HDL32E Software Version V2.0

Description of New Functionalities and Changes

December 4, 2012 (Wolfgang Juchmann)

HDL32E Version 2.0 Software Overview

New Features:

- WebServer with GUI and API
- Calibrated Reflectivity Values
- Zero Horizontal Angle Calibration
- Improved GPS and Timestamp Handling

Noticeable changes to previous Software (V1.0):

- Default IP address now 192.168.1.201 (changeable via WebServer)
- Intensity now represents 256 calibrated reflectivity values (not 11 laser powers)

Noticeable changes to Version 1.0

- Default IP address is now 192.168.1.201
  - With the introduction of the WebServer functionality with Version 2.0, the IP addresses as well as the Gateway and Network addresses can now be configured by the user. Therefore there is no need to ship HDL32E with different IP address, but all of them will be shipped with the default address 192.168.1.201.

- Intensity now represents 256 calibrated reflectivity values (not 11 laser powers)
  - As a result of better differentiation between diffuse reflectors and retro-reflectors, diffuse reflectors are now represented with values in the range from 0-100 and retro-reflectors from 101-255.
  - Depending on the users choice of color scaling, this might result in a shift of colors from what the user is used to. Adjustment of color scaling corresponding with the definition for diffuse and retro-reflectors in Version 2.0 will help with better differentiation for the reported calibration values.

HDL32E V2.0 WebServer Functionality

November 30, 2012 (Wolfgang Juchmann)

WebServer with GUI and API

- The HDL32E now contains a WebServer that allows the user to monitor configuration parameters, choose network settings, control rotational speed and upload new firmware and/or calibration files
- The WebServer can be accessed by a GUI using Internet Explorer (other browsers are mostly compatible but have small issues with the live update portion of the GUI) or by issuing “JSON” commands and receiving “XML” style returns via a computer

- JSON Commands:
  - http://<hdl-ip-addr>/cgi/settings.json
  - http://<hdl-ip-addr>/cgi/status.json
  - http://<hdl-ip-addr>/cgi/info.json
  - http://<hdl-ip-addr>/cgi/diag.json

  with default <hdl-ip-addr> = 192.168.1.201

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How to use WebServer

- Plug Ethernet cable into Host Computer
- Disable all other Internet / Ethernet / Wireless connections
- Plug GPS into HDL32E adapter box (optional)
- Plug Power into HDL32E adapter box
  - after 5-8 seconds the HDL32E should start spinning
- Open Internet Explorer browser
  - other browsers might work but are not supported at this time
- Type in IP address of HDL32E sensor:
  - Default: http://192.168.1.201
- Internet Explorer will show HDL32 WebServer screens

- The “Download Snapshot” button on the Configuration Screen allows for recording of all configuration parameters at once in a text based (xml) file.

Settings and Status

Default <hdl-ip-addr> : 192.168.1.201

Settings (settings.json)
curl -s http://<hdl-ip-addr>/cgi/settings.json | python -mjson.tool

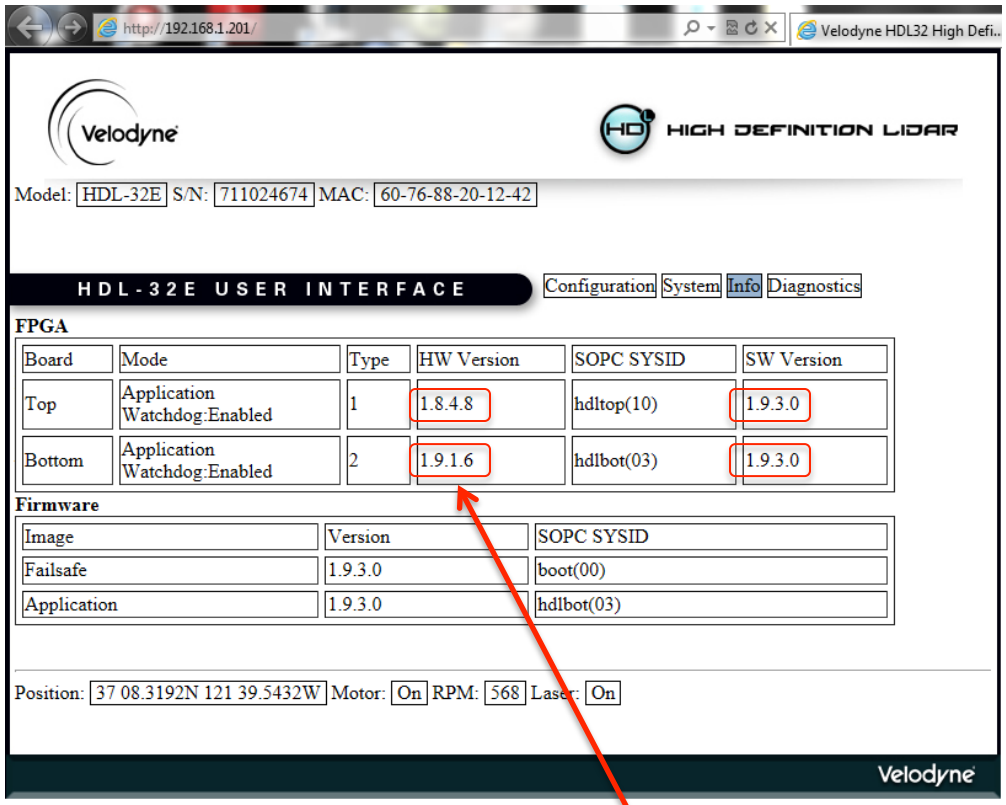
```
{
   "laser":"On",
   "rpm":600,
   "host":{
     "addr":"255.255.255.255"
   },
   "net"{
     "addr":"192.168.1.201",
     "mask":"255.255.255.0",
     "gateway":"192.168.1.1",
     "dhcp":"Off"
   }
}
```

