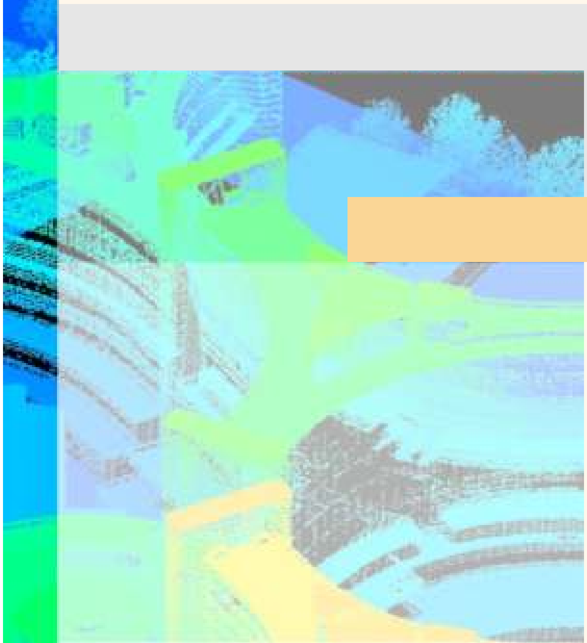
Airborne Laser Scanner for Full Waveform Analysis

LMS-Q560



- *full waveform analysis for unlimited number of target echoes*
- *high laser pulse repetition rate up to 240 kHz*
- *high mean measurement rate up to 160 000 measurements/sec*
- *high ranging accuracy of 20 mm*
- *interface for smooth integration of GPS*
- *eye safe for operation at any altitude*
- *parallel scan lines*
- *compact and rugged design, single power supply*
- *wide operating temperature range*

The *RIEGL*® LMS-Q560 is a revolutionary 2D laser scanner applying the latest state-of-the-art digital signal processing technique which meets the most challenging requirements in airborne laser scanning.

The *RIEGL* LMS-Q560 gives access to detailed target parameters by digitizing the echo signal online during data acquisition, and subsequent off-line waveform analysis. This method is especially valuable when dealing with difficult tasks, such as canopy height investigation or target classification. The operational parameters of the *RIEGL* LMS-Q560 can be configured to cover a wide field of applications. Comprehensive interface features support smooth integration of the instrument into complete airborne scanning systems.

The instrument makes use of the time-of-flight distance measurement principle of nanosecond infrared pulses. Fast opto-mechanical beam scanning provides absolutely linear, unidirectional and parallel scan lines. The instrument is extremely rugged, therefore ideally suited for the installation on aircraft. Also, it is compact and lightweight enough to be installed in small twin- or single-engine planes, helicopters or UAVs. The instrument needs only one power supply and GPS timing signals to provide online monitoring data while logging the precisely time-stamped and digitized echo signal data to the rugged *RIEGL* Data Recorder.

Topography & Mining
Corridor Mapping
City Modeling
Mapping of Lakesides & River Banks
Agriculture & Forestry
Target Classification
Glacier & Snowfield Mapping
Power Lines

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RIEGL®
LASER MEASUREMENT SYSTEMS

