF Power Switch

2 – Control Jack (CTRL OUT)
This BNC jack is for connecting either a tether-mode control cable or a radio-based tracker strober (transmitter) for controlling the markers or TCM(s).

3 – External BNC Trigger Jack (EXT TRIG)
This is for synchronizing all trackers to operate as a single multi-tracker system. It is also for externally starting a capture session in precise synchronism with other equipment if desired (see related Caution).

4 – DB9 Interface Connector
Connect the supplied data cable from this connector to a high speed serial data port on the host computer.

5 – Power Jack
Connect the supplied tracker power adaptor to this jack.

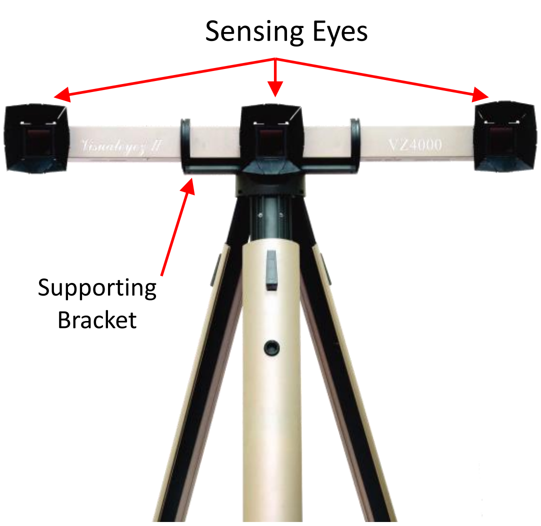
6 – Sensing Eyes
The tracker detects the 3D positions of markers through these three optical sensing windows.

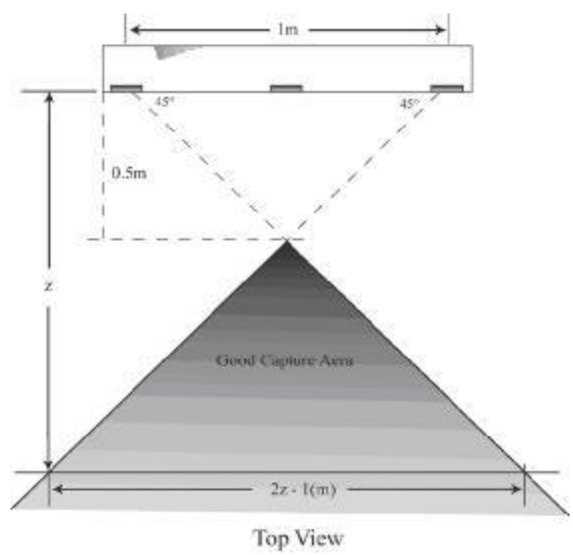
7 – Tripod
For portable mounting and storage of the Visualeyez

2.1.1 SENSING EYES

The three sensing eyes on each Visualeyez tracker capture lights from a 'point-light-source' target for subsequent computation of its coordinates. Each eye has an operating angle of +/- 45 degrees (total 90 degrees) in both the pitch and yaw directions. In order to compute the coordinates of a target/marker, **all three eyes must see the target simultaneously when the target is illuminated**. The separation distance between the two outside eyes, together with the very wide 90 deg. sensing angle of each eye, result in only a small quadrilateral blind region directly in front of the tracker. This makes it possible to operate a tracker equally well at a very close distance as at a long distance, which significantly increases the utility of a Visualeyez system.

The operating distance of each eye depends on intensity of the marker light. For scientific applications in which the capture subject orientation is not expected to change greatly, narrow angle high intensity LEDs can be used as markers. Such LEDs can emit intense lights over a long distance. For large motion (e.g., full-body motion) captures in which the orientation of the subject(s) is less controllable, wide emission-angle powerful LEDs should be used as markers to minimize loss of data due to occlusion. Such LEDs tend to yield lower light intensity at a given distance. Phoenix Technologies (PTI) regularly stocks high quality custom LEDs of different emission angles for a variety of applications, ranging from 170 degrees for full-body motion capture, to narrower angle LEDs for longer distance applications. Please contact PTI for markers most suitable for your particular application.





2.1.2 SUPPORT BRACKET AND MOUNTING

A Visualeyez tracker is normally held on a metal support bracket. It can be mounted practically at any orientation. When mounted horizontally, the operating range of a 1m long tracker is about 8m x 7m wide at 4m distance from the unit (see drawing below). To track markers at unusual angles from a tracker, rotate the unit appropriately around the bracket if possible. If necessary, the tripod legs can also be stretched to different lengths to tilt the tracker to a better angle for capture.

2.2 THE TRIPOD

The PTI custom tripod has been creatively designed to integrate rigidity, extendability, portability and low center of gravity into a compact aesthetic metal protective case. A tracking unit can be mounted on a tripod either horizontally or vertically depending on the desired shape of the operating space.

2.2.1 EXTENSION LIMIT

The PTI tripod has been designed for an extension range from a low of approximately 120cm to a high of about
200cm.

CAUTION: To prevent toppling, DO NOT EXTEND THE TRIPOD BEYOND 200cm HIGH! Leave each inner and outer leg pair overlapped for at least 30cm to ensure tripod stability and safety.

2.2.2 FOOT BUTTONS

The three conical buttons on the insides of the three rubber feet are for holding the three tripod legs together to form a protective shell when storing or transporting a tracking unit. This hold will occur only when the buttons are mated with the three holes on an end-cap of the tracker while the tracker is enclosed by the legs.

2.2.3 MOUNTING PLATFORM

The tripod mounting platform has been designed for both horizontal and vertical mountings of the tracking unit. To mount a tracker vertically, hold the unit securely with one hand while tightening the four screws on the platform rear panel to it. Since the tracking unit is relatively sensitive to jarring forces, it is recommended that this procedure be carried out by two people. Mounting a tracker horizontally is easier. Just place the unit horizontally on top of the mounting platform and secure it with the single mounting screw from under the center of the platform.

2.2.4 CAPTURE ANGLE

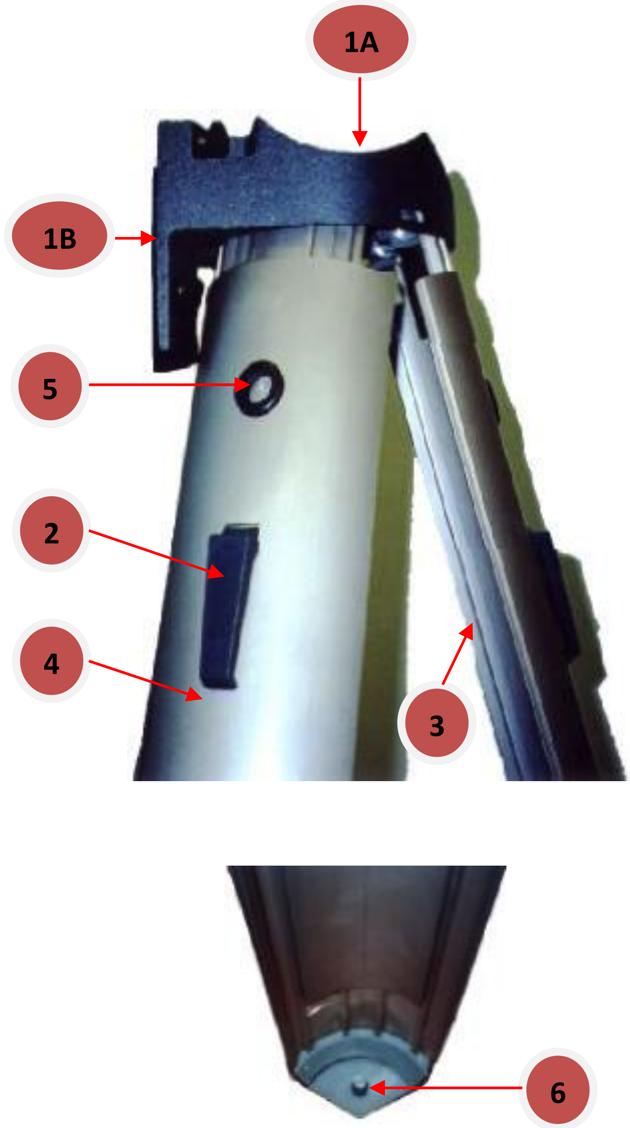
When mounted horizontally, a tracker can of course see just down to -45 degrees from horizontal. By rotating the tracker downwards while on a PTI tripod, it can be made to see down to about -70 degrees. By extending the tripod back leg(s) until the front legs are vertical (NOTE: do not extend beyond such angle!), the tracker can be made to see as far down as about -80 degrees from horizontal. This will allow a 4-tracker system arranged over a 6m x 6m space, with each tracker at 2m height, to obtain approximately a 5.2m x 5.2m 4-tracker-overlapped floor capture space. Such overlapped capture space can be increased even further by mounting the trackers on a truss, walls or the ceiling.

CAUTIONS:

1. Never over-extend the outer legs of a tripod. Always leave at least 30cm of overlap between each inner and outer leg pair and lock them together tightly to ensure tripod stability.

2. Do not pull on the plastic lock handle when extending or retracting a tripod outer leg. Use the pull-hole on the outer leg for pulling when necessary.

3. Ensure all mounting screws are securely tightened to the tracker before letting the unit stand with the tripod.



1 - **Mounting Platform** – holds the tracking unit vertically or horizontally.
1A) Vertical Platform – secure the tracker here for vertical mounting.
1B) Horizontal Platform – secure the tracking unit here for horizontal mounting.

2 - **Security Locks** -- clamp outer legs to inner legs to secure tripod at the desired height; also lock the legs together to form a protective case for containing the tracking unit.

3 - Inner Tripod Legs

4 - Outer Tripod Legs

5 - Pull Hole -- pull here to extend the outer leg length.

6 - Foot Buttons -- for holding the legs together when mated with the holes on a tracker end-knob while the tracker

2.3 TARGET CONTROL MODULE (TCM)

The function of a TCM is to turn on connected “standard” LED markers according to the target flashing sequence. This sequence is specified by the user via the TARGET SEQUENCE EDITOR panel in the VZSoft GUI (see VZSoft GRAPHICAL USER INTERFACE). It is programmed into the TCM(s) by the master tracker via either a tether (tether-mode control) cable or a radio-based tracker-strober & marker-synchronizer(s) set. After programming, each TCM waits for the activation signals to come from the master tracker to turn on and off one LED marker at a time, so that the tracking unit(s) can capture the marker lights synchronously.

TCM is a lightweight, compact electronic box with open slot(s) around the side(s). Through each open slot are standard LED marker connection pin-pairs. They allow the connection of different maximum numbers of LED markers depending on which TCM model is used. Either a supplied lithium-polymer rechargeable battery or a TCM power adaptor can be used to power a TCM for operation. To allow for programming a TCM in the tether-mode, the supplied TCM power and control cable must be connected from the TCM(s) to the CTRL OUT jack of the master tracker. This may require extra cable splitter(s) which are available as optional accessories from PTI. Recall (see MARKER IDENTIFICATION) that each tracking system can control up to 512 LED targets with up to eight different TCMID’s. Thus a Visualeyez system can potentially consist up to 512 TCMs, with one TCMID assigned to 64 TCMs and one LED target connected to each of these TCMs in such way that each LED target has a distinct LEDID.

2.3.1 TCM OUTPUT POWER RATING

Two output power ratings are available for the TCMs. These have been developed to maximize the performance and life span of different types of LED markers available for operating with a Visualeyez system.

2.3.1.1 Regular-Power TCM
The ‘regular-power’ type of TCMs can operate any type of LED markers normally stocked by PTI. Unless one or more of the precautions on Appendix E, Approximate Frame Rate Chart (FPS), is violated, the LED markers should be able to operate without performance degradation according to their corresponding manufacturers’ specifications.

2.3.1.2 High-Power TCM
The ‘high-power’ type TCMs should only be used with the ‘6-chip’ type LED markers available from PTI. This type of TCMs can permanently damage a single-chip type LED target within a few seconds. Hence the following precaution must be observed!

CAUTION: PERMANENT DAMAGE RISK!
Beware of the ‘type’ of a TCM being used. The ‘regular-power’ type can be used with any PTI

stock LED targets. However, the 'high-power' type TCMs can only be used safely with the PTI '6- chip' LEDs. Using any other type of LED(s) with a high-power TCM will permanently damage the LED (s) within seconds!

2.3.2 32-CHANNEL TCM (not recommended for new applications)

A 32-channel TCM ('TCM32') has thirty-two connector pin-pairs for controlling up to thirty-two standard LED markers during a capture. These 32 connector pin-pairs can be assigned either LEDID bank 1~32 or bank 33~64. This assignment is done by plugging a jumper over a tiny 2-pin pair inside the device cover. The tiny-2-pin-pair is normally denoted by 'LBk' (for 'LED Bank'). To assign LEDID bank 1~32 to a 32-channel TCM, plug the jumper over the tiny-2-pin-pair. To assign LEDID bank 33~64 to the TCM, do not plug the jumper over the tiny-2-pin-pair. In the latter case, you may plug the jumper over one single pin of the tiny-2-pin-pair instead, for safe keeping the jumper.

2.3.3 16-CHANNEL TCM

A 16-channel TCM ('TCM16') functions the same as a 32-channel version, except it only has sixteen connector pin-pairs for connecting up to sixteen standard LED markers during a capture. These 16 connector pin-pairs can be assigned either LEDID bank 1~16, 17~32, 33~48 or bank 49~64. This assignment is done by plugging two jumpers over two tiny-2-pin-pairs inside the device cover. The two tiny-2-pin-pairs are normally labeled 'BLk2' and 'BLk1'. To assign LEDIDs to bank 1~16, 17~32, 33~48 or 49~64, plug the jumpers over the BLK2-BLk1 tiny-2-pin-pairs as ON-ON, ON-OFF, OFF-ON and OFF-OFF respectively, where 'ON' means the jumper is plugged over both pins of a tiny-2-pin-pair. Again, the unused jumper (for the 'OFF' setting, if any) can be plugged over one single pin of the tiny-2-pin-pair for safe keeping purpose.

2.3.4 REVERSED POLARITY

A LED marker must be correctly connected in polarity to a connector pin-pair in order to be properly turned on by the TCM. If a LED is connected correctly in polarity, for any TCM, it will flash for two seconds, starting from the 3rd second, following power-up. When all LEDs light up for two seconds only starting from the 3rd second on, they indicate proper connection of all the LEDs and initialization of the TCM.

To prevent reversed connection, ensure that the white-dot on every standard marker connector faces the white-line or white-dot on the TCM case when making the connection.

If a marker does not flash for 2 seconds on power-up, its connection on the TCM may be reversed, and should be corrected.

When turning off a TCM, wait for 30 seconds to let it reset properly before you turn it back on.

2.3.5 UNDER-VOLTAGE DETECTION

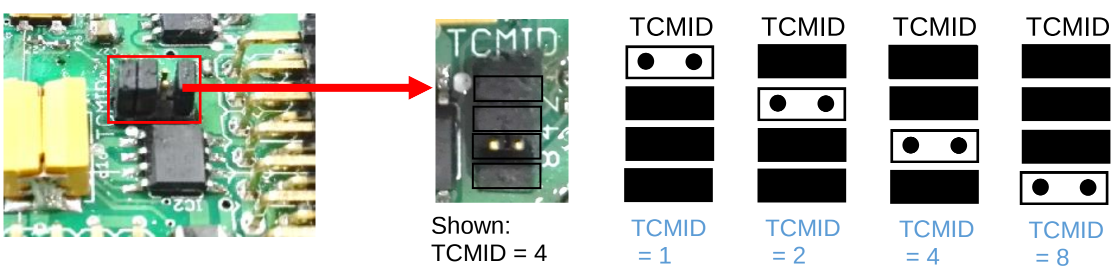
When the power supply voltage level is too low for optimal operation of a TCM, the power indicator of the TCM will flash at about once per second. The flashing will become more distinct and the frequency will increase as the voltage level drops. This will normally happen only when a TCM is powered by a battery.

2.3.6 SETTING THE TCM_ID

In order for a Visualeyez system to program the TCMs properly, each TCM must be assigned a TCMID number from 1 to 8. It is recommended that smaller TCMIDs be used whenever possible, especially when a short sampling period will be used for the capture, and particularly when tetherless mode operation is employed.

To set the TCMID (if not yet appropriately set):

1) Place the TCM on a table and open the top cover.
2) Change the binary jumper settings (labeled '8 4 2 1' on the printed circuit board).



2.4 STANDARD LED MARKERS

The standard wired light emitting diode (LED) marker (interchangeably called ‘target’) is the most mature type of marker of a Visualeyez system. It requires a target control module (TCM) to operate properly. The TCM(s) control these markers so that only one is lit for position sensing at any one time. This is accomplished by first assigning one or more MarkerID(s) to each physical LED marker, then turning on the desired marker by addressing one of the MarkerID(s). A MarkerID is made up by the combination of a TCMID and a LEDID. That is,

MarkerID = (TCMID, LEDID).

Example:
A LED marker connected to the 10th connector pin-pair of a TCM16 with TCMID=5 and BLk2-BLk1 jumper settings as OFF-ON (bank 33~48; see 16-CHANNEL TCM) would have the marker ID as:

MarkerID = (TCMID, LEDID) = (5, 42) = 542.

At least three major types of LEDs are now available from PTI for use as markers. They are ‘single-chip’ (or ‘1- chip’), ‘6-chip’ and ‘12-chip’ LEDs (see also TCM OUTPUT POWER RATING).

The single-chip type emits light from a tiny silicon chip which closely approximates a point-light source, hence would normally yield more accurate position data when captured.

The 6-chip type generates light with six silicon chips arranged in a flower shape to increase the light emission angle. This makes a 6-chip LED target more visible to a tracker and hence would yield more 'good' motion data. However, the hexagonal chip arrangement will generally make the captured motion data less accurate than those captured with single-chip LED targets.

A 12-chip LED is made up by twelve silicon chips also arranged in a flower shape. It is meant for applications in environments with relatively intense ambient lighting, such as the outdoors. It also allows for longer capture range (>10m indoor). It needs to be powered by a special TCM. For more information on this special LED, please contact PTI.

2.5 WIRELESS SELF-IDENTIFIED MARKERS

A wireless marker system consists of three major parts. The first part is of course the self-identified marker itself, which at the time of this writing comes in at least four models, SIK, SIVK, SI2VK and SI3K. These different models may be referred to as SIKMarker, SIVKMarker, SI2VKMarker and SI3KMarker respectively whenever a distinction needs to be made, or simply as 'SIKMarker' in general whenever they all possess a similar feature.

Each self-identified wireless marker consists at least one (up to three) LED, a controller, and a miniature radio-based marker synchronizer within its housing. A second part of the marker is a rechargeable battery (‘SITBatt’) for powering the marker. The third part is a radio-based tracker strober (transmitter). A 'VK' type SIKMarker would further consist a vibration motor for tactile feedback purpose.

To operate a SIKMarker, simply slide a SITBatt battery into the marker’s battery compartment. There is no on/off switch for a wireless marker. The LED will light up momentarily, which indicates that the SIKMarker has received power and initialized properly. The tracker strober must be connected to the CTRL OUT jack on the back panel of the master tracker to broadcast control signals to all SIKMarkers for tetherless and completely wireless control operation. Below shows a SIKMarker.

SIKMarker with battery

2.5.1 HOT SWAPPABILITY

A wireless SIKMarker is designed significantly different from a standard marker controlled by a TCM. Due to this difference, a SIKMarker can tolerate power interruptions during a capture. This allows the user to replace a SITBatt at any time during a capture session. Operation of the SIKMarker will resume as soon as the power is replenished.

However, the hot swappability does not normally apply to a SIKMarker in the first TCM-group of the target flashing sequence (TFS). In fact, a SIKMarker in the first-TCM-group would normally not turn on at all after the first capture cycle. Nevertheless, this problem can be overcome by invoking the 'SI/OCT' function in the provided VZSoft GUI, with a small trade-off. More details on this are in the Target Sequence Editor section. This prompts the following note for now.

NOTE:
Activate the SI / OCT function in VZSoft if there is any SIKMarker within the first-TCM-group of the TFS.

2.5.2 SIKMARKER ID & OPERATION

A wireless SIKMarker is still identified by a 3-digit number. However, the second and third digits of a SIKMarker's ID bear a different meaning from those of a standard wired marker. Recall that a standard marker is automatically assigned a MarkerID as (TCMID, LEDID) when it is connected to a connector pin-pair of a TCM. A wireless SIKMarker is factory-assigned a SIMarkerID as:

SIMarkerID = (TCMID, LED_COUNT).

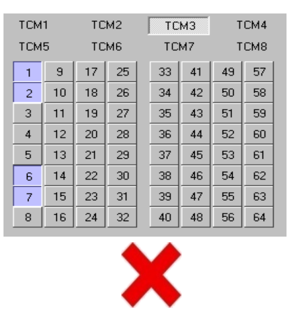
This ID cannot be changed by the user, and MUST BE SPECIFIED when ordering a replacement.

A SIKMarker operates by lighting up and be captured on the LED_COUNTth sampling period when the TCM-group it belongs to is flagged to operate. For example, a SIKMarker labeled '517' will light up and be captured on the 17th sampling period after TCM-5 is flagged to operate.

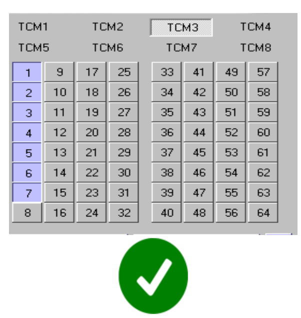
Similarly, a SIKMarker labeled '403' will light up and be captured on the 3rd sampling period after TCM-4 is flagged to operate. Therefore, if TCM-4 is flagged to operate for only two or fewer sampling periods each time, then SIKMarker-403 will never light up and hence never be captured! For example, if the user specified the target flashing sequence by (TCMID, LEDID) to be {212, 204, 259, 213, 403, 411, 101, 102, 123}, then SIKMarker-403 will never light up because TCM-4 will never operate for more than two sampling periods before it is made to sleep until the next cycle (despite the fact that MarkerID '403' is specifically named within the sequence!).

NOTE: All LEDIDs lower than a SIKMarker's LED_COUNT under the same TCMID must be enabled in order for that SIKMarker to be captured. There must be no gap in between.

Example: To capture SIKMarker 305, you must enable MarkerIDs 301 to 304 too.



Here, if 306 or 307 is an OctMarker/SIKMarker, it won't be captured properly because of the gap in the marker ID sequence!



303, 304, 305 must also be enabled to capture 306 or 307 properly!

2.5.3 SIKMARKER DATA LABELING

(*** IMPORTANT! ***)

A SIKMarker does not have a LEDID, but its output data must continue to be labeled with the combination (TCMID, LEDID) for backward compatibility. The 'LEDID' for its data will be the LEDID that the user assigns to the marker via the VZSoft™ GUI. If the assigned LEDID is different from the marker's LED_COUNT, then some confusion may arise when using the data later. Hence it is important to pay attention to avoid this potential problem when using SIKMarker(s). A simple rule to follow to prevent such confusion is to always assign the LEDID to be the same as the LED_COUNT, hence the following note. This is further mentioned in the Target Sequence Editor (TSE) section.

NOTE: Make sure the 'LED' and 'COUNT' numbers are always the same in the Target Sequence Editor panel of the VZSoft, to facilitate data usage later. (The captured data will always be associated with the LEDID only)

2.5.4 SIKMARKER BATTERY

The battery for a SIKMarker ('SITBatt') is made with a rechargeable lithium polymer battery cell and an electronic battery protector. The protector is for preventing it from getting overcharged or over-discharged. However, a lithium polymer battery cell may still suffer from internal chemical breakdown. When this happens the soft shell will balloon and eventually leak gas. Before that it will already not be able to hold much charge and should be replaced. This prompts the following notes.

Note 1: Charge a SITBatt battery only with the PTI-supplied lithium polymer battery charger.
Note 2: A completely depleted standard (190mAh) battery should take about two hours to charge to 95%.
Note 3: Replace a battery when it seems to get fully charged and/or depleted unusually quickly.

CAUTION: PERMANENT DAMAGE RISK!

Never leave a rechargeable battery plugged into a charger for more than 6 hours!
(* OVERNIGHT IS TOO LONG! ***)**

2.5.4.1 Battery Depletion Effects and Replacement

During a capture, a SITBatt battery will deplete by a constant standby current plus an operating current which is proportional to the sampling rate (FPS) of the marker and the Sample Operation Time (SOT) selected in VZSoft.

So for the regular battery normally supplied with a SIKMarker, the operating duration for a fresh fully charged battery, capturing at 100 frames per second, should be close to 90mn for a VZ10K system with Sample Operation Time (SOT=) 2. The standby duration (i.e., FPS=0) should be close to one full day.

When the battery is nearly fully depleted, the yellow LED indicator on the SIKMarker will flash repeatedly at approximately one second interval. When this occurs, the battery must be unplugged and replaced with a fresh one and capture can resume immediately.

Note that while the yellow indicator flashes, the SIKMarker will continue to operate, however the performance may already be degrading. This will last until the battery eventually shuts down by its own internal protector.

2.5.5 SIKMARKER BATTERY CHARGER

A SIKMarker battery charger (‘SITChg8’) consists eight fully independent charging circuits with indicators. The meanings of the indicators are:

Red Indicator - ON indicates that the charger is powered up.
Yellow Indicator:

ON continuously - battery is plugged in and charging.
Blink intermittently - battery is almost full. (This may be very brief for some batteries.)
OFF (or faintly lit) - battery is fully charged.

To charge a battery, simply insert it all the way into a charging compartment with the battery contacts facing down.

Normally about two to three (2~3) hours should be enough to fully charge a 190mAh battery. When the charge is finally full, the indicator should shut off practically completely.

After charging, always remove the battery from the charger, and disconnect the power from the charger too.

CAUTION: PERMANENT DAMAGE RISK & FIRE HAZARD!

Never leave a battery plugged into a charger for more than 6 hours!

Never leave a charger to idle with the power on! (* Overnight is too long! ***)**

2.6 SEMI-WIRELESS SELF-IDENTIFIED MARKERS

A semi-wireless octopus marker ('OctMarker') system is made up by five components - self-identified marker(s), power and control wire(s), battery pack, marker synchronizer, marker strober, and battery charger. It combines advantages of the standard marker system (requires one single power source) and the wireless marker system (requires very few wires).

Functionally, each OctMarker operates exactly the same as a wireless SIKMarker, except it gets its power and control signal from the wire connected to it. (Hence it does not require its own battery nor the 'miniature marker synchronizer'!)

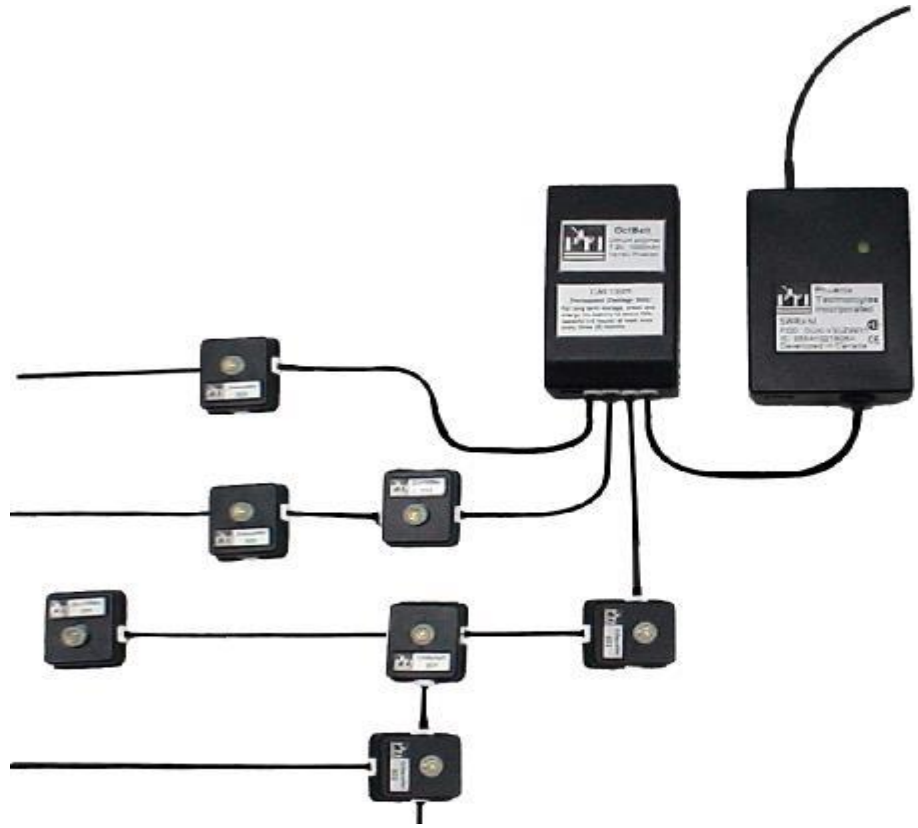
Up to about 30 OctMarkers can be connected in parallel using up to three sets ('branches') of OctWire wires, one OctBatt battery pack, and one OctRx marker synchronizer (receiver), to form a tetherless semi-wireless marker tree. To control them, simply connect a tracker-strober to the CTRL OUT jack of the master tracker. The OctBatt can be recharged using the ('VZChgr2C2') battery charger when depleted.

Each OctMarker contains three functionally identical tiny connectors which allow it to serve as a wire splitter (like the junction of a tree branch) while drawing power and control signal from the input wire. The OctWires also come in different lengths to allow OctMarkers to be placed over different inter-marker distances to points of interests on a capture subject. Constructing an OctMarker tree is therefore very easy. Nevertheless, due to the relatively large number of connectors used, the user must make sure that every connection is well-made in order for an OctMarker system to operate reliably!