Status (status.json)
curl -s http://<hdl-ip-addr>/cgi/status.json | python -mjson.tool

```
{
   "gps":{
      "position":"37 08.3192N 121 39.5432W "
    },
   "motor":
      "state":"On",
      "rpm":742
   },
   "laser":{
      "state":"On"
   }
}
```

Variable	Type	Description	Typicial/Default	Range	Rules/Comments
Laser	Set and Read	Provides power to upper board and turns lasers on/off	ON	ON or OFF	If Laser is OFF, there will be no distance packets.
RPM	Set	selects the approx. motor speed in rotations per minutes	600	0 and 300-1200	Allowed values: 300-1200 RPM. Values outside this range are truncated. Setting "0" will disable rotation and lasing. Actual RPM read value is scaled and may not equal RPM exactly. Do not set RPM's that result in >1200 actual RPMs
Host IP	Set and Read	chooses/shows Host IP address of computer controlling sensor	255.255.255.255		
Network Address	Set and Read	chooses/shows Network IP address of sensor	192.168.1.201	IP address format	none
Network Mask	Set and Read	chooses/shows Network Mask of sensor	255.255.255.0	IP mask format	none
Network Gateway	Set and Read	chooses/shows Network Gateway of sensor	192.168.1.1	IP gateway format	none
Network DHCP	Set and Read	selects DHCP of sensor as ON or OFF	OFF	n/a	none
SET Button	Set	activates the Network settings after changes	Press Button	n/a	none
SAVE Config	Set	saves all settings on this page into sensor after changes	Press Button	n/a	All values take effect immediately, but are not saved over power cycle until save config button has been pressed.
Download Snapshot	Read	Saves all internal configuration parameters into HDLxxxSNxxx.hdl file	Press Button	n/a	none

Information



- This screen shows which Hardware and Software versions are being used in the sensor
- It also shows if the sensor has been switched from an application to a failsafe mode
- API displays software versions as numerical values that can be converted to version format
  - 17367302 = 0x01090106 => 0x01 09 01 06 > 1.9.1.6