Echo Digitization of the *RIEGL* LMS-Q560

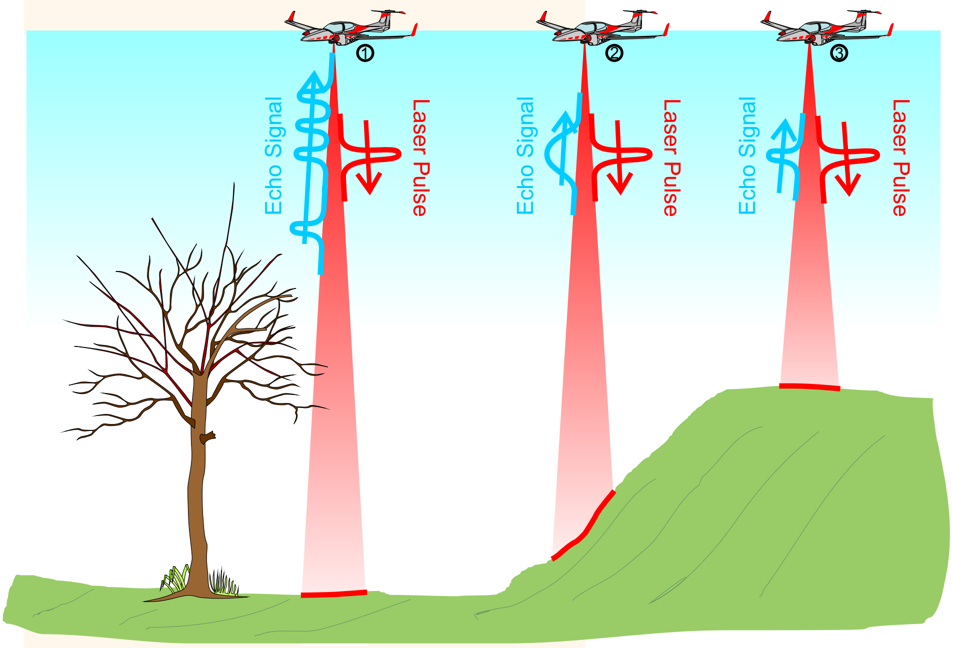


Fig. 1 Echo signals resulting from different types of targets

The digitization feature of the *RIEGL* LMS-Q560 enables the user to extract most comprehensive information from the echo signals. Figure 1 illustrates a measurement situation where 3 laser measurements are taken on different types of targets. The red pulses symbolize the laser signals travelling towards the target with the speed of light. When the signal interacts with the diffusely reflecting target surface, a fraction of the transmitted signal is reflected towards the laser instrument, indicated by the blue signals.

In situation 1, the laser pulse hits the canopy first and causes three distinct echo pulses. A fraction of the laser pulse also hits the ground giving rise to another echo pulse. In situation 2, the laser beam is reflected from a flat surface at a small angle of incidence yielding an extended echo pulse width. In situation 3, the pulse is simply reflected by a flat surface at perpendicular incidence resulting in one single echo pulse with a shape identical to the transmitted laser pulse.