2.6.1 OCTMarker Tree Construction

To construct an OctMarker tree (refer to the figure below):

1. Attach OctMarkers to points of interest on the capture subject(s).
2. Place an OctBatt at a location such that no markers will be occluded by it during operation (normally around the waist of a human or animal subject).
3. Starting from the OctBatt, connect up to three long enough OctWires from the battery pack to the nearest markers such that there will be some slack on each wire during capture operations.



4. Connect more OctWires of sufficiently long lengths from the above starting markers to other nearest markers, and so on until all markers are connected. Make absolutely certain that there will be some slack on each wire during the capture operations.
5. Connect an OctRx marker synchronizer to the OctBatt and attach it right beside the battery pack.
6. Turn on the power switch on the battery pack.

2.6.2 Charging OctBatt Battery

When an OctBatt battery pack is depleted, simply plug the output connector of a 'VZChgr2C2' charger into its charge port for charging. Note that it is possible to continue operating an OctMarker system while charging the battery pack if desired.

Note 1: To fully charge an OctBatt, the power switch on it must be turned ON. (Charging with the switch off will result in the battery being only half charged at most.)
Note 2: Charge an OctBatt only with the PTI-supplied charger.
Note 3: A completely depleted OctBatt should take about two hours to charge to 95%.

2.7 MULTI-RATE SAMPLING

Multi-rate sampling means some markers are sampled at a different frequency than others. This can be used to capture motions of vastly different speeds simultaneously yet yield data with relatively similar spatial resolutions. Such function is particularly useful for advanced scientific R&D purposes.

All Visualeyez system markers can be multi-rate sampled. However, the standard markers controlled by TCM(s) allow such function to be carried out more easily than the self-identified markers.

To implement multi-rate sampling with a TCM, first select the desired multi-rate sampling option (see the relevant subsection under Target Sequence Editor) for that TCMID. This would cause that TCM to assign multiple LEDIDs to each physical LED marker connected to it. Then by manually arranging the MarkerIDs of the physical marker to be sampled at multiple frequency ('special MarkerIDs') over appropriate intervals, interlaced with the ordinary MarkerIDs, the special LED marker will be sampled multiple number of times per capture cycle. More details on this function can be found in the Target Sequence Editor section.

2.8 TETHERLESS CONTROL SYSTEM

Visualeyez system uses a radio-based tracker strober as data and control signal sender, radio-based marker synchronizer(s) as receiver(s), and battery set to eliminate tethers between the tracker(s) and the capture subject(s). To operate the system in tetherless mode, first connect a tracker strober to the CTRL-OUT jack on the master tracker's back panel. Then, if using standard wired markers, connect a marker synchronizer, one or more TCMs, and a battery, together with a supplied interconnection cable on the capture subject. If using SIKMarkers, simply plug a SITBatt battery into each SIKMarker and attach the assembly to the capture subject. If using semi-wireless OctMarkers, connect the marker branches and a marker synchronizer to the battery pack. Note that a marker synchronizer must be set to operate on exactly the same frequency as the tracker strober, in order for them to operate as a remote tetherless control set.

2.8.1 RECHARGEABLE BATTERY

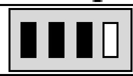
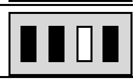
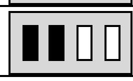
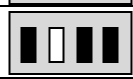
The standard battery supplied for tetherless motion capture operation is made with rechargeable lithium polymer battery cells. When the voltage of such a battery is too low for optimum operation, the indicator on a TCM32, TCM16, as well as on a SIKMarker will flash. When this occurs, disconnect/unplug the battery and recharge it with the supplied charger for about two hours to replenish the charge to about 95% full, or about three hours to full level.

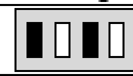
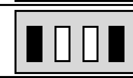
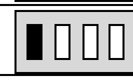
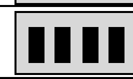
NOTE:
Although a standard PTI rechargeable battery for operating the TCM(s) is equipped with an internal protector to prevent it from overcharging or over- discharge, it is still recommended to disconnect a battery from a charger as soon as it is fully charged. It is further recommended to disconnect it from any electronics whenever it is not being used. Both overcharging or over-discharging can permanently damage the battery cells within a battery pack!

2.8.2 STROBER-SYNCHRONIZER SET

2.8.2.1 900MHz ISM Band Model

The 900MHz industrial-scientific-medical (ISM) radio band is allowed to be used in North America without a radio operator license if the tracker strober power is low enough. The strober-synchronizer set provided by PTI in this band can operate on one of eight possible frequencies. Unless there is solid evidence of radio interference degrading the system performance, there is no need to ever change the frequency. In case necessary, three jumpers (or mini switches) are available within the device case for changing it. Keeping the 'white-dot' (or label '1') beside the jumpers/switches on the right side, the jumpers/switches can be set to change the frequency as follows (a black rectangle represents a jumper/switch is in the 'ON' position):

Frequency	Jumper Settings	Binary Code
1 (906.37Mhz)		0001
2 (907.87Mhz)		0010
3 (909.37Mhz)		0011
4 (912.37Mhz)		0100

Frequency	Jumper Settings	Binary Code
5 (915.37Mhz)		0101
6 (919.87Mhz)		0110
7 (921.37Mhz)		0111
0 (903.37Mhz)		0000

Note: The above frequencies are also used by some cordless phones in North America. Please avoid using cordless phones nearby whenever tetherless-mode operation is desired.

2.8.2.2 868MHz Model

This model is normally recommended for use in Europe. It operates on one single frequency only - 868MHz and cannot be changed currently.

2.8.3 MAXIMIZING RADIO OPERATION DISTANCE

By regulation, most countries allow only a low-power radio strober to be used by a civilian without a radio operator’s license. Most PTI radio strobers are such low-power devices. As a result, they cannot send signals over very long distances. To maximize the operating distance under such limitation, it is recommended to:

1. Keep the antenna away from any highly electrically conductive objects (such as the tracker’s metal housing). If the strober must stay close to a metal surface, then at least keep the antenna perpendicular to it. For a strober with soft or long antenna, attach it to the bottom of the master tracker so that the antenna hangs straight down and perpendicular to the tracker’s metal housing.

2. Avoid pointing the strober antenna straight at any synchronizer. Always keep it as perpendicular from the directions to all the synchronizers as possible.

2.9 ACCESSORIES & OPTIONS

2.9.1 EOF OPTION FOR SYNCHRONIZATION

For many scientific and engineering applications it is necessary to collect other signals or data in synchronism with motion capture. To accomplish this, an End-Of-Frame (‘EOF’) signal pulse can be brought out of a TCM to trigger other equipment to sample the additional signals. This requires adding a second short cable terminated with a female BNC connector to the TCM, which a TCM16 is particularly suitable for carrying. The EOF pulse occurs immediately after the last marker of the target flashing sequence is sampled by the Visualeyez tracker(s). The electronic specifications of this pulse can be found in the SPECIFICATIONS section.

2.9.2 VZPROBE

This is a rigid sword-like mechanical device with at least 3 LEDs mounted in a triangular pattern. After properly calibrating the device relative to its tip, the VZProbe function within VZSoft can deduce the 3D position of the tip of the device by capturing the positions of the three LEDs. Thus, as long as the three LEDs are visible to the capture unit(s), a VZProbe can be used to digitize any point by simply touching its tip at that point, even when the point itself is occluded from the capture unit(s)! Furthermore, since the device tip location is not dependent on the positions of the three LEDs, user can outfit the VZProbe with a tip of their own design for digitizing any special point(s) they desire. For example, by outfitting it with a hook-like tip, a VZProbe can even digitize the bottom of an object where it is not directly visible to any tracker at all.

Typical applications of a VZProbe include establishing the coordinate reference frame (CRF) for a motion capture session, digitizing the shapes and sizes of large and/or complex objects, and establishing reference landmarks on a patient before a medical operation or motion analysis.

NOTE: A VZProbe has been combined with a system calibration wand (for older system applications) so that a single device can serve both functions and is referred to as a ‘VZWProbe’. As a result, a VZWProbe consists of four LEDs, but only the top three LEDs should be used for the VZProbe function.

At the time of this writing, the VZProbe application software function is placed under the Settings / User Options / Coordinate Reference Frame / Define Coordinate Reference Frame subpanel of the VZSoft GUI. To use a VZProbe, do the following:

1. Treat the LEDs on a VZWProbe as standard LED markers, set up a TCM with a battery pack and a marker synchronizer for tetherless operation, or a TCM with a power-and-

control cable and a TCM power adaptor for tethered operation (see the TRYING IT OUT section).

2. Connect the LEDs to the TCM and turn on the TCM.
3. Enable the top three LEDs of the VZWProbe in VZSoft.
4. Go to the Define Coordinate Reference Frame subpanel and press the ‘With VZProbe’ button.
5. Click the Modify or Continue button as appropriate on the Safety Confirmation panel when it appears, to set the Sampling Period and Sequence Intermission Period to appropriate values for operation (if the Dominate checkbox on the Frame Rate subpanel of VZSoft is not checked). VZSoft will also start to capture automatically, and two of the VZWProbe LEDs should come on.
6. When the VZProbe window appears, follow the instructions to make it start running.
7. Go to VZProbe / Calibration and press Start.
8. Point the tip of the VZWProbe at a small dent on a stationary rigid body (e.g., the floor).
9. Wiggle the handle of the VZWProbe in any way you like while keeping the probe tip fixed in the dent (so that the LEDs move around the surfaces of hemispheres all centered at the probe tip). While wiggling, press the pushbutton switch on the VZWProbe and you should hear some beeping as the probe is being calibrated.
10. After about one minute, press Stop on the VZProbe / Calibration menu to finish the calibration.
11. Go to VZProbe / Operation and press Start to begin using the calibrated VZProbe.
12. To digitize the position of a point, simply point the VZWProbe tip at that point and press the push button switch. You should hear a beep when the tip point is digitized.

NOTES:

1. The VZProbe software function is normally meant for defining a coordinate reference frame (‘CRF’) for a capture session.
2. To use the calibrated VZWProbe to define a CRF, press the ‘Proceed...’ button on the Settings / User Options / Coordinate Reference Frame panel in VZSoft now.
3. To use a VZWProbe for digitizing points for any other purpose, you need to have the VZAnalyzer software in order to view the digitized points. For more information on the VZAnalyzer, please contact PTI.

2.9.3 HAND TRIGGER

This is a small 9V battery operated device with a push-button switch for generating one long and one short electronic pulses and one optical pulse meeting specifications of the Visualeyez systems. The short electronic pulse is for initiating the capture process via an 'Ext Start Input' coupler when the system is placed in the STANDBY operation mode. The long electronic pulse is for starting the capture process via a host computer’s COM port when the system is in the COM Start operation mode. The optical pulse is a flash of the green LED indicator on the device. It is for synchronization of the motion capture operation with that of a video camera or other equipment, as frequently required in movie production and/or motion research.

2.9.4 LED RISER

This is a small wedge made of a piece of plastic foam with Velcro surfaces. It is for placing between a LED marker and the capture subject to help direct the LED light more towards the tracker(s) for sensing and thus improve the capture data quality. The device has a nominal wedge angle of about 22.5 degrees. Two can be stacked up to create a 45-degree device. Note that the user can easily make such devices to help improve the motion capture data quality by themselves too.

III. HARDWARE INSTALLATION

This chapter describes how to setup a Visualeyez system for motion capture. It will also show how to pack and unpack a tracking unit into a tripod for storage and/or transportation.

PLEASE READ AND USE THE QUICK START GUIDE FIRST TO FAMILIARIZE YOURSELF WITH BASIC SYSTEM OPERATION.

CAUTION: NEVER USE parts (cables, connectors, adaptors, etc.) not-supplied or not-certified by Phoenix Technologies Inc. with the tracking system. USE OF SUCH PARTS MAY PERMANENTLY DAMAGE THE SYSTEM and void the warranty.

3.1 SINGLE-TRACKER SYSTEM CONNECTION

1. Insert the supplied serial communications card into an empty PCIe slot in the host computer and install a proper software driver for it by following the instructions that come with it.

2. Install the VZSoft GUI in the host computer according to the instructions provided. Then install the dongle driver, before you plug it into your computer.

3. Take the tracking unit out of the tripod (see Packing & Unpacking the Tracking Unit section), mount it on the tripod vertically or horizontally as desired, set it up on a firm flat surface and securely lock the legs.

4. Connect the data communications cable from the male DB9 connector on the tracker, **over the tripod platform (to minimize stress on the connector; see image below)**, to one of the COM ports installed in step 1. Note: The data cable is directional. Make sure it is connected correctly according to the labels on its two ends.

5. Connect the tracker power adaptor to the tracker, hang the cable over the tripod platform, and plug the adaptor power cord into an AC outlet meeting the adaptor specifications (see Specifications). Turn on the tracker.

6. For tetherless operation, first connect an appropriate tracker strober to the CTRL-OUT jack on the tracker. Then either connect a standard wired marker system, or a wireless marker system, or a semi- wireless marker system on each capture subject.

7. For tethered operation, connect the 'TCM power & control cable' from the CTRL-OUT

jack on the tracker, over the tripod platform, to the interconnection cable connecting the TCM(s). Note that either a battery or a TCM power adaptor can be used to power the TCM(s) (via the cable).

8. Turn on all power(s). All LEDs should flash for two seconds starting from the 3rd second.

9. Locate VZSoft (usually installed in a “Phoenix Technologies” folder in your “Program Files” folder on C drive) to start VZSoft and operate the Visualeyez system.

Hang cables over the tripod platform

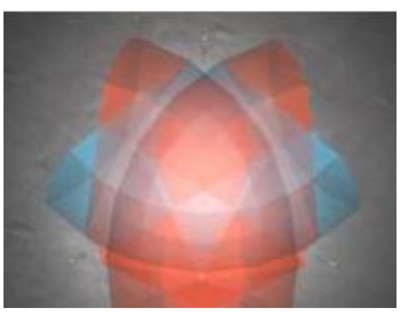
3.2 MULTI-TRACKER SYSTEM CONNECTION

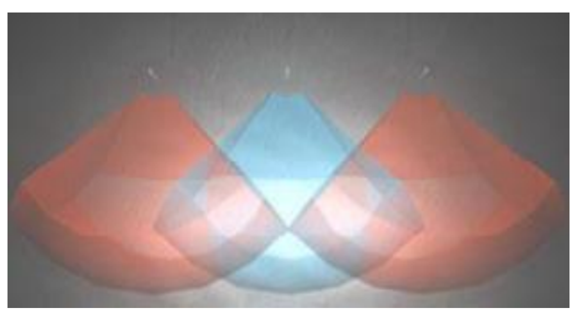
A multi-tracker system requires VZAutoCal software to operate. This software comes with VZSoft and is installed in the same computer as the VZSoft GUI.

A multi-tracker system must contain a 'master tracker'. Any tracker can be designated the master. The other trackers are designated 'slave' trackers. The captured target positions are referenced to the master tracker. The trackers communicate with each other through their external trigger (EXT-TRIG) jacks.

The physical arrangement between the multiple trackers ('configuration') should be carefully considered to achieve a good balance between data quality and capture space size, which oppose each other. A single tracker can capture the 3D position of a target from one view only. Multiple trackers can capture the same target from multiple views to reduce occlusion (hence improve data quality), but only if the target is within the overlapping portions of the multiple trackers' capture spaces. Therefore, in order to simultaneously capture targets around a subject with multiple trackers facing the subject, the trackers' capture spaces must overlap significantly.

To calibrate the configuration of a slave tracker relative to the master, the slave's capture space must also overlap with those of other slaves, in continuity, all the way back to the master. This means the capture spaces of every adjacent pair of trackers, slave or master, must overlap in order to calibrate the configuration of a multi-tracker system! The more overlap between adjacent tracker capture spaces, the more accurate the configuration calibration will be. It is recommended that adjacent tracker capture spaces overlap by at least one-third (1/3) to ensure high quality calibration and capture results. Two examples of overlap for a three tracker system are shown below.





Examples of capture space overlaps for a three-tracker system

To improve data quality, it is recommended that the trackers be raised relatively high and aim slightly down towards the middle of the capture subject. Such orientation of trackers will also reduce the amount of ambient lights shining into the tracker eyes from the ceiling lights above and enlarge the floor-level capture space of the system.

INSTALLATION PROCEDURES:
(Read the Quick Start Guide first for installation instructions)

1. Install as many supplied high-speed serial communications card(s) into appropriate empty I/O bus slot(s) in the host computer as necessary to support the number of trackers to be used, and install a driver software for each card following the card manufacturer's instructions.

2. Install the VZSoft GUI, with VZAutoCal (Automatic Calibration Software).

3. Take out and mount the trackers. Arrange them on firm flat surfaces as desired, and securely lock the legs.

4. Connect a data communication cable from each tracker, over its tripod platform (to minimize stress on the connector), to a data port just installed in the host computer. Note that this cable is directional. Ensure the two ends are connected according to their labels.

5. Connect a small male-male BNC cable to each tracker's multi-tracker chaining connector (EXT TRIG). Then connect a BNC leader cable to male-male BNC cable jack of each tracker.

6. Starting from the master tracker, connect the female end of a supplied BNC extension-type (i.e., one male end and one female end) trigger cable from the master's leader cable, over the tripod platform, and route the other (male) end close to the nearest slave tracker. Put a T-splitter on this end of the cable, and connect the other female end of the T-splitter to the slave leader cable.

7. Repeat step 6, until the last slave tracker is connected by a BNC extension cable.

8. Connect the supplied cable 'terminator' (labeled 'PTI CUSTOM') to the remaining male end of the T- splitter on the last slave tracker.

9. Connect a supplied tracker power adaptor to each tracker power jack, plug its power cord into an AC power outlet meeting the adaptor's specifications (see Specifications), and turn on the tracker.

10. For tetherless operation, first connect an appropriate tracker strober to the CTRL-OUT jack of the master tracker. Then either connect a standard wired marker system, or a wireless marker system, or a semi-wireless marker system on each capture subject.

11. To operate in tethered mode, connect the 'TCM power & control cable' from the CTRL-OUT jack of the master tracker, over the tripod platform, to the interconnection cable connecting the TCM(s) on a capture subject. Either a battery or a TCM power adaptor can be used to power the TCM(s) (via the cable).

12. Turn on all markers (for standard markers, turn on the TCM(s)). All LEDs should flash for two seconds starting from the 3rd second.

13. Operate the VZAutoCal and VZSoft according to their instructions.

3.3 PACKING & UNPACKING A TRACKING UNIT

The tracking unit should always be stored inside the tripod when not expected to be used for a long time. See below the procedures of packing the tracking unit inside the tripod. Reversing the procedures will unpack it from the tripod.

1. Holding the tracker with one hand, loosen the mounting screw (s) with the other and remove the unit from the tripod. Put the unit safely on the floor nearby.

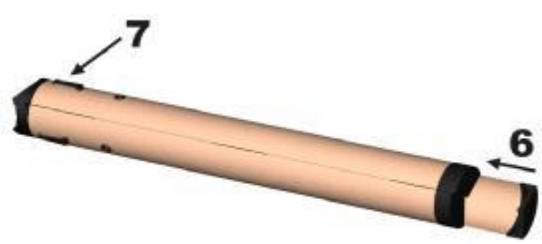
2. Bring the tripod legs together and lay the tripod on the floor. Unlatch all locks and fold the two lower legs close to each other while leaving the third leg still relatively open.

3. Carefully insert the tracker through the opening and all the way to the top, so that the top tracker end-cap contacts the top-insides of the legs.

4. Retract one of the lower two legs so that its foot button engages with a hole on the tracker end-cap. Rotate the tracker slightly to achieve this if necessary.

5. Close the top leg with the lower two, ensuring that the tongues and grooves along them are engaged properly.

6. Retract the remaining legs until the buttons on their feet mate with the remaining two holes on the plastic end-cap.



7. Latch all locks temporarily and stand the tripod upright.

8. Unlatch all locks again and let the tripod settle to the most- retracted length possible by its own weight. Wiggle the assembly a little if necessary.

9. Re-latch all locks securely to complete the packing process.

CAUTION:

Never place hands between two legs which are about to close!
The relatively heavy weight of the metal legs can cause potential injury to hands/fingers.

IV. VZSOFT GRAPHICAL USER INTERFACE

This chapter introduces VZSoft, a Windows based graphical user interface (GUI) for the Visualeyez system. Besides allowing users to completely control operations of the motion trackers, VZSoft also provides a few highly valuable 3D data editing functions for the system. Moreover, it can output the captured data to many popular animation and scientific software packages via plug-ins in real-time.

Fully understanding the VZSoft GUI functions is necessary for the optimal utilization of a Visualeyez system. The rest of this chapter is for enhancing this understanding. It consists of the following information to help the users achieve this goal:

- Host computer requirements
- VZSoft installation
- VZSoft GUI Components
- The Menu Bar
- The Target Sequence Editor
- The Target Association Editor
- The Motion Capture Display panel
- Plug-In Installation License Information Troubleshooting

4.1 HOST COMPUTER REQUIREMENTS

The minimum recommended host computer requirements for operating a Visualeyez system are as follows:

Components	Minimum Requirements	Comments
Operating system	Windows XP, 7,8,10	OpenGL driver Microsoft DirectX 9.0 Visual C++ 2010 Redistributable Microsoft .NET Framework 4 May be Required (Usually provided with VZSoft Installation CD)
CPU	Pentium III 500 or higher	
RAM	2 GB	~22 bytes per 3D marker data sample
Hard disk space	200 MB	
CD Drive		
Video Card	Open GL compatible	
Monitor Resolution	At least 1024x768	

Note: These are only the bare minimum specifications for running the software of a Visualeyez system. If any other application software must run on the same computer, the specifications must be increased according to the requirements of that other software.

4.2 VZSOFT INSTALLATION

4.2.1 NOTES BEFORE INSTALLATION

- Ensure all minimum host computer requirements are met to prevent computer malfunction.
- When installing VZSoft, do not copy the Setup program to a temporary directory.
- Activate the Setup program directly from the provided CD or USB thumb drive.

4.2.2 INSTALLING THE VZSOFT PROGRAM

The VZSoft setup program will guide you through the installation procedures. To invoke the setup program:

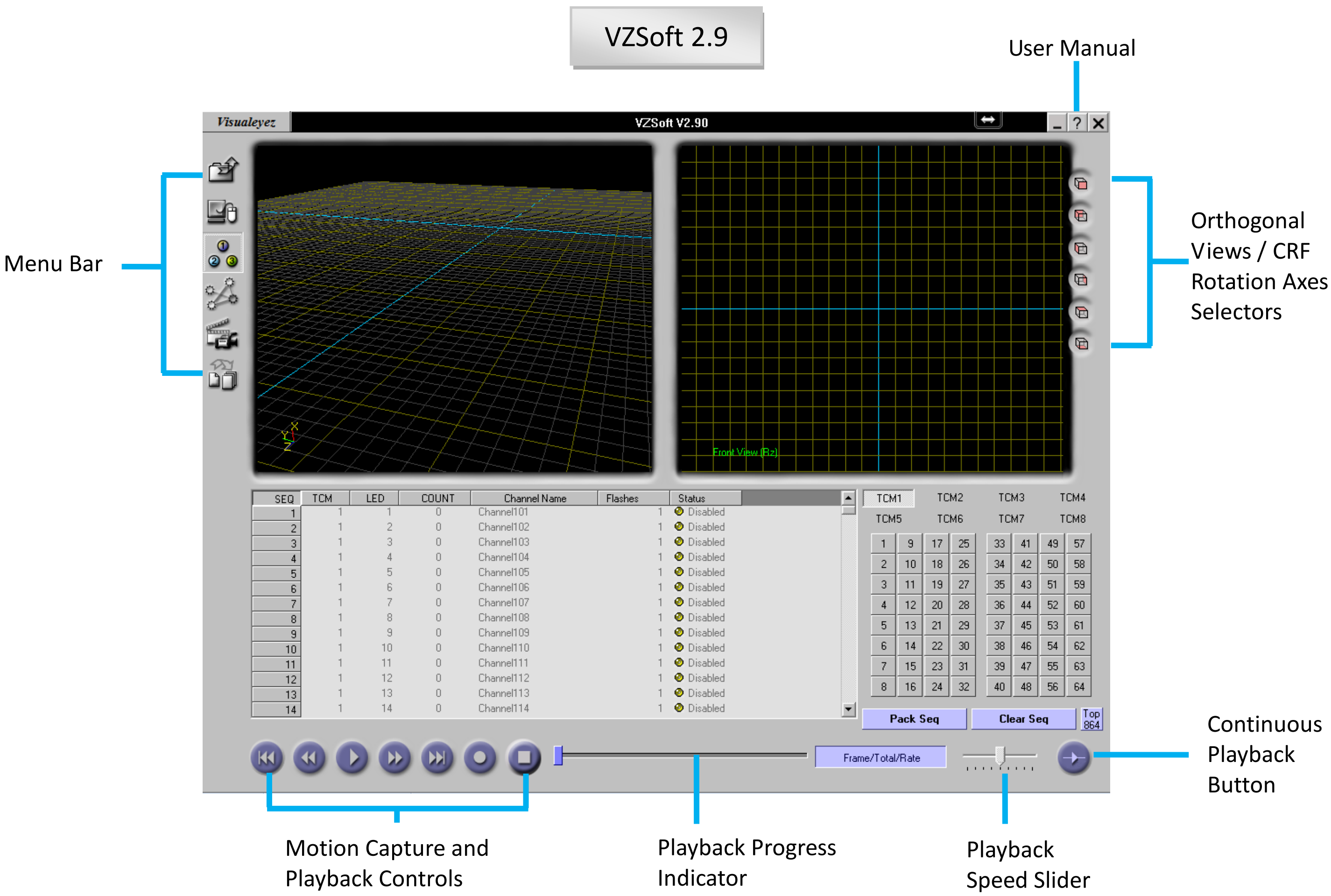
1. Insert the supplied CD into the CD-ROM Drive, or connect the provided USB thumb drive to your PC.
2. Find VZSoft.exe on the CD / USB thumb drive.
3. Double click to start the setup, and follow the installation instructions until successful completion.
4. If you have not installed the dongle driver yet, then install it now (the dongle driver installation file is on the CD / USB thumb drive).
5. You can start VZSoft from the installation file (Location:/Local Disk / Program Files / Phoenix Technologies).

Note:

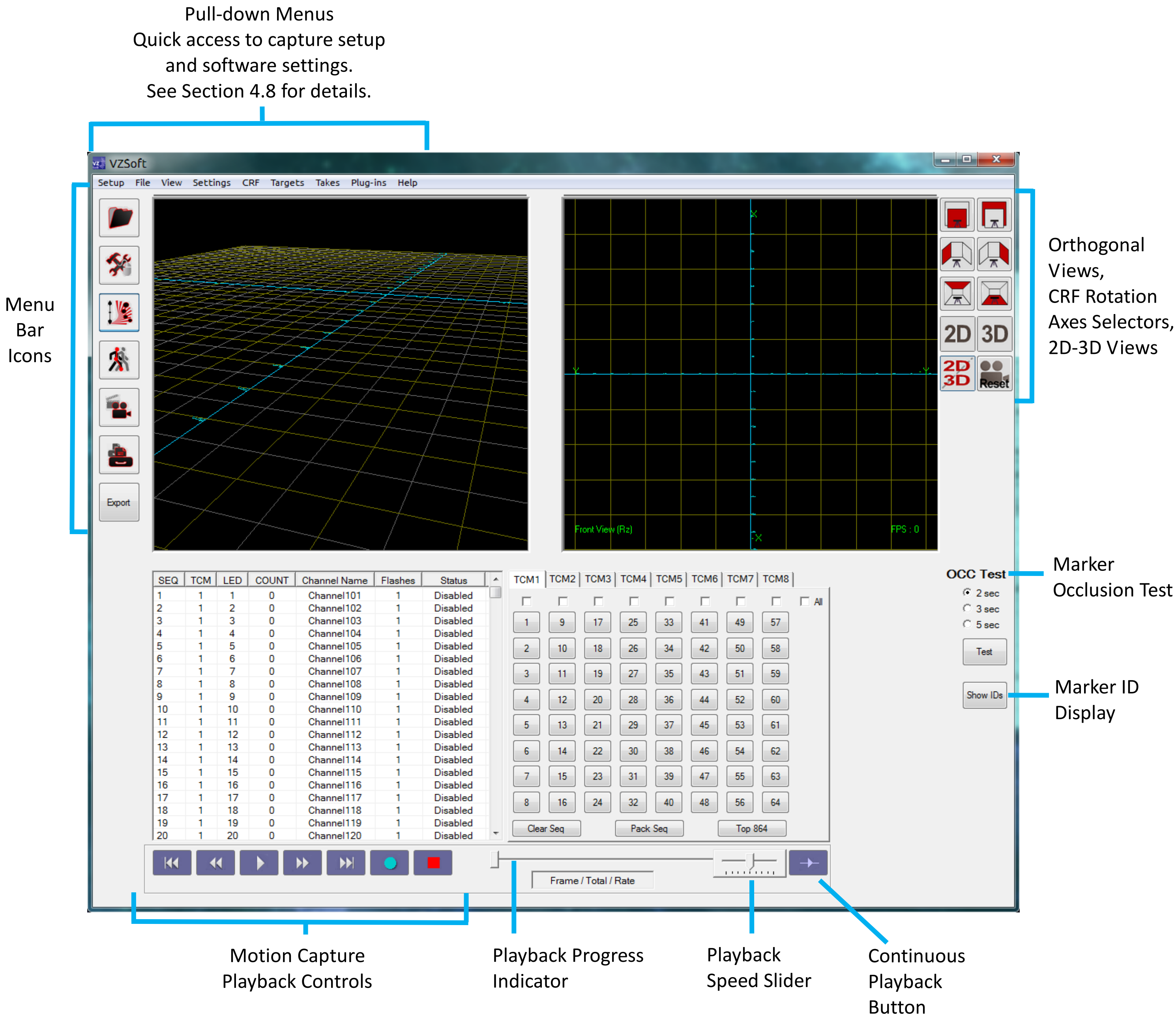
Read the **Quick Start Guide** first to learn how to detect your tracker(s)
and start a motion capture session.