Information (info.json)
curl -s http://<hdl-ip-addr>/cgi/info.json | python -mjson.tool


```
{
  "model":"HDL-32E",
  "serial":"711024674",
  "mac_addr":"60-76-88-20-12-42",
  "image":{
    "failsafe":{
      "signature":2779096485,
      "version":17367808,
      "timestamp":1348862775,
      "data_length":293836,
      "data_crc":4045072806,
      "res1":1212435456,
      "res2":1343364855,
      "header_crc":3114870981
    },
    "application":{
      "signature":2779096485,
      "version":17367808,
      "timestamp":1352183794,
      "data_length":364496,
      "data_crc":3862843394,
      "res1":1212435459,
      "res2":1351184552,
      "header_crc":3972623176
    }
  },
  "sysid":{
    "bot":{
      "id":1212435459,
      "timestamp":1351184552
    },
  "top":{
    "id":1145588752,
    "timestamp":1343356599
    }
  },
  "state":{
    "bot":{
      "factorymode":0,
      "powerup":0,
      "runconfig":0,
      "wdtimer":0,
      "nstatus":0,
      "crcerr":0,
      "nconfig":0,
      "appmode":1,
      "wden":1,
      "prevaddr":0,
      "appaddr":16777216,
      "wdto":118489096
    },
```



```
  "top":{
      "factorymode":0,
      "powerup":0,
      "runconfig":0,
      "wdtimer":0,
      "nstatus":0,
      "crcerr":0,
      "nconfig":0,
      "appmode":1,
      "wden":1,
      "prevaddr":0,
      "appaddr":917504,
      "wdto":262144008
    }
  },
  "fpgaid":{
    "bot":{
      "id":2,
      "version":17367302,
      "timestamp":0
    },
    "top":{
      "id":1,
      "version":17302536,"
      timestamp":0
    }
  },
  "appid":{
    "bot":{
      "type":2,
      "version":17367808,
      "timestamp":1352183659
    },
    "top":{
      "type":1,
      "version":17367808,
      "timestamp":1348862211
    }
  }
}
```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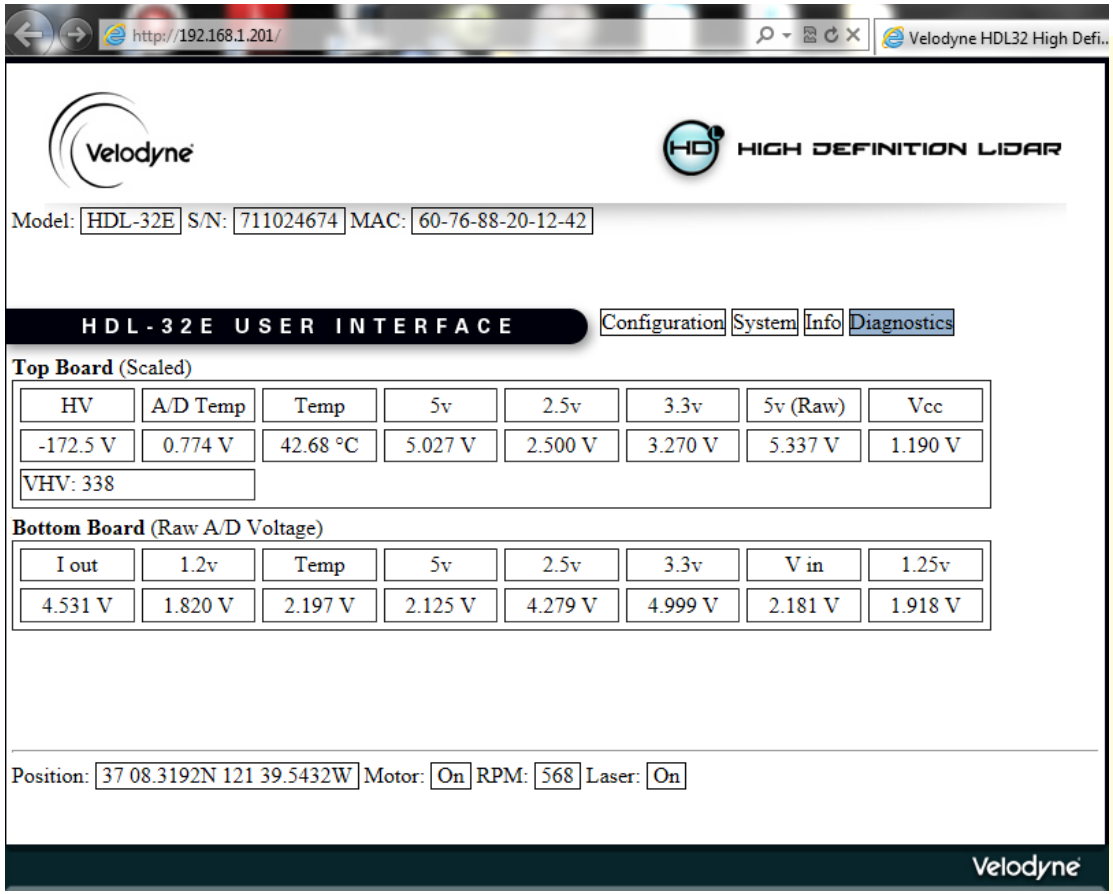
Diagnostics



Diagnostics (diag.json)
curl -s http://<hdl-ip-addr>/cgi/diag.json | python -mjson.tool


```
{
   "volt_temp":{
      "bot”:{
         "i_out":3719,
         "pwr_1_2v":1489,
         "lm20_temp":1800,
         "pwr_5v":1743,
         "pwr_2_5v":3519,
         "pwr_3_3v":4095,
         "pwr_v_in":1785,
         "pwr_1_25v":1583
      },
      "top":{
         "hv":2657,
         "ad_temp":629,
         "lm20_temp":1086,
         "pwr_5v":2063,
         "pwr_2_5v":2049,
         "pwr_3_3v":2681,
         "pwr_5v_raw":2183,
         "pwr_vccint":976
      }
   },
   "vhv":363
}
```


- This screen is for factory diagnostics purposes.
- Values are not calibrated and only have limited meaning