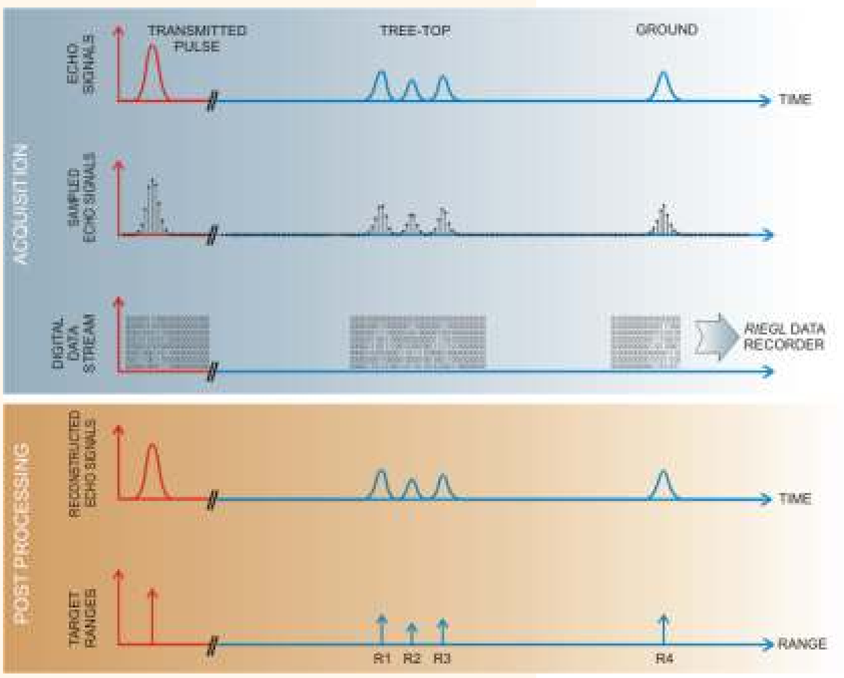


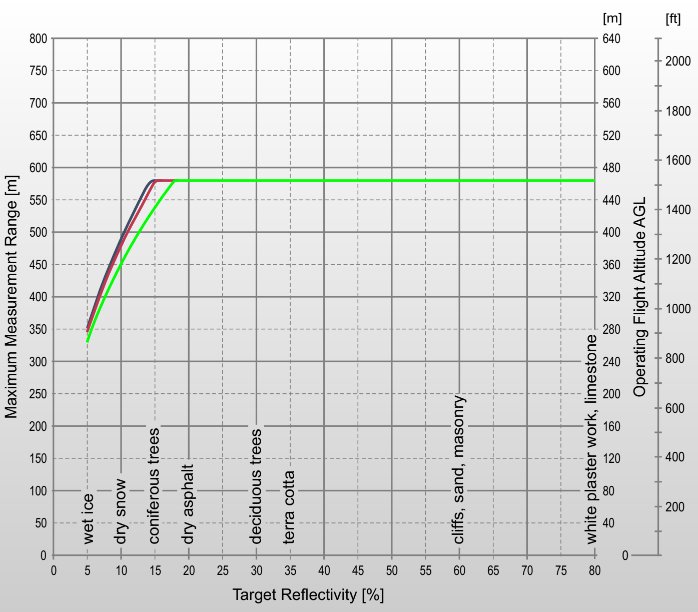
Fig. 2 Data acquisition and post processing

The upper line of the acquisition diagram shows the analog signals: the first (red) pulse relates to a fraction of the laser transmitter pulse, and the next 3 (blue) pulses correspond to the reflections by the branches of the tree; the last pulse corresponds to the ground reflection.

This analog echo signal is sampled at constant time intervals (middle line) and is, in the following, analog-to-digital converted, resulting in a digital data stream (bottom line of the acquisition section). This data stream is stored in the *RIEGL* Data Recorder for subsequent off-line post processing, as indicated in the post-processing section of the diagram.

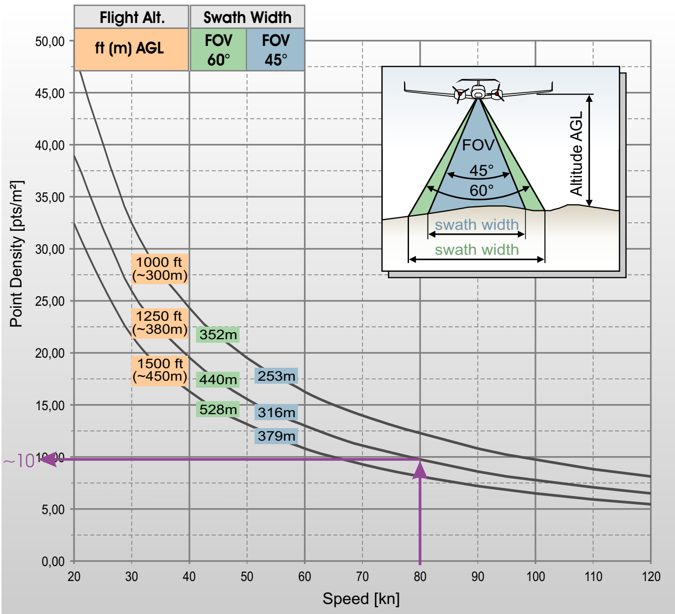
Based upon *RIEGL*'s long-standing expertise and experience in designing, manufacturing and marketing digitizing laser rangefinders for challenging industrial and surveying applications, and due to the careful design of the analog and digital front-end electronics, the LMS-Q560 records the complete information of the echo signal over a wide dynamic range. Thus, in post-processing the signal can be perfectly reconstructed and analyzed in detail to precisely derive target distance, target type, and other parameters .