4.3 VZSOFT USER INTERFACE WINDOW

The VZSoft window appears as shown below. This window provides a graphical environment for the user to set parameters and send control instructions to the master Visualeyez tracker, which in turn controls the TCM(s) and LED targets.



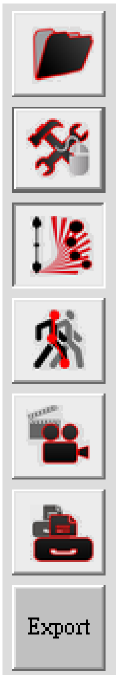
VZSoft 3.x



Pull-down Menus
Quick access to capture setup
and software settings.
See Section 4.8 for details.
VZSoft
Setup File View Settings CRF Targets Takes Plug-ins Help
Menu Bar Icons
Export
Front View (Rz)
FPS : 0
Orthogonal Views,
CRF Rotation
Axes Selectors,
2D-3D Views
2D
3D
Reset
SEQ TCM LED COUNT Channel Name Flashes Status
TCM1 TCM2 TCM3 TCM4 TCM5 TCM6 TCM7 TCM8
All
Clear Seq
Pack Seq
Top 864
OCC Test
2 sec
3 sec
5 sec
Test
Show IDs
Marker
Occlusion Test
Marker ID
Display
Frame / Total / Rate
Motion Capture
Playback Controls
Playback Progress
Indicator
Playback
Speed Slider
Continuous
Playback
Button

4.4 MENU BAR

The Menu Bar provides several option screens for the user to control the Visualeyez system and setup the VZSoft GUI. The buttons and their screen contents are described in this section.



FILE MENU

SYSTEM SETTINGS

TARGET SEQUENCE EDITOR

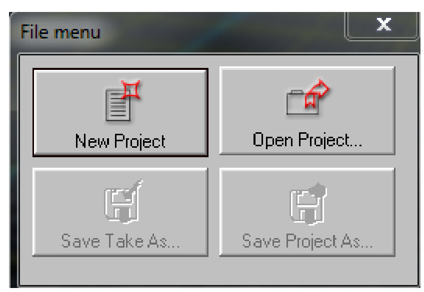
TARGET ASSOCIATION EDITOR

MOTION CAPTURE DISPLAY

ADD ONS

DATA EXPORT MENU

4.4.1 FILE MENU



New Project: Creates a new project environment (file) for containing the settings and data to be captured. The new project will start with the same settings as the previous project.

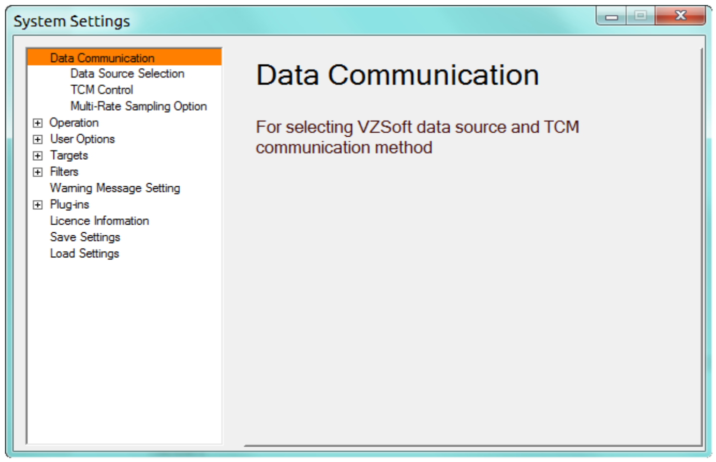
Open Project: Opens an existing project file for replay or further work.

Save Take As: Saves the data and settings of the take high-lighted in the MOTION CAPTURE DISPLAY screen to a file. In case the file already exists, the take is appended to it. If no take is selected, this option is not available (VZSoft 3.x).

Save Project As: Saves the current project contents including all takes and their settings to a specified file. In case the file already exists, the current project is appended to it.

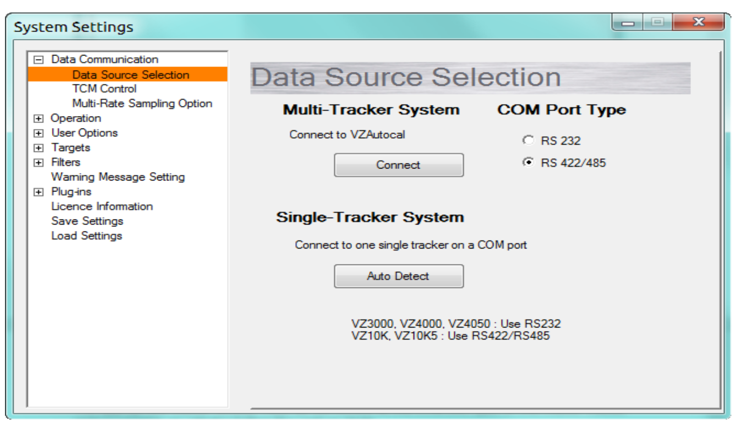
4.4.2 SYSTEM SETTINGS

The System Settings menu allows the user to control and customize the Visualeyez system operation for a motion capture session. The settings are divided into nine groups: Data Communication, Operation, User Options, Targets, Filters, Plug-ins, License (Dongle) Information, Save Settings and Load Settings.



4.4.2.1 DATA COMMUNICATION

a) Data Source Selection
This is for telling VZSoft whether a single-tracker or multi-tracker system has been installed.

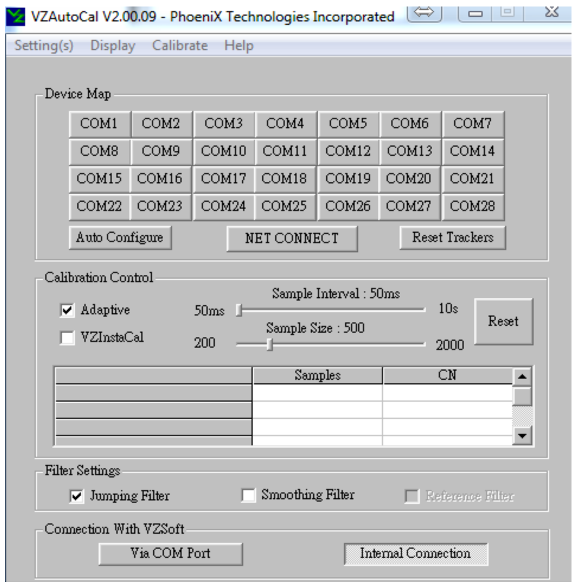


Multi-Tracker System:
Press the 'Connect' button to invoke the VZAutocal for a multi-tracker system and connect the VZSoft output to it. This will launch the VZAutocal software for multi-tracker system and detect the connected trackers automatically too.

Note that tracker detection is a slow process, so be patient. You can also press Auto Configure manually to start the detection process again too.

InVZAutocal **(see picture below)**, make sure that:

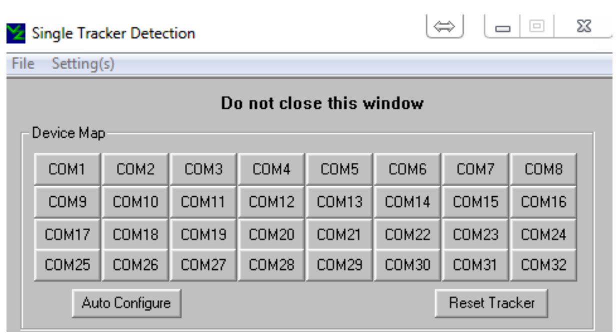
- ***Adaptive* option is on**
- ***Jumping filter* is on**
- ***Internal Connection* button is on**



Note: Do not close this window or your tracker will no longer be detected!

Single-Tracker System:
Press the 'Auto Detect' button to launch the VZAutocal for single-tracker system software, connect the VZSoft output to it, and automatically detect the COM port that the tracker is connected to.

Note: In case the tracker COM port is not detected automatically within approximately one minute, manually press the 'Auto Configure' button in VZAutocal to try to detect it again.

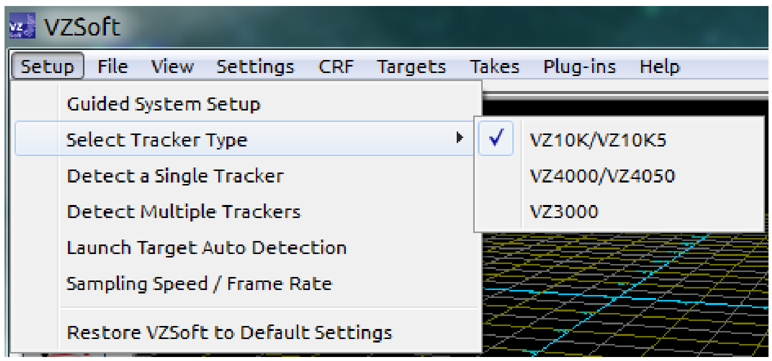


Note: Do not close this window or your tracker will no longer be detected!

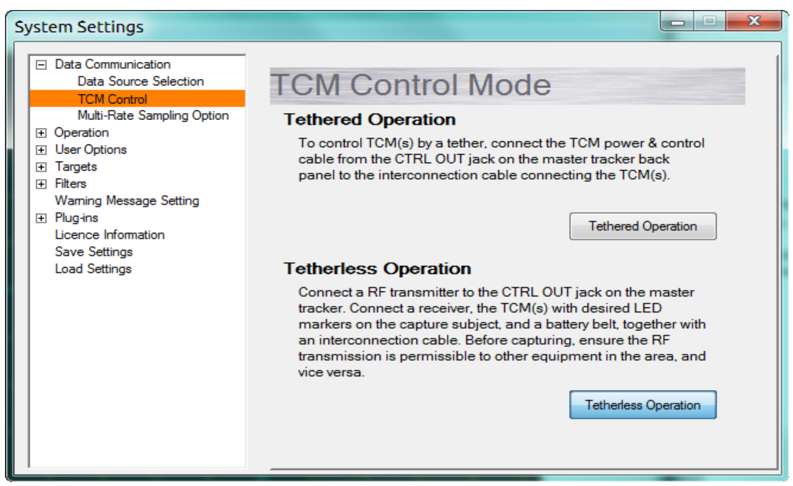
RS 232:
This option is for the older Visualeyez systems.

RS 422/485:
Select this option under COM Port Type whenever you use a VZ10K/VZ10K5 tracker(s).

Note: It is recommended to first verify that the correct tracker type has been selected under the Setup menu. This will cause the 'RS422/RS485' option to be checked automatically.



b) TCM Control Mode



Tethered Operation:
Select this mode when all TCMs are connected to the CTRL OUT jack of the master tracker via the TCM power & control cable. This makes the system operate more reliably.

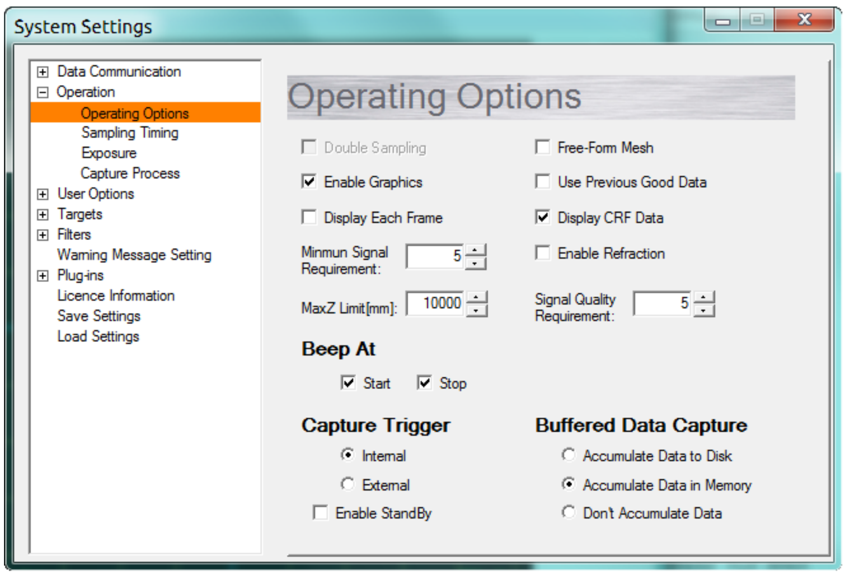
Tetherless Operation:
Select this mode when any TCM is to be controlled without a tether cable. The appropriate tracker strober must be connected to the CTRL OUT jack of the master tracker and powered by an adaptor before the capture starts.

NOTE: Tetherless control operation is accomplished by broadcasting radio frequency (RF) signals. Ensure the frequency (see Specifications) of your strober will not interfere with other surrounding equipment before activating this option.

4.4.2.2 OPERATION

a) Operating Options

Select the desired operating conditions to suit your application as follows:



a.1) Double Sampling: Leave this option checked for normal operation. When checked, two captures are actually performed by the tracker for each target sampling. One capture is done when the target LED is off, and one when it is on. Then the off-signal (the ambient light) is subtracted from the on-signal, and the result used to compute the 3D target coordinates. Thus it removes ambient light noises from the tracked target signals, making the computed coordinates more accurate and less-sensitive to ambient lighting condition. Single sampling does not perform the noise cancelling procedure. This permits capturing of a single continuously lit target for special applications.

Note: Single-sampling operation is quite sensitive to ambient lights. However, the system can operate at a faster rate.

a.2) Enable Graphics: Check this box to make VZSoft display the captured data in the two graphic windows. Deselect this option to save computing power for other functions when data display is unnecessary.

a.3) Display Each Frame: Check this box if you want VZSoft to replay each and every frame of captured data. The replayed motion may become jittery and/or slower than expected for slow computers. This setting is ignored during motion capture.

a.4) Free-Form Mesh: This setting is for 3D digitization of an object with a VZLaser which is an optional accessory. As the laser spot position is being captured, VZSoft will display the latest 50,000 good data points. When more than 50,000 good points have been displayed, VZSoft will also display every tenth of the 500,000 good points collected before the latest 50,000. Thus VZSoft will display at most 100,000 good data points only. All other data points are still saved and will all be displayed when digitization is stopped. Then the data file can be exported to a mesh-generation application for modeling and/or reverse-engineering applications.

A Free-Form Mesh take can be appended to a previous take. Just highlight the previous take when starting a new digitization process and the newly digitized points will be appended to the highlighted existing take. The coordinate reference frame (CRF) can also be redefined between two digitization sessions. Hence one can digitize an object from one view, save the take, rotate the object, redefine the CRF, and digitize it again with the new points appended to the previous take. This can be repeated indefinitely, until an object is digitized from all possible views to form a complete 3D solid if desired.

The exact steps are as follows:

1) Define a CRF for the object based on three carefully selected reference points which will be fixed relative to the object throughout the entire digitization.
2) Digitize the object with a VZLaser or a VZProbe and save the results as a take.
3) Rotate/move the object, with the reference points, to a new view.
4) Redefine the CRF using the same reference points.
5) Highlight the take saved in (3).
6) Digitize the new portion of the object. The data will be appended to the previous take.
7) Repeat steps (3) to (6), until you have digitized the object as completely as desired.

a.5) Use Previous Good Data: This setting applies only to the data passed via the plug-ins to their corresponding application software. When the signal from a target is too weak to compute the target position reliably, the user has two choices on what values to pass to the application software. Selecting this option will cause the last good position data of the target to be sent and designated as ‘G’ood. Not selecting this option will cause the computed unreliable (but may still be correct) data to be sent and designated as ‘B’ad.

a.6) Display CRF Data: This box should always be checked to make VZSoft display the data passed to the application software via the plug-ins. The unchecked option is reserved for future use.

a.7) Minimum Signal Requirement (MSR): This specifies the minimum total (ambient + target) signal that the tracker must detect before the signal is used to compute the 3D target position. This allows the user to control the reliability of the captured data.

a.8) Max Z Limit: This specifies the maximum possible z-value (distance away from the tracker) of a target position. VZSoft will declare a computed target position to be ‘B’ad if the z-value is larger than this limit. This can be used as a simple threshold detector to benefit some applications. (Note: the Z-Limit unit is always in millimeters.)

a.9) Signal Quality Requirement (SQR): This specifies the minimum signal-to-noise difference that the tracker will check, after computing a target position, before declaring that position to be either ‘G’ood or ‘L’ow in quality (see “Data Status”).

A detected target signal for which no target position is computed due to other problem(s) is declared as ‘B’ad.

a.10) Capture Trigger Source: A capture can be carried out in several ways:

1) Internal: The tracker will generate the trigger signals required to initiate the sampling process by itself. This is the default capture method.

2) External: This mode is reserved for multi-tracker system operation and for PTI’s internal development purposes only. Each sampling process is triggered by a properly timed and conditioned pulse applied through the Ext Trig Jack.

3) Enable Standby: This mode allows the capture operation to be started remotely either manually by the user or by external equipment. When the Record button is pressed in VZSoft, the tracker will wait for a single electronically clean pulse (see Specifications section) to be applied via the ‘Ext Start In- put’ adaptor to the Ext Trig Jack before proceeding with the specified capture operation. Once the tracker receives this external-start pulse, the capture operation commences as if the operation had been started by pushing the Record button in a normal operation.

CAUTION: PERMANENT DAMAGE RISK!

The electronic requirements on the signal that can be applied to the Ext Trig Jack are highly stringent. Please see Specifications for details. **Please contact PTI before applying any non-PTI-supplied device output signals to the Ext Trig Jack!** (See COM Start for alternative much safer external-start solution.)

a.11) Buffered Data Capture: These three options allow you to specify how you want VZSoft to save the data during a capture.

1) Accumulate Data to Disk: Check this option to make VZSoft store data immediately into the hard-disk during motion capture. This safe-guards the data against possible computer malfunctions. Depending on the type of hard-disk drive you use, it may or may not slow- down the VZSoft operation. This option is most suit-able for lengthy captures.

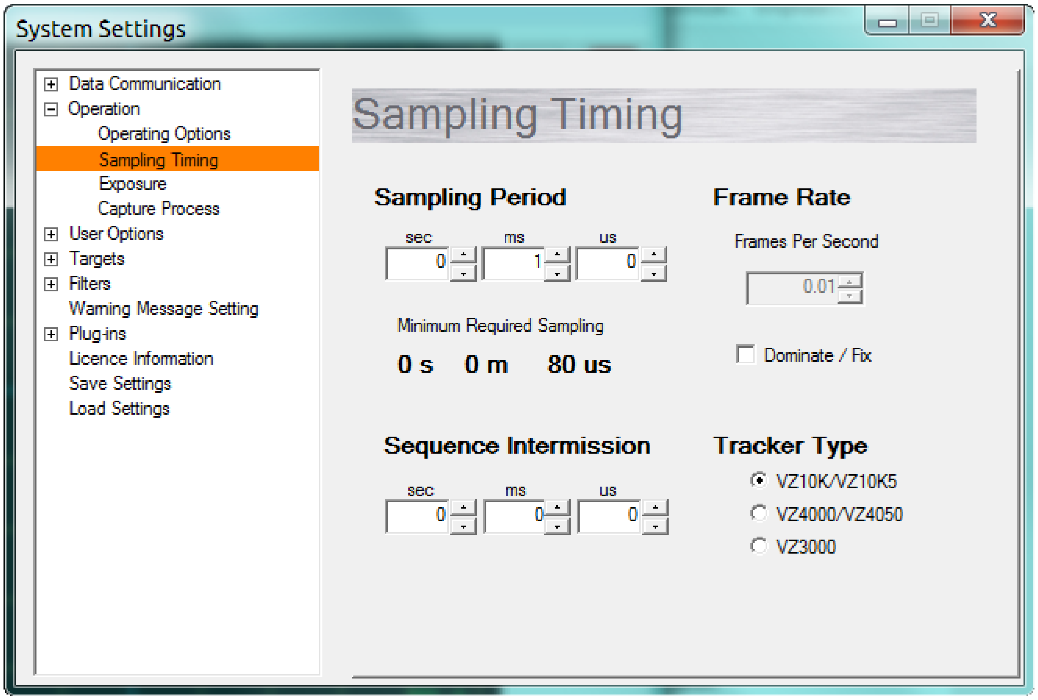
2) Accumulate Data in Memory: Saves the data in RAM during motion capture until either the capture is stopped or the RAM is filled, then transfers the accumulated data to the hard-disk automatically.

3) Don’t Accumulate Data: When checked, VZSoft will not save any data. However, it will still display them and pass them via plugin(s) to other software application (s). This is most useful when testing the system, rehearsing before a motion capture session, or when the other application(s) have good facilities for saving the data directly.

NOTE: To record captured data, either the ‘Accumulate Data in Memory’ or ‘Accumulate Data to Disk’ box must be selected before starting the capture.

b) Sampling Timing

Use this panel to set the desired target sampling period and the capture frame rate as follows:



b.1) Sampling Period: Sampling Period is the time from sampling one marker to sampling the next marker in the 'target flashing sequence' (see Target Sequence Editor).

Since a Visualeyez system samples the markers one at a time, the inverse of Sampling Period (i.e., 1/(Sampling Period)) is the maximum possible number of marker positions that can be sampled in one second.

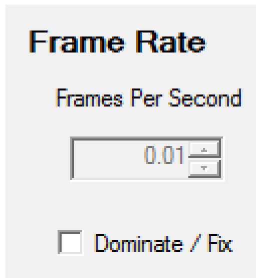
The exact number of times per second a particular marker is sampled depends on the number of LEDIDs assigned to that marker and enabled by the user in the target flashing sequence (see TARGET CONTROL MODULE and 8-CHANNELTCM sections). When this period is below the Minimum Required Sampling Period, the minimum required value will turn red to indicate the violation for proper operation.

CAUTION: PERMANENT DAMAGE RISK! Sampling an LEDmarker too many times per second can permanently damage the LED! To avoid this, check the Approximate Frame Rate Chart in Appendix E.

b.2) Minimum Required Sampling Period: This is the shortest sampling period you can set for proper tracker operation. It is a function of the tracker type being used, the Double Sampling option setting in the Operating Options panel, and the Maximum Extended Exposure (or Extended-Exposure, whichever is on if any) setting in the Exposure panel.

b.3) Frame Rate: A 'data frame' (interchangeably 'motion frame', 'capture frame', or 'capture cycle') consists of one position data from each and every marker in the target flashing sequence. Frame rate is the number of data frames captured per second by the system.

1) Frames Per Second: This space is for entering the desired capture frame rate. It works in conjunction with the Dominate checkbox. Note that many decimal digits are allowed. These digits must be cleared to properly change the desired value.



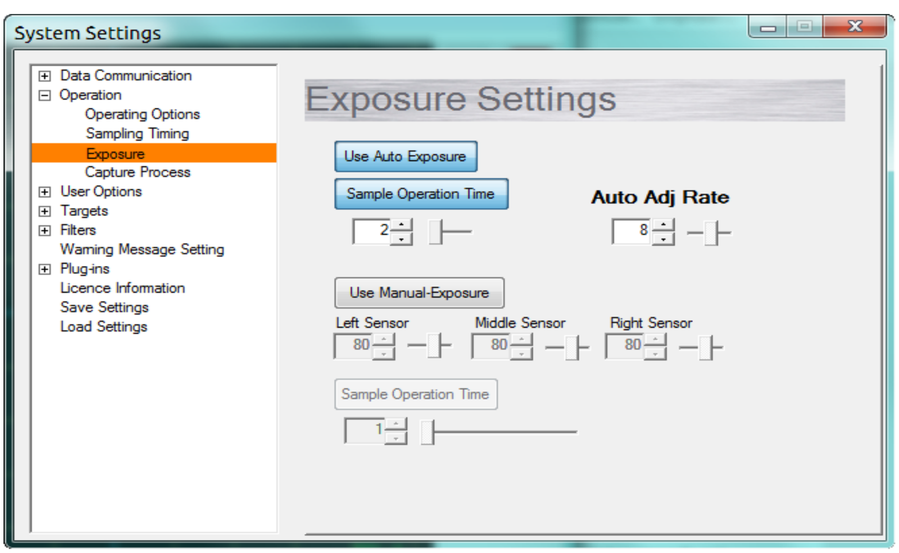
2. Dominate: When this box is checked, VZSoft will change the Sequence Intermission Period (SIP) in order to capture the markers at the frame rate in the Frames Per Second box. The SIP is calculated based on the Sampling Period, the Tracker Type, the Exposure Settings and whether Double Sampling is selected or not. If the desired frame rate cannot be reached by the hardware, a warning message will pop up and the Dominate selection will be released.

b.4) Sequence Intermission Period (SIP): SIP is the idle time between two capture frames. Zero SIP means the markers in the user-specified target flashing sequence will be repeatedly sampled without any break between two capture frames (cycles).

b.5) Tracker Type: Different tracker models operate with at least different speeds. Select which model of tracker(s) is in use to ensure the SIP will be computed correctly to reach the desired capture frame rate when Dominate is selected.

c) Exposure Settings

These adjust the length of time the tracker sensors are exposed to the target light when sampling. To ensure high accuracy in the captured target position, exposure period must be just the right length. Too long will saturate the sensors, too short will yield overly-low signal levels which will result in lower position accuracy.



A Visualeyez tracker employs two settings to expose its sensors to the marker light. The 'Sample Operation Time' (SOT) sets the maximum amount of time each sensor is allowed to be exposed to the light of a marker, within which the actual exposure duration is automatically adjusted to optimize the captured signal quality if the 'Use Auto Exposure' option is on. Hence the maximum possible sampling frequency of the system will decrease if the SOT is increased.

Since the sensed signal level is also dependent on the incident marker light intensity, which is marker orientation dependent and not normally under user control, exposure is not an easy parameter to set manually. Hence Use Auto Exposure is always turned on by default. The SOT is set to 2 by default. These can be changed by the user if desired.

Below are some general guidelines for determining the best exposure settings.

c.1) Use Auto-Exposure: This option should be selected whenever the light intensity of any target is expected to change over a wide range, or be significantly different from those of the others, even if only temporarily. For example, if a target may turn away from the tracker during capture, whether its position changed or not, its intensity as seen by the tracker will change from full to zero. Therefore, this automatic exposure option should be applied.

An advanced feedback control algorithm will track the light intensity variation of each and every target precisely, and adjust their exposure durations appropriately so that the best signal qualities are obtained for computing the target coordinates.

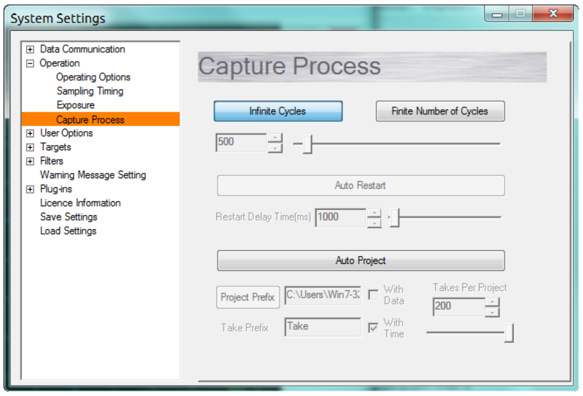
c.2) Sample Operation Time (SOT):
The default value of 2 here is sufficient for ensuring high quality data will be obtained for most PTI-supplied markers within the standard capture range and in ordinary indoor fluorescent lighting conditions.

To ensure high data quality at longer capture range, the SOT value can be increased such that (SOT+1) is roughly proportional to the square of the increased range. Note that this will change the maximum possible marker sampling frequency inversely proportionally.

c.3) Use Manual Exposure: This option is mainly for scientific applications. Select it and set the exposure values manually to eliminate exposure variations and the related possible small electronic noise. This will improve repeatability of the system. However, the combination of three exposure values required for the three eyes of a tracker to sense properly simultaneously (in order to capture the 3D coordinates of a marker) are not easy to set. Hence it is recommended that this option be used only under 'controlled' scientific environments with DC-powered lighting.

When attempting to use this option, keep in mind that the light intensity sensed by each eye is dependent on three factors:
1) the distance to the marker;
2) the marker pointing direction relative to each tracker sensing eye (sensor);
3) angular position of the marker relative to each tracker eye.

d) Capture Process



This panel allows the user to set an automatic stop then possibly a restart and the number of times to repeat this pattern on a capture process.

d.1) Infinite Cycles: Selecting this option alone will result in continuous capture until the user manually stops it by pressing the Stop button (see Motion Capture and Play Control section).

d.2) Finite Number of Cycles: When this option is selected alone, the user can set the number of capture cycles after which the capture process will stop automatically.

d.3) Auto Restart: This option is permitted only if Finite Number of Cycles is chosen. It is also normally selected together with 'Auto Project' (see next section). Selecting this option without selecting Auto Project will cause the capture process to stop after the specified number of capture cycles and prompt the user to enter a take name for saving the captured data. After saving the data, the capture will restart automatically after waiting through the specified Restart Delay Time. The process will repeat until manually stopped by pressing the Stop button.

d.4) Auto Project: Selecting this option together with Finite Number of Cycles and Auto Restart will cause the capture process to stop after the specified number of capture cycles, save the data under a numbered take-name prefixed with Take Prefix, wait for the Restart Delay Time, then restart. The number in the take-name is incremented each time the capture process is repeated.

When the number of takes specified in Takes Per Project have been captured, they are saved together as one single project under a numbered project file name prefixed with that directory information specified in Project Prefix. Then the capture process is repeated. The number in the project file name is incremented each time a project is saved.