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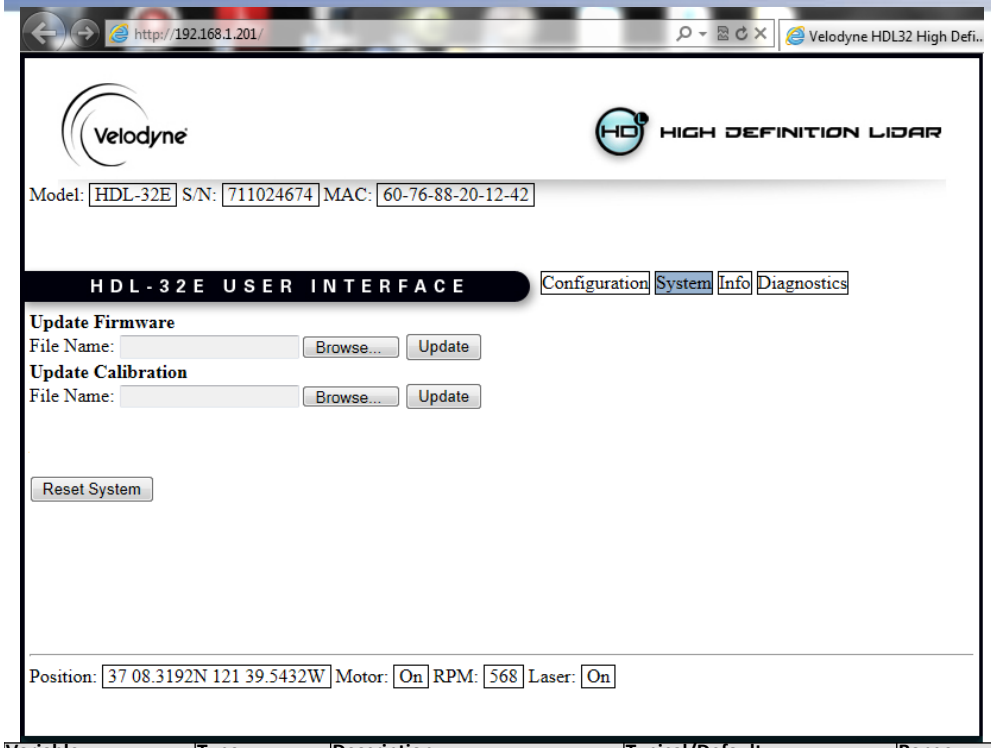
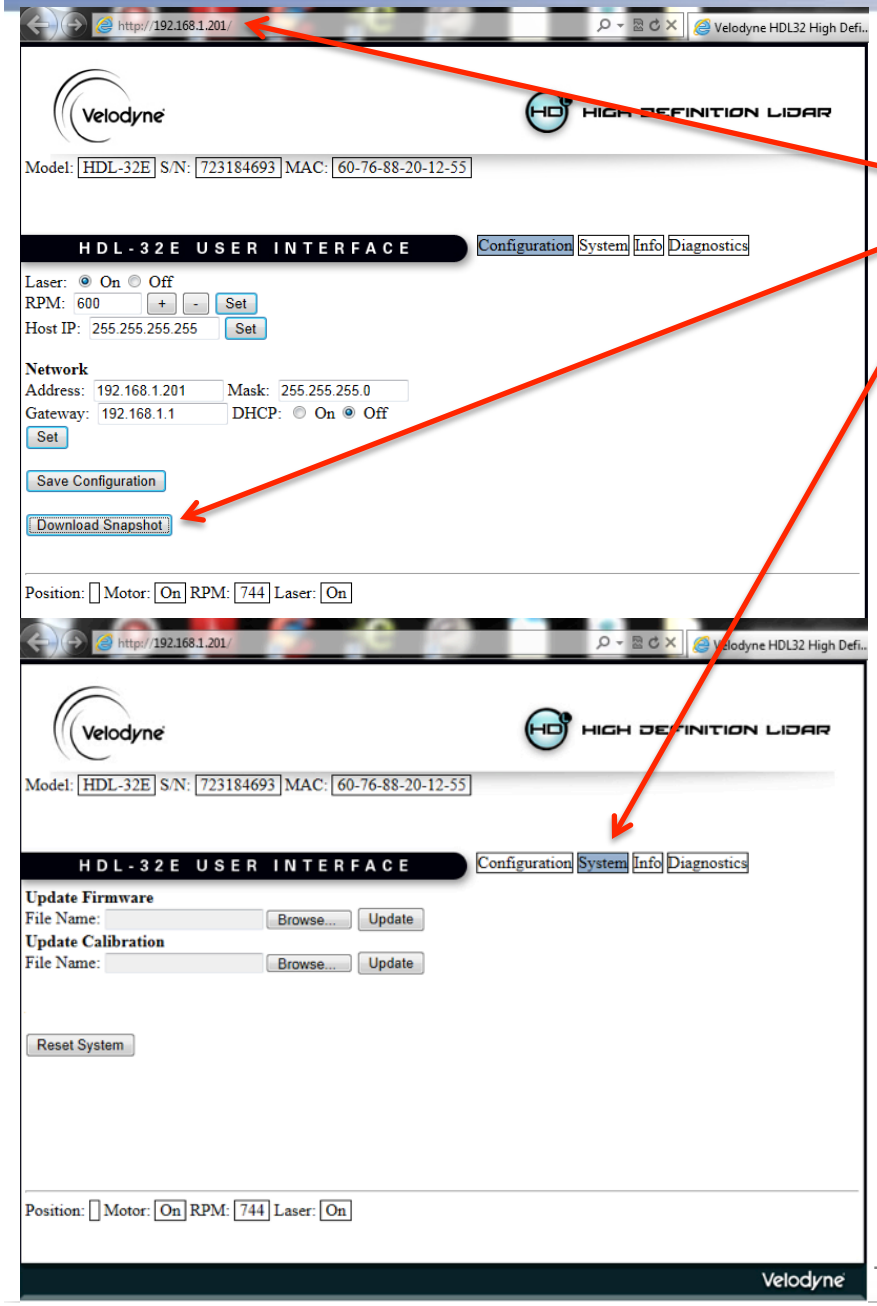
System