PRR = 240 kHz



- @ visibility 23 km
- @ visibility 15 km
- @ visibility 8 km

PRR = 240 kHz

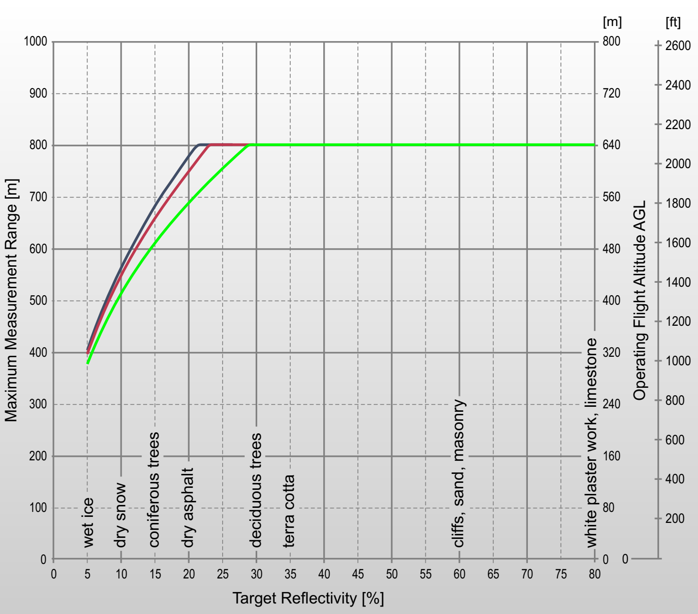


Example: Q560 at 240,000 pulses/second
Altitude = 1250ft AGL, Speed = 80 kn
Resulting Point Density ~ 10 pts/m²

For the Operating Flight Altitude AGL, the following conditions are assumed

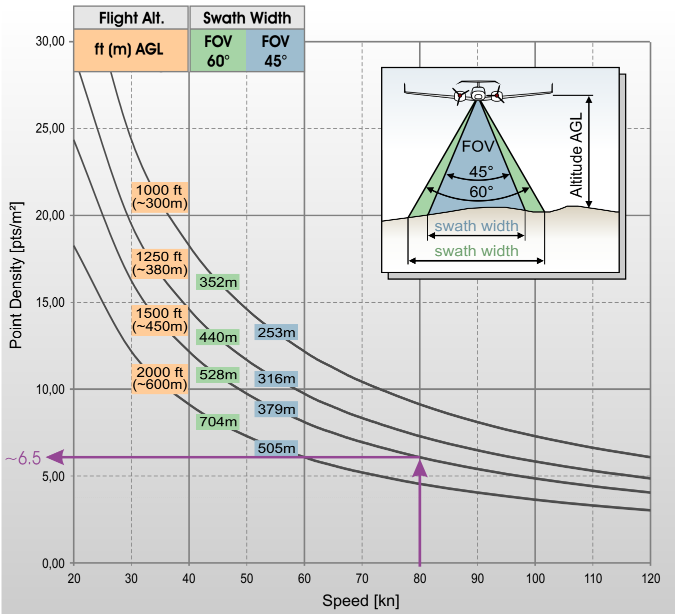
- target size ≥ laser footprint
- scan angle 60°
- average ambient brightness
- roll angle +/-6°

PRR = 180 kHz



- @ visibility 23 km
- @ visibility 15 km
- @ visibility 8 km

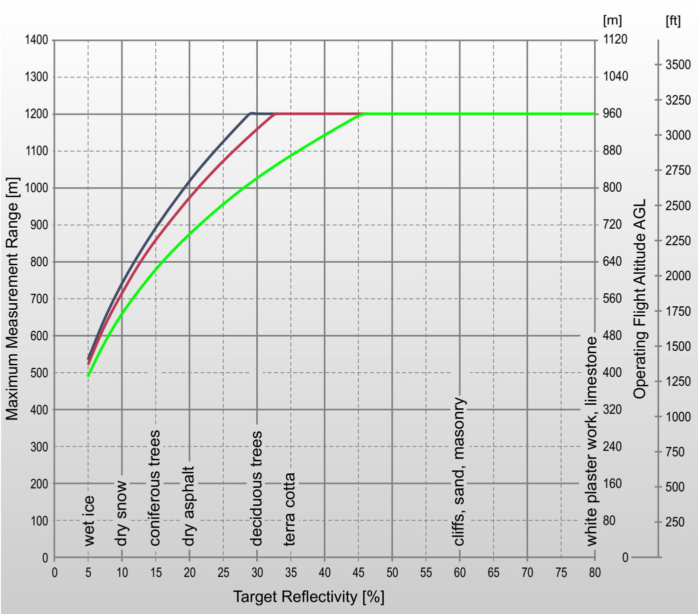
PRR = 180 kHz



Example: Q560 at 180,000 pulses/second
Altitude = 1500ft AGL, Speed = 80 kn
Resulting Point Density ~ 6.5 pts/m²

