

## TECH NOTE :: Wireless Cellular Network Integration of QuantumX

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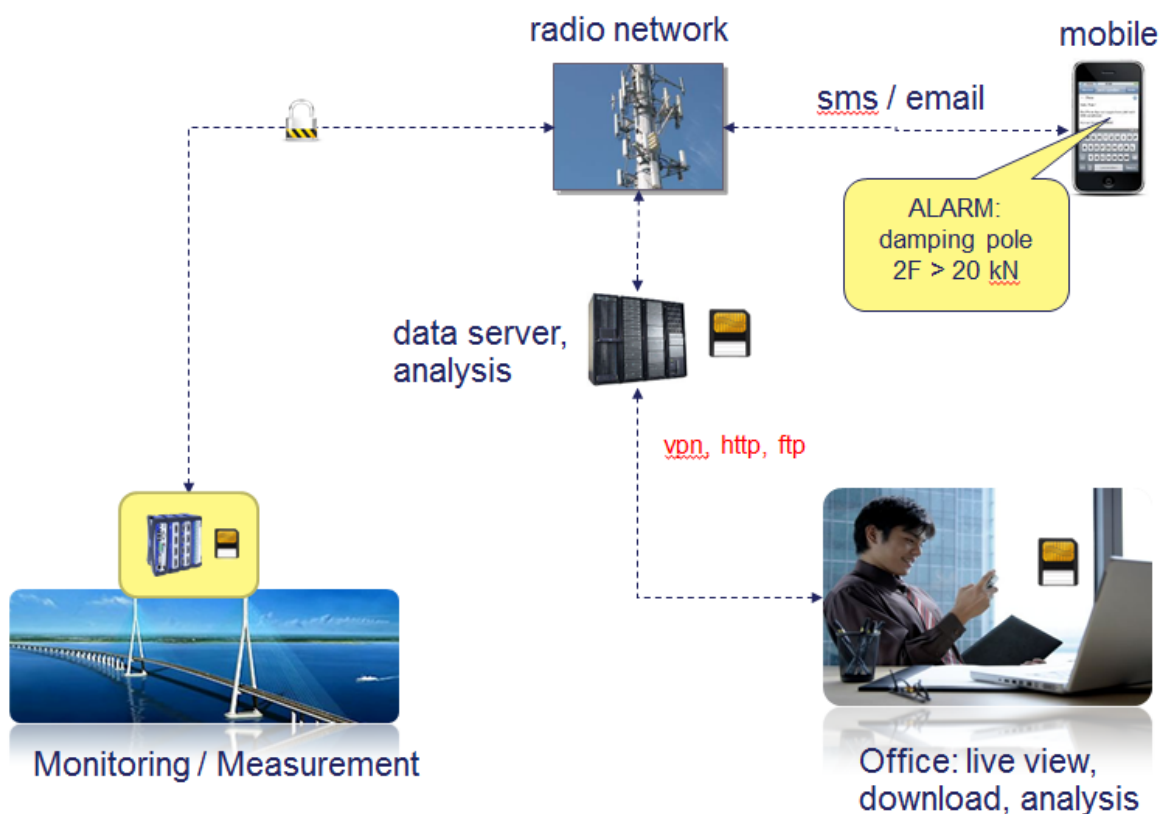
Status: public

### Abstract

The benefits of in field data recording, analysis and its remote access from all over the world is clear – you can spend your time with something else, perhaps under palms on the beach as your “HBM Monitoring Solution” will let you know if something interesting happens and pushes the data automatically to your data server accessible from all over the world.

The benefits in a nutshell:

- Time and cost reduction – no need to drive on-site getting access to data or overall condition
- Simultaneous engineering – data analysis on-site, automatically on central server or in office
- Simultaneous monitoring – of several different monitoring sites from the office



## Intro

The demand for remotely accessible data acquisition systems is increasing in a wide range of applications and its pushed by technology, available infrastructure.

Getting field data with real loads is a key factor for many industries to improve

- Product development: automobile, commercial vehicle (truck, bus, trains, mining, agriculture, forestry, construction, logistics, ...) and military
- Maintenance: infrastructure (bridges in civil engineering, power grid in energy, railway tracks), machines (injection molding, turning, milling, ...)

Especially in vehicle testing this is a way to handle many new variants with fewer engineers. Finding issues or faults by constantly monitoring load, user activity, electronics, ambient condition and many more factors improves service quality and customer satisfactory.

Because of so many application types all monitoring projects at HBM in the recent years have been different in the following aspects:

- mobile short term testing of vehicle(s) and machines
- stationary long-term unattended load monitoring of large scale structures (pipeline, bridge, railway, ...) or machines
- number and type of measurement spots, transducers and sensor technologies
- different ambient environment and weather conditions
- type of possible network integration (LAN, WLAN, GSM, UMTS, LTE, ...)
- data processing and handling (decentralized or centralized data processing, web operation, backup, ...)
- data security

Thus, a flexible data acquisition or overall solution and an experienced partner are key factors in successfully setting up this kind of projects and getting the most out of it.

HBM enjoys a global reputation for state-of-the-art test & measurement solutions providing a "seamless measurement chain" – from transducers for torque, rotational speed, force, pressure, strain, displacement, to data acquisition systems and powerful software packages. In general HBM offers a wide range of products and services dedicated to monitoring and diagnosis of structures through measurement of geometry, forces, dynamic behavior and environment. Even environmental influences can be measured by integrating weather stations, sensors evaluating earthquakes or cameras noticing traffic or other events.

QuantumX is a modular distributable data acquisition solution from HBM for measurement and testing, solving demanding tasks for quicker innovation and higher value in service and maintenance. The data acquisition modules offer highly accurate inputs acquiring physical quantities in a wide field of mechanical, thermal, hydraulics, electrical and electronic with data rates from 0.1 to 100 kS/sec per channel. QuantumX acquires all kind of sensors and transducers measuring force, strain, torque, pressure, temperature, displacement, speed, position, acceleration, inclination, flow, voltage, current and many more. QuantumX offers superb A/D inputs supporting bridge inputs for strain gages, piezo resistive or inductive transducers, IEPE, LVDT, PT100/PT1000, thermocouple, voltage, current and many more. Also highly accurate digital timer based pulse and frequency inputs or absolute encoders (SSI) can be acquired in parallel. Digital signals from bus protocols like CAN, CCP, xCP can be acquired time synchronous to all inputs. All modules can be freely scaled and offer Ethernet connection. In some applications additional ambient information need to be acquired. Examples are picture or video stream (camera); position, movement or time information by GPS or GLONASS satellite sensor; telemetry or noise and acoustics (microphone) or weather. The HBM software *catman* can acquire all this necessary inputs, visualize its data, react, analyse it, reduce it, automate it and report about your monitoring project – everything with one software solution, easy-to-use.

QuantumX Data Recorder is the ideal tool for your monitoring applications as it combines all of the above functionality. Its software *catman* is responsible for system and channel parameterization, visualization, online calculation, statistics (min, max, mean), intelligent trigger, strain gage rosette calculation, thermal compensation, data classification (time-at-

level, Rainflow) or frequency analysis. The powerful integrated alarming tool is easy to use and brings a wide range of functionality for monitoring application. All signals in time or frequency domain, real or calculated can be evaluated and set as alarm. An alarm can activate a digital output which can work as a local reaction, can send an email or sms with working as warning or alarm report including values and graphics, or generate an entry into a log file.

The main focus of this TECH NOTE is how to integrate and to get access to a remotely placed data recorder.

## Network Integration

The QuantumX Data Recorder offers an Ethernet interface and is working with standard TCP/IP protocol which offers many ways to integrate into all kind of networks.

In the simplest way we have a direct integration into a “private” company network (LAN) by just linking the unit to a server or router. This can be done in a wireless way as well by using a WLAN gateway. There are several products available in the market. Our partner here is N-TRON offering even time sync mechanisms.

Integrating data recorders to the internet via a mobile or cellular network offering data transfer. In most of the cases this is a public service offered by a telecom company and an elegant way of using an existing network infrastructure.

The tasks can vary here from:

- Remotely accessing the data recorder from office and via internet for re-parameterization, status check, data download
  - via internet browser
  - via Team Viewer session
  - Microsoft Remote Access
- Automatic data transfer
  - to a dedicated data server by FTP mechanisms (cloud)

Several questions come up when thinking about this type of commercial integration.

What network type is available on-site and what offers the best price performance ratio?