Variable	Type	Description	Typical/Default	Range	Rules/Comments
Model	Read	shows model number	HDL-32E	HDL-32 versions	none
SN	Read	shows unique Serial Number	711024674	9 digit number	none
MAC	Read	shows unique MAC address	60-76-88-20-12-42	12 digit MAC format	none
Configuration	Set and Read	selects Configuration screen	white or blue when selected	white,blue	only one screen selected
System	Set and Read	selects Diagnostics screen	white or blue when selected	white,blue	only one screen selected
Info	Set and Read	selects Info screen	white or blue when selected	white,blue	only one screen selected
Diagnostics	Set and Read	selects Diagnostics screen	white or blue when selected	white,blue	only one screen selected
Update Firmware	Set	allows new firmware upload	yyyyy.flash	n/a	n/a (only upload factory recommended firmware updates)
Update Calibration	Set	allows new calibration upload	xxxxx.srec	n/a	n/a (careful with uploading the wrong calibration file)
Reset System	Set	restarts processors to a fresh power on state	n/a	n/a	takes about 30 seconds
Position	Read	shows GPS position if connected	37 08.3027N 121 39.5421W	n/a	none
Motor	Read	Shows motor status	ON	ON or DISABLED	Lasers will be disabled when rotations are below 200 RPM's
RPM	Read	shows actual measured rotations per minutes	600	0 - 3000	RPM actual read value does have an offset to set value, since there is no feedback loop connecting set and read value. Do not set RPM;s that result in > 1200 RPM measured
Laser	Read	shows if laser is ON or DISABLED	ON	ON or DISABLED	Laser turns OFF when measured motor speed is less than 200 RPM's

Firmware Upload Procedure



This procedure should only be performed if instructed by Velodyne to upload a new firmware version.

- Establish communication via internet explorer and the IP address
  - Default: https://192.168.1.201
- For backup purposes, press Download Snapshot and save file
  - HDL<sensor serial number>.hdl
- Switch to Systems page

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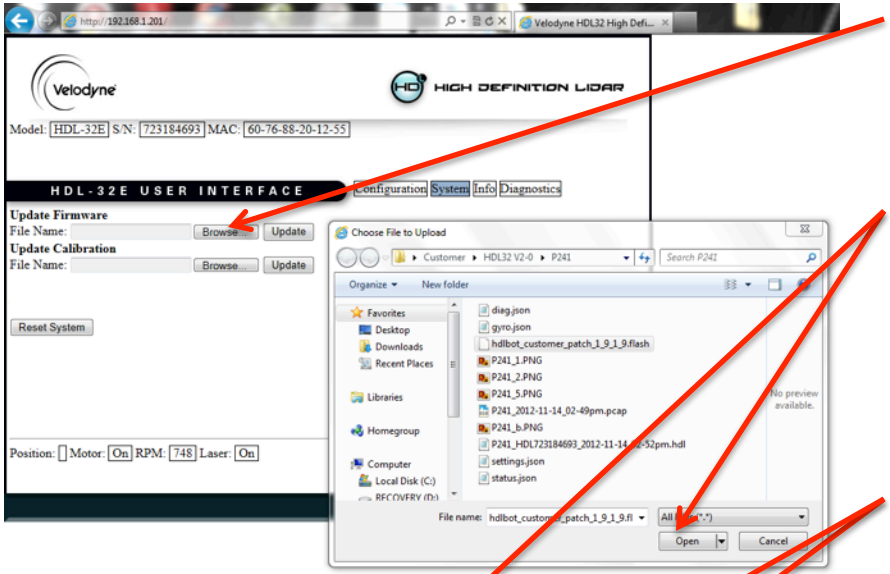
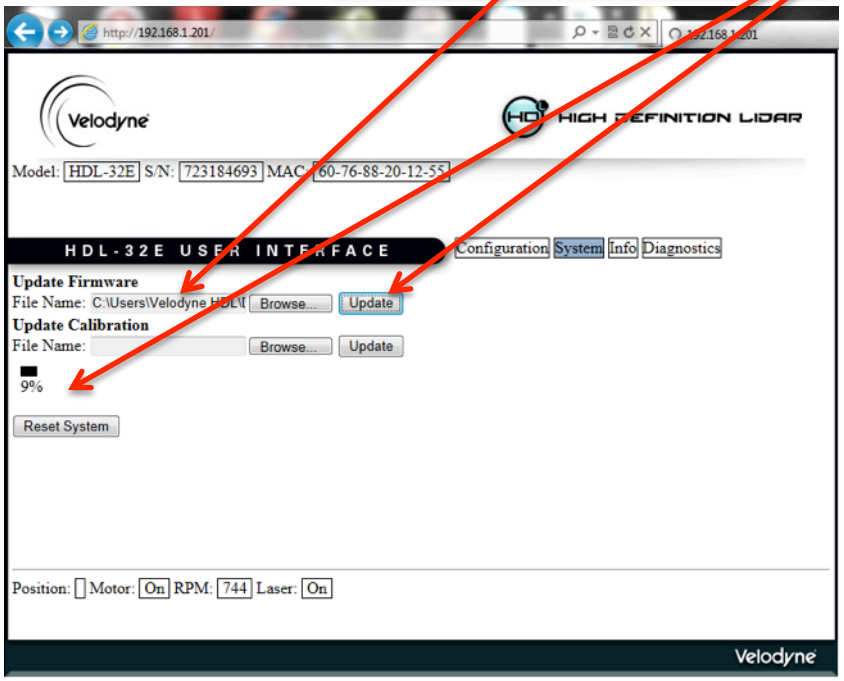
Firmware Upload Procedure