To stop an Auto Project operation, manually press the Stop button while motion capture is taking place. Note that pressing the Stop button while the system is saving data or waiting through the Restart Delay Time will not cause the operation to stop!

d.5) Auto Project with COM Start / Stop: The Auto Project operation can be synchronized with external start/stop signal(s) applied according to the COM Start function (see COM Start section).

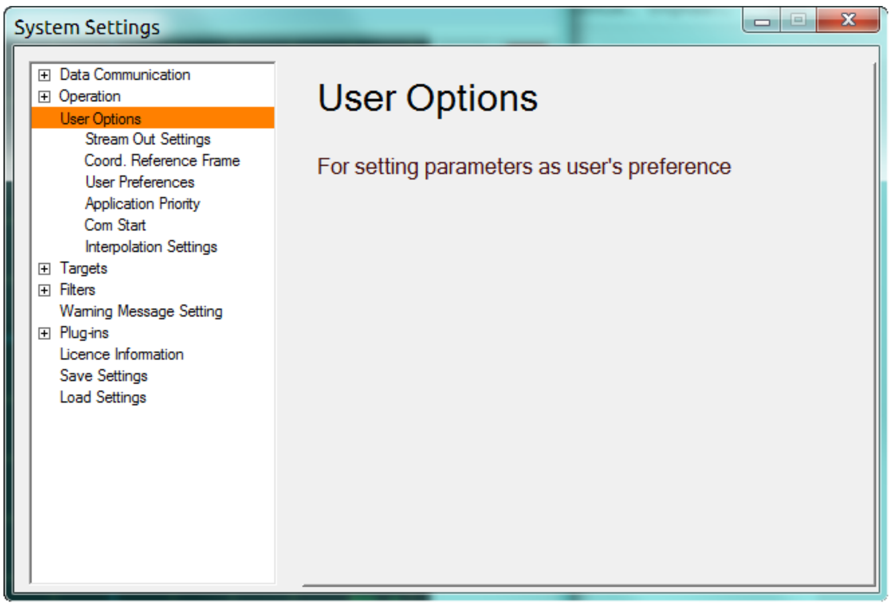
To activate this operation, select Infinite Cycles and Auto Project, then go to the COM Start/Regen panel and select Enable COM Start Mode. Select a Start Mode signal that can start then stop the capture process. Repeatedly apply this signal to the selected COM port and the capture process will repeat for each take. To stop the operation, simply stop applying the external start/stop signal(s).

d.6) **With Date:** When selected, the current computer (calendar) date will be appended to the end of the saved project file name when a project data file is saved.

d.7) **With Time:** When selected, the current computer time will be appended to the end of the take name when a take is saved.

NOTE: Some time is required for VZSoft to prepare the hardware for the next take. This time depends on the computer power and the CPU load. We recommend setting the Restart Delay Time at three seconds or longer for the preparation.

4.4.2.3 User Options



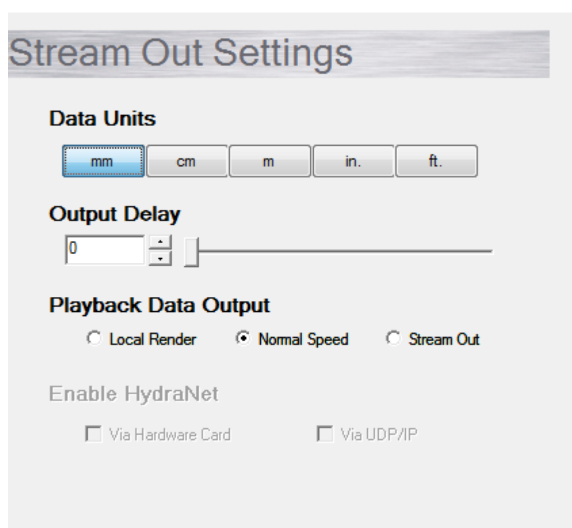
a) Stream Out Settings

a.1) Data Units

Select the desired measurement unit in which to store and export the marker X, Y, Z coordinates.

a.2) Output Delay Time

For some applications it is desirable to delay the output data by a known fixed amount during real-time streaming. Up to 2000ms (2 seconds) in 50ms increments of such delay can be implemented by simply entering the amount here. Note that the motions displayed on the VZSoft windows are not affected.



a.3) Playback Data Output Priority

When playing back a previously captured take, VZSoft will attempt to maintain the playback speed based on the data timestamp values at all times. However, some computers lack the power required to display the data, stream out the data values still maintain the proper playback timing. Therefore, it is necessary to prioritize the playback functions.

1) Local Render:

VZSoft gives priority to the display of the data frame in both the perspective and orthogonal view windows. When the computer is unable to keep up with a timestamp value, it will ignore the timestamp and continue with the task of delivering every data frame. In this case, the plug-in(s) and the VZSoft display will receive the data frames at a slower pace than originally captured.

2) Normal Speed:

VZSoft gives priority to the timing of the data playback. When the computer is unable to keep up with a timestamp value, it will skip both the data output and display, until it has time to carry out both tasks again. In this case, the plug-in(s) and the VZSoft display will receive the data frames at the same pace as originally captured. However some data frames may be skipped.

3) Stream Out:

VZSoft gives priority to streaming the captured data out to another application. When the computer is un- able to keep up with a timestamp value, it will stop displaying the data in VZSoft to gain more CPU time for outputting the data to the plug-in(s). If the computer is still unable to output data to the plug-in(s) it will slow the playback down. With this setting no data output will be skipped.

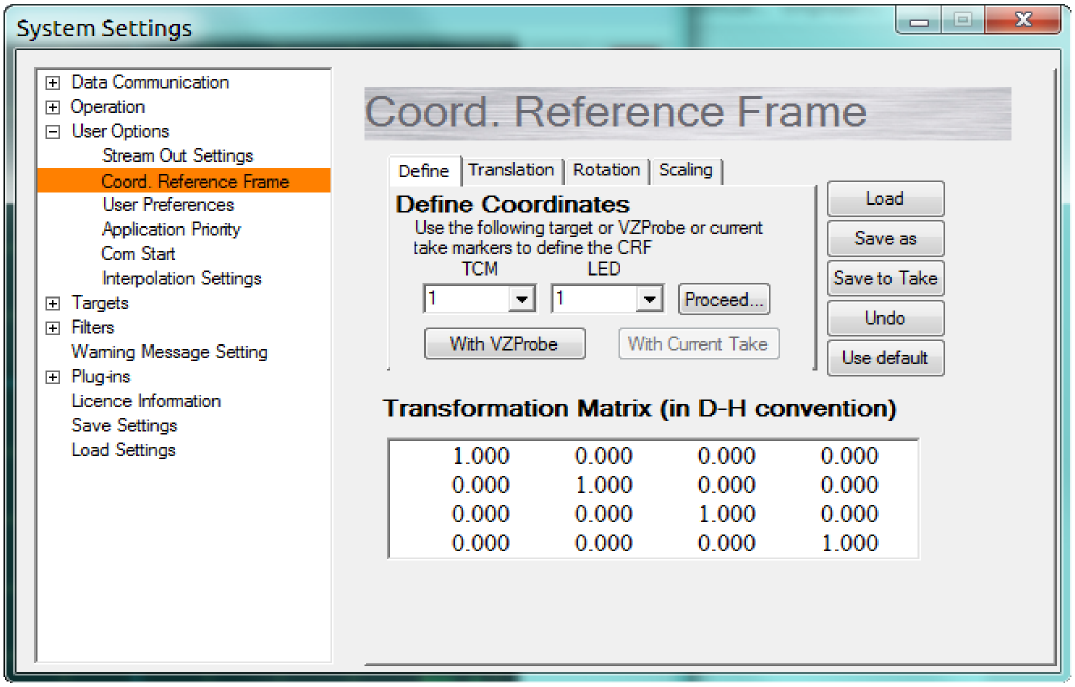
NOTE: The data output operation during a real-time capture is not affected by the setting in this panel.

a.4) Enable HydraNet (also called VZServer)

HydraNet is a function that allows motion data captured by a Visualeyez system to be streamed out via network cables and switches (or hubs) to other computer(s) for parallel applications. It also allows data captured by multiple Visualeyez motion capture systems to be merged for composition or virtual interaction applications. For more information, please see Appendix R.

For VZ10K/VZ10K5 trackers, Hydranet is directly implemented via the VZServer function available from the Plug-ins menu.

b) Coordinate Reference Frame



By default, the origin of the data coordinates generated by a Visualeyez system is at the center of the middle sensing eye of the master tracker, with the distance from the master tracker being the z-axis and the line along the tracker length being the y-axis. For most applications, it is desirable to re-define this coordinate reference frame (CRF) based on some physical landmarks in the capture environment instead.

VZSoft provides five different methods for re-defining the captured data CRF. Each method is beneficial for different applications. Those methods involving the use of LED(s), VZProbe or VZLaser allow the user to define the origin and the xy-plane of the CRF only. However, after the definition, the user can simply flip the defined plane in 90 degree increments around any axis by pressing the ‘X’, ‘Y’ or ‘Z’ buttons on the Rotation sub-panel to obtain the final desired CRF.

After re-definition, the new CRF can be saved for reloading next time. Should a mistake be made during the re-definition, pressing ‘Undo’ will cause the initial CRF to be reloaded.

To re-define the CRF, start by selecting the Define tab, the following details how to apply the five methods to re-define the CRF for the captured data.

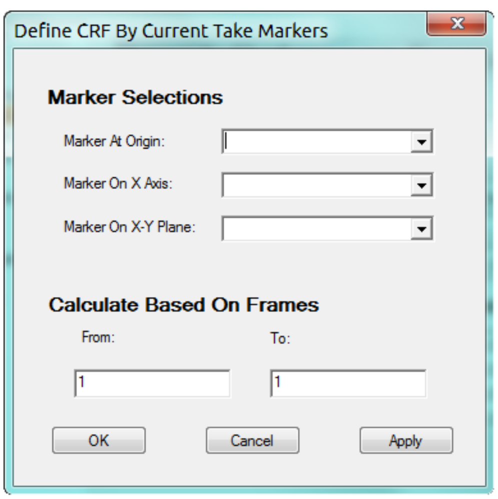
b.1) Use a single target:
This is a quick method. Specify an LED target to be used as the indicator by its TCMID and LEDID, press “Proceed” and follow the instructions to:

Step 1. Indicate the desired new origin location.
Step 2. Indicate a point along the desired +x-axis (should be >50cm away from the origin).
Step 3. Indicate a point on the desired new

+xy- plane (should be >50cm away from both preceding points).

b.2) Use three targets: This method can be highly precise as it uses multiple sets of data to define the CRF. To start, first capture a take with at least three targets: one at the desired CRF origin, one at a point along the +x-axis, and a third one at a point on the +xy-plane. Keep them widely apart for higher accuracy.

Select the Motion Capture Display menu. Use File Menu/Open Project to load in the just captured take (if not already shown in the Take List). **Highlight the take by clicking it**. Then press the 'With Current Take' button on the Coord Reference Frame panel to bring up the following 'Define CRF By Current Take Markers' screen.



Fill in IDs of the markers used for defining the desired CRF. Specify the data frame range to be used for the CRF definition calculations, and press OK or Apply.

Note: if no take is selected in the Take List, the 'With Current Take' button will be greyed out.

b.3) Graphical manipulation: This quick rough method is good for presentation and computer graphics applications. Double right-click within one of the orthogonal graphic view windows to bring up the current system's CRF. Right-click and drag the CRF in the orthogonal-view window to translate it. (NOTE: If the red data dots do not move with the CRF, go to Operating Options screen and turn on the 'Display CRF Data' option.

To rotate the CRF about the axis indicated at the lower left corner of the orthogonal-view window (e.g. Front Z Rear Z Left Y Right Y Top X Bottom X '(Rz)' for rotation about z), hold down the Ctrl key, right-click and drag the mouse horizontally . To rotate the CRF about another axis, select the corresponding orthogonal view, and repeat the above procedures.

b.4) Use VZProbe: This method requires using an optional VZProbe or VZWProbe device. To proceed:

1) Connect the three (four for a VZWProbe) LED markers on the probe to any three connection pin- pairs of a TCM.

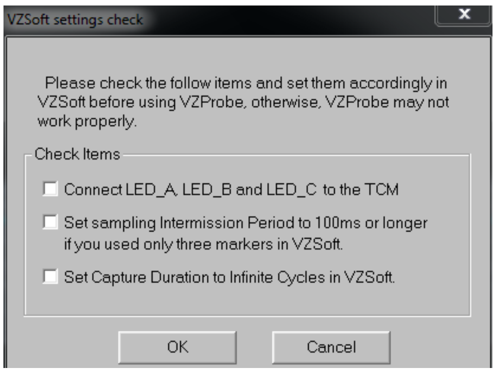
2) Go to Target Sequence Editor menu, enable the three (upper three for VZWProbe) markers.

3) Set the sampling period and sequence intermission according to instruction period to the shortest possible and the frequency to about 10 frames per second to ensure high accuracy and safe marker operation.

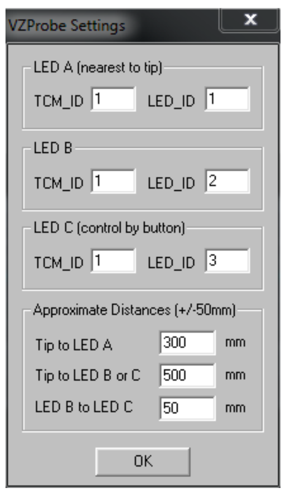
4) Press 'Do With VZProbe' on the Coord. Reference Frame screen. Correct whatever is necessary following the warning messages (if any). Then the 'Record' button will activate

automatically and the VZProbe window will open.

5) Confirm all the VZSoft settings as requested.



6) Go to the Settings screen on the VZProbe window. Specify the Marker-IDs corresponding to step 1.



Specify the rough distances between the VZProbe markers (if not already correct by default), and specify the desired Capture Speed (Slow, Medium or Fast).

7) Click on Calibration/Start.

8) Pivot the VZProbe tip at a firm point (e.g., the center of a small dent on the concrete floor). Steady the probe and click the button on it until you hear a beep from the computer (should be immediate if the markers are facing the tracker(s) properly). This means a set of good calibration data has been collected.

NOTE 1: To be accurate, DO NOT allow the probe tip to shift during the calibration process!

NOTE 2: A bad data capture will beep with a lower- frequency tone.

9) Without moving the probe tip, maneuver the VZProbe around and continue pressing the button to collect more calibration data sets. The more data sets you collect the more accurate the calibration will be (minimum is 4). It is recommended to collect 20~30 data sets for a reasonably accurate calibration. After collecting the data, click Calibration/Stop to stop.

10) Save the calibration parameters for the probe if you do not expect the probe LEDs to move before you use it again.

11) Now click on Operation/Start to define the CRF.

12) Point the VZProbe tip at the desired CRF origin and click the button on the probe until it beeps correctly.

13) Move the tip to a (second) point along the desired x-axis (and at least 50cm away from the origin) and click the button again until it beeps correctly to define the +x-axis.

14) Move the probe tip to a (third) point on the desired
+xy quadrant of the CRF (at least 50cm from both preceding points) and press the button until it beeps correctly for a final time.

15) After the three points are collected, the CRF is established, the VZProbe program will close and you should be looking at the Coord Reference Frame window. The 'Transformation Matrix' panel should display

the numbers corresponding to the CRF.

16) Close the Coord Reference Frame window. You are now ready to start capturing motions relative to the newly defined CRF.

b.5) By specifying values

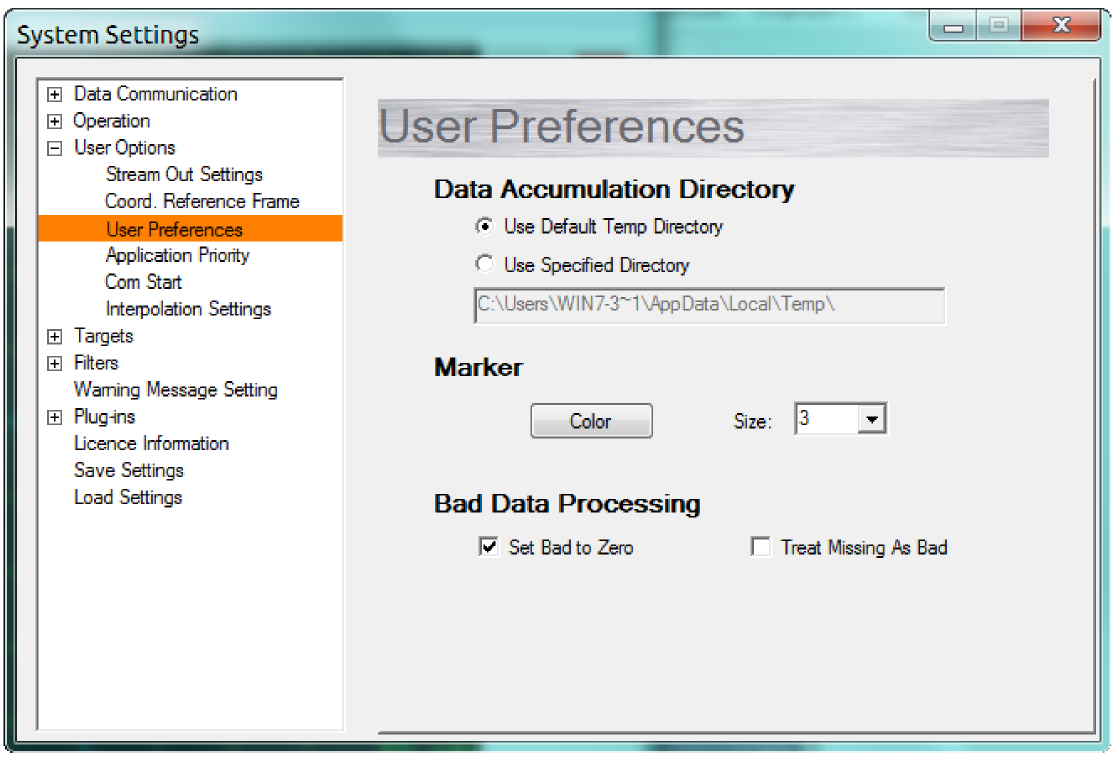
Simply click on the Translation or Rotation tab and specify the desired values to change the current CRF.

NOTE 1: You can also have the motion capture data multiplied by a scaling factor by clicking on the Scaling tab and enter the desired values.

NOTE 2: 'Use default' returns the CRF to the one associated with the take being displayed.

NOTE 3: 'Save as' and 'Load' are for storing and using CRF(s) in *.crf files for repeated usage.

c) User Preferences



Use this panel to specify a directory for temporary storage of the system data during capture, the color of the dots representing the marker positions on the display panels, what to do when a bad data is generated, and which digits of the timestamp to save.

c.1) Data Accumulation Directory: By default, VZSoft stores its working files during a capture session in the conventional C:\Temp\ directory. These files will be removed automatically before VZSoft closes.

Unless the default C: drive may not have sufficient free space left, there is no need to change this default directory. Should a file ever be lost during a capture, this is also the place most likely to find it.

c.2) Marker Color/Size: This is for selecting a color and size to display the 3D marker positions in the two graphics windows

c.3) Bad Data Processing: This sub-panel allows for selecting how to treat bad data samples. (Note that another option for treating a bad data is to replace it by the last good data. This Use Previous Good Data option is on the Operation/ Operating Options panel.)

1) Set Bad to Zero: When a data sample is found to
have unusable values (i.e., data is 'B'ad), you can choose to leave it as is or replace its values by zeroes by checking this box. Note that this will affect only the data streamed out to external applications. The data stored in *.vzp or exported to *.txt files will not be affected.

2) Treat Low Quality Data As Bad: When the light received from a marker by the tracker may be insufficient to accurately calculate 3D coordinates, the data set is marked as 'L'ow Quality Data. This checkbox lets the user declare it as 'B'ad instead. Note that this will affect both the exported *.txt files and data streamed out to external applications.

NOTE 1: Good data is marked with 2, Low Quality data is marked with 1, and Bad data is marked with 0, in an exported *.txt file.

Good data is marked with 'G', Low Quality data is marked with 'L', and Bad data is marked with 'B', when streaming out to external applications.

NOTE 2: For VZSoft to operate properly with the Autodesk MotionBuilder animation software, you are required to un-check the Operating Options/ Use Previous Good Data box and check the User Preferences/ Set Bad to Zero box. This will result in zeros being passed with a 'B'ad flag to MotionBuilder (via the optional plug-in for MotionBuilder).

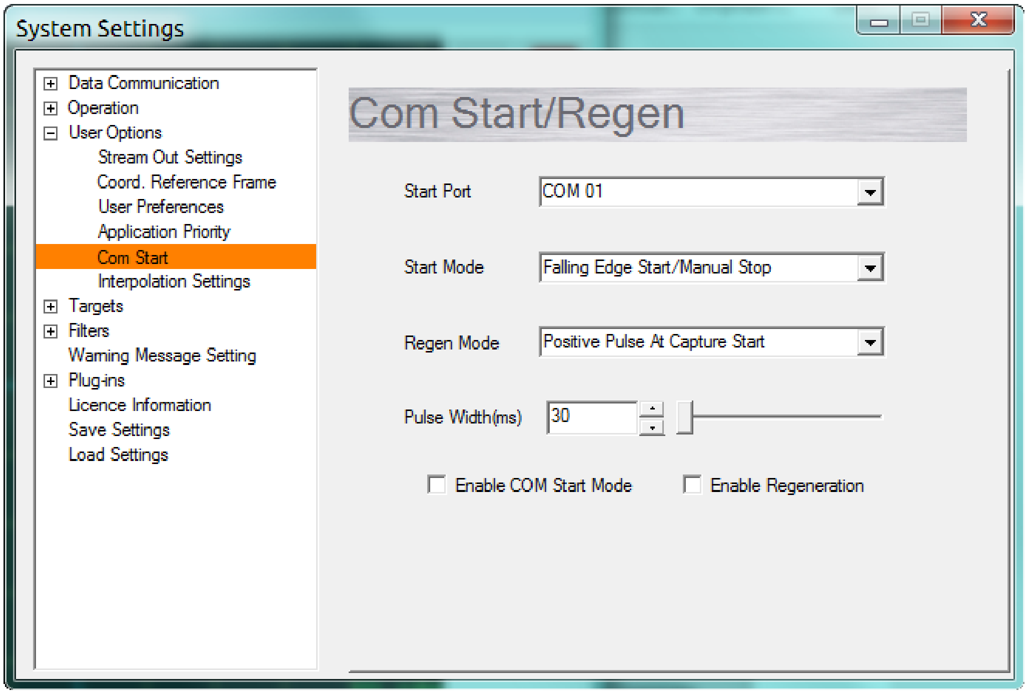
c.4) Timestamp Precision: These two options allow the user to tailor the precision of the streamed-out and exported timestamps. The 'Upper Digits Only (default)' setting will output the upper digits only (hence less precise) and allow a longer capture duration before the timestamp rolls around. The 'Full Lower Digits' setting will output more decimal digits and hence higher precision timestamps, but will roll around sooner. The latter is recommended for scientific applications.

d) Application Priority

This setting specifies the relative priority the host computer should attend to the VZSoft GUI tasks, compared to the Windows OS tasks. Setting the priority to 'Real Time' commands the highest possible priority for the VZSoft GUI. Depending on the power of the host computer, 'Real Time' priority may be necessary for ensuring uninterrupted capture of the target coordinates according to the user settings.

NOTE: Depending on the operating system, the host computer may override the selection made here. Set- ting the priority to 'Real Time' may also affect the host computer's ability to simultaneously run other applications at sufficient priority.

e) COM Start ('Software Standby')



When enabled (by checking the Enable COM Start Mode box), VZSoft will simply wait for a standard RS422 signal to come through the selected COM port before initiating the capture process.
NOTE: There is no need to press the Record button to start a capture under this operating mode.

Therefore, this operation mode can be thought of as a 'Software Standby' mode, because the operation concept is similar to the Standby setting under Operating Options (see 'Standby' via the Index) which can be thought as the 'Hardware Standby'.

This is for synchronizing the motion capture process with the operation of equipment.

The specifications for the COM Start signal are not as stringent (see Specifications) as those for the Stand by trigger signal. The achievable synchronization precision is also not as stable, about 20 milliseconds compared to 1 microsecond respectively. Nevertheless, this operation mode is still recommended for all synchronization applications, because the use of a standard COM port provides a very low-cost layer of protection against any potential tracker damage.

Below are the details regarding the options under this operating mode.

e.1) Start Port: This is for selecting the COM port through which the capture process must receive a RS232 pulse, via the DSR and GND pin pair, before starting or stopping.

For a standard 25-pin (DB-25) COM port connector on the host computer, DSR and GND are on pins #6 and #7 respectively. For a standard 9-pin (DB-9) connector on the host computer, DSR and GND are on pins #6 and #5 respectively.

e.2) Start Mode: The RS232 signal for initiating the capture may be a single pulse, two pulses, or a voltage level generated by an electronic device such as a Hand Trigger or by a third party equipment. This is selected according to the signal descriptions below.

NOTE: An electronic engineer or technologist should be consulted on the generation and connection of this signal to the selected COM port on the host computer.

One of eight types of signals can be applied to the COM port to initiate the capture process. Some of these can also stop the process after starting it.

1) Falling Edge Start/ Manual Stop: The first falling edge detected on the COM port starts the capture. User must manually stop the capture.

2) Rising Edge Start/ Manual Stop: The first rising edge detected on the COM port starts the capture. User must manually stop the capture.

3) Positive Pulse Start/ Manual Stop: Detection of a rising edge followed by a falling edge on the COM port starts the capture. User must manually stop the capture.

4) Negative Pulse Start/ Manual Stop: Detection of a falling edge followed by a rising edge on the COM port starts the capture. User must manually stop the capture.

5) Positive Pulse Start/ Stop: Detection of a rising edge followed by a falling edge on the COM port starts the capture. Detection of another rising edge followed by another falling edge on the COM port stops the capture.

6) Negative Pulse Start/ Stop: Detection of a falling edge followed by a rising edge on the COM port starts the capture on the rising edge. Detection of another falling edge followed by another rising edge on the COM port stops the capture on the rising edge.

7**) Low Level Active:** Changing from a normally high-level signal to low-level on the COM port starts the capture. Changing back to high-level stops the capture.

8) High Level Active: Changing from a normally low-level signal to high-level on the COM port starts the capture. Changing back to low-level stops the capture.

e.3) Reversed Synchronization Output: Due to latency o f the Windows operating system in responding to a COM port input signal, the exact moment at which the capture process is initiated by VZSoft can be as long as 50ms after application of the COM Start signal. To partially alleviate this timing uncertainty problem, VZSoft can regenerate a RS232 output pulse on the DTR pin of the selected COM port immediately after initiating the capture process. This regenerated pulse can be monitored and/or used to trigger the external equipment operation(s), thus accomplishing ‘reversed synchronization’ instead.

Since there is no known latency problem in generating the DTR output pulse, reversed synchronization will be significantly closer in timing and more stable. DTR is on pin #20 of a DB-25 (25 pin) COM port connector, or on pin #4 of a DB-9 (9-pin) connector on the host computer.

e.4) Regen Mode: The regenerated RS232 signal on the DTR pin can be specified by the user via selecting one of these eight Regen Modes. In case a 'pulse' mode is selected, the pulse width can also be specified.

1) Positive Pulse At Capture Start: A positive (active-high) pulse of the specified width will be generated immediately after initiating the capture process.

2) Negative Pulse At Capture Start: A negative (active-low) pulse of the specified width will be generated immediately after initiating the capture process.

3) Positive Pulse At Capture Stop: A positive (active -high) pulse of the specified width will be generated immediately after stopping the capture process.

4) Negative Pulse At Capture Stop: A negative (active-low) pulse of the specified width will be generated immediately after stopping the capture process.

5) Positive Pulse At Start/Stop: A positive (active -high) pulse of the specified width will be generated immediately upon starting as well as upon stop- ping of the capture process.

6) Negative Pulse At Start/Stop: A negative (active -low) pulse of the specified width will be generated immediately upon starting as well as upon stop- ping of the capture process.

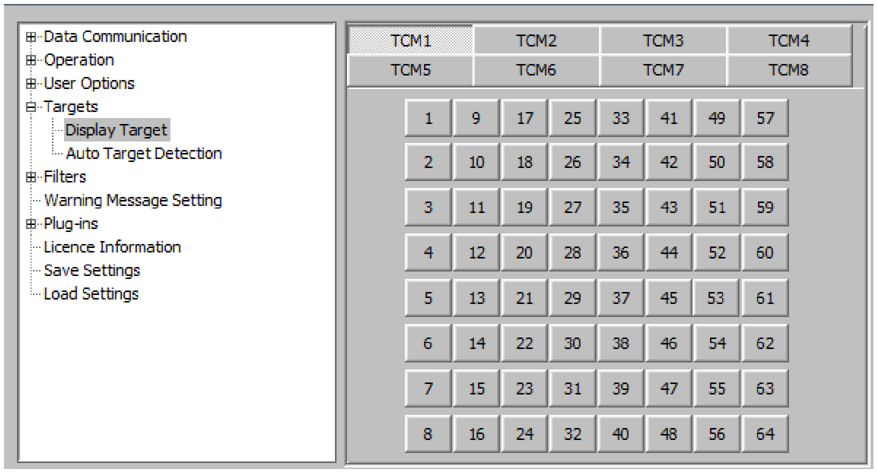
7) High Level During Capture: The normally-low
DTR signal will become high while capturing.

8) Low Level During Capture: The normally-high
DTR signal will become low while capturing.