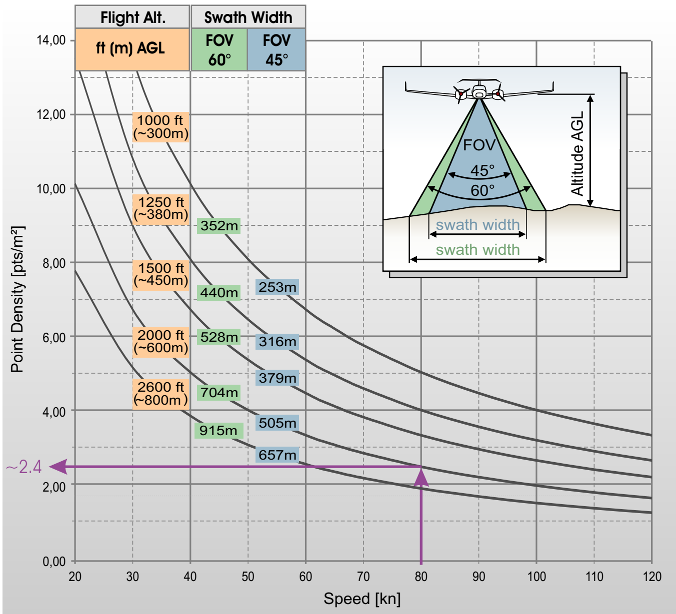
Maximum Measurement Range & Point Density for *RIEGL* LMS-Q560

PRR = 100 kHz



- @ visibility 23 km
- @ visibility 15 km
- @ visibility 8 km

PRR = 100 kHz

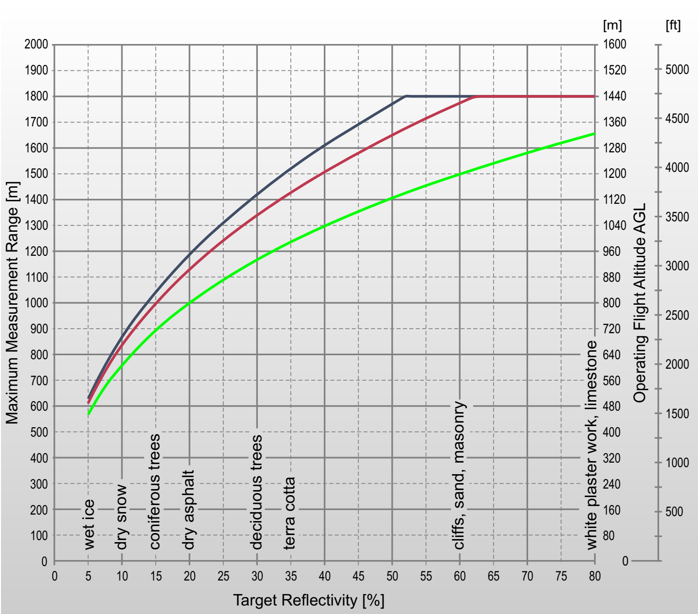


Example: Q560 at 100,000 pulses/second
Altitude = 2000ft AGL, Speed = 80 kn
Resulting Point Density ~ 2.4 pts/m²

For the Operating Flight Altitude AGL, the following conditions are assumed

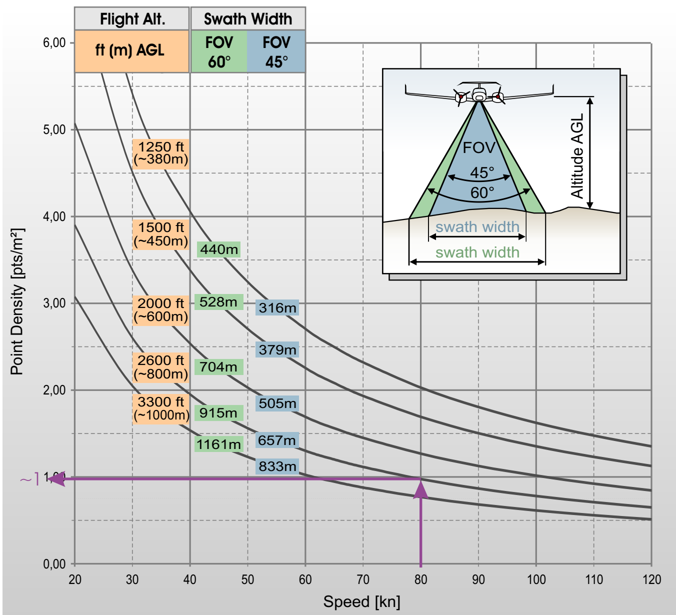
- target size ≥ laser footprint
- scan angle 60°
- average ambient brightness
- roll angle +/-6°