- Click Browse and locate firmware to be uploaded
  - xxxx.flash format
- Click Open and see file path in window
- Click Update and notice progress status (next slide

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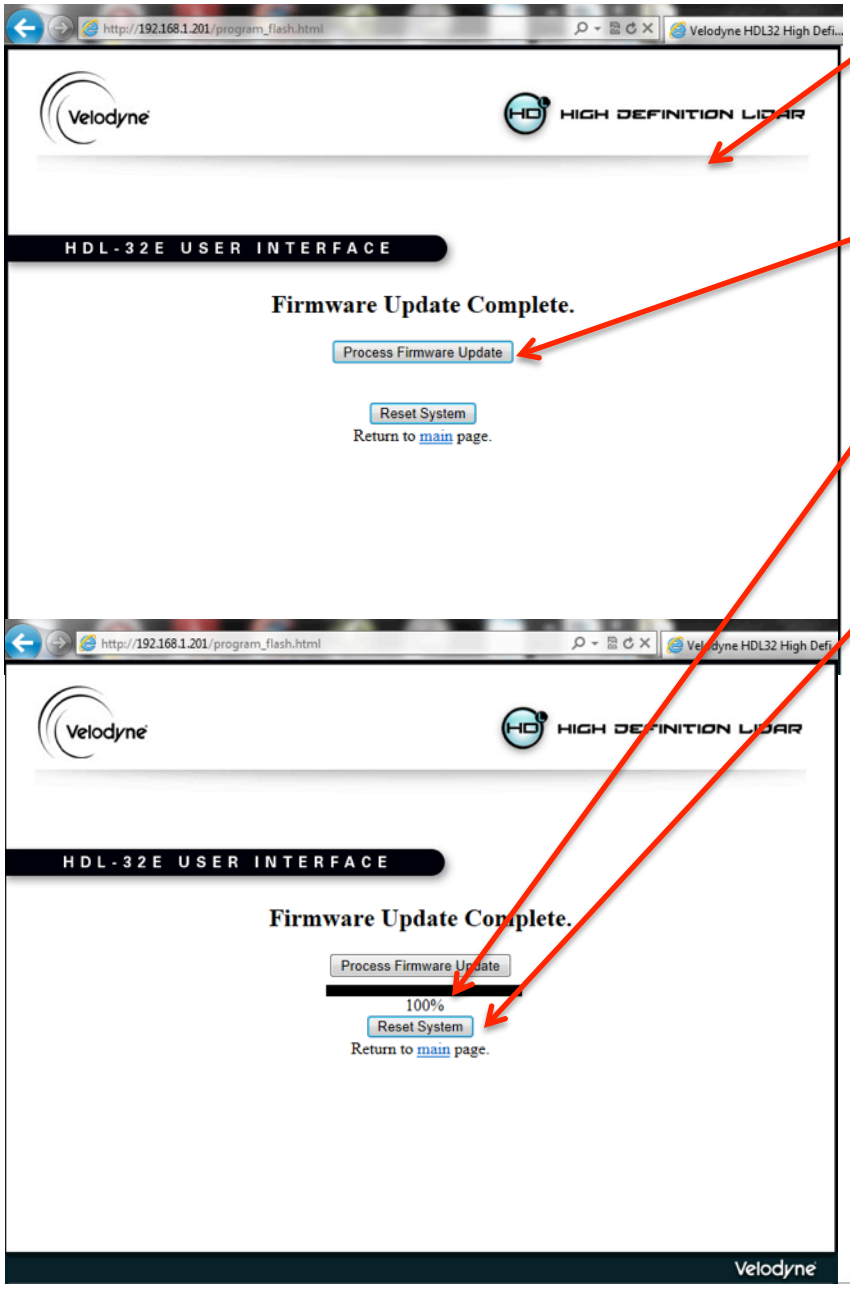
Firmware Upload Procedure



- Once uploaded the following window will open
- Press Process Firmware Update
- Monitor Progress status
- Once 100% has been reached, press reset system
- Main Page will appear again after reset (next slide)