- GPRS, EDGE, UMTS, HSDPA or LTE

What amount of data needs to be transferred, when and in what package size?

- All data, only result, status or report
- And thus what type of contract is the best (flat rate), several countries (roaming), ...

What is necessary in terms of security?

- virtual private network (VPN) building up a private network

Security is a hot topic discussed in terms of “Internet-of-Things (IoT)”, “Industry 4.0”, “Smart Manufacturing Leadership Coalition (SMLC)” or “The Industrial Internet” or in a wider range “Big Data”.

On a global scale we always recommend a local solution provider with HBM supporting.

## Mobile Network Gateways

There are many “Cellular Routers” or gateways available and the market is rapidly changing. Basically it is a dial-up network integration like a cell phone.

So far the theory and everyone who tried to use mobile phones in remote locations far away from urban regions has experience how difficult it is to get a good connection and a good data throughput. Therefore it is important that a remote access or network integration can handle low performance or even interrupts in connection.

Best practise tip: go to the place where you want to install the cellular router and try to watch a video from the cloud live. How is the performance? Do the same for mobile data acquisition.

HBM recommends the following cellular routers for mobile network connection (DSL or WAN)

- LUCOM VPN Mobile Network Router UR5i v2
- WeloTec VPN Mobile Network Router TK704U

#### LUCOM VPN Mobile Network Router *UR5i v2*



##### Interfaces

- 3 x Ethernet 10/100
- 2 x SIM card slots
- 1 x UMTS/HSPA+
- 2nd optional SIM port if data limit is reached or for roaming issues

##### Functional Description

- Maximum download speed 3.6 Mbit/s, upload 384 Kb/s
- Supports VPN for secure connection (IPsec, X.509, OpenVPN or L2TP)
- status monitoring and control via SMS
- VRRP, DHCP, NAT, NAT-T, DynDNS, NTP, GRE, SSH, PPPoE Bridge
- SNMP to perform diagnostics of selected functions
- Web server configuration
- SMS control of selected functions
- FTP server, option to create user applications

##### Environmental

- temperature range from -30°C to +60°C

On a project base we integrated the LUCOM UR5i into QuantumX housing.



#### WeloTec VPN Mobile Network Router *TK704U*



##### Interfaces

- 4 x Ethernet 10/100
- 1 x SIM card slot
- 1 x UMTS/HSPA+
- 2nd optional SIM port if data limit is reached or for roaming issues

### Functional Description

- Network features: DHCP, SSH, NTP and many more
- Huawei EM770W, HSUPA 850 / 900 / 1800 / 1900 / 2100 MHz Quad Band
- Maximum download speed 7,2 Mbit/s, upload 5,76 Mb/s
- Authentication: CHAP, PAP, MS-CHAP / MS-CHAP2
- APN Functions: APN (Access Point Name), VPDN (Virutal Private Dialup Network, operators IP VPN)
- Dial on demand: Activated by Call / SMS / Local Data Flow
- Always Online: PPP LCP and ICMP keep alive for link inspection
- Web browser based configuration
- Watchdog (alive)

## Environmental

- temperature range from -25°C to +70°C
- IP30
- 12 – 48 V DC Supply Voltage / 300 mA@12 V

On a project base we integrated the WeloTecs TK704U into QuantumX housing.



The default IP Address of this Router is 192.168.2.1. For setup you just connect to that interface with your web browser as described in the User Manual. Here we just point to the main important settings that need to be considered when using this router. The router needs to be configured if the QuantumX Data Recorder CX22 needs to be accessed directly from anywhere in the internet. This is only possible with a public IP. The mobile network provider needs to offer this service. To use the UMTS router a special data rate and SIM card is necessary. It is not possible to use a standard mobile phone SIM card even if a data transfer rate is booked on the mobile phone.

The following settings are an Example configuration of the router, to be able to access the Web Server on the CX22. Other configurations are possible; this example should just point to the most important properties.

System	Network	Services	Firewall	QoS	VPN	Tools	Status
<b>Admin Access</b>							
Enable	Service Type	Service Port	Local access	Remote access	Allowed addresses from WAN (Optional)	Description	
<input checked="" type="checkbox"/>	HTTP	8010	<input checked="" type="checkbox"/>	<input type="checkbox"/>			
<input type="checkbox"/>	HTTPS	443	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			
<input checked="" type="checkbox"/>	TELNET	23	<input checked="" type="checkbox"/>	<input type="checkbox"/>			
<input type="checkbox"/>	SSHD	22	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			
<input checked="" type="checkbox"/>	Console						
<b>User Authentication</b>							
Authentication Type		Local					

It is recommended to change the service port of the router to 8010. After that change you have to use the routers IP address and the port to open the Web Interface. For example 192.168.2.1:8010.

Now configure the dialup parameters:

System	Network	Services	Firewall	QoS	VPN	Tools	Status
<b>Dialup</b>							
Enable	<input checked="" type="checkbox"/>						
Time schedule	ALL Schedule Management						
SHARED	<input checked="" type="checkbox"/>						
Network Provider (ISP)	Custom Manage						
APN	internet.t-d1.de						
Access Number	*99#						
Username	t-mobile						
Password	●●						
Network Select Type	Auto						
Band	ALL						
Static IP	<input type="checkbox"/>						
Connection Mode	Always Online						
Redial Interval	30 Seconds						

**Show Advanced Options** ☒

Initial Commands

PIN Code

RSSI Poll Interval  Seconds

Dial Timeout  Seconds

MTU

MRU

TX Queue Length

Authentication Type

Enable IP head compression ☒

Use default asynmap ☐

Use Peer DNS ☒

Link Detection Interval  Seconds(0: disable)

Link Detection Max Retries

Debug ☐

The important setting here is the MTU and the MRU size which is recommended to be changed to 1492 usually. If there are issues with the network access it might be necessary to setup this parameter manually. Please enter all other relevant parameters you got from your provider:

- Access Point Name (APN)
- Access Number
- Username and Password
- PIN of your SIM card

Instead of the Dial Up connection it is also possible to setup the router with e.g. a DSL.

Now setup LAN:

System	Network	Services	Firewall	QoS	VPN	Tools	Status
<b>LAN</b>							
MAC Address	<input type="text" value="00:04:25:00:83:7A"/>		<input type="button" value="Default"/>				
IP Address	<input type="text" value="192.168.2.1"/>						
Netmask	<input type="text" value="255.255.255.0"/>						
MTU	<input type="text" value="Manual"/>		<input type="text" value="1468"/>				
Detection host	<input type="text" value="0.0.0.0"/>						
WOL MAC Address	<input type="text"/>		<input type="button" value="Device List"/>				

And DHCP settings:

System	Network	Services	Firewall	QoS	VPN	Tools	Status
<b>DHCP Service</b>							
Enable DHCP	<input checked="" type="checkbox"/>						
IP Pool Starting Address	<input type="text" value="192.168.2.101"/>						
IP Pool Ending Address	<input type="text" value="192.168.2.199"/>						
Lease	<input type="text" value="60"/> Minutes						
DNS	<input type="text" value="192.168.2.1"/> <a href="#">Edit</a>						
Windows Name Server (WINS)	<input type="text" value="0.0.0.0"/>						

Port Mapping for Web Server Access:

System	Network	Services	Firewall	QoS	VPN	Tools	Status	
<b>Port Mapping</b>								
Enable	Proto	Source	Service Port	Internal Address	Internal Port	Log	External Address (Optional)	Description
Yes	TCP	0.0.0.0/0	80	192.168.2.2	80	No		
<input checked="" type="checkbox"/>	TCP	<input type="text" value="0.0.0.0/0"/>	<input type="text" value="8080"/>	<input type="text" value=""/>	<input type="text" value="8080"/>	<input type="checkbox"/>	<input type="text" value=""/>	<input type="text" value=""/>
<a href="#">Add</a>								

In this example we assume, that the QuantumX Data Recorder CX22 has been assigned a fixed IP address. That is necessary to be able to use Port Mapping and access the unit through a public IP over the internet.

### Remote Access

If network connection is done and you are able to remotely access the recorder the following requirements need to be solved:

- How do I get full control over the recorder and I am able to work with the unit in the same way I would do if it would be installed next to my desk?
- How do I setup a secure, robust and efficient transfer of my measured data to my own PC or server
- How can I share this access with others with different user rights in the way “just watch - don’t touch”

These requirements can be addressed using the following components which have been tested in a reliable way. Other tools might also work in this case. For each component a thorough testing is necessary to make sure once the device is in a remote location the system is working in a proper way.