PRR = 50 kHz

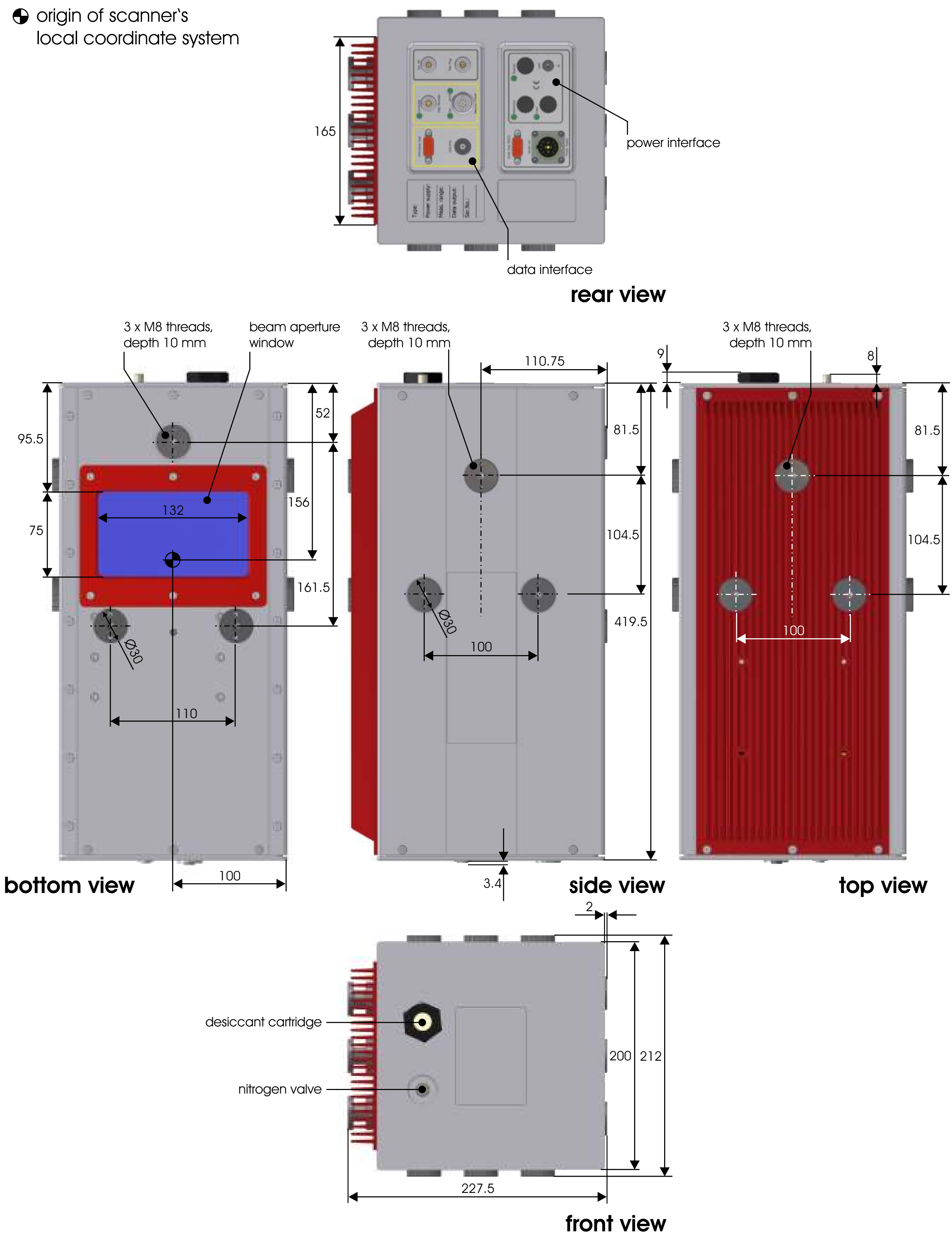


- @ visibility 23 km
- @ visibility 15 km
- @ visibility 8 km

PRR = 50 kHz



Example: Q560 at 50,000 pulses/second
Altitude = 2600ft AGL, Speed = 80 kn
Resulting Point Density ~ 1 pts/m²



all dimensions in mm

Technical Data *RIEGL* LMS-Q560

Laser Product Classification	Class 1 Laser Product according to IEC60825-1:2007 The following clause applies for instruments delivered into the United States: Complies with 21 CFR 1040.10 and 1040.11 except for deviations pursuant to Laser Notice No. 50, dated June 24, 2007.