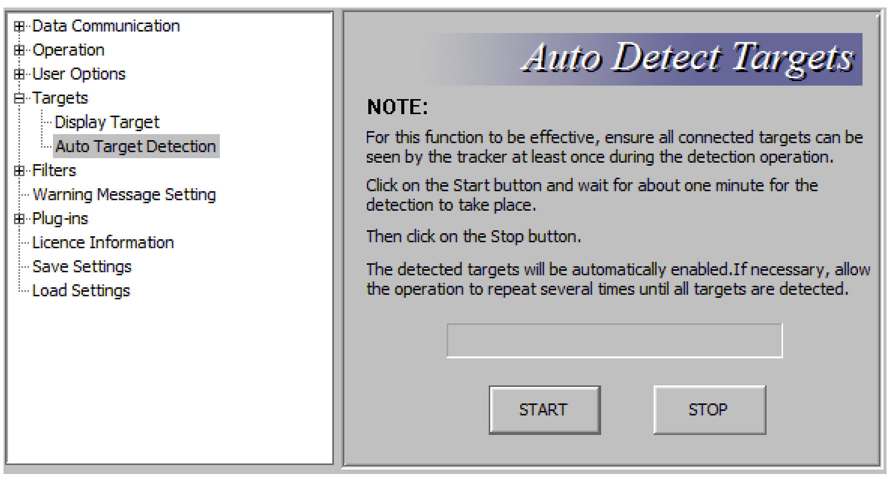
e.5) Optical Synchronization: The output pulse generated by the COM Start operation on the DTR pin of the selected host computer COM port can also be used to flash a LED indicator. Such flash can serve to confirm initiation of the capture process. It can also be picked up by a movie or video camera for dubbing or other synchronization purposes during post- production. An electronic technologist should be consulted on the LED indicator design. Avoid using a near-infrared LED, for it may interfere with the LED marker operation.

4.4.2.4 Targets

a) Display Target
Use this panel to activate a regular target and visually locate where it is on the capture subject. (Note that this function does not work on a SIKMarker). If the Target Sequence Editor (TSE) panel is displayed at the same time, the user can easily assign a name to the displayed target by double-clicking on the corresponding target label on the TSE panel.



b) Auto Target Detection



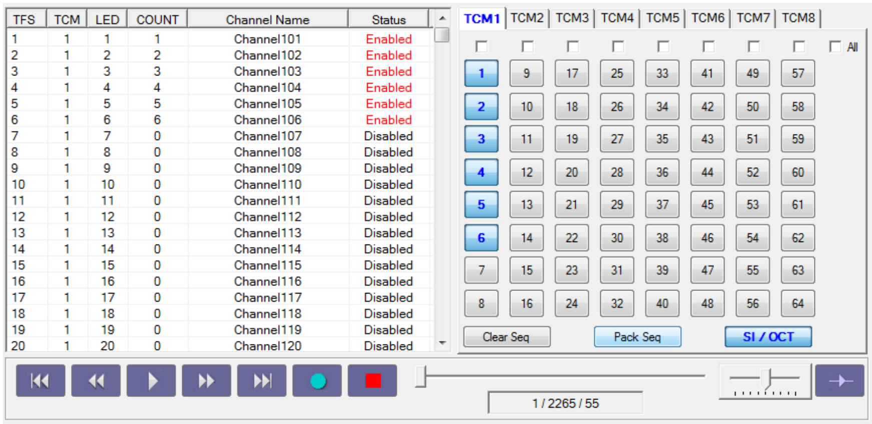
This function allows targets connected to the capture subject(s) to be detected and enabled automatically. This makes attaching targets on the motion capture subject(s) easier for the user. The detected targets will show up on the Target Sequence Editor panel(s) as enabled. Of course, the user can also activate these targets manually (see Target Sequence Editor).

NOTE: The user must still ensure that a target is seen by all eyes of at least one tracker when it is lit, in order for the system to detect its presence.

When all targets attached to the capture subject(s) have been detected and automatically enabled, the user can normally start a capture by simply pressing the Record button. An exception is when the self-identified OctMarker / SIKMarker(s) are being used.

When OctMarker and/or SIKMarker(s) are used, the user should click on the 

button to make VZSoft control the markers somewhat differently, so that OctMarker(s) or SIKMarker(s) will respond properly to the control signals.



4.4.2.5 Filters

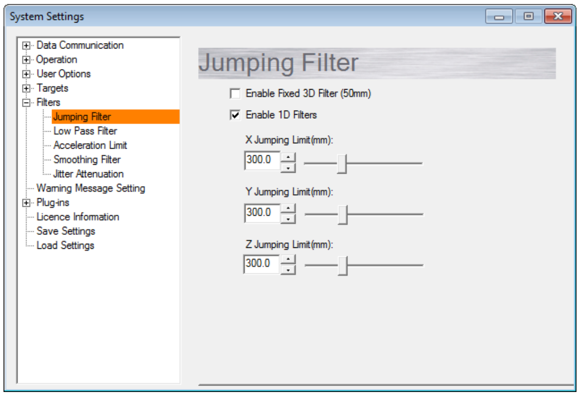
Filters are implemented within the VZSoft for conditioning the captured data for visual display and for possibly exporting to third-party application(s) only. They are not implemented by the Visualeyez trackers. The raw data captured by the trackers will always be saved 'as is' (by VZSoft) in the PTI-standard output file format (*.vzp) first, before any filter is applied to it. Therefore, if no data is exported to any application software in real-time, the filtered data is only displayed on the VZSoft windows, then dumped immediately.

a) Jumping Filter
These are simple filters of data deemed physically impossible to have.

Enable Fixed 3D Filter (50mm):
This will filter out data of a marker which changed more than 50mm from its preceding 3D position, by declaring it as 'B'ad.

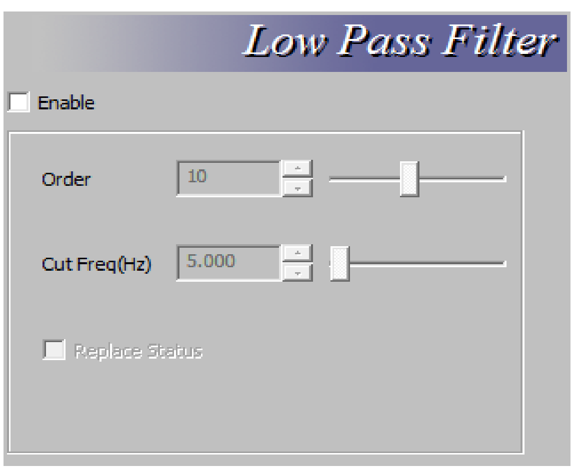
Enable 1D Filters:
This will filter out data of a marker which changed any one of its three 1D position

coordinates by more than the specified Jumping Limit from its preceding value, by declaring it as 'B'ad.



b) Low Pass Filter

This is an effective filter which will remove the high frequency components from the captured raw data. In addition, it will replace all 'B'ad data by the interpolated values. The user can choose to replace their status or not in the streamed-out data.



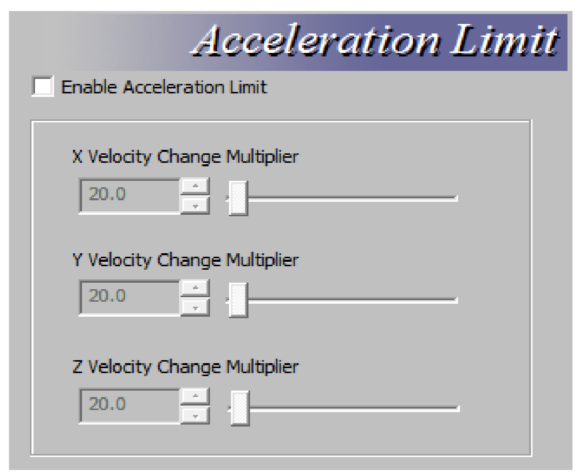
b.1) Enable: Check this box to apply a lowpass filter on the captured data. When enabled, the three captured coordinates of each marker will individually undergo a digital lowpass filtering process before streaming out to external applications.

b.2) Order: The order of the lowpass filter. It specifies the number of consecutive data points used in the filtering process. The maximum value is 20.

b.3) Cut Freq: The cut-off frequency of the lowpass filter. Motion components of frequencies higher than this value will be cut out of the original captured data. Motion components of frequencies lower than this value will pass through the filter and appear in the filtered data.

b.4) Replace Status: When a captured raw data is 'B'ad, the lowpass filter will normally replace only the bad data by the interpolated values produced by the filtering process. Checking this box will further replace the 'B' status by 'G'ood before streaming the data out to other applications.

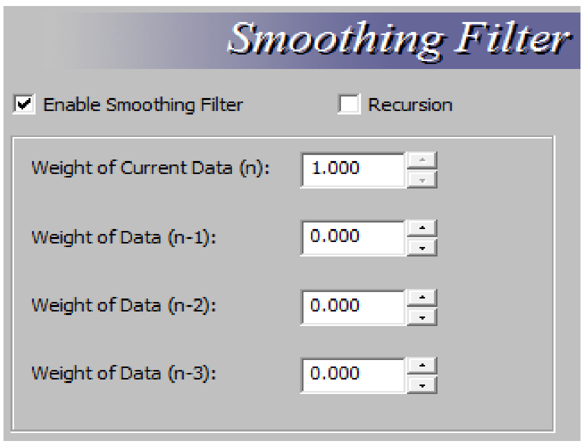
c) Acceleration Limit



Abrupt changes of a computed target velocity may be a symptom of sensing problem. This problem can be detected by comparing the latest coordinate velocity of a target, with its average previous velocity multiplied by an acceptable change factor ('Velocity Change Multiplier'). For example,

suppose the previous x-velocity of a target was 10m/sec. An X Velocity Change Multiplier of 5 implies that the current x-velocity of the same target cannot be greater than
50m/sec. Exceeding 50m/sec would result in the latest sampled data being designated as 'B'ad.

d) Smoothing Filter



d.1) Enable Smoothing Filter: Checking this box will enable a simple smoothing filter which will modify the latest captured marker coordinates to be the weighted-sum of the current and previous coordinates. This can filter out some undesirable data jitters.

For example, for weights of 0.7, 0.1, 0.05, 0.15 for data n, n-1, n-2, n-3 respectively, with the latest four sets of coordinates of a target being (333.3, 222.2, 111.1), (336.3, 220.2, 114.1), (339, 228, 117), (332.3, 221.2, 110.1) respectively, the filtered output coordinates for the target will be:

0.7*(333.3,222.2,111.1)
+0.1*(336.3,220.2,114.1)
+0.05*(339,228,117)
+0.15*(332.3,221.2,110.1)
= (333.735, 222.140, 111.545).

d.2) Recursion: Checking this box will cause the original data to be replaced by the filtered output for the next filtering computation. Depending on the data condition, this may yield better results than without the recursion. However, in this case the 'Weight of Current Data (n)' value cannot be 0. Setting it to 0 will get an error message and the Recursion checkbox will be unchecked automatically.

e) Jitter Attenuation Filter (VZSoft 3.x)

Enable this filter to apply a granular smoothing filter to smooth out jitters on the VZSoft marker display windows.

The threshold slider sets the distance between 2 consecutive positions of a marker to trigger the jitter filter.

Note: even static markers can exhibit micro jitters when displayed in VZSoft graphical window. This is normal and due to the high sensitivity of the tracker sensors combined with the very fine sub-millimeter graphical display function used by VZSoft.

4.4.2.6 Installed Plugins

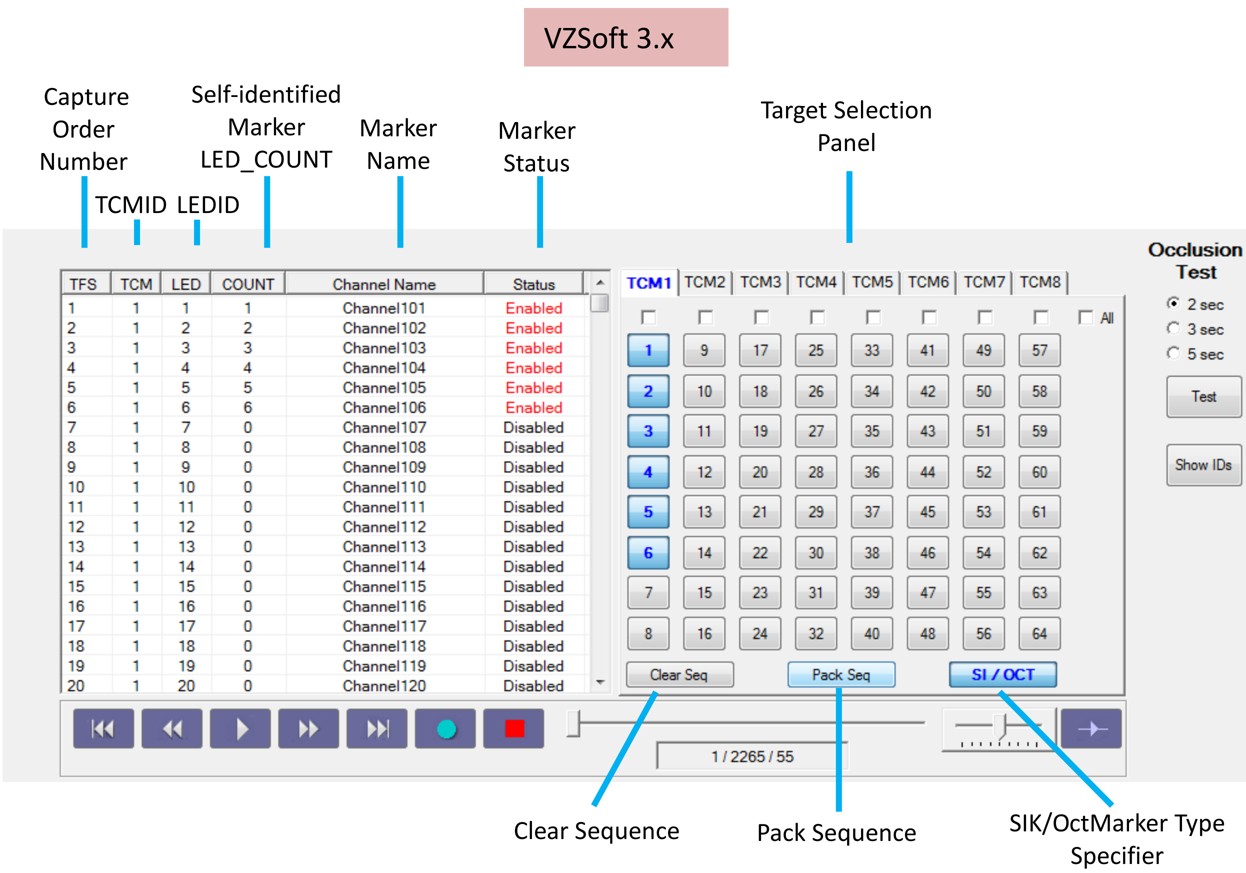
This panel simply displays the plug-ins that have been installed to support interactions between the VZSoft and other third-party software applications.

4.4.2.7 License Information

Click the 'Info' button will display the PTI software license information contained within your dongle. Please contact PTI (at www.ptiphoenix.com) regarding updating your PTI software license(s) when needed.

4.4.3 TARGET SEQUENCE EDITOR (TSE)

A Visualeyez tracker captures the 3D position of one marker at a time, at very high speed. To capture coordinates of more than one target, the user must first specify the sequence in which they are to be captured. When the system switches from capturing the position of a target powered by one TCM to capturing another target powered by another TCM with a different TCMID, it may skip one capture to yield time for the switching process, if the sampling period is short. Hence it is undesirable to arrange the targets to be captured in such order as to necessitate frequent switching between TCMIDs. The following describes how to use the Target Sequence Editor (TSE) to design a target flashing sequence.



4.4.3.1 Target Selection Panel

Select the targets to be captured via this panel. First identify the ID of the TCM the targets are physically connected to and click the corresponding TCM ID in the panel. Then select the targets to be sampled. When a target is selected, its corresponding row of information on the left side of the panel will highlight and indicate that it is 'Enabled'. This can also be done by double-clicking the 'Enabled' button.

4.4.3.2 Pack Sequence

Click this button to compact the information rows of enabled targets together at the top of the panel. Note that once packed, this button becomes identical to the 'SEQ' button on the panel and is disabled until the enabled sequence is altered.

4.4.3.3 Capture Order Number

This column of numbers indicates the order in which the 'Enabled' targets will be captured. When Pack Sequence button is pressed, the enabled target information rows will appear packed on the top portion of this list.

NOTE 1: The ordering can be re-arranged by left- click and drag an information row up or down.

NOTE 2: The elements within each column can be sorted by simply clicking the column label: 'SEQ','TCM', 'Target', 'Channel Name', 'Flashes', or 'Status'.

4.4.3.4 TCMID

This column shows the TCMIDs of the enabled markers. They range between 1 to 8.

4.4.3.5 LEDID

This column lists the LEDIDs assuming all markers are standard wired markers. The combination of (TCMID, LEDID) uniquely identifies a standard marker connected to and driven by a TCM. Every captured marker output data of a Visualeyez system is also labeled by this combination number to distinguish it from the data of another marker.

4.4.3.6 LED_COUNT

This column lists the LED_COUNT in case the marker being used is a self-identified marker (an OctMarker or SIKMarker).

A SIKMarker is uniquely and permanently assigned a combination-label of (TCMID, LED_COUNT) on the physical device (see Wireless SIKMarkers section). However, its captured data will be labeled with the combination (TCMID, LEDID) as displayed in this TSE panel. This means the captured data label of a SIKMarker may be different from the SIKMarker's ID! For example, as shown in the following figure, the captured data for a SIKMarker labeled (TCMID, LED_COUNT) = (3, 04) will be labeled with (TCMID, LEDID) = (3, 09) in the data file!

Similarly, the data of the SIKMarker-306 will be labeled with (TCMID, LEDID) = (3, 34) in the data file.

SEQ	TCM	LED	COUNT	Channel Name
1	8	64	1	Channel864
2	3	4	1	Channel304
3	3	7	2	Channel307
4	3	8	3	Channel308
5	3	9	4	Channel309
6	3	10	5	Channel310
7	3	34	6	Channel334
8	3	5	7	Channel305
9	1	1	0	Channel101

To avoid such potential inconsistent labeling problem, always enable a TCM group containing SIKMarkers sequentially, starting from 1, so that the SIKMarker labels will be exactly identical to their data labels. This is shown in the next figure (which assumes marker-864 is not a SIKMarker).

SEQ	TCM	LED	COUNT	Channel Name
1	8	64	1	Channel864
2	3	1	1	Channel301
3	3	2	2	Channel302
4	3	3	3	Channel303
5	3	4	4	Channel304
6	6	1	1	Channel601
7	6	2	2	Channel602
8	1	1	1	Channel101
9	1	2	2	Channel102
10	1	3	3	Channel103
11	1	4	0	Channel104

This prompts the following note.

NOTE: To ensure captured data will be labeled the same as the marker IDs, always enable a TCM-group containing OctMarker(s) or SIKMarker(s) sequentially, starting from 1.

4.4.3.7 Target Name

The name of a marker can be changed by double- clicking on its Target Name and type in the desired name. The maximum number of characters allowed for a target name is 50.

4.4.3.8 Enable Buttons

These buttons are for toggling the targets on and off. They serve the same functions as the Target Selection Panels.

4.4.3.9 Clear Sequence

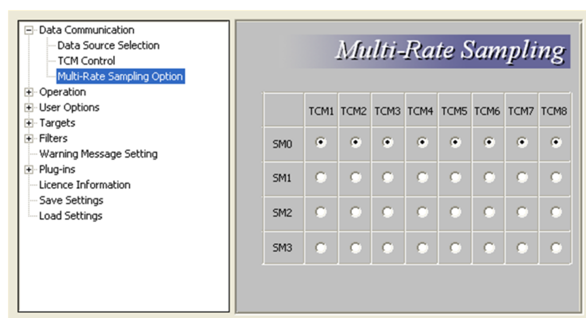
Click this button to de-select and disable all previously enabled targets (on all eight TCM panels).

4.4.3.10 Multi-Rate Sampling

A TCM has the ability to light up one physical LED marker multiple number of times for sampling within one capture cycle (frame). A self-identified OctMarker or SIKMarker can also be made to do so, but requires a substantial amount of user design efforts. Sampling one physical LED marker more times than other marker(s), within one single capture cycle, is referred to as 'multi-rate sampling'.

a) Standard Markers

Each TCM for the VZ10K or VZ10K5 Visualeyez system can be programmed to assign either 1, 2, 4 or 8 LEDIDs to a single connected physical LED marker. To do this, simply select the desired sampling option (SM0, SM1, SM2, or SM3) for that TCM under the System Settings / Data Communication / Multi-Rate Sampling Option menu.



SM0: This is the default sampling mode in which a standard LED marker is assigned a single LEDID, and therefore can only be sampled once per capture cycle.

SM1: A TCM set in this mode will assign two LEDIDs to each marker connected to its lowest 32 connectors (the connectors which would be assigned LEDIDs 1~32 by default). The marker connected to the connector with LEDID=1 by default, will now possess LEDIDs 1 and 33, and similarly for markers connected to the other 31 connectors.

If both LEDIDs of a marker are enrolled in the TFS, then that marker will flash twice per capture cycle.

SM2: A TCM set in this mode will assign four LEDIDs to each marker connected to its lowest 16 connectors (the connectors which would be assigned LEDIDs 1~16 by default). The marker connected to the connector with LEDID=1 by default, will now possess LEDIDs 1, 17, 33 and 49, and similarly for markers connected to the other 15 connectors.

If all four LEDIDs of a marker are enrolled in the TFS, then that marker will flash four times per capture cycle.

SM3: A TCM set in this mode will assign eight LEDIDs to each marker connected to its lowest 8 connectors (the connectors which would be assigned LEDIDs 1~8 by default). The marker connected to the connector with LEDID=1 by default, will now possess LEDIDs 1, 9, 17, 25, 33, 41, 49 and 57, and similarly for markers connected to the other 7 connectors.

If all eight LEDIDs of a marker are enrolled in the TFS, then that marker will flash 8 times per capture cycle.

NOTE: All the other connectors of the TCM (if any) will be assigned no LEDID at all! So a marker connected to any of them will never be flashed.

b) Self-identified Markers

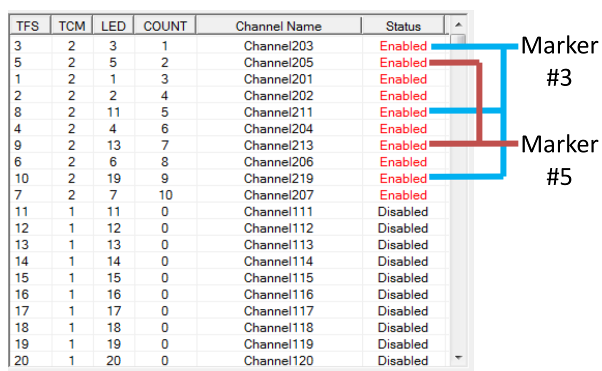
Please consult with PTI if you wish to do multi-rate sampling with the self-identified OctMarker(s) and/or SIKMarker(s).

c) Attaining Higher Spatial Resolution

Having sampled a special marker at higher frequency than the others does not automatically yield higher spatial resolution for that marker's data. To attain higher spatial resolution, the multiple LEDIDs of the special marker must be spaced out as uniformly over the TFS as possible.

Below shows an example of how to multi-rate sample two standard markers connected to connectors #3 and #5 of a TCM16 with TCMID=2 and SM3 mode selected. Three of the LEDIDs assigned to the marker in connector #3, (203, 211, 219), have been enabled. Two of the LEDIDs assigned to the marker in connector #5, (205, 213), have been enabled. The other markers are each enabled with just one LEDID.

The LEDIDs of the multi-rate sampled markers can be simply dragged up or down the TFS in VZSoft to achieve the uniform spacing requirement.



TFS	TCM	LED	COUNT	Channel Name	Status
3	2	3	1	Channel203	Enabled
5	2	5	2	Channel205	Enabled
1	2	1	3	Channel201	Enabled
2	2	2	4	Channel202	Enabled
8	2	11	5	Channel211	Enabled
4	2	4	6	Channel204	Enabled
9	2	13	7	Channel213	Enabled
6	2	6	8	Channel206	Enabled
10	2	19	9	Channel219	Enabled
7	2	7	10	Channel207	Enabled
11	1	11	0	Channel111	Disabled
12	1	12	0	Channel112	Disabled
13	1	13	0	Channel113	Disabled
14	1	14	0	Channel114	Disabled
15	1	15	0	Channel115	Disabled
16	1	16	0	Channel116	Disabled
17	1	17	0	Channel117	Disabled
18	1	18	0	Channel118	Disabled
19	1	19	0	Channel119	Disabled
20	1	20	0	Channel120	Disabled

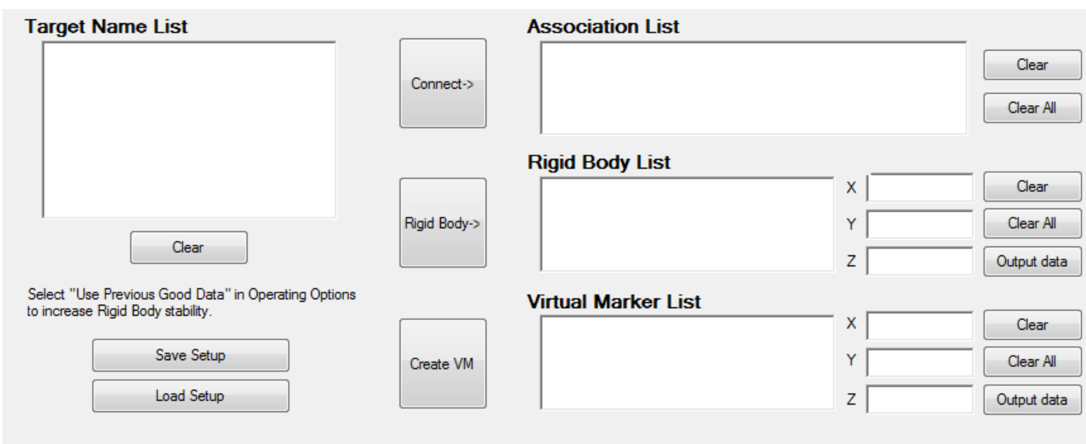
4.4.4 TARGET ASSOCIATION EDITOR (TAE)

The Target Association Editor (TAE) allows the user to associate a target with one or two others. Once associated, the captured target points as displayed on the two VZSoft graphical windows will be joined by lines. This creates a stick-figure of the subject wearing the targets.

In VZSoft 3.x, the TAE also allows the user to define rigid bodies and virtual markers. A Rigid Body (RB) can be defined with at least three markers and no more than ten, and uses mathematical algorithms to compute the locations of the occluded markers from those which are visible (not occluded) at any time.

A virtual marker (VM) is computed from the positions of three or more real physical markers as if the virtual one forms a rigid body with the physical markers.

VZSoft 3.x

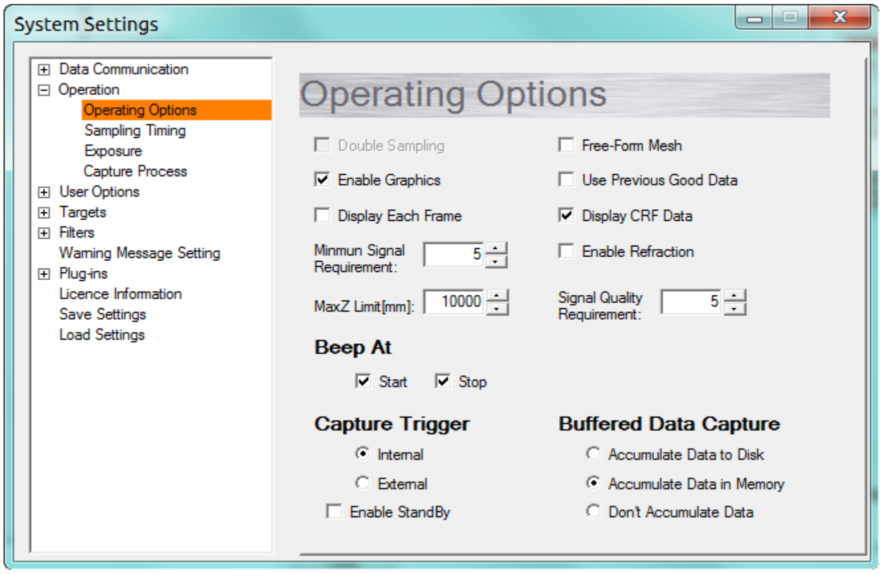


4.4.4.1 Rigid Body and Virtual Marker

A rigid body or virtual marker can be defined by selecting markers in the Target Name List window, then clicking on the Rigid Body or Create VM button respectively.

To delete a RB or VM, select it in the Rigid Body List or Virtual Marker List window respectively, and click the *Clear* button. The *Clear All* button will delete all rigid bodies or virtual markers.