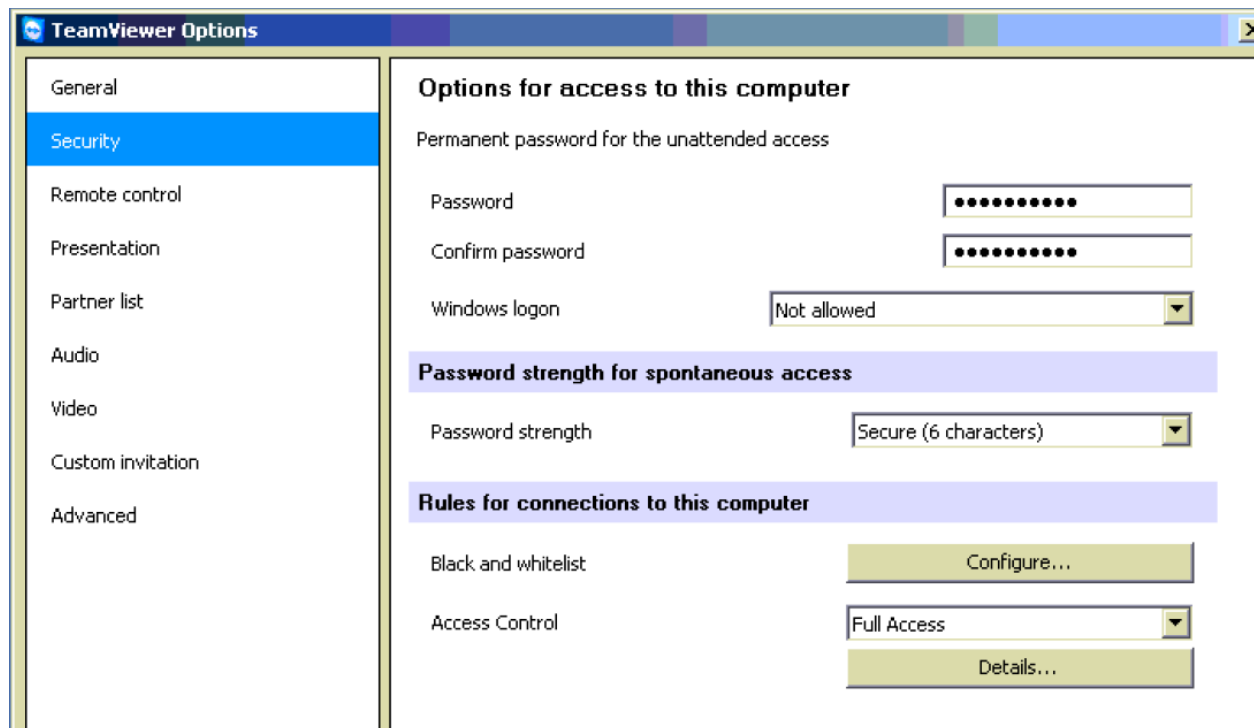
**IMPORTANT:** Any of the below basic software changes to the QuantumX Data Recorder CX22-W needs to be saved permanently as we have an Enhanced Write Filter running on the CX22 which basically prevents any modification to the operating system of the unit. This can be done in the so called “shell2 by the command “commit changes and reboot”!

In most of the projects we installed the following additional software on the Data Recorder:

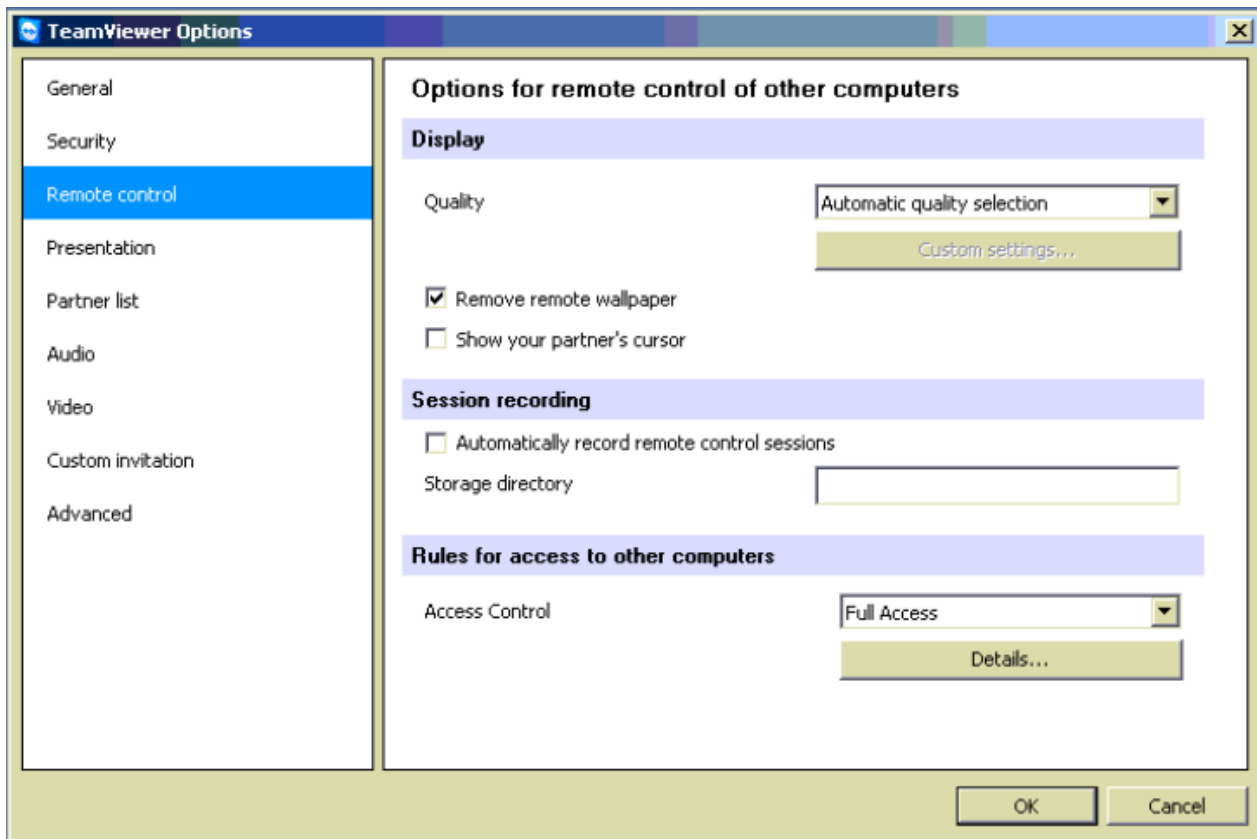
- Team Viewer
- Turbo FTP Service



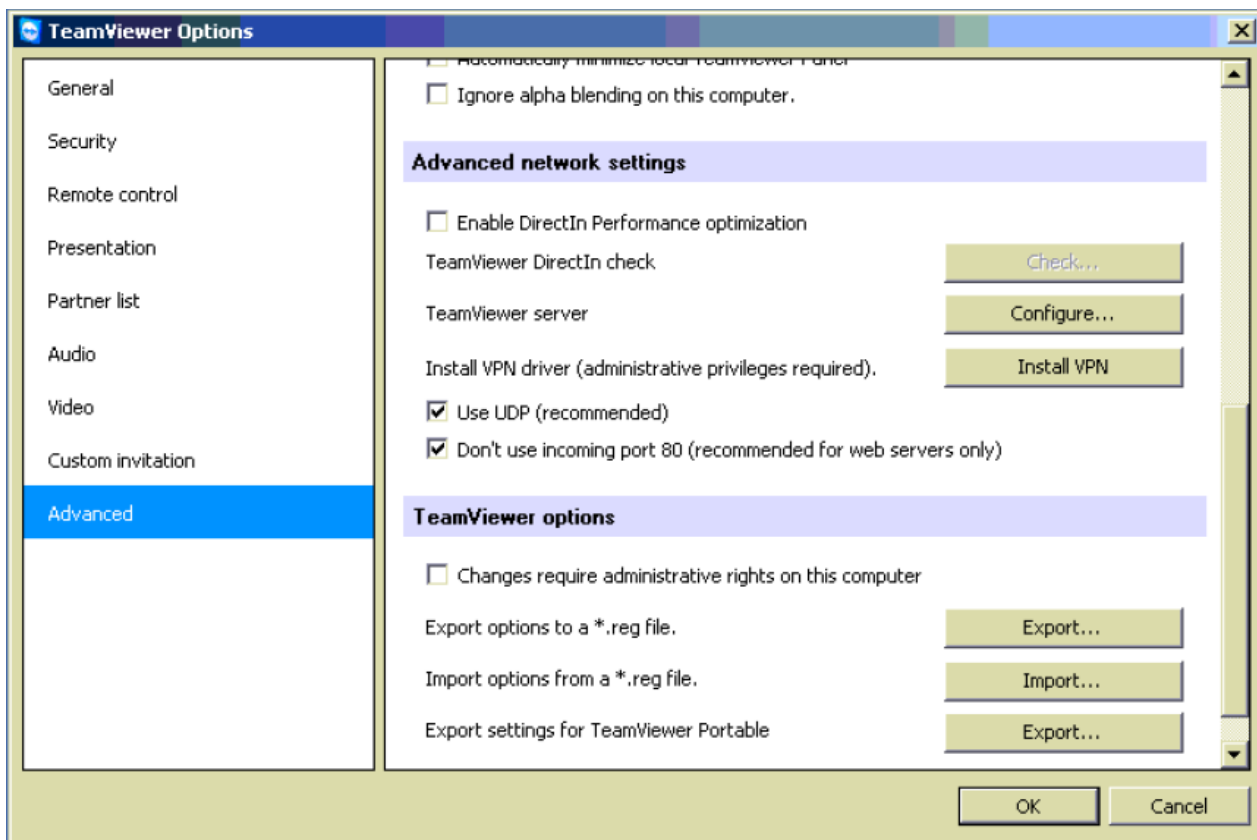
**TeamViewer** is an easy to use tool for our purpose which works as a Remote Control Application. By default the CX22 is configured to accept incoming Remote Desktop Connections. With Remote Desktop there are several issues. One problem is, that it locks the CX22 session when you close the Remote Desktop session. If the CX22 is connected using a WLAN connection and this connection is interrupted once the network connection will not be established anymore. This means a remote access is not possible anymore. Only one client can connect at a time.



Make sure remote access is configured as required (Full Control etc.).



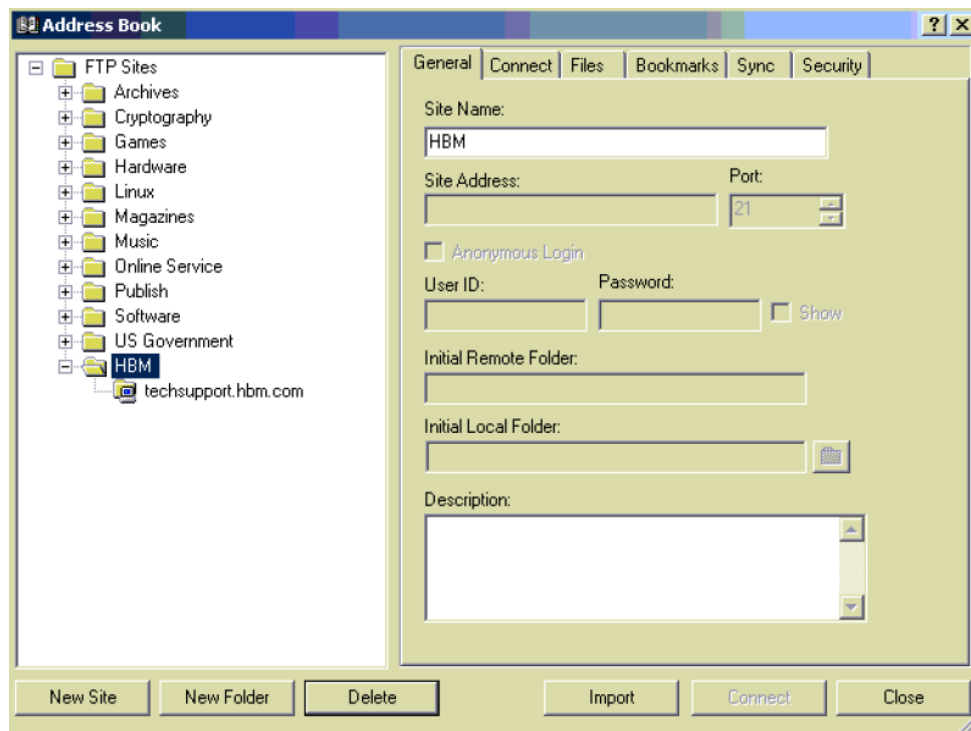
Make sure to set the option “Don’t use ... port 80 ...” in Advanced network settings



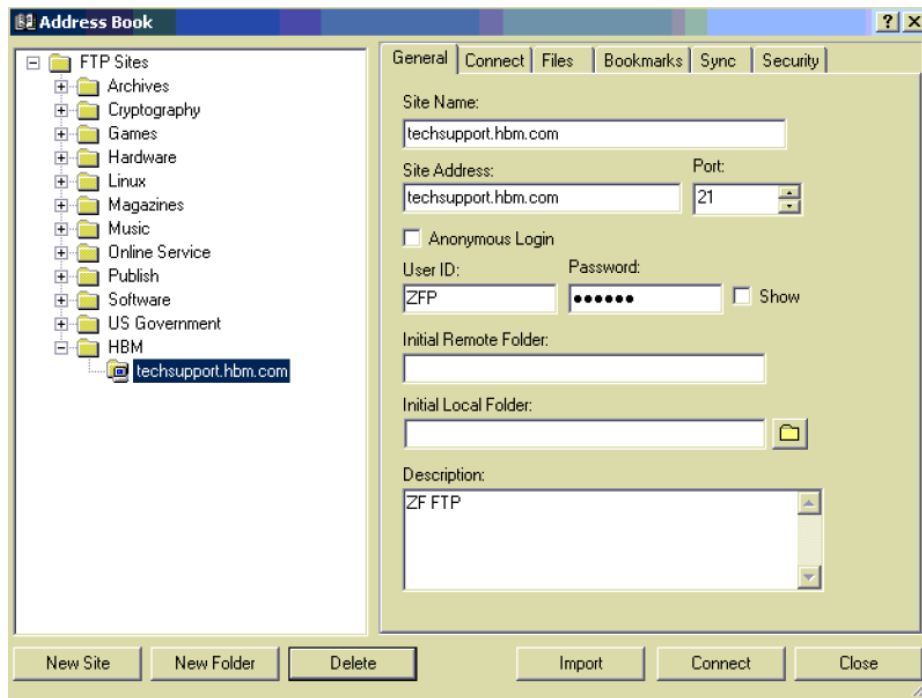
Now the Data Recorder CX22 can be accessed using the shown ID as soon as the CX22 is connected to the Internet. If one creates an account on the TeamViewer site it is also possible to monitor the activities of the registered partners (CX22s).

**TurboFTP** allows the user to setup interactively Windows Services Tasks running automatically in the background. These tasks can be configured with different settings to automatically upload e.g. new files in a specific directory to an ftp server. For the setup of the service, different options are available including the delete of successful transferred files and sending of Emails. After Installation of Turbo FTP follow the following exemplary steps to setup the service.