CLASS 1 LASER PRODUCT

Range Measurement Performance

as a function of PRR and target reflectivity

Laser Pulse Repetition Rate	*50 kHz*	*100 kHz*	*180 kHz*	*200 kHz*	*240 kHz*
max. Unambiguous Measurement Range[1]					
natural target ρ ≥ 20 %	1200 m	1000 m	780 m	700 m	580 m
natural target ρ ≥ 60 %	1800 m	1200 m	800 m	700 m	580 m
max. Operating Flight Altitude AGL[2]	1000 m 3300 ft	800 m 2600 ft	600 m 2000 ft	550 m 1800 ft	450 m 1500 ft

1) The following conditions are assumed: • target is larger than the footprint of the laser beam • perpendicular angle of incidence • average ambient brightness • visibility 23 km

2) Reflectivity 20 %, max. scan angle 60°, additional roll angle +/- 5°

Minimum Range	30 m
Accuracy[3,4]	20 mm
Precision[3,5]	10 mm
Laser Pulse Repetition Rate[6]	up to 240 000 Hz
Effective Measurement Rate	up to 120 kHz @ 45° scan angle to 160 kHz @ 60° scan angle
Laser Wavelength	near infrared
Laser Beam Divergence[7]	≤ 0.5 mrad
Number of Targets per Pulse	digitized waveform processing: unlimited[8] online monitoring data output: first pulse or last pulse

Scanner Performance

Scanning Mechanism	rotating polygon mirror
Scan Pattern	parallel scan lines
Scan Angle Range	± 22.5° = 45° total (± 30° = 60° total[9])
Scan Speed	10 - 160 lines/sec
Angular Step Width $\Delta\vartheta$[6] between consecutive laser shots	$\Delta\vartheta \geq 0.004°$ (for PRR in excess of 100 000 Hz[10])
Angle Measurement Resolution	0.001°
Scan Sync	option for synchronizing scan lines to external timing signal

3) Standard deviation one sigma @ 250 m range under *RIEGL* test conditions.
4) Accuracy is the degree of conformity of a measured quantity to its actual (true) value.
5) Precision, also called reproducibility or repeatability, is the degree to which further measurements show the same result.
6) User selectable
7) 0.5 mrad correspond to 50 cm increase of beam width per 1000 m distance
8) Practically limited only by the maximum data rate allowed for the *RIEGL* Data Recorder
9) Up to 60° with 90% of maximum measurement range
10) Minimum angle step width increasing linearly to 0.008° @ 50000 Hz laser pulse repetition rate

Intensity Measurement

For each echo signal, high-resolution 16-bit intensity information is provided which can be used for target discrimination and/or identification/classification.

Data Interfaces

Configuration	TCP/IP Ethernet (10/100 MBit), RS232 (19.2 kBd)
Monitoring Data Output	TCP/IP Ethernet (10/100 MBit)
Digitized Data Output	high speed serial data link to *RIEGL* Data Recorder
GPS-System	serial RS232 interface, TTL input for 1pps synchronization pulse, accepts different data formats for GPS-time information

General Technical Data

Power Supply	18 - 32 VDC
Current Consumption	approx. 5 A @ 24 VDC
Main Dimensions (L x W x H)	420 x 212 x 228 mm
Weight	16 kg
Protection Class	IP54
Max. Flight Altitude (operating)	16 500 ft (5 000 m) above MSL
Max. Flight Altitude (not operating)	18 000 ft (5 500 m) above MSL
Temperature Range	0°C up to +40°C (operation) / -15°C up to +50°C (storage)
Mounting of IMU-Sensor	steel thread inserts on the top and on the sides of the laser scanner, rigidly connected to the inner structure of the scanning mechanism

RIEGL®
LASER MEASUREMENT SYSTEMS

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