Note: It is recommended to select 'Use Previous Good Data' in Operating Options to increase rigid body stability in real-time:

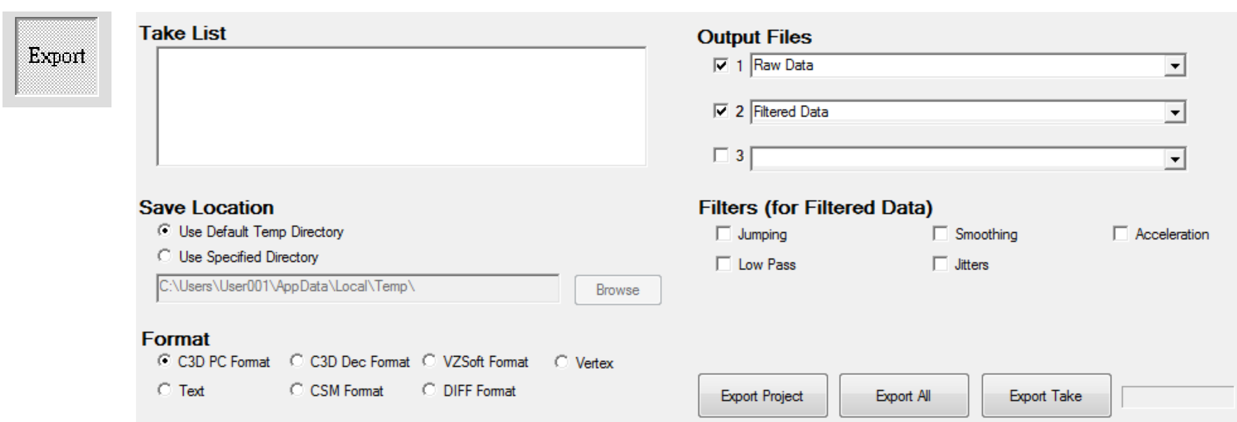


4.4.4.2 Data Output for Rigid Body and Virtual Marker

The *Output Data* button under the Rigid Body List and Virtual Marker List will output the respective computed data to a text file.

Note that by default the output data is always calculated from the individual markers' raw captured data, without using any active filters.

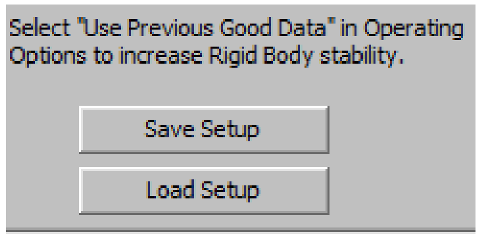
In order to make VZSoft use filtered data to compute a RB and/or VM, the user must first make VZSoft export Filtered Data to a *.vzpf file via the Export menu.



Then load the *.vzpf file back into VZSoft, setup the Rigid Body and/or Virtual Marker for the physical markers in the *.vzpf file, followed by outputting the RB and/or VM marker results to a new *.vzpf file.

4.4.4.3 Saving/Loading Setups for Rigid Body and Virtual Marker

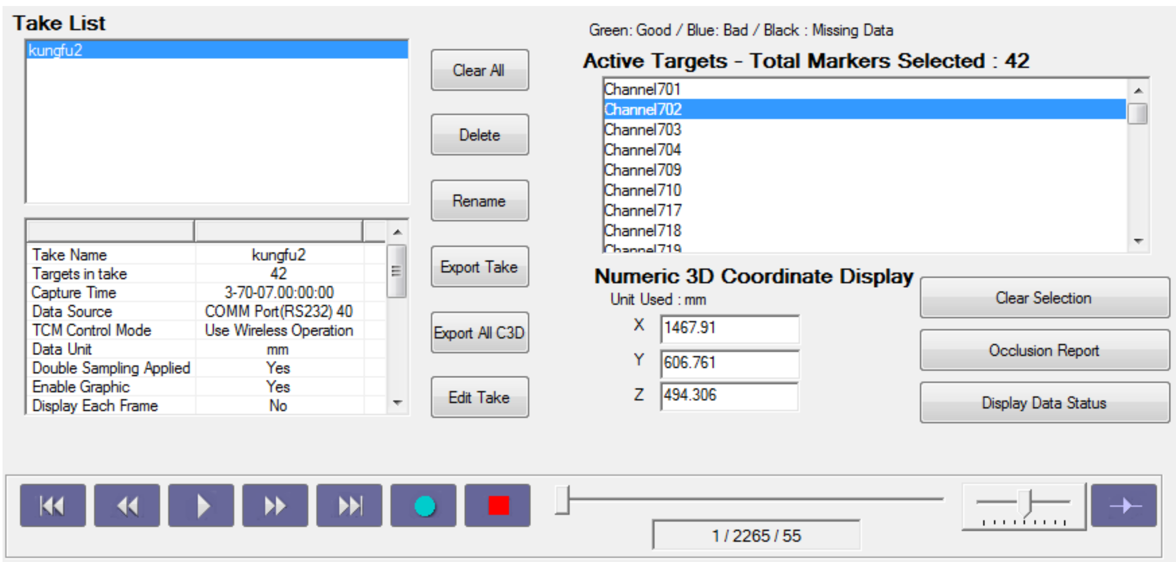
User can save the RB and/or VM setups (definitions) to a Setup file that can be loaded back later for use with another capture or data post-processing session. These are done via the Save Setup and Load Setup functions in the TAE panel.



4.4.5 MOTION CAPTURE DISPLAY

This panel allows the user to examine the status of a motion capture take.

VZSoft 3.x



4.4.5.1 Take List

This window lists the data takes in the opened project.

4.4.5.2 Take Information

When a take within the Take List is highlighted, information about the take are indicated in this sub-panel.

4.4.5.3 Active Targets List

This sub-panel lists the targets in the highlighted take, which is also being displayed in the VZSoft graphical windows. Selecting a target changes the color of its position point in the graphical windows. Double-clicking it will pop up an editor for changing the target name.

4.4.5.4 Numeric 3D Coordinates Display

When a target in the Active Targets List is highlighted, this sub-panel displays the XYZ coordinates of the target in the default CRF.

4.4.5.5 Display Control

a) Clear Selection
Press this button to deselect the highlighted target in the Active Targets List.

b) Display Data Status
During a motion capture or playback, clicking this button will assign a color (green, red or

blue) to each of the marker names displayed in the Active Targets panel. This color indicates whether the captured target data is 'G'ood (green), 'B'ad (Red), or 'L'ow quality (Blue).

4.4.5.6 Take Control

a) Clear All
Press this button to close all listed takes. This will not affect the saved contents of the project file.

b) Delete
Press this button to delete only the highlighted take.

NOTE: This will actually delete the take from the saved contents of the project file!

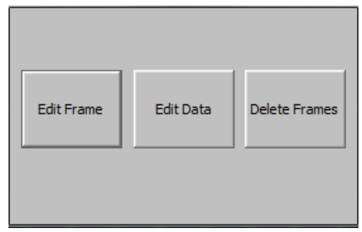
c) Rename
Press this button to rename the highlighted take.

d) Export Take
Click this to export a captured or re-opened VZSoft (*.vzp) data file to another file in a different format for further processing and/or analysis. For example, a *.txt file generated by this function can be easily imported into a spread-sheet program or a scientific software such as MATLAB™ or LabView™, and a *.c3d file can be opened by most popular animation applications.

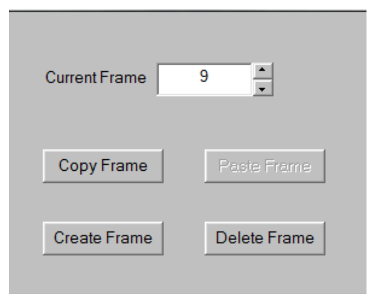
e) Export All C3D
Clicking this button will cause each and every take in the Take List (whether highlighted or not) to be export to a *.c3d file. This is meant to facilitate exporting a large number of takes, which a motion capture session for an animation application often generates.

NOTE: A *.vzp (VZP) file can also be converted into the DXF format for CAD and /or modeling applications. This function is available through the ADD ON’s panel or EXPORT panel (VZSoft 3.0). The same panel also permits exporting a VZP data file to be in the XYZ format.

f) Edit Take
Press this button to bring up the ‘VZEdit’ sub-menu below for editing data in the highlighted take.

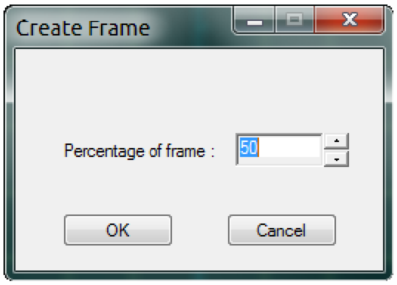


f.1) Edit Frame: Opens the menu below for editing data of the selected take one frame at a time.



- **f.1.1) Current Frame:** To edit a frame, first enter its index here to make it ‘current’.
- **f.1.2) Copy Frame:** Press this button to copy the selected frame.
- **f.1.3) Delete Frame:** Press this to delete the selected frame.
- **f.1.4) Paste Frame:** Click this will paste the previously copied frame after the current frame.
- **f.1.5) Create Frame:** Select this button to create a new data frame between the current frame and the frame before it.

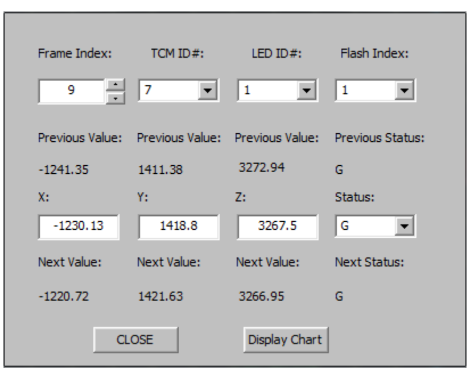
The new frame is created by first bringing up the following panel for specifying a percentage weight for the current frame,



then computing the weighted-sum of the current frame and the frame before it. The newly created frame will be inserted between them (and thus become the new 'current' frame).

f.2) Edit Data

Press this button to open the following panel for editing data of the selected take numerically, one target position coordinate at a time.

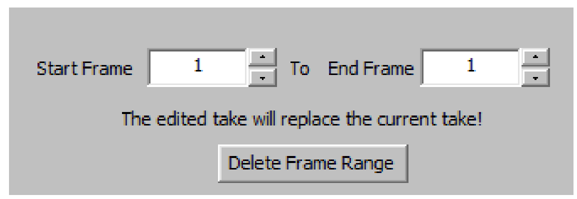


After specifying the particular target position to edit, the user can modify its current coordinate values as well as its 'G'ood, 'B'ad, 'L'ow-quality status. Note that the previous and the next values of the specified target position are also displayed for reference to facilitate modification.

Note: Target position data can also be edited graphically (see section Editing Data Graphically via Table of Contents).

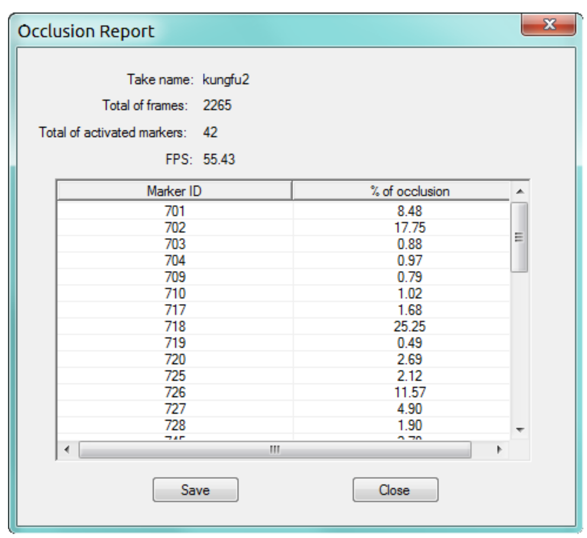
f.3) Delete Frame

Press this button to open the following panel for deleting a range of data frames.



4.4.5.7 Occlusion Report

Press this button to generate an occlusion report for the highlighted take in the Take List window.

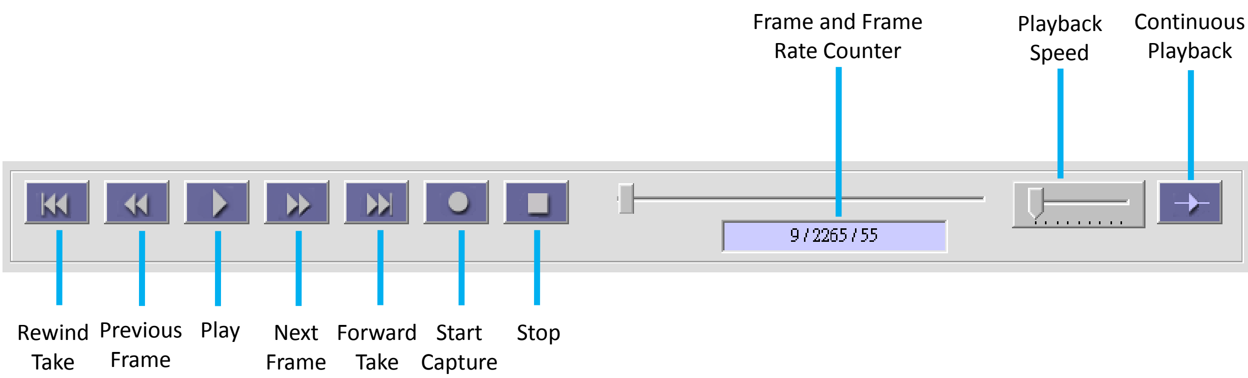


4.4.6 MOTION CAPTURE AND PLAYBACK CONTROL

These panels are visible at all times.

4.4.6.1 Motion Capture Controls

The motion capture control panel provides buttons for controlling a motion capture session as well as for playing back an existing take data.



a) Start Capture
This button initiates a capture session. The captured target positions will display on the perspective and orthogonal view windows (unless disabled).

When the Capture button is pressed, VZSoft first calculates the frame rate based on the sample operation time (SOT) setting, sampling period, sequence intermission period, the number of enabled targets and whether double sampling is on or off. If the frame rate is too high that the LED targets may burn out, a confirmation window will pop up on the screen to give the user the choice to cancel or proceed with the capture session.

Then VZSoft will program the trackers according to the user settings before finally starting to actually capture the LED marker positions. During this time, a 'busy' indicator will appear and circles around the Record (Start Capture) button to indicate that the process has begun. All buttons are also greyed out to prevent another button from being pushed (which would mess up the system).

b) Play
Pressing this button starts a replay of the Take highlighted in the Motion Capture Display panel. By default, this will replay the latest captured Take.

Note: The highlighted Take can also be replayed backwards. To do that, right-click the Play button (right-click it again to return to forward replay).

c) Stop
This stops either a motion capture session or a replay, whichever is on.

d) Rewind
Press this button to rewind the highlighted Take back to the beginning.

e) Step Back
This makes the display go back to the previous frame.

f) Forward
Winds the highlighted Take all the way to the end of the Take.

g) Step Forward
Advances the Take being replayed one frame forward.

h) Playback Slider
When a Take is being replayed, this slider will move to show the progress. By clicking and scrubbing it left or right, the displayed frame can be stepped back or forward quickly.

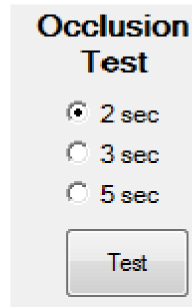
Note: Do not scrub the slider faster than the Windows' response time; it may cause data corruption! It is best to stop the replay before scrubbing.

i) Playback Speed
Drag this slider left or right to slow down or speed up the playback speed. Each decrement or increment of this slider halves or doubles the speed respectively.

j) Continuous Playback
Press this button to toggle between single or continuous playback of the highlighted Take.

4.4.6.2 Occlusion Test

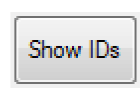
This is for testing the capture quality for a brief period and generate an occlusion report. The results can be used as a guide to adjust the marker position/orientation on the capture subject(s), as well as the tracker(s) viewing angle, so as to minimize occlusion.

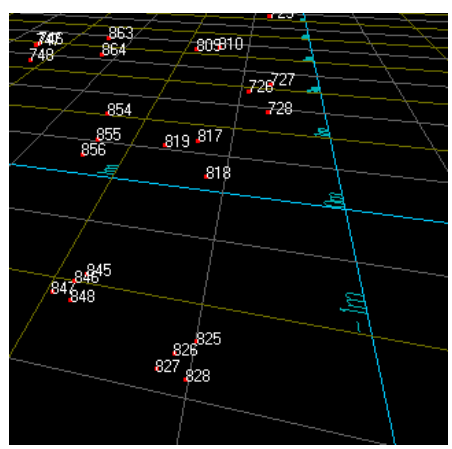


To start, simply select the desired duration of the test and click Test.

4.4.6.3 Show IDs

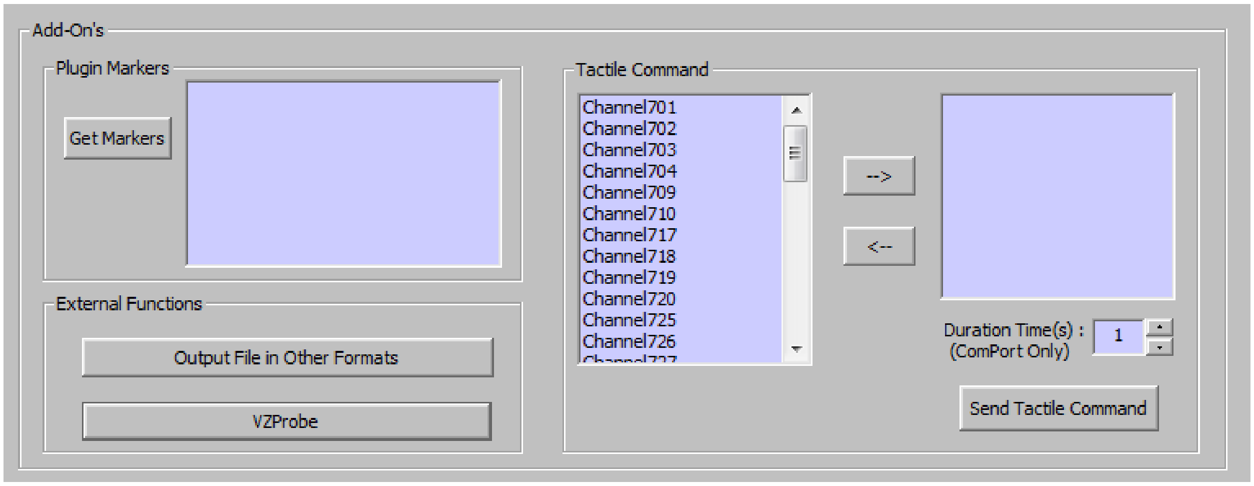
Clicking this button will make VZSoft display the MarkerIDs for the marker points shown in the graphical windows.





4.4.7 ADD ON'S

This panel allows the user to invoke some special functions.



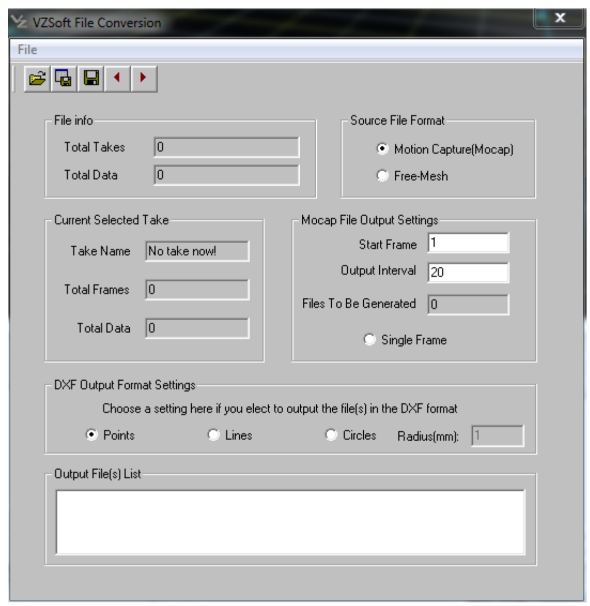
4.4.7.1 Get Markers

This function is for operation with the MotionBuilder™ real-time animation software only. Press this button to list the MotionBuilder 'markers' that can be retrieved and exported to other applications. For more information about this feature, please contact PTI or see the documentation included with the 'Get Marker' plugin available from PTI.

4.4.7.2 External Functions

a) Output File In Other Formats

This function allows exporting a captured VZP data file to the DXF and/or XYZ format for applications such as AUTOCAD. For more information, please refer to the application software which requires such data format.

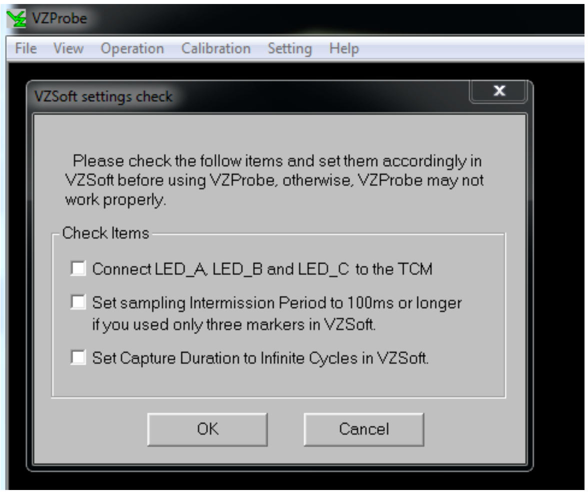


b) VZProbe

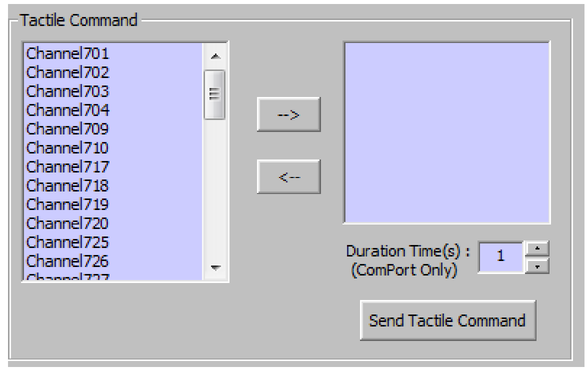
This function is for 3D digitization of objects for modeling and/or points for defining a coordinate reference frame (CRF) with an optional VZProbe device.

Please see the section on VZProbe and

Coordinate Reference Frame / With VZProbe for more details.



c) Tactile Command Console (VZSoft 3.x only)

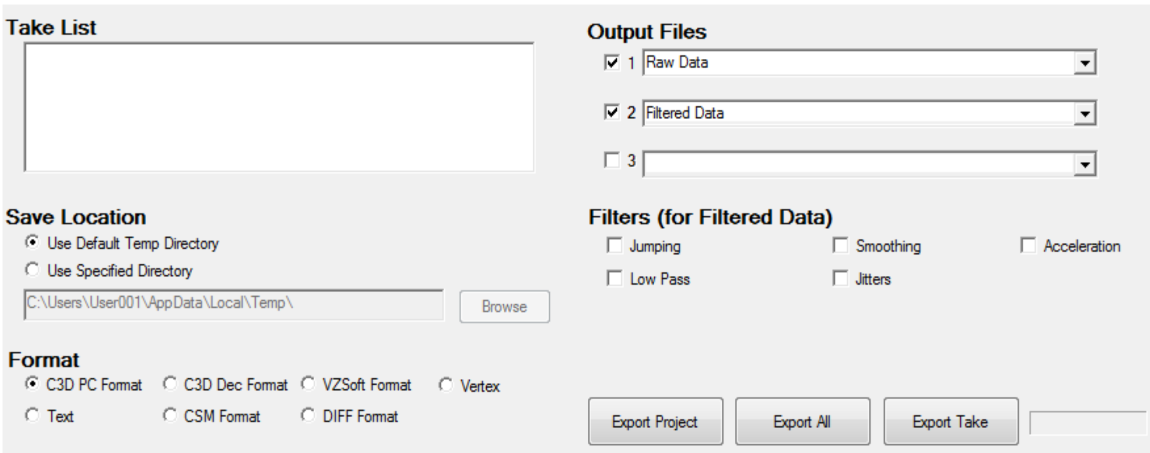


This console lists all activated MarkerIDs. Markers with built-in tactile feedback capability can be triggered by clicking the Send Tactile Command button.

Please contact PTI if you require more information on tactile markers and their advanced functions.

4.5 EXPORT PANEL (VZSoft 3.x)

This panel provides several options to export motion capture data.



4.5.1 Take List

This window displays the current takes loaded in VZSoft.

4.5.2 Format

Different data formats can be selected. Only one format at a time must be activated for data export.

If the motion capture system is synchronized with other 3rd-party equipment to collect **analog data** via the VZDaq software, the analog data will be exported together with the motion capture data when either VZSoft Format, C3D PC Format or C3D Dec Format is selected.

4.5.3 Output Files

Up to three different data files can be generated for each take selected in the Take List. These files can contain different kinds of motion data selectable from the pull-down menu:

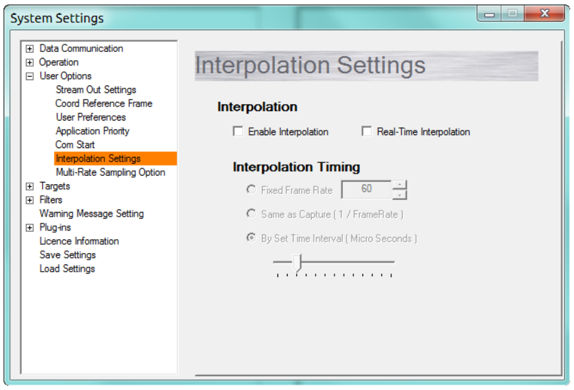
- Raw Data
- Interpolated Data
- Filtered Data
- Raw with Rigid Bodies

4.5.3.1 Raw Data

This option will produce a *_Raw.vzp file containing the raw capture data that came straight from the tracker and has not been filtered in any way at all.

4.5.3.2 Interpolated Data

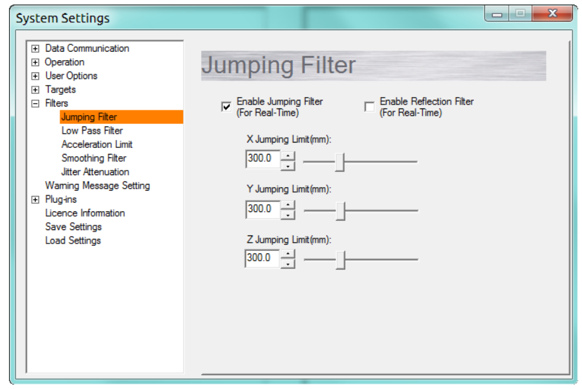
This option will produce a *_Interpo.vzp file containing the raw capture data interlaced with interpolated data generated according to the settings selected in the Interpolation Settings panel.



4.5.3.3 Filtered Data

This option will produce a *_Filter.vzp file containing the data generated after passing the raw capture data through the filter(s) selected under the Filters (for Filtered Data) list.

The setting(s) for each individual filter can be adjusted in the System Settings > Filters menu, or by pressing the F9 Key.



Note: The exported filtered data is **<u>not</u>** generated by the filter(s) which may have been used during the real-time capture!

4.5.3.4 Raw with Rigid Bodies

This option will produce a *_RB.vzp file containing the raw capture data with the occluded ones replaced by those computed by the RB algorithm defined on the Target Association Editor panel.

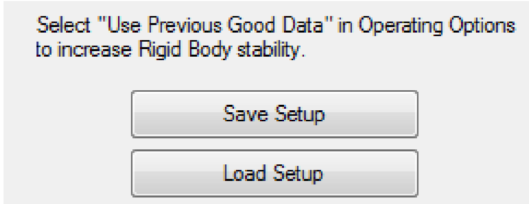
4.5.4 Exporting Filtered Data with RB

To export filtered data with rigid body(s):

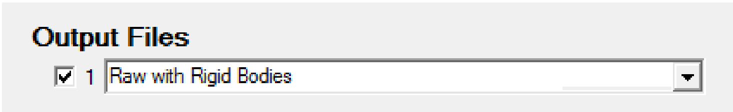
1/ Export the capture data as Filtered Data, with the desired filter(s) checked in the Filters (for Filtered Data) list, to produce a *_Filter.vzp file.

2/ Load the *_Filter.vzp file back into VZSoft. VZSoft will treat this data file exactly the same as a *_Raw.vzp file.

3/ Setup the desired rigid body(s) on the Target Association Editor, or load in a previously saved rigid body setup file.



4/ On the Export panel, select the 'Raw with Rigid Bodies' option for one of the Output Files to produce a *_RB.vzp file. This output file will now consist of filtered capture data with the defined rigid bodies.



4.5.5 Export Project / All / Take

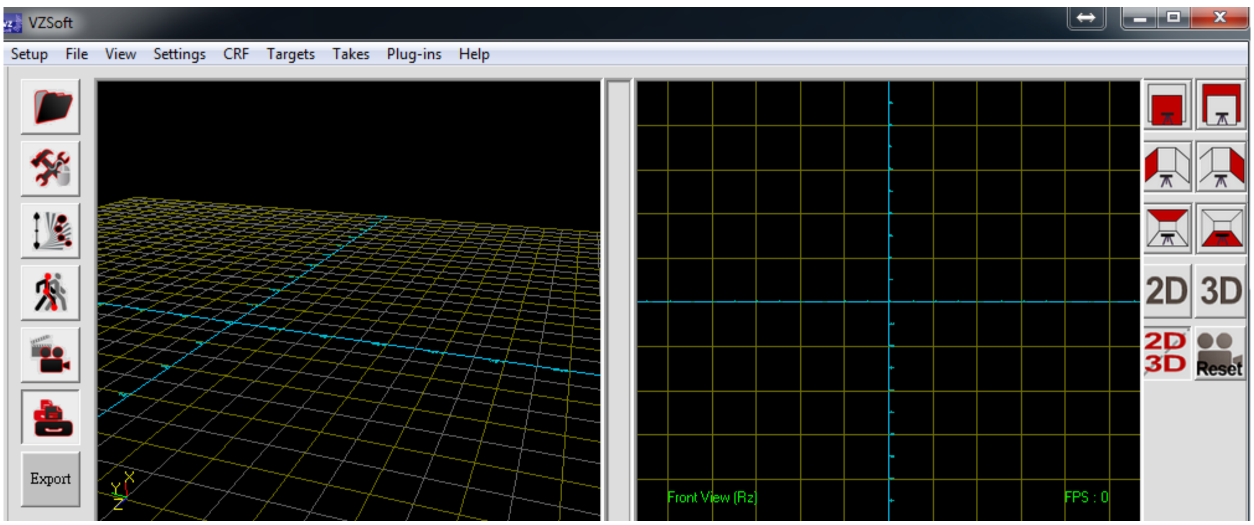
Export Project: Exports all takes as one single large file in the VZSoft format or Text format or Vertex format. Other formats do not allow saving multiple takes into one single file.