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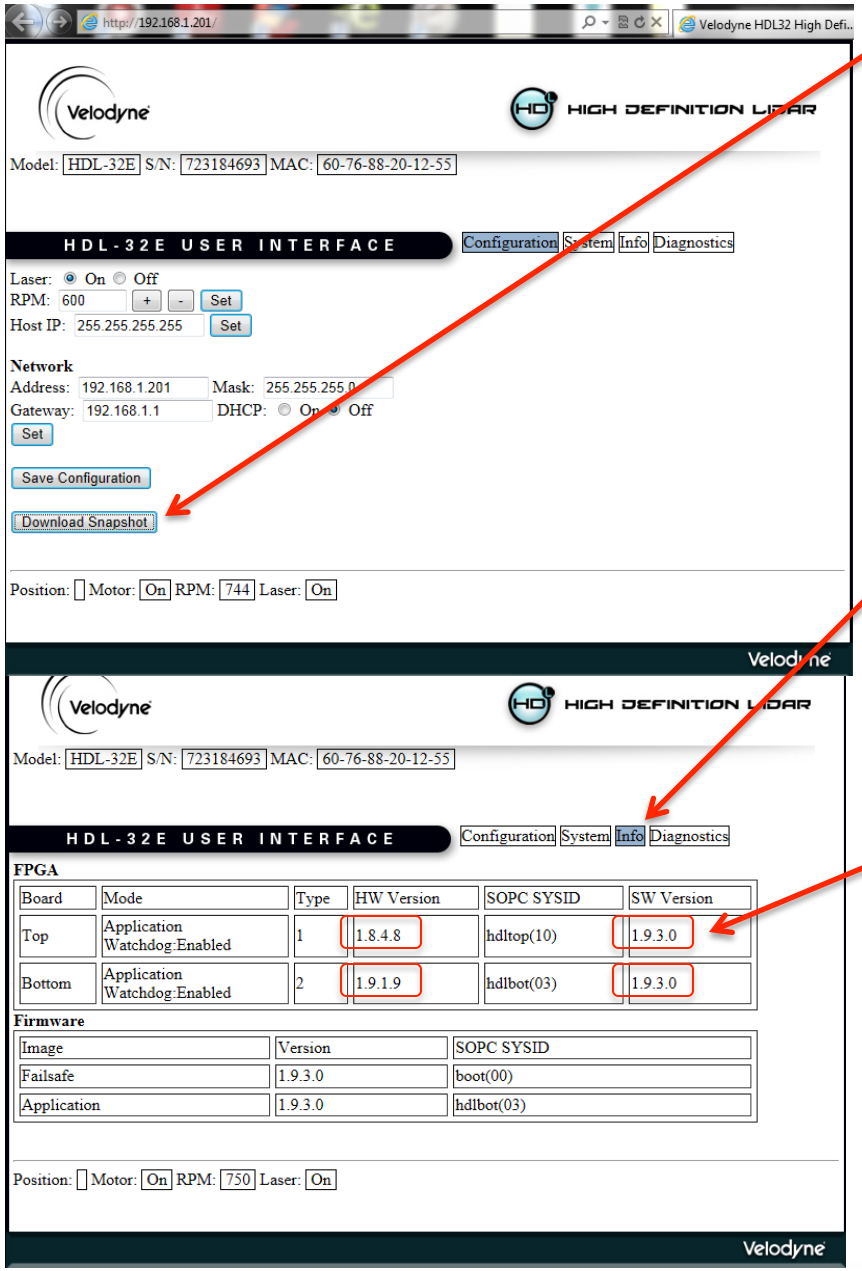
Firmware Upload Procedure



- Press Download Snapshot to safe configuration after upload
- Change to Info screen to see new versions of software
- API displays software versions as numerical values that can be converted to version format
  - 17367302 = 0x01090106 => 0x01 09 01 06 > 1.9.1.6

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HDL32E: V2.0 Calibrated Reflectivity

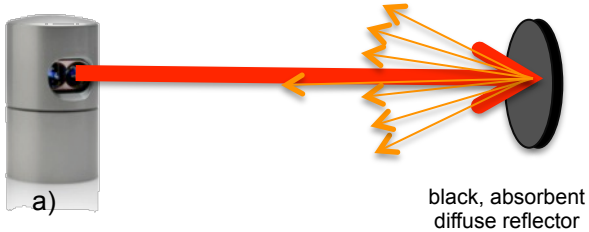
November 30, 2012 (Wolfgang Juchmann)

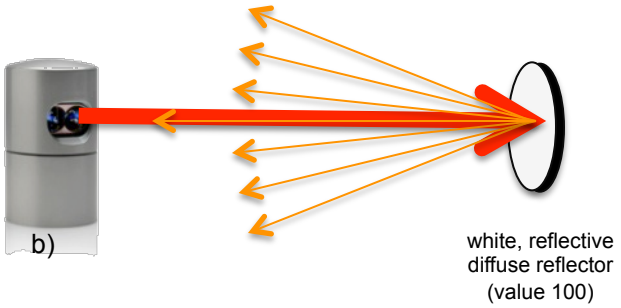
Calibrated Reflectivity Value (Version 2.0)