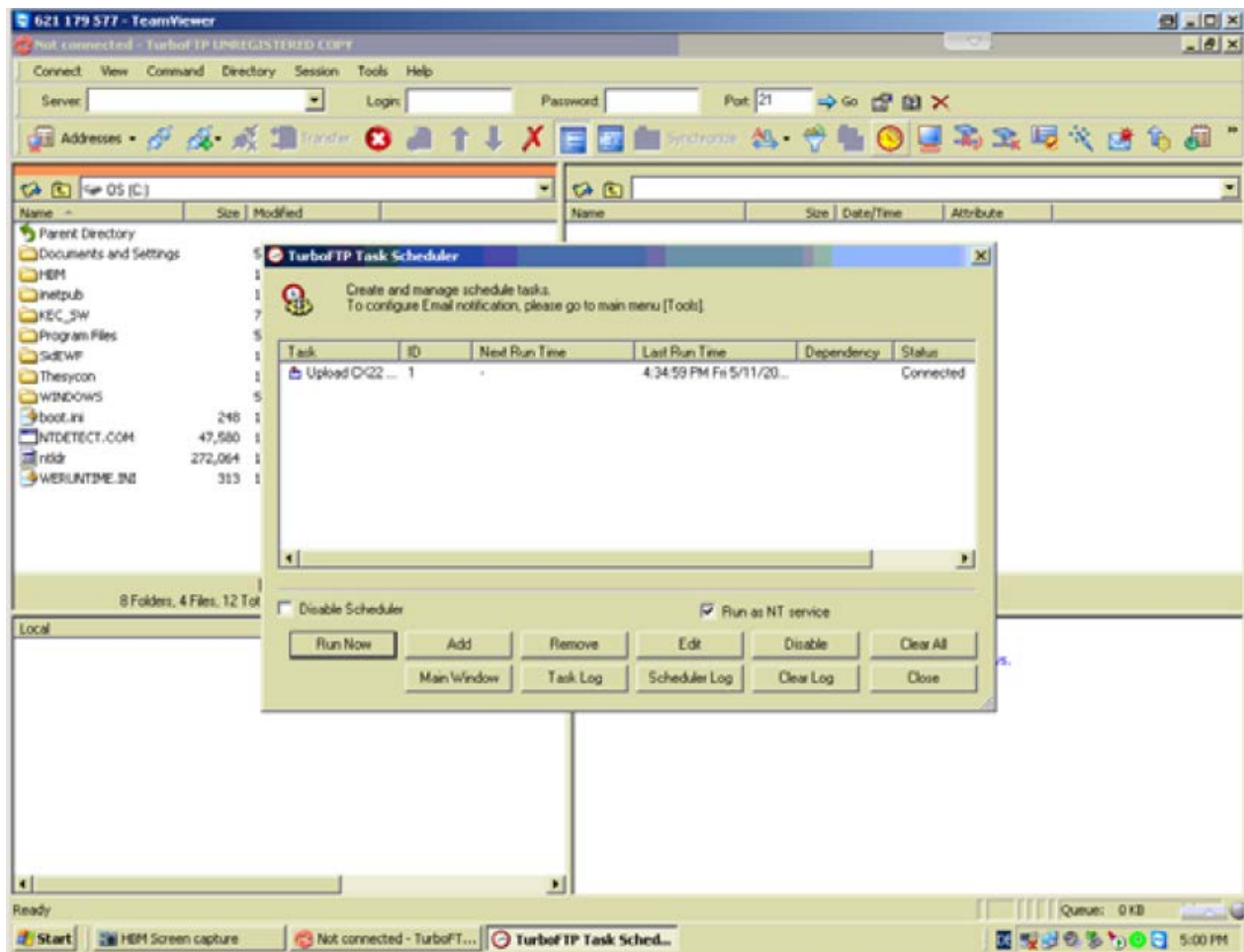
Create a new folder in the FTP Address book:



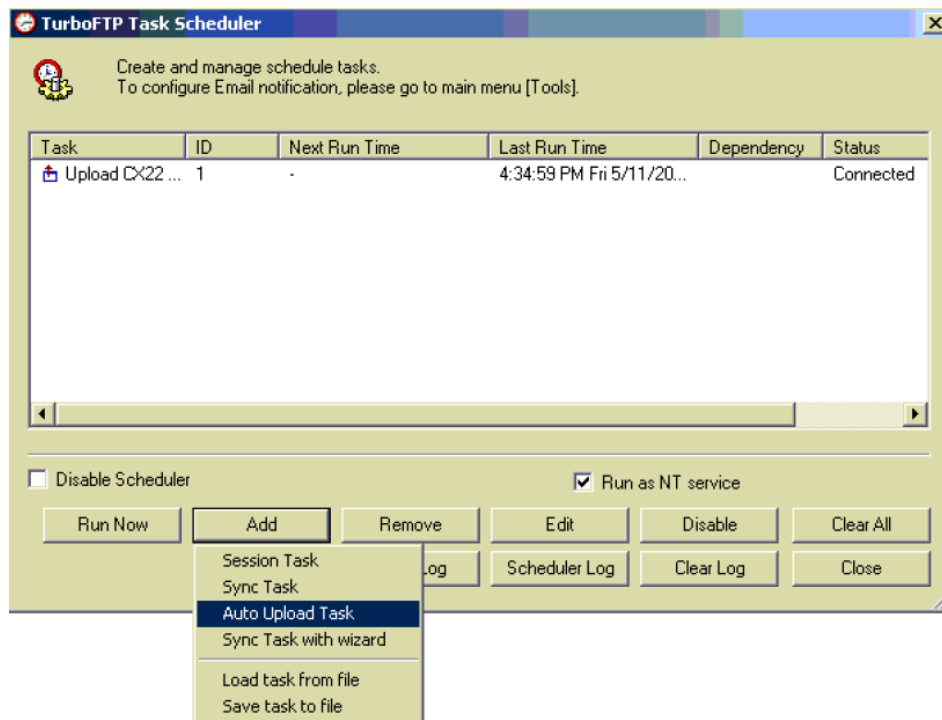
Add your site to the FTP Address Book:



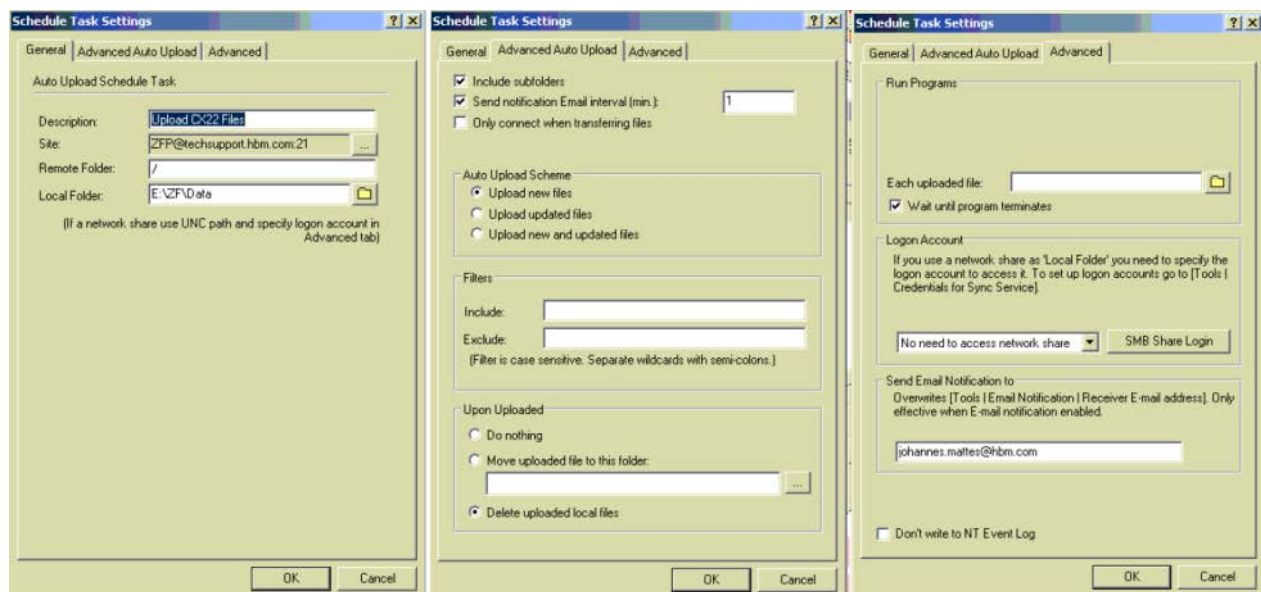
Open the scheduler by clicking on the clock symbol in the toolbar:



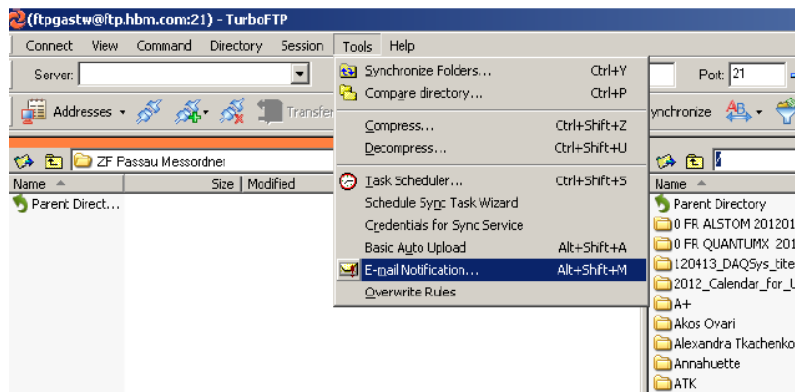
Add a new Auto Upload task to the scheduler and set checkboxes as below:



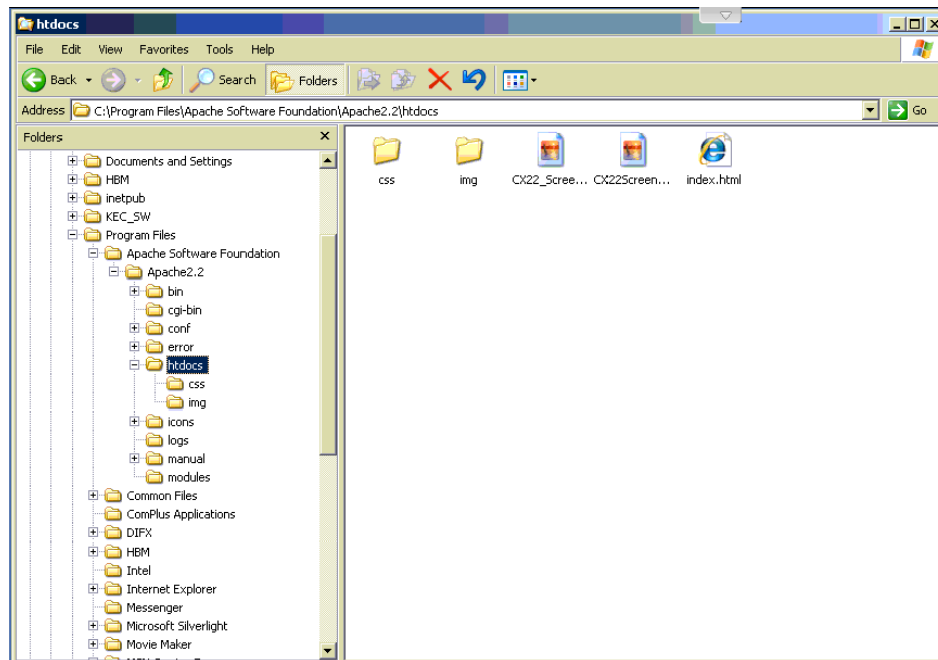
Select your FTP site from your list and setup the task with your preferences:



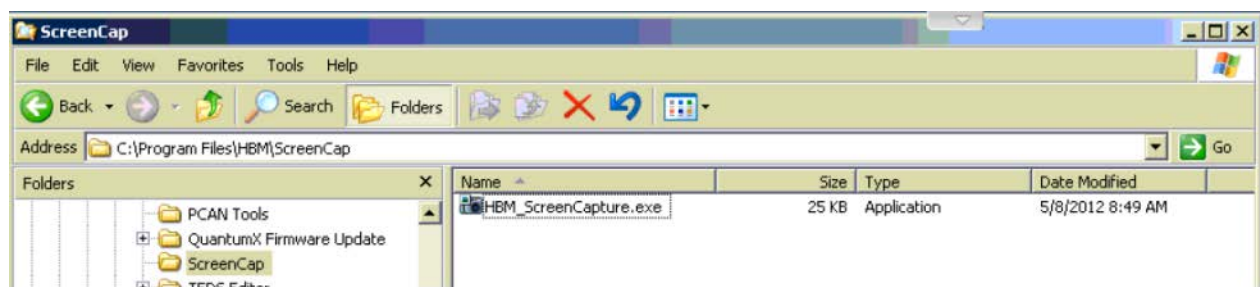
If you intend to send Emails setup the Email Notification in TurboFTP and select your preferred options regarding notification. Ask your IT department or provider for the necessary information.



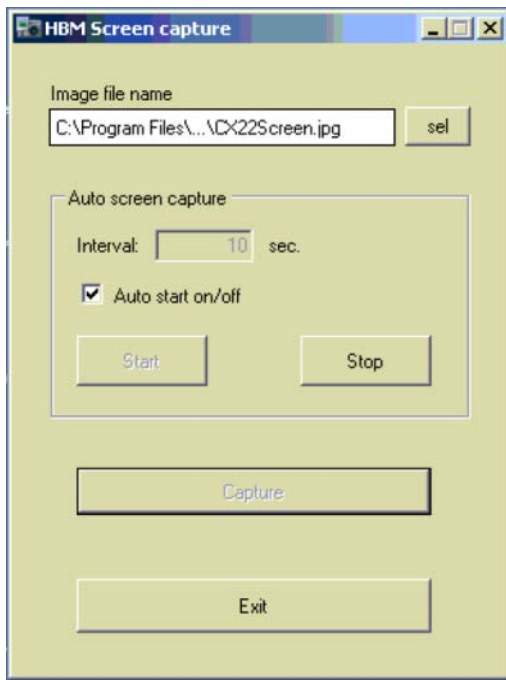
**WebServer Apache** and ScreenCapture. If you want to be able to monitor the screen or allow others to monitor the current state of the CX22 this can be done by using a Web Server. The Apache Web Server 2.2 has been tested with the CX22 and the setup is quite easy. The advantage of using a Web Server is, that you can access the information provided from any device that can run a Web Browser. This could be a Smartphone, an iPad or a notebook. There is a default small application provided by HBM that captures a screenshot timer controlled and stores in to a specified location. Together with the Webpage and the style sheet the Web Server will always provide the latest screenshot of the CX22 as a Webpage. The benefit is that the operator is free to design his own layout of the screen. The data of the picture to be transferred is rather small and therefore even if the bandwidth is limited a transfer is possible. The installation of the Apache Web server is rather simple and self-explaining. After the installation procedure copy the Webpage you want to use in the htdocs directory of the installation. Index.html will be the default page shown when connecting to the CX22:



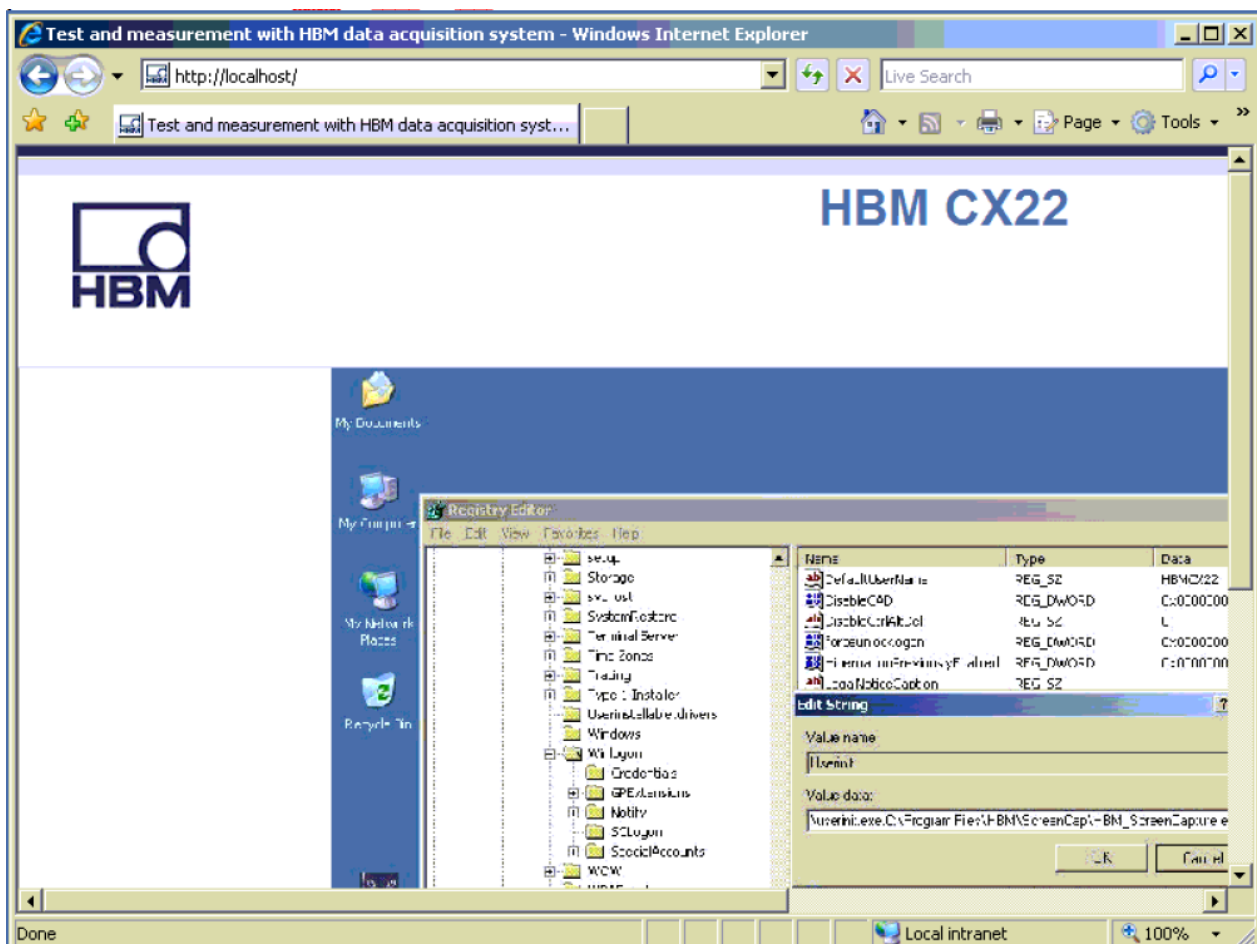
To use the ScreenCap tool copy the HBM\_Screencapture.exe file in an appropriate directory:



Set the tool up according to your needs. The path and filename of the Image must correspond with the Webpage used for this application:



To check if the Web server is running start the Internet Explorer on the CX22 and type localhost in the address bar. You should see the Webpage similar to the picture below:





The last thing to do is to make sure this tool is started together with the other services automatically at boot of the CX22. Since this tool is not available as a service up to know it is necessary to edit the registry. Type regedit in the run text box of the start menu and add the path to the HBM\_ScreenCapture.exe file to the UserInit Key:

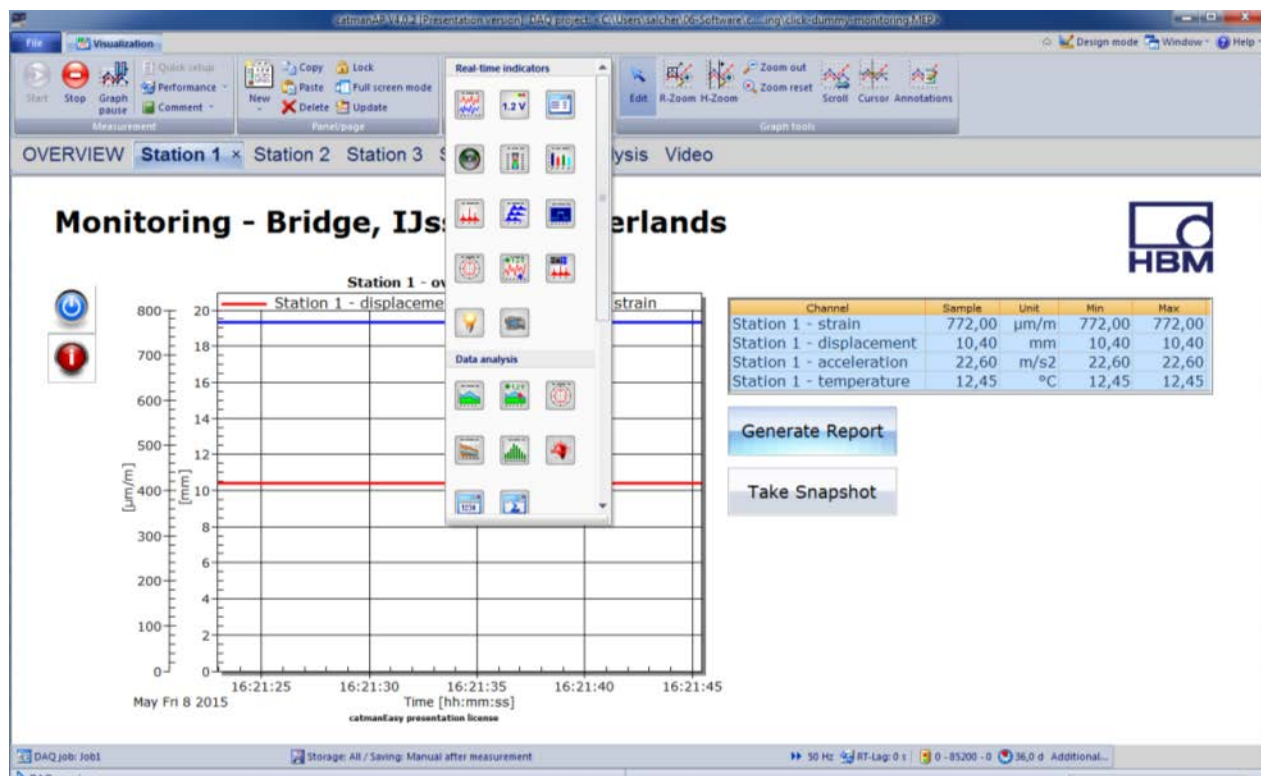
HKEY\_LOCAL\_MACHINE\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Winlogon\Userinit

### QuantumX Data Recorder Software


QuantumX Data Recorder is the ideal tool for your monitoring applications. Its software catman is responsible for system and channel parameterization, visualization, online calculation, statistics (min, max, mean), intelligent trigger, data classification and many more. All kind of signals, real or calculated can be evaluated and set as alarm. An alarm in return can activate a digital output which can works as a local reaction, can send an email or sms with a warning or alarm report including values and graphics or generate an entry into a log file.

In this chapter we want to show some typical aspects relevant for monitoring.

### Visualization / Current Status



## Online Calculation and Data Reduction


**Algebra and formulas**

Formula editor

Fixed formulas

Computes channels in sample rate timing. You can use channel names, numbers, operators and functions in the formula. All channels used in a formula must belong to the same sample rate group.

Name and unit for computation channel

Station-1-strain-sum      Name            Unit

Expressions last used

Edit expression

$(\text{strain-f12} + \text{strain-f13} + \text{strain-f14})/3$


Operators and functions

7	8	9	/	L	=	<>	<	POW	SQRT	Additional functions		Paste
4	5	6	*	J	>	<=	>=	EXP	LN	<input type="button" value="Modulo division"/> <div> Modulo division  Floor  Ceil  Min(Arg1,Arg2)  Max(arg1,arg2)  asin  acos  atan  atan2  Random number (0..1) </div>		
1	2	3	.	Pi	AND	OR	SIN	COS				
0	.	C	+	e	ABS	INT	TAN	LOG				

[Help on algebraic functions](#)      [Which operators?](#)

Drag a channel onto the formula or doubleclick the channel

## Class Counting


**Class counting**

Applies class counting to a DAQ channel (Rainflow, Time at level)

Counting method

☒ Rainflow FromTo      ☐ Time at level      ☐ Span pairs  
☐ Rainflow RangeMean      ☐ Joint time at level (compound counting)

Name of computation channel      TAL strain-f12

Channel to count     

Configure class counting

Number of classes  
 Lower class limit  
 Upper class limit  
 Minimal amplitude (in % of total range)

☐ Determine limits from sensor measuring range  
☒ Count symmetrically  
☐ Close residuum

[Help on class counting](#)

Drag a channel onto the formula or doubleclick the channel to use it as an argument.

## Measurement Storage – Local, Network

### DAQ start and stop conditions

General settings

**Sample rate groups**

▶ 10 Hz ▼ Slow [Useful sample rates](#)

▶▶ 50 Hz ▼ Default

▶▶▶ 2400 Hz ▼ Fast

**DAQ start**

Trigger ▼

☐ Burst mode 0 Max. bursts

Trigger mode  
Above level ▼

Trigger channel  
Station 1 - strain ▼

10 Pre-trigger (s) 2 Minimal hold time (s)

220 Threshold [µm/m]


[How are triggers working?](#) [What is the meaning of burst mode?](#)

**Execute automatically on DAQ start**

☐ Zero balance of hardware channels

☐ Zero balance of computation channels


☐ Reconnect and initialize devices before DAQ start.  
This mode allows to reconnect to devices if during the course of a DAQ project the connection gets lost for some time.