Export All: Exports all takes, producing one independent file for each take.

Export Take: Exports only the highlighted take(s).

4.6 PERSPECTIVE AND ORTHOGONAL GRAPHIC WINDOWS

These two windows will display the target positions just captured or of the take being replayed. The Perspective view display can be zoomed, translated and rotated, while the six Orthogonal view displays can each be zoomed and translated only. To zoom in or out, for both windows, hold down the **Ctrl key and drag up or down respectively**. To rotate the Perspective view or translate an Orthogonal view display, **simply left-click and drag the display**. To translate the Perspective display, **hold down Shift key, and drag the mouse**. A left mouse double-click on a display window will make the display go back to its initial state.



4.6.1 TARGET ID DISPLAY

The label of a target point shown in these windows will appear automatically when the cursor is brought close to the lower right corner of the data point.

4.6.2 CHANGE GRID PLANE

By default, the grid shown in the Perspective view window is attached to the YOZ plane. This can be changed. To change, first left-click on the window to highlight and make it current. Then press the "g" or "G" key to toggle the grid plane to be either the XOY, YOZ, ZOX plane, or to turn off the grid entirely.

4.6.3 EDITING DATA GRAPHICALLY

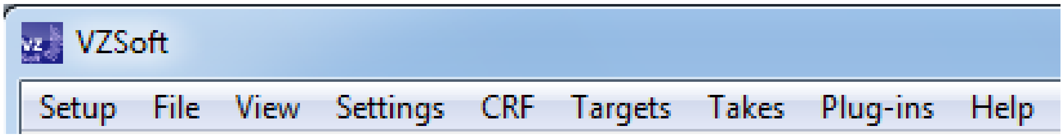
The 3D position of a target as displayed in the orthogonal views window can be edited graphically right on the window. To do this, first make the target label visible (see above). Then press the Shift key and drag the point to the desired new location. Release the mouse first, then the Shift key. A message will pop up. Answer the message to complete the edit.

Note: Releasing the Shift key first will cancel the edit operation!

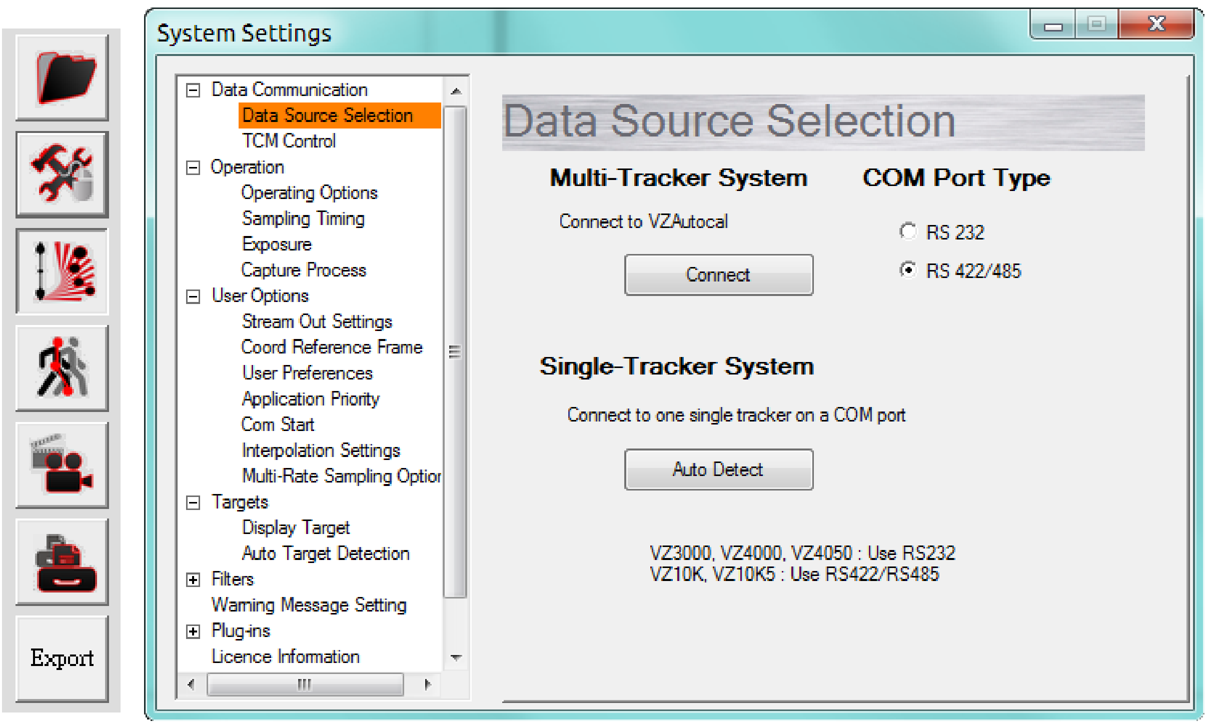
4.6.4 2D/3D VIEWS (VZSoft 3.x)

Clicking the 2D button will display the 2D window only. The 3D button enables the 3D display window only. The 2D/3D button brings back the 2D/3D dual view. The Reset Camera button will make the display go back to its initial state.

4.7 VZSOFT MENU BAR



VZSoft 3.x menu bar provides easy access to all the functions and settings available from both the left-side icon bar and the Settings Tab:



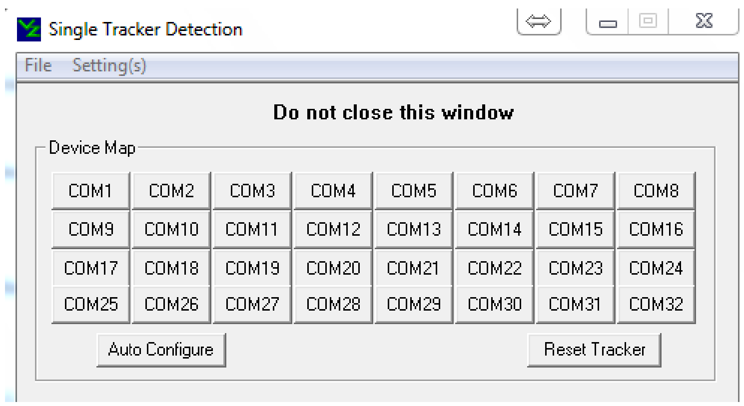
All of these functions are explained in full details in previous sections of this manual.

4.7.1 SETUP SUBMENU

Guided System Setup
Select Tracker Type
Detect a Single Tracker
Detect Multiple Trackers
Launch Target Auto Detection
Sampling Speed / Frame Rate
Restore VZSoft to Default Settings

The SETUP menu conveniently regroups the few important steps to start a motion capture rapidly:

1a) Detect a single tracker: launches the single-tracker detection window



Click Auto-Configure if your tracker is not being detected.

1b) Detect multiple trackers: VZSoft connects to VZAutocal software (multi-tracker automatic and continuous calibration software)

2 Launch target auto detection: VZSoft makes all markers flash and will determine the ID's for those visible to the tracker(s). The visible markers will have their corresponding IDs displayed in the Target Sequence Editor panel.

3 Sampling Speed / Frame Rate: Displays the Settings tab to adjust the sampling speed and the frame rate.

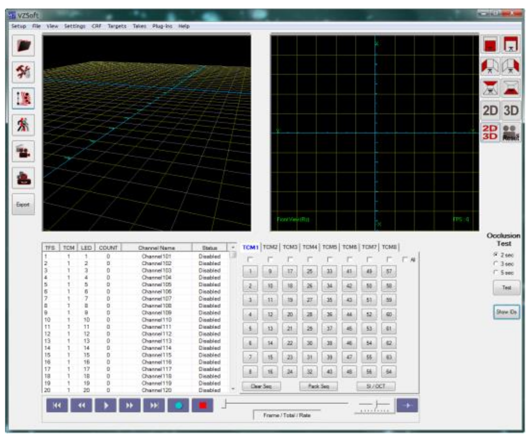
4 Restore VZSoft to default settings: restore all motion capture default settings.

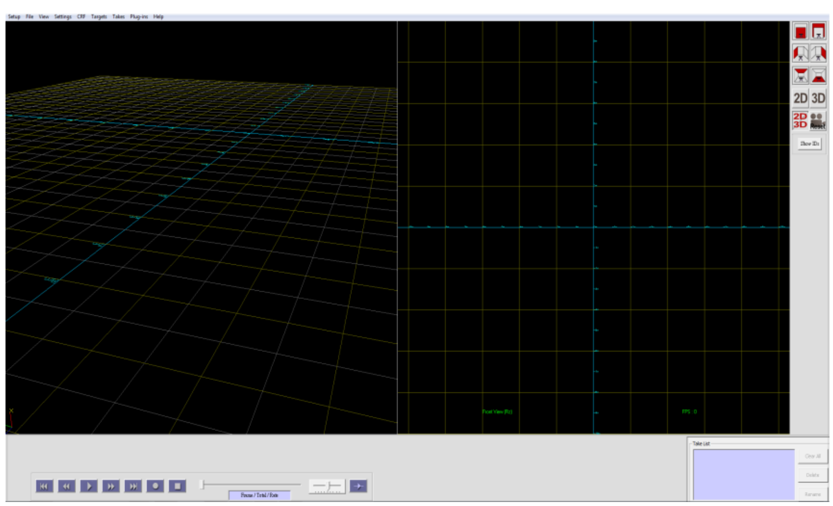
4.7.2 FILE SUBMENU

New Project	Starts a new project
Open Project	Opens an existing capture file (.vzp)
Save Take As…	Saves the selected take
Save Project As…	Saves the current project
Export	Opens the Data Export panel

4.7.3 VIEW SUBMENU

Compact View	The smallest display to operate VZSoft
Full Screen	VZSoft will fill the entire screen, with approx. half of the screen dedicated to the graphical window
Large View	VZSoft will fill the entire screen, with 9/10 of the screen dedicated to the graphical window





4.7.4 SETTINGS SUBMENU

Data Source Selection	Opens the COM port Type and Single/Multi Tracker Setup
TCM Control Module	Opens the TCM Tethered / Tetherless option panel
Operating Options	Opens the Operating Options panel
Sampling Timing	Opens the Sampling Timing panel
Exposure	Opens the Exposure Settings panel
Capture Process	Opens the Capture Process panel
Stream Out Settings	Opens the Stream Out Settings panel
User Preferences	Opens the User Preferences panel
Application Priority	Opens the Application Priority panel
COM Start	Opens the COM Start panel
Interpolation Settings	Opens the Interpolation Settings panel
Filters	Opens the Filters panel

4.7.5 CRF SUBMENU

CRF Setup	Opens the Coordinate Reference Frame Setup panel
Load CRF	Loads a Coordinate Reference Frame settings file
Save CRF	Saves a Coordinate Reference Frame settings file

4.7.6 TARGETS SUBMENU

Target Sequence Editor	Opens Target Sequence Editor panel
Target Association Editor	Opens Target Association Editor panel
Display Target	Opens Display Target panel
Target Auto Detection	Opens the Target Auto Detection panel

4.7.7 TAKES SUBMENU

Take List	Displays the Take List panel
Occlusion Report	Generates an Occlusion Report for the selected take

4.7.8 PLUG-INS SUBMENU

Displays the plug-ins panel with VZProbe and Tactile Command functions

4.7.9 HELP SUBMENU

VZSoft Manual	Opens the Visualeyez manual
About VZSoft	Displays the VZSoft splash screen with version number
Quick Start Guide	Opens the Quick Start Guide

4.8 DONGLE UPDATE

The license of VZSoft or the optional plug-in(s) may need to be renewed once in a while if it carries an expiry date on it. Normally you should receive an automatic notification regarding the renewal requirement and the procedures to renew a few weeks before the license expiry date. In case you did not receive such automatic notification from PTI, and the license software flashes a warning about the pending expiry on your screen, simply contact Phoenix Technologies Incorporated by the contact information provided on the PTI website:

http://www.ptiphoenix.com.
support@ptiphoenix.com

Note that it is possible to get a dongle with no expiry date (i.e., a permanent license) that does not need to be renewed periodically. However, there is a significant charge for replacing a lost dongle with a permanent license.

V. MULTI-TRACKER SYSTEM

A Multi-Tracker System consists of more than one Visualeyez trackers setup to operate together but output the captured target data as if only a single tracker is being applied. It can be used to capture target motions from more views than one and therefore reduces the possibility of target occlusion. The setup requires that the External Trigger (Ext Trig) Jacks on all sensors be connected in parallel. It also needs either the VZServer or the newly released optional VZAutoCal™ software for interfacing the multiple trackers with the VZSoft.

5.1 EXT TRIG CONNECTIONS

There are many ways to interconnect the Ext Trig jacks of multiple trackers together, in parallel, to serve as a multi-tracker system (see section Multi-Tracker System Connection via the Table of Contents for a standard set of procedures). Three key points to observe are:
1. Please use the supplied external trigger cables that came with the Visualeyez system;
2. Each cable branch must be terminated with a 'PTI Custom' coupler and terminator;
3. Up to two cable branches are allowed.

Appendix C shows a typical multi-tracker system cabling diagram. Please contact PTI for optional accessories available to extend the Ext Trig jack cabling requirements beyond the above limitations, if you need to.

CAUTION: Use of any hardware accessories, equipment, cables and/or connectors not supplied by PTI, with any PTI systems, may permanently damage the Visualeyez sensor(s) and void the warranties. Please consult with PTI before applying any such parts to any Visualeyez systems.

5.2 VZAUTOCAL (VZ4000, VZ4050, VZ10K/10K5 Trackers)

VZAutoCal™ provides the revolutionary 'automatic and adaptive configuration calibration' capabilities. The 'automatic calibration' capability eliminates all manual calibration work requirements of the operator. The 'adaptive calibration' capability continuously optimizes the calibration quality of a multi-tracker system throughout the motion capture session, and thus frees the user from any concern of calibration degradation due to any system hardware environmental instability over time. Therefore, while a regular optical motion capture system needs to go through a manual calibration procedure before every capture session and ensure that the system configuration does not get altered throughout the session, a Visualeyez multi-tracker system with VZAutoCal can simply start with the capture subject(s) jumping into the motion capture area.

5.3 SOFTWARE COMMUNICATION

The two essential software of a multi-tracker system, VZAutoCal and VZSoft, can be setup to operate the system and stream data to user applications in at least three ways. These will be explained using a two-tracker system and a power-demanding user application, MotionBuilder, as example. For more complete details on how to connect a multi-tracker system, please refer to Appendix C.

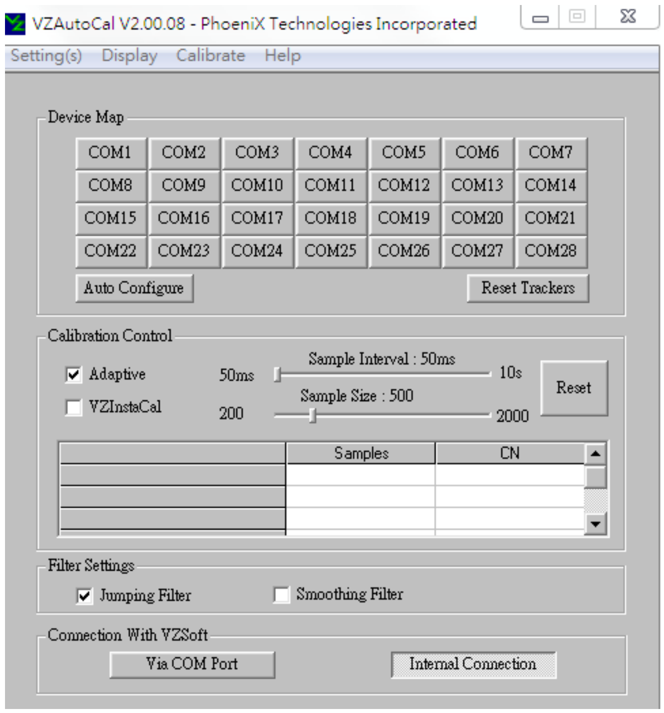
5.3.1 VZAUTOCAL-VZSOFT ON ONE COMPUTER

- See the provided Quick Start Guide to simply and quickly try out a motion capture.
- When using more than one tracker, VZAutoCal needs to be installed separately from VZSoft only if you are using VZSoft 2.9.
- If you are installing VZSoft 3.x, all required software including VZAutoCal is automatically installed within the VZSoft software.

a) Communicating with Trackers

After connecting and turning on all hardware and invoking all software (VZSoft and VZAutoCal), you should have a VZAutoCal and VZSoft installed and running on the same computer.

To control the trackers, VZAutoCal must first establish communication with them. This can be done by either manually selecting the COM ports that the trackers are connected to, or pressing the 'Auto Configure' button to let VZAutoCal find them automatically. In this case, when using two trackers, two ports should open and each displays an '-S-' to indicate that it is being treated as a slave tracker. Three connected trackers will show three ports, etc.

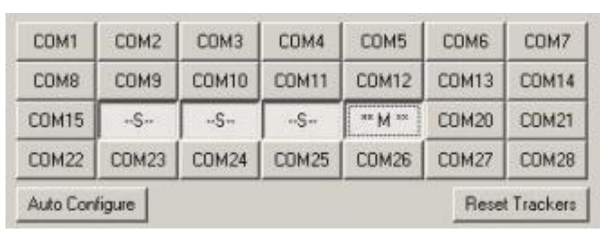


VZAUTOCAL standard settings (with no tracker detected yet)

b) Designating A Master Tracker

Before connecting the trigger cables to the EXT-TRIG jacks of the trackers, the physical ‘master tracker’ should have been decided already, because the way to connect the trigger cables depends on this designation (see Appendix C).

To indicate this particular tracker as the master to the VZAutoCal, temporarily turn off its power. Click the 'Auto Configure' button and observe which COM port became closed, that would be the port connected to the turned-off master. Turn the power for the master tracker back on, and click 'Auto Configure' once more. When its COM port opens up again, click the '-S-' symbol and it will change to become '-M-' to indicate that it is now the master.



VZAUTOCAL with 4 detected trackers, one of them is set as (M)aster

c) Select “Internal Connection”

By default, the “Internal Connection” button is pressed. This is used when VZSoft is running internally on the same computer. When VZSoft is running on another computer, the “Via COM Port” setting must be pressed to tell VZAutoCal to output its results through the “OUTPUT” COM port to the VZSoft.

When VZSoft is running on another computer, the “Via COM Port” setting must be pressed to tell VZAUTOCAL to output its results through the “OUTPUT” COM port to the VZSoft.

d) Setting up VZSoft

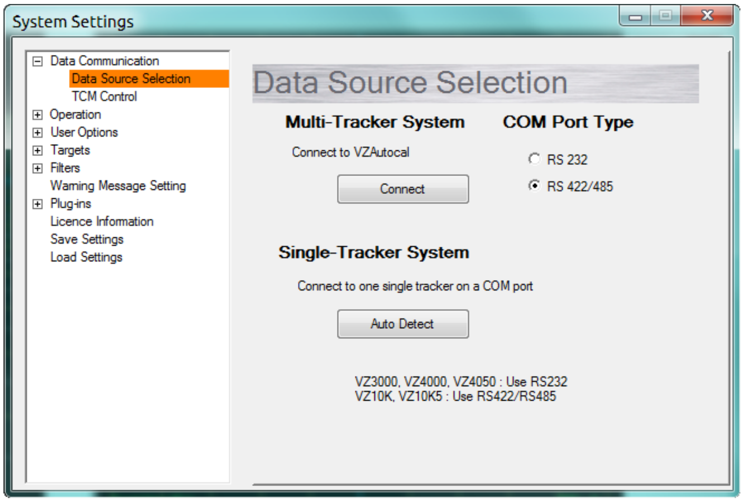
For VZSoft to control and receive results of the multi-tracker system, its “Data Source Selection” must be properly set. To do this, click on the “Settings” icon on the left side of the screen and select Data Communication/ Data Source selection. Two choices can be made here to setup communication between the VZSoft and VZAutoCal.

1. Select RS422/485 if you are using a VZ10k, VZ10k5 tracker.

2. For a multi-tracker system, press the Connect button to launch VZAUTOCAL. From there, click on the Auto Configure button to detect the trackers.

   For a single-tracker system, press the Auto Detect button to launch the single-tracker detection window. From there, click on the Auto Configure button to detect the tracker.

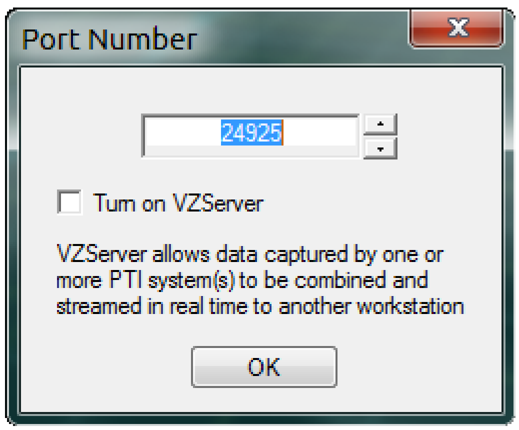
NOTE: Do not close the window when going back to VZSoft or the tracker(s) will no longer be detected.



5.3.2 USER APPLICATION ON A SEPARATE COMPUTER

When desirable to run a user application on a separate computer from the Visualeyez software, possibly with a long distance between the two computers, the optional VZServer add-on can be used.

This will allow a Visualeyez system to run independently and stream out data to a network HUB where it can be routed to as many other user application computers as needed. In fact more than one Visualeyez system outputs can be added to the data stream, resulting in data merging which is necessary for many applications, provided that no data are labeled in conflict to each other.



Please contact PTI for more information on this topic.

VI. 3D MOTION CAPTURE OPERATION

6.1 MARKER ATTACHMENT

Active motion capture system markers (normally LEDs) are small and can be activated individually to distinguish one from another. This makes them relatively highly accurate and easy to track in real-time, which are of great benefits to users. However, they must be powered, which normally means they must be connected by wires to a power source, unless the totally wireless SIKMarkers are used. Attaching a large number of such wired markers between various parts of particularly a live-subject and the TCM(s) can be a discouraging experience if some wire management skills are not patiently applied. Phoenix Technologies Inc. (PTI) has, to a large extent, alleviated this problem by supplying a two-piece bodysuit with pre-wired targets. This suit can be purchased by contacting PTI. For applications without a pre-wired bodysuit, the following are some recommendations for attaching markers on a live subject (assumed to be a person).

Suggested Procedures:

1. Carefully design the cable routes before routing.
2. Distribute cables via as few routes as possible, so that they can be bundled together easily.
3. Control targets for the upper and lower bodies with separate TCMs.
4. Use cables with about 100mm of slack to allow for stretching due to movements.
5. Avoid dangling cables to prevent catching and breaking them.
6. Use Velcro strips and pads for bundling and attaching bundled cables to clothing.
7. Use medical-grade double-sided tape for attaching cables and/or targets directly to skin.
8. For facial-expression capture, first route cables along the back of neck to the top of the subject’s head (or at least above ear-level) and support them there, by a head-band or strap if necessary. Then bring down the markers to attach to the desired facial locations. This reduces weights of the markers and cables on the face.

NOTE 1: See Appendices for suggested marker attachment locations for a full body motion capture.

NOTE 2: To prevent breakage, always handle the weakest part (the wires) of a cabled accessory first!

6.2 MOTION CAPTURE WITH VZSOFT

Operating a Visualeyez tracker via the VZSoft is relatively easy. Following are the typical procedures:

1. After properly connecting all necessary cables for the tracker and targets for the TCM, turn on the tracker power, then the TCM power.
2. From System Settings / Data Communication / Data Source Selection, invoke 'Auto Detect' to detect and connect the tracker to the serial COM port to which the tracker data cable is connected.
3. Set up other operating options on the System Settings / Operation / * panels as desired.
4. Press 'Record' (the green round button) on the Motion Capture and Playback Control bar to start capturing motion of the subject.
5. Monitor quality of the capture in real-time from the two graphic display windows, or record and replay the captured data on the Motion Capture panel. Press the Display Data Status button to display data status.

6.3 PLUG-IN INSTALLATION

VZSoft can export captured motion data into various 3D animation and scientific software: Motionbuilder™, 3DSMax™, Matlab™, Labview™, ROS…

Appropriate plugins need to be installed to establish links between VZSoft and these applications. Instructions for installing a plug-in are provided on the PTI Software CD.

Please contact PTI if you require additional information, at:

support@ptiphoenix.com

VII. 3D MOTION CAPTURE OPERATION

Technical specifications must be observed before any user supplied signal can be applied to a Visualeyez system. Otherwise permanent hardware damages may result which cannot be repaired under warranty terms. This chapter lists the important system technical specifications.

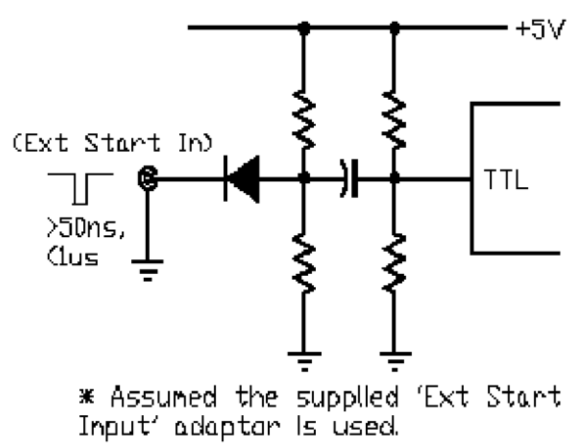
7.1 VZ10K TRACKER SPECIFICATIONS (NOMINAL)

Position Resolution	0.015mm at 1.2m distance
Nominal 3D Volume Accuracy	Depends on tracker model. <0.30mm ~ <0.65mm RMS (calibrated over ± 30° in pitch, ± 40° in yaw, 0.6m to 2.5m in distance)
Power Supply Adaptor Input	100-240 VAC, 50-60Hz
Tracker Power Input Requirements	+5VDC(+/-5%) @ 3~4A
Tracker Power Consumption	13W
Tracker Dimensions	10.2cm diameter X 115cm length
Tracker Bar Mass (VZ10K)	2.2kg
Ext Start Input	Normally high (+3~5V), negative-going, single pulse, 50ns~1us wide. RTL, TTL, or open-collector source only.

CAUTION:
CAUTIONS:

1. The Ext Start Input is for highly precise 'Standby' mode operation and internal development purposes only.
2. All user supplied signal input(s) must go through an optional 'Ext Start Input' adaptor to ensure safety to the tracker!
3. Warranty voids if the above and following specifications are not adhered to!

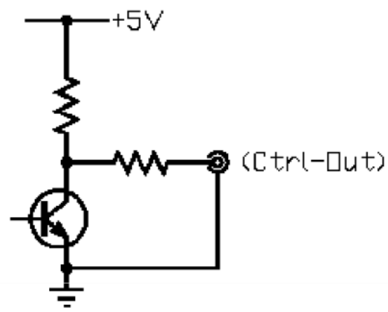
Ext Start Input' Model
(Assumes an optional 'Ext Start Input' adaptor is used.)
* Please contact PTI to purchase this adapter.



Ctrl-Out Output
(For TCM control purposes only.)

Normally high (~+4V), negative-going, data and control signals

Ctrl-Out Output Model
(For TCM control purposes only.)



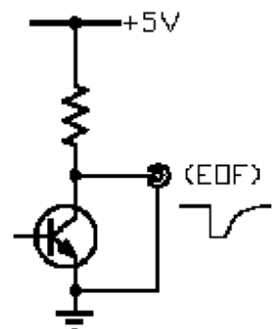
7.2 TRIPOD SPECIFICATIONS (CUSTOM PTI MODEL)

Dimensions	15.2cm diameter X 120.6cm length
Mass	8.0 kg
Maximum / Minimum Height	120 cm - 200 cm

7.3 TARGET CONTROL MODULE (TCM) SPECIFICATIONS

End-Of-Frame (EOF) Output (optional, for external equipment synchronization.)	Normally high (~+4V) negative-going pulse, 0.2us wide, RTL driver output

'End-Of-Frame Output' Model



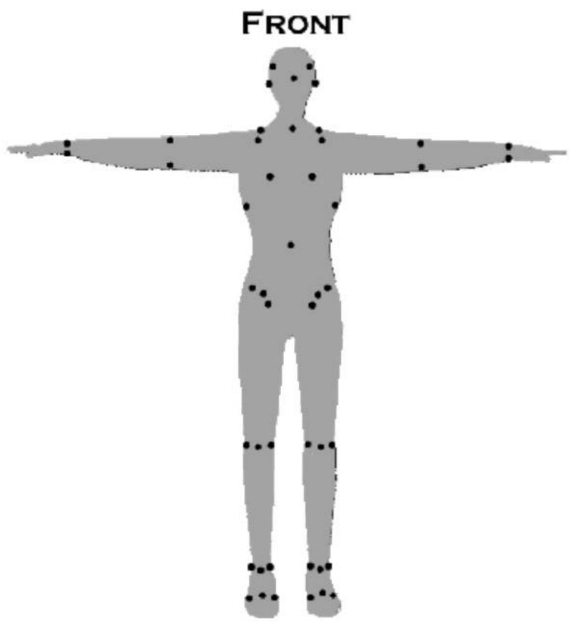
7.4 COM START SIGNAL SPECIFICATIONS

DSR (trigger input)	**RS422, 30~50ms wide (if pulse type trigger is selected)**
DTR (pulse output)	**30ms, RS422, normally-low active-high (can be monitored or used to blink an LED)**

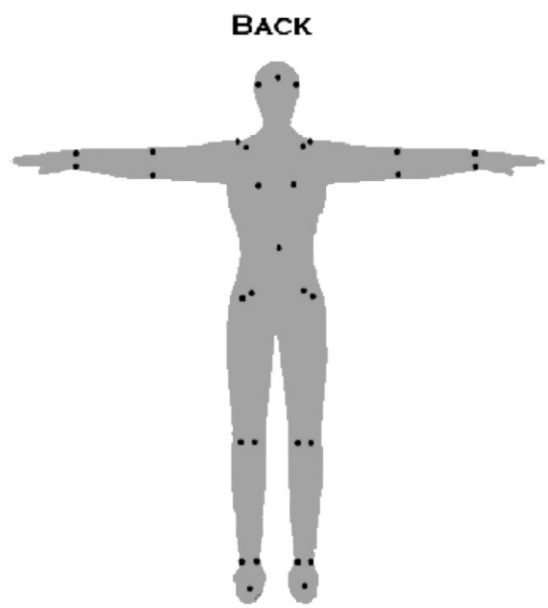
APPENDICES

A. SUGGESTED TARGET PLACEMENT FOR FULL-BODY MOCAP

B.1 Single Tracker System

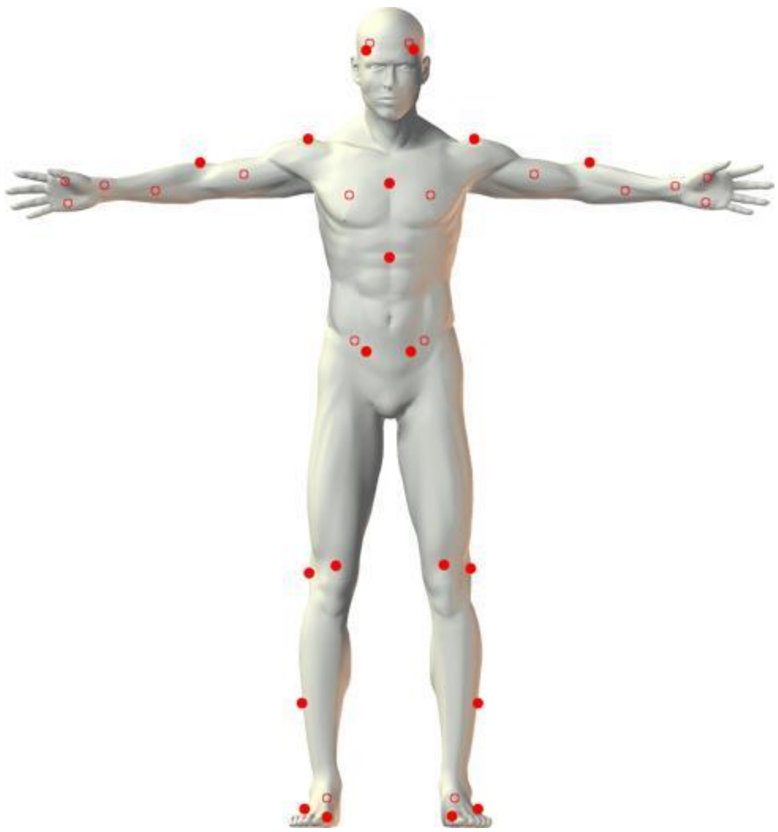


NOTE 1: Full body motion capture with a single tracker requires many markers and the use (and solid scientific understanding) of the so-called 'rigid- body' or 'optimal-pose' extrapolation function. Even then, the capture results may not be as good as those of a multi-tracker system due to the large amount of extrapolation required and the inaccuracy of the extrapolation due to inevitable problems alluded to in NOTE 2.

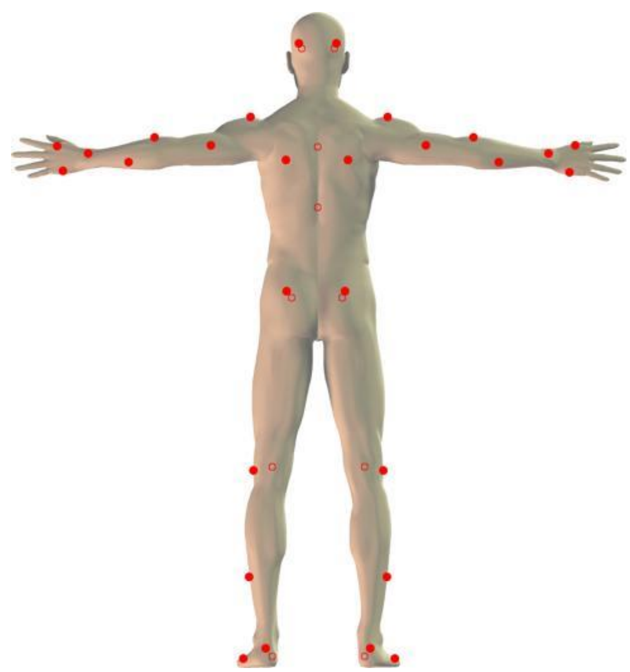


NOTE 2: LED placements on a body should be on stable surfaces such as bones around joints. Placement on muscles may cause markers to slide and result in inaccurate sensor readings. For example, muscle flexing may cause the markers to rise away from the bone.

B.3 Three or More Tracker Systems



Three or more trackers arranged around a subject can see all surfaces of a subject simultaneously. Therefore, significantly fewer markers are required to capture the subject's full body motion. The marker locations suggested on this page have been applied in commercial full body motion captures with good results. However, they may still not be appropriate for highly special motion captures. Users are advised to follow these suggestions with discretion.

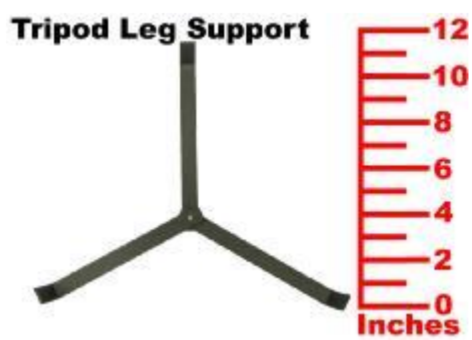


NOTE: Marker placements on a body should be on stable surfaces such as bones around joints whenever possible. Placement on muscles may cause targets to slide and results in inaccurate sensor readings. For example, muscle flexing may cause the targets to rise away from the bone. Similarly, loose bodysuit may cause markers to shift around during motion capture, yielding inaccurate results.

B. TRIPOD LEG SPREADER

The supplied PTI tripods must normally be kept spread out to prevent toppling. This can be accomplished with the supplied new simple Leg-Spreader(s). To apply a new leg-spreader:

- First set up the tripod so that the legs are opened at their maximum span.
- Look on the inside of the tripod legs and note the Velcro strips attached.
- Fan out the spreader fingers to roughly the 4-, 8- and 12-o'clock positions.
- Carefully insert the spreader between the tripod legs, with the fingers of the spreader pointing downwards.
- Position the fingers in line with the Velcro strips on the inside legs. Gently push the spreader up until the Velcro on each spreader finger is adhered firmly to the Velcro on the leg.
- Make adjustments if necessary to ensure that the tripod legs cannot be closed (collapsed) without removing the spreader.

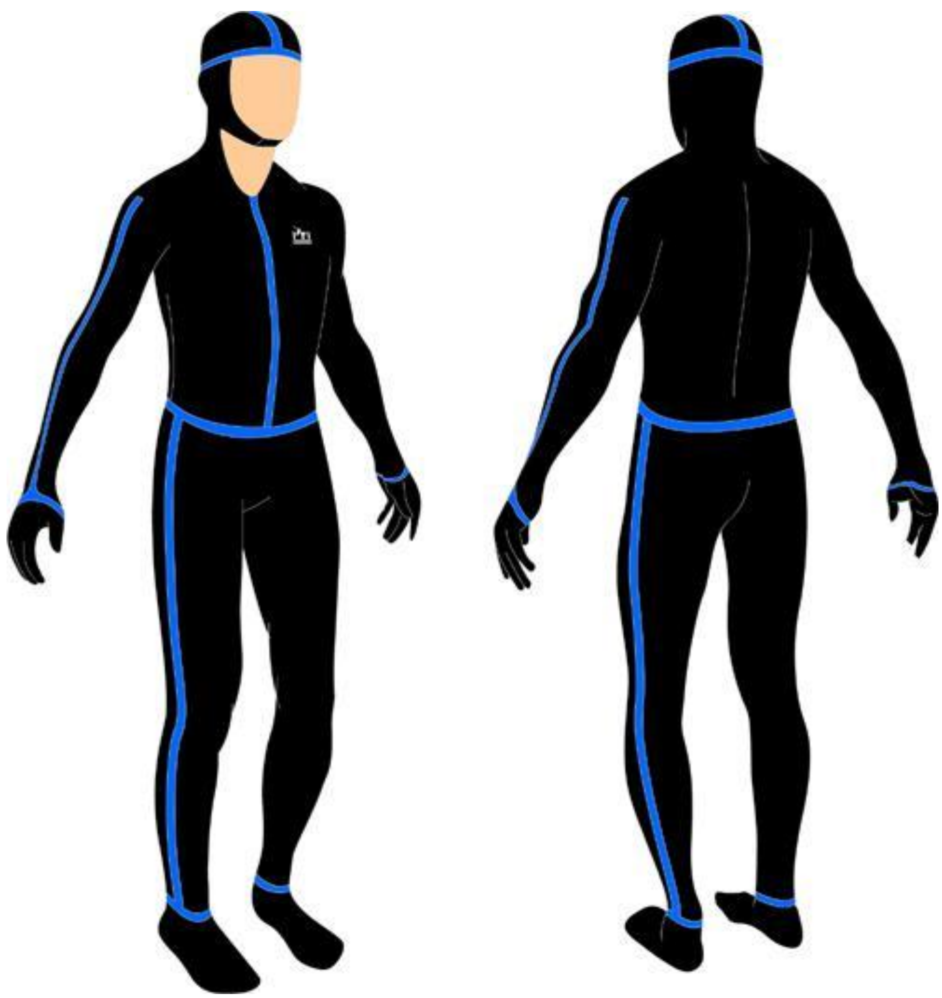


C. VZSUIT II USE AND CARE

The optional VZSuit II is a highly stretchable, fully Velcro-compatible, two-piece tight bodysuit. The top shirt comes with a zipper on the front, nets under the armpits, a hood and gloves. The gloves have openings to allow hands to slip out when necessary. The bottom pants come integrated with socks. Thus the complete suit is very good for not only full-body motion capture, but also finger captures.

Due to the stretchy fabrics used, this suit should never be subjected to high temperature during use or cleaning. Therefore, lightly wash or clean it with cold to at most lukewarm water only. Do not dry it in a dryer! Do not use dry-cleaning either!

Since the suit by itself is not costly any more, it is recommended to purchase spares to facilitate changing and cleaning.



When using standard markers with wires on the suit , cover the exposed wires with short (~ 5 cm long) Velcro stripes. Do not use long stripes as t hat would reduce the stretchability of the fabric. While single-sided Velcro is sufficient for covering the wires, double-sided stripes are recommended because they give better feel to the wearer, since the back-side of a double-sided Velcro is made of similar soft material (loops) as the suit fabric.

D. VZLASER DIGITIZATION PROBE

(IEC 60825-1 Class 3A Laser Product)

The optional VZLaser digitization probes are hand-held laser pointers each with a push-button switch. Two models of this product are available. The model for VZ3000 trackers yields visible lights, while the model for VZ4000 trackers yields nearly-invisible lights. Each is designed to plug into a TCM to operate like a LED marker, except with a switch for the user to turn it fully on for digitization or half-on for aiming.

When sampling frequency is set high enough (30~100Hz) and capture is activated, a VZLaser will turn on partially, allowing the user to see (with bare eyes for the visible-light model, or through a video camcorder for the near-invisible-light model) where it is pointing at and for focusing. When the switch is pushed, the laser will turn on fully whenever it receives a capture pulse from the TCM and for the duration of the pulse which is set by the Exposure and Extended Exposure settings.

This probe is for shining at an object to generate a strong enough reflection for the Visualeyez tracker(s) to digitize the 3D dimensions of the object. Since it is not based on contact, even a soft object such as fabric may be digitized, provided that its surface is 'diffusively reflective' enough.

The width of the pulses from the TCM can be varied via VZSoft, but must be kept at no longer than 200µs (Extended Exposure ≤ 1 for VZ3000, and ≤3 for VZ4000) wide to prevent damage.

For safety, before using this device, you **MUST READ the WARNING - Eye Safety, PRECAUTIONS, and LIMITED LIABILITY** sections of this user manual. The following are the device specifications.

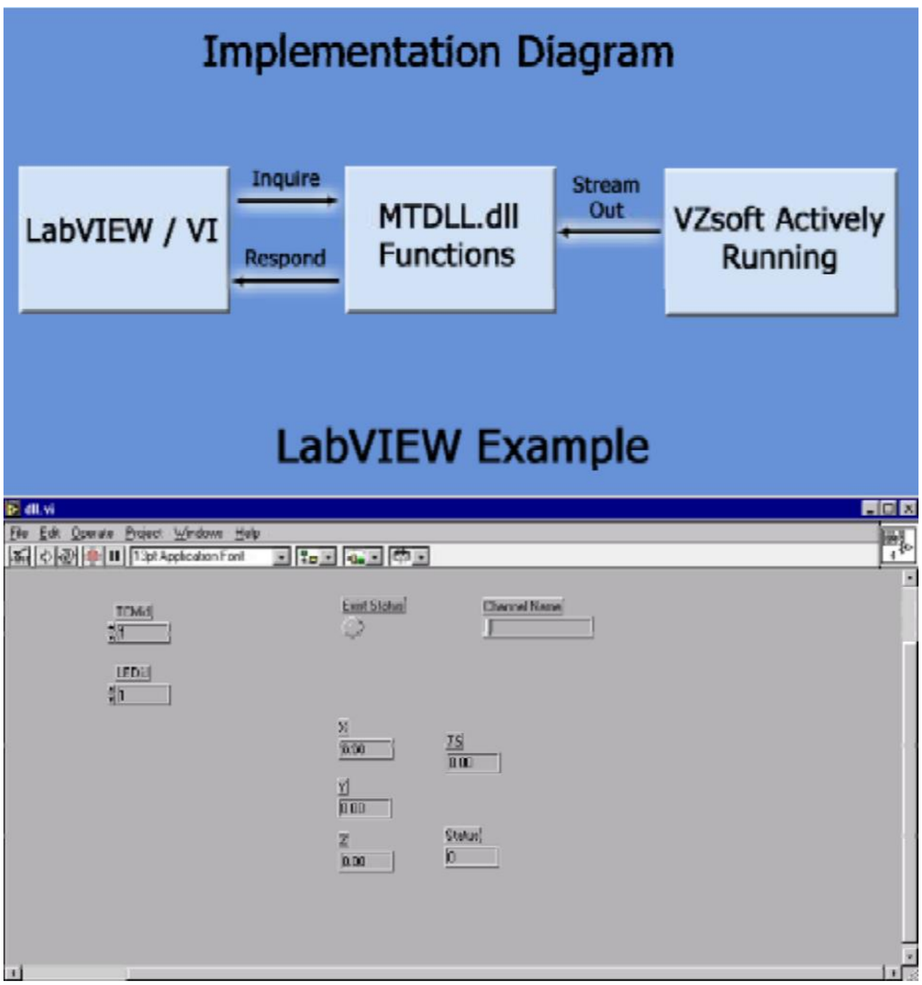
- Laser Diode Characteristics and Safe Operating Conditions:
- Conforms to DHHS regulations 21 CFR Chapter 1, Subchapter J Wavelength: 685nm (visible, bright red)
- Required Operating Pulse Width: 58 µs ~ 200µs (Extended Exposure ≤ 1 for VZ3000, and ≤3 for VZ4000)
- Peak instantaneous electrical input power: 0.72W (under above operating conditions)
- Average electrical input power: 0.05W (under above operating conditions)
- Laser Safety Risk: IEC 60825-1 Class 3a
- **WARNING: EYE AND SKIN HAZARD!**

Never look into the source, directly or specular.
Do not stare at the reflected point at close distance nor for a prolonged duration.

E. IMPORTING LIVE VZSOFT DATA INTO LABVIEW

The VZSoft 3D position data output stream can be accessed by third party applications via DLL communications. For National Instruments' LabView, the VI system contains embedded functions which can be used to call the VZSoft DLL functions and return with VZSoft output data. Through careful programming within the LabView/VI environment, a seamless real-time connection between VZSoft and LabView can be established and thus enabling real-time scientific analysis of motion data.

This appendix describes an example on how to program within LabView to acquire the VZSoft data and status values. The project name for this example is "dll.vi". In this example we display the VZSoft data, the status and the timestamp of a selected LED target on the LabView window in real-time, with the VZSoft replaying a previously captured take. Such data display is unnecessary in a practical application and is in fact not recommended in a user application since it consumes a significant amount of CPU time.



Note that it is not the intention of this appendix to teach the reader on how to LabView. The reader is referred to the LabView user's manual for any questions and answers regarding its use.

The following LabView diagram depicts the VZSoft- LabView interface operation. When VZSoft is capturing a take or replaying a previously recorded take, the active markers' position data and related information are continuously refreshed. The 'MTDLL.dll Functions' block consists of three functions provided by VZSoft for acquiring these data and information. These functions can be called by any application, including LabView.

Function 1:

_GetChannelStatus@12(int32 TCMid, int32 LEDid, int32 * status);

When this function is called with a **TCMid** (1 to 8) and a **LEDid** (1 to 64), whether the particular target (marker) specified by these parameters is active or not will be returned in status. A 1 returned in status indicates the specified marker is active, a 0 indicates that it is not active in the take.

This function allows a user to identify the presence or absence of a position marker without having to under- stand the physical meaning of a TCM or a LED. By calling this function once for each possible **TCMid** and **LEDid** combination, those position markers which are present ('active' in VZSoft) can be immediately identified. (Henceforth processing can be applied only to the active targets, thus saving processing time.)

Function 2:

_GetChannelName@12(int32 TCMid, int32 LEDid, cstr * name);

Call this function to return the name of the active marker specified by **TCMid** and **LEDid**. If the markers of the take being captured or replayed have been named by a professional system, then calling this function allows a user to identify the markers by their professional names, hence facilitate application development.

Function 3:

_GetSingleCoord@28(int32 TCMid, int32 LEDid, float *x, float *y, float *z, float *ts, float *sta);

Call this function to acquire the latest position data and related information of the active marker specified by **TCMid** and **LEDid**. The returned information are:

- x -- the x-coordinate of the marker's latest position.
- y -- the y-coordinate of the marker's latest position.
- z -- the z-coordinate of the marker's latest position.
- ts -- the timestamp (in microseconds) of the marker's latest position sample.
- sta -- the 'G'ood (1) or 'B'ad (0) status of the marker's latest position data.

Definitions of dll.vi Project Variables:

Number input controls -- TCMid: int32
LEDid: int32

Indicator output controls -- Exist status: Boolean ChannelName: String X: coordinate x
Y: coordinate y Z: coordinate z TS: time stamp
Status: good or bad status of the returned data

Meanings of other unnamed virtual variables should be clear by simply examining the project diagram of dll.vi.

F. IMPORTING VZSOFT PROJECT FILE DATA INTO LABVIEW

The LabVIEW plugin for reading VZP data is developed based on several win32.dll functions and is implemented as the included dynamic linkable library called VZPvi.dll. Following are the calling protocols of these functions.

Unless otherwise specified, all functions are called using the "C" convention. *int* is a 4 byte signed integer. *Float* is a 4 byte single precision value.

1. int GetTakeCount(char * vzpname);

Input:

vzpname - Pointer to the *.vzp VZSoft project filename string. The filename string must specify the full path to the *.vzp project file.

Return: The number of takes in the project file, or –1 if the file does not exist or is invalid.

2. int GetTakeName(char *vzpname, int takeindex, char * buf, int buflen);

Input:

vzpname - Pointer to the *.vzp project filename string. The filename string must specify the full path to the *.vzp project file.

takeindex - Sequential index, from 1 (not 0-based), of the take whose name will be returned.

buf - Pointer to the buffer containing the returned name of the take specified by *takeindex*. The buffer must be at least 50 bytes long.

buflen - Length of the buffer for containing the take name on return. It must be at least 50 and correspond to the actual length of *buf*.

Return: -1 if failure occurred, else success.

3. int GetTakeFrames(char * vzpname, int index);

Input:

vzpname - Pointer to the *.vzp project filename string. The filename string must specify the full path to the *.vzp project file.

index - Sequential index, from 1 (not 0-based), of the take of interest.

Return: The number of frames of data in the take specified by index or 1 if error occurred.

4. float GetTakeFrameRate(char * vzpname, int index);

Input:

vzpname -	Pointer to the *.vzp VZSoft project filename string. The filename string must specify the full path to the *.vzp project file.
Index -	Sequential index, starting from 1, of the take of interest in the *.vzp project file.

Return: Frame-rate at which the specified take was captured, in 4-byte single procession format.

5. int GetTakeMarkers(char * vzpname, int index);

Input:

vzpname -	Pointer to the *.vzp project filename string. The filename string must specify the full path to the *.vzp project file.
index -	Sequential index, starting from 1, of the take of interest in the *.vzp file.

Return: The total number of markers used when the specified take was captured.

6. int GetTakeFrameData(char * vzpname, int takeindex, int frameindex, int * statusbuf, int * tcmidbuf, int * ledidbuf, float * xbuf, float * ybuf, float * zbuf, float * timestampbuf);

Input:

vzpname -	Pointer to the *.vzp project filename string. The filename string must specify the full path to the *.vzp project file.
takeindex -	Sequential index of the take of interest in the *.vzp project file.
frameindex -	Sequential index of the frame of interest in the specified take. This index must be within the range of 1 ~ GetTakeFrames();
statusbuf -	Pointer to the returned column of status ('G', 'B' or 'L') of the data in the specified frame. The buffer must be at least as long as the number of markers returned by GetTakeMarkers(). ('G' = good, "B" = bad, "L" = low-level).
tcmidbuf -	Pointer to the returned column of TCMIDs of the data in the specified frame.
ledidbuf -	Pointer to the returned column of LEDIDs of the data in the specified frame.
xbuf -	Pointer to the returned column of x values of the 3D marker coordinates.
ybuf -	Pointer to the returned column of y values of the 3D marker coordinates.
zbuf -	Pointer to the returned column of z values of the 3D marker coordinates.
timestampbuf -	Pointer to the returned column of timestamps of the 3D marker coordinates.

Return: –1 if failure occurred, otherwise success.

7. int GetTakeMatrix(char * vzpname, int index, float * matrix)

Input:

vzpname - Pointer to the *.vzp project filename string. The filename string must specify the full path to the *.vzp project file.

index - Sequential index of the take of interest, starting from 1 (not 0-based).

matrix - Pointer to a 16 element array for returning the 4x4 D-H coordinate reference frame transformation matrix of the specified take. The 16 elements of the D-H matrix will be returned in the order of R(ow)1C(olumn)1, R1C2, R1C3, R1C4, R2C1 …etc.

Return: 1 if success, -1 if the *.vzp file does not exist or is invalid, -2 if the specified take does not exist.

Example:

The included LabView subVI, loadvzp.vi, simply calls the above PTI-LabVIEW plugin functions to generate a 3 dimensional data array. The individual data value within this array can be addressed by the three indexes (frame-index, marker-index, data-index). Their ranges and definitions are:

frame-index - From 0 to (GetTakeFrames() - 1).

marker-index - From 0 to (GetTakeMarker() – 1).

data-index -

0 - marker data status (‘G’=good, ‘B’=bad, ‘L’=low-level signal)
1 - marker TCMID
2 - marker LEDID
3 - x coordinate of the marker position
4 - y coordinate of the marker position
5 - z coordinate of the marker position
6 - timestamp at which the above marker position was captured

The subVI also provides the capture frame-rate, the total number of markers enabled during the capture, and the total number of data frames captured. It requires an input to specify the take-index. That index should be within 1 and GetTakeCount().

G. REAL-TIME DATA ACQUISITION IN MATLAB

Visualeyez™   Software Setup For Real-Time Acquisition of the Captured Data in MatLab™

Due to the simplicity of setting up this software package, no automatic installation program is needed. The idea of the installation is to copy four files to a subdirectory within Matlab's library functions search path. To install, just follow the following few steps.

1. Copy the VZMatlab.zip and the Readme.doc files to one of your favorite directories for storage.

2. Unzip VZMatlab.zip within the same directory. This should yield four (4) files:
    nVzgetnam.dll
    nVzgetnam.m n
    Vzgetdat.dll n
    Vzgetdat.ml n
    Readme.doc

3. Locate the directory under which your Matlab software is installed. (Use the "Find/Search" function under the Microsoft Windows Start Menu if necessary.)

4. Under the Matlab directory, there should be a "*\MATLAB\toolbox\local" subdirectory.

5. Copy the four files unzippd in step 2 above, and paste them into the "*\MATLAB\toolbox\local" directory.

6. Run Matlab.

7. In the Matlab window, enter 'help vzgetnam' and 'help vzgetdat' to learn how to use these two VZMatlab interface functions.

8. Have fun analyzing the real-time captured motion data in MATLAB.

H. DATA PROCESSING IN MATLAB

MATLAB - VZP Functions

These functions let you access and manipulate Phoenix Technologies' motion capture project (VZP) files from within MATLAB.

These functions are packaged within the 16 files below. To install, simply copy these files into your \\MatlabRxx\toolbox\Local folder then restart Matlab to use them.

Vzpgetframedata.dll,	Vzpgetframedata.m
Vzpgetmarkerid.dll,	Vzpgetmarkerid.m
Vzpgetmarkername.dll,	Vzpgetmarkername.m
Vzpgettakecount.dll,	Vzpgettakecount.m
Vzpgettakefremes.dll,	Vzpgettakefremes.m
Vzpgettakemarkers.dll,	Vzpgettakemarkers.m
Vzpgettakeframerate.dll,	Vzpgettakeframerate.m
Vzpgettakecrf.dll,	Vzpgettakecrf.m

The *.dll files constitute the function body and *.m files are the help files.
The *.dll files ar replaced with *.mex32 files for latest versions of MatLab.

Function Descriptions

1. [data] = VZPGETTAKECOUNT(*'Filename'*)
Filename is the name of the VZP file together with its full path. This function returns the number of takes in the VZP project file.

2. [data] = VZPGETTAKEFRAMES(*'Filename', TakeIndex*)
Returns the number of frames within the take indexed by *TakeIndex* in the VZP file specified by *Filename*.
TakeIndex is 0 based, where 0 is the first take in the file. *Filename* must include the full path of the file.

3. [data] = VZPGETTAKEMARKERS(*'Filename', TakeIndex*)
Returns the number of enabled markers within the take indexed by *TakeIndex* contained in the VZP project specified by *Filename*. The *TakeIndex* is 0 based. The *Filename* must include the full path.

4. [name] = VZPGETMARKERNAME(*'Filename', TakeIndex, MarkerIndex*)
Returns the marker name in string format. *Filename* must include the full path. *TakeIndex* is the 0 based index of the take from which the marker name is being retrieved. *MarkerIndex* is the 0

based enabled marker index.

5. [data] = VZPGETMARKERID(*'Filename', TakeIndex, MarkerIndex*)
ReturnstheTCMID and the LEDID of the specified marker. *Filename* is the VZP project file name with its full path. *TakeIndex* is the 0 based index of the take from which the marker identification labels are being retrieved. *MarkerIndex* is the 0 based enabled marker index.

6. [data] = VZPGETFRAMEDATA(*'Filename', TakeIndex, FrameIndex*)
Returns a N x 7 matrix that contains a whole frame of VZP data in a take. The seven columns of the returned data frame correspond to [TCMID LEDID X Y Z TIMESTAMP STATUS]. The combination (TCMID, LEDID) identifies a marker. X, Y, and Z, are the 3 coordinate values of the captured marker 3D position. TIMESTAMP is the internal tracker time (in microseconds) the data is captured. STATUS is the condition of the captured data, where '1' means a good data, '0' means a bad data, and '–1' means the data quality is uncertain. *Filename* is the VZP project file name with its full directory path. *TakeIndex* is the 0 based index of the take within the project file being accessed. *FrameIndex* is the 0 based captured frame index. To determine the maximum frame number within a take, use *vzpgettakeframes*() function to get the frame count in the take.

7. [data] = VZPGETTAKEFRAMERATE(*'Filename', TakeIndex*)
Returns the frame rate of the specified take when it was captured. *Filename* is the VZP project file name with its full directory path. *TakeIndex* is the 0 based index of the take from which the capture frame rate is being retrieved.

8. [data] = VZPGETTAKECRF*('Filename', TakeIndex*)
Returns the 4 x 4 transformation matrix or CRF (Coordinate Reference Frame, in the 'DH' convention) of the take indexed by the parameter *TakeIndex* contained in the VZP project specified by *Filename*. *TakeIndex* is a 0 based index, where 0 is the first take in the file. *Filename* must include the full directory path of the VZP file being accessed.

The returned CRF is in the format:
a11 a12 a13 a14
a21 a22 a23 a24
a31 a32 a33 a34
0 0 0 1

To transform from point (x1, y1, z1) to point (x2, y2, z2)
x2 = a11*x1 + a12*y1 + a13*z1 + a14
y2 = a21*x1 + a22*y1 + a23*z1 + a24
z2 = a31*x1 + a32*y1 + a33*z1 + a34.