- Version 1.0 of the HDL32E reports in the data packages the measured distance as well as a value labeled intensity. The reported intensity value is based on one of 11 laser powers that the sensor has dynamically chosen based on best signal to noise ratio on the detector for the previous shot form that laser.
  - Low reflectivity targets generate small signal and a high laser power is chosen and reported.
  - High reflectivity targets report a high signal and a low laser power is chosen and reported.
  - Therefore in V1.0 the reported laser power values are an inverse measure of the reflectivity.
- Version 2.0 of the HDL32 measures the true reflectivity of a target independent of laser power and distance with true 256bit resolution.
  - Diffuse reflectors report values from 0 to 100 for 0-100% reflectivity
  - Retro-reflectors report values from 101 to 255 with 255 being the reported reflectivity for an ideal retro-reflector and 101 – 254 being the reported reflectivity for partially obstructed retro-reflectors or imperfect retro-reflectors.
- The HDL32E is calibrated using commercially available reflectivity standards.
- A ~95 m test range allows for accurate calibration of reflectivity values independent of distance.
- As a result of better differentiation between diffuse reflectors and retro-reflectors, diffuse reflectors are now represented with values in the range from 0-100 and retro-reflectors from 101-255.
- Distances of < 0.5 m and from beyond the detection range are reported as zero meters.
- Depending on the users choice of color scaling, this might result in a shift of colors from what the user is used to. Adjustment of color scaling corresponding with the definition for diffuse and retro-reflectors in Version 2.0 will help with better differentiation for the reported calibration values.
- A customer reported error were retro-reflectors “plume” out and form a “cloud” or “ghost image” in front of or behind their exact location has been fixed.

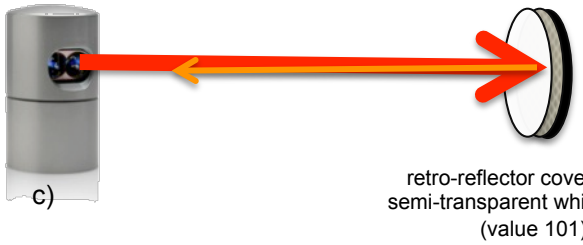
HDL32E: Intensity Data

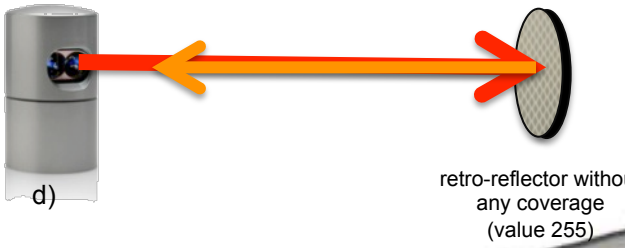
- Intensity data output format the same as previously (8 bit, 0-255 values)
- value 0 – value 100 = 0 – 100% reflectivity from diffuse surface
  a) value zero means 0% reflectivity, which means that 0% of light is reflected back to the sensor (black, absorbent surface)
  b) value 100 means 100% reflectivity, which means that 100% of light is reflected (white, highly reflective surface) into many directions of which a small angle is captured by the sensor





- Values higher than 100% reflectivity are possible, if the surface is not a diffuse surface but a highly reflective surface like a retro-reflector
- Anything higher than 100% is defined as a partial reflection from a high reflector
- Value 101 – 255 = partial reflection from retro-reflector
  c) value 101 means reflection is almost the same as white, reflective diffuse reflector (b) plus small amount of reflection from the retro-reflector
  d) value 255 means ideal reflection of the retro-reflector (perfectly clean retro-reflector, no coverage)





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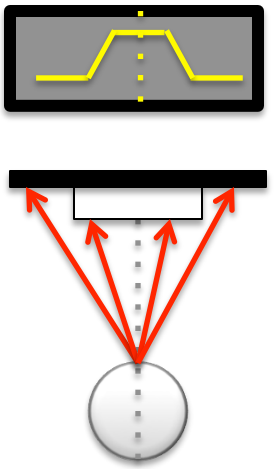
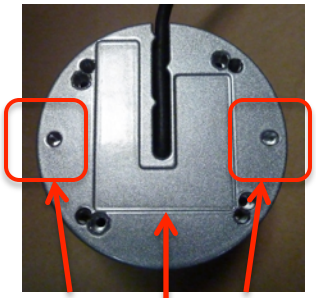
HDL32E V2.0 Zero Angle Calibration

November 30, 2012 (Wolfgang Juchmann)

Zero Angle Calibration (Version 2.0)

- Zero Horizontal Angle Calibration
  - The HDL32E provides two holes on the bottom side for precision mounting using dowel pins. In order to reproduce unit to unit reproducibility the zero angle (for the rotational axis) is calibrated with respect to the dowel pins.
  - Previously the the zero angle accuracy was limited by manufacturing and assembly tolerances of several rotational assemblies, while with Version 2.0 the zero angle is calibrated to the dowel pin holes after the assembly providing much better unit to unit repeatability.
  - The target is centered to the mounting holes for dowel pins which are permanently fixed to the floor
  - Several scans of laser 15 (horizontal) across the target are used to determine the center position from the edge locations
  - The accuracy of the calibrated zero angle is about 0.05 degrees
  - The unit to unit repeatability has additionally been increased with Version 2.0 by not coating the bottom side of the HDL32E sensor, thereby avoiding inaccuracies for mounting introduced by non-uniform coatings.





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New Features of Version 2.0

- GPS Fix
  - Customer had reported problems with the $GPRMC sentence related to the timing after a full second and also with some missing characters. Both problems have been fixed in Version 2.0

- Timestamp Fix
  - Customers had reported problems with the timestamps “jumping” around especially after full hours. This problem has been fixed with Version 2.0