

ABEM Terrameter LS 2

RESISTIVITY AND IP IMAGING

Performance through scalability



ABEM Terrameter LS 2 – Redefining greatness

The new generation of ABEM Terrameter LS constantly pushes the boundaries by introducing features previously never seen in commercial resistivity meters. The latest upgrade of Terrameter LS 2 has a new IP feature using 100 % duty cycle, resulting in increased measuring speed as well as improved data quality.

Resistivity/IP surveying is a versatile geophysical method suitable for a broad range of applications and environments such as groundwater prospecting, mineral exploration, geological mapping and geotechnical investigations. System design can vary depending on the application. ABEM Terrameter LS 2 is available in many different configurations to perfectly match your requirements.

ABEM Terrameter LS 2 introduces a unique software licensing system, making it scalable and easy to upgrade. Every instrument comes preinstalled with all hardware modules and software features, but depending on product package not all need be activated. Product packages range from basic to advanced. Upgrades are made by downloading a license code from the internet or USB. Future development will include time-limited licenses, making it possible to rent upgrades.

ABEM Terrameter LS 2 is a standalone solution featuring built-in measurement channels, high power current transmitter, electrode selector, computer and graphical user interface. Surveying techniques range from 1D to 4D measurements. The robust and rugged aluminum casing meets IEC IP66 classification and allows for use in the harshest of conditions.

The measurement channels on Terrameter LS 2 have a new filter design for improved IP performance. Using a new measurement mode for IP (100 % duty cycle), data collection will be twice as fast and have twice the signal to noise ratio compared to the conventional IP method (50 % duty cycle) using the same settings.

Utilizing new technology alongside upcoming features in the Workbench processing package from Aarhus GeoSoftware, it will be possible to extract spectral information from time-domain IP data.

Typical applications

- ▷ Geological mapping
- ▷ Geotechnical pre-investigation
- ▷ Groundwater prospecting
- ▷ Mineral exploration
- ▷ Mapping and monitoring of contamination
- ▷ Geothermal prospecting
- ▷ Sub-bottom mapping of marine environments
- ▷ Monitoring of permafrost
- ▷ Archaeology

ABEM Terrameter LS 2

ABEM Terrameter LS 2 offers up to 12 measurement channels for greater efficiency and productivity in the field. The built-in electrode selector allows for connection of up to 81 electrodes, providing high resolution and impressive depth capabilities. With the use of external electrode selectors over 16 000 electrodes can be connected. Guideline Geo offers a wide range of land, marine and borehole cables.

The built-in field computer in the ABEM Terrameter LS 2 offers increased computing power, an easy to use graphical user interface and connectivity such as USB, Ethernet, Wi-Fi and 3G. The internal GPS supports GLONASS, which improves positioning accuracy. Data is stored on a removable 16 GB microSD memory card, with a capacity of millions of data readings.

Remote connectivity can allow the ABEM support team to assist with software upgrades, give support or troubleshoot if necessary. This unique feature ensures that the system is always up to date, operating correctly, with the risk of downtime kept to an absolute minimum.

New functionality

- Scalable through software licensing system
- 100 % duty cycle – New IP measure mode for faster data collection and better data quality
- 3G and Wi-Fi connectivity
- 16 GB removable and expandable data storage
- Built-in charger for internal battery
- GPS with GLONASS for improved accuracy
- Faster CPU module for a smooth user experience
- New power connector



Features

- ▷ Up to 12 measurement channels
- ▷ Unique design of measurement channels and high power current transmitter
- ▷ IP measurements with 100 % duty cycle
- ▷ 1D, 2D, 3D and 4D measurements
- ▷ IEC IP 66 classification
- ▷ Wi-Fi and 3G connectivity
- ▷ Software licensing system

Advantages

- ▷ Optimized for productivity, minimizing field time
- ▷ Outstanding quality of data even in the toughest conditions
- ▷ Measure IP faster and with better quality
- ▷ Basic or advanced measurements, no limitations
- ▷ Rugged and robust – measure anywhere, anytime
- ▷ Remote connectivity allows assistance onsite
- ▷ Scalable and easy to upgrade

ABEM Terrameter LS 2

Designed for efficiency

ABEM Terrameter LS 2 continues its great heritage of adding advanced and useful features to resistivity meters. With its latest addition, the Terrameter LS 2 is increasing both measuring speed and data quality by adding an IP feature using 100 % duty cycle in the advanced configurations.

The graphical user-interface makes it easy to use and the entire user experience is streamlined for productivity. During measurement, the system gives continuous information of data quality, showing results directly on screen. Multichannel arrays, such as the Multiple Gradient, ensure measurement tasks can be completed quickly.

The commitment to data quality and productivity does not stop with the instrument. ABEM software can be used for maintaining instruments, simplifying downloading and processing of data before inversion. After the inversion, visualization tools can be used to make the inversed data more presentable and ready for use in a report. With the new software licensing system the ABEM Terrameter LS 2 is scalable and future-proof, ensuring a return of investment no matter what system you start on – basic or advanced.

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Guideline Geo is a world-leader in geophysics and geo-technology offering sensors, software, services and support necessary to map and visualize the subsurface. Guideline Geo operates in four international market areas: Infrastructure – examination at start-up and maintenance of infrastructure, Environment – survey of environmental risks and geological hazards, Water – mapping and survey of water supplies and Minerals – efficient exploration. Our offices and regional partners serve clients in 121 countries. The Guideline Geo AB share (GGEO) is listed on NGM Equity.

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ABEM Terrameter LS 2 is a world leading resistivity/IP instrument which can be used for a wide range of applications. With an extensive software licensing system it becomes available in multiple configurations, developed to match your requirements. The Terrameter LS 2's latest feature is the IP 100 % duty cycle added for increased measuring speed and improved data quality.

General

Casing	Rugged aluminum case meets IEC IP66
Computer	Embedded ARM 9, 400 MHz
GPS	Built-in GPS with support for GLONASS
Display	8,4" Active TFT LCD, full colour, daylight visible
I/O ports	2x KPT 32 pin for imaging AUX, Interconnect, USB A, RJ45 for LAN
WLAN	IEEE 802.11 b/g/n, built-in antenna
3G/GSM ¹	3G (UMTS/HSPA+) and GSM (GPRS/Edge), built-in antenna Five bands 3G: 850/800, 900, 1900 and 2100 MHz Quad-band GSM: 850/900/1800/1900 MHz
Measure modes	Resistivity, SP, Resistivity and IP using 50 % or 100 % duty cycle depending on model configuration
Service point	Accessible through Internet
Memory capacity	16 GB, microSD card accessible from outside
Power	12 V, 8 Ah internal battery, built-in charger 12-18 VDC external power
Dimensions	39x21x32 cm (WxLxH)
Weight	13.9 kg, 12.2 kg without internal battery
Ambient temperature range	-20 °C to + 70 °C operating ^{2, 3} -30 °C to + 80 °C storage ⁴

Note 1: Measuring speed may be reduced in high ambient temperature combined with high output power

Note 2: The performance of the LCD is not guaranteed below 0 °C

Note 3: Non-condensing