☐ EasyScript  Edit

**DAQ stop**

Manual ▼

**Execute automatically on DAQ stop**

☐ EasyScript  Edit

### Storing Data

catmanAP V4.0.2 [Presentation version] DAQ project: <C:\Users\salcher\06-Software\c...ing\click-dummy

File DAQ channels Video cameras DAQ jobs Visualization

Start DAQ Measurement

New DAQ job Insert DAQ job Use as default

Delete DAQ job Up Reset default settings

Copy DAQ job Down Check

General Data storage Channel parameters Video Job parameters Advanced

Settings

Job list

DAQ jobs

Bridge XYZ Monitoring

Settings for storage and saving of measurement data

**Data storage and saving**

Keep all data ▼ Storage mode

Periodically during measurement ▼ Data saving

12 h 0 m 0 s Interval of periodic saving

One file per interval ▼ Mode of periodic saving

☐ Merge single files of periodic saving after job stop (catman standard format only)

HBM catman standard format ▼ File format

8-Byte ▼ Precision

Store all data ▼ Saving depth

Saving file

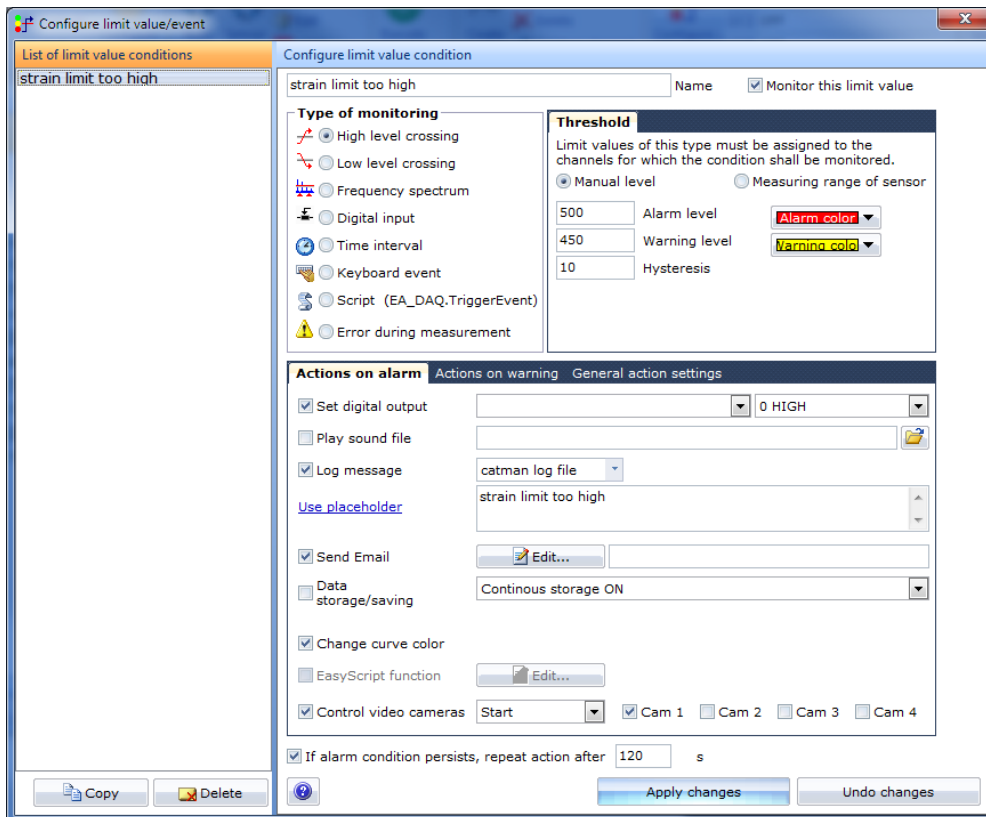
Placeholder ▼ E:\NAS\Monitoring-Station\Data\%DateTime%-DAQ-data-%Job%

File comment

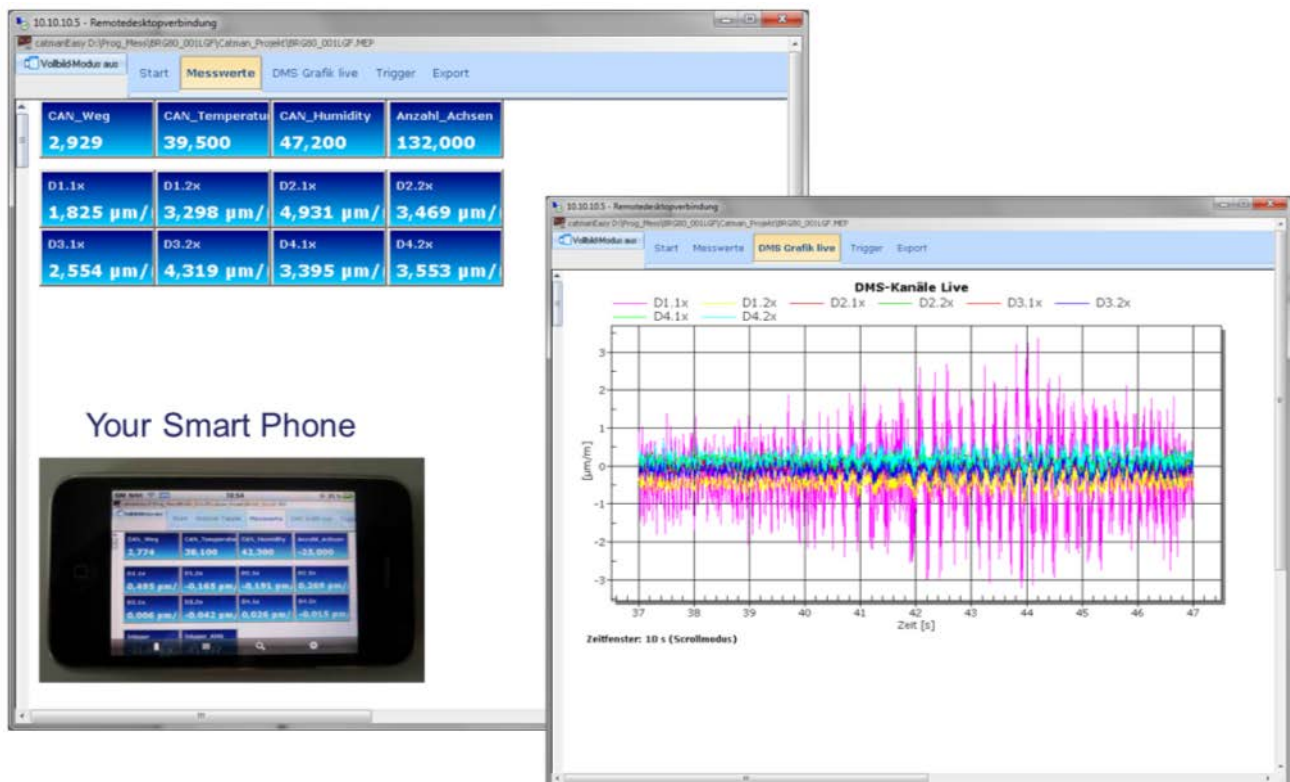
## Event Monitoring – Warning, Alarm / Alert

### Functions:

- Set digital output
- Send Email or sms
- Control video camera
- ...



## Remote View and Operation of the Data Recorder



## Overall Cost Estimation

Estimated initial cost for Remote Data System Access

- Cellular Router
- Software installation and licenses for Team Viewer and TurboFTP
- Apache Webserver and Screen Capture Tool

Budget price approx.: 4.000,00 €

Estimated cost for managing RDSA service per handled device

- SIM card handling in Germany
- DynDNS and Host name handling
- FTP- and Webspaces Rent and Administration

Budget price in Europe around: 500 €/Month

Attention!!!

All prices are budgetary prices and take the use case that the end user is responsible for the whole setup.

## Summary and Conclusion

Cellular network integration of Data Recorders and remote access to it is technology driven and possible. The CX22 is a perfect open platform that can be used and there are many established tools available. Providing a reliable overall system some network knowledge is necessary, web hosting and admin skills are necessary and most likely to be provided by a local service provider who also takes care about data backup and maintenance. There is some work that to do in setting up such a system but in general all build up knowledge can be used in the next project – easier if the unit is integrated in the same cellular network. The most important point is, that the tools that are used are working stable and reliably even if the data transfer is slow or interrupted. Several building blocks are available to setup such systems and knowledge has been built up at HBM Germany to support world-wide. The experience shows that each application is different and the building blocks need to be selected and configured according to the needs of the end user.

There is potential in an overall solution if we think ahead and take an automatic post-process data analysis centrally running on a server to account. Based on this a full web oriented monitoring system can reduce overall service and maintenance cost but needs investment.

-- end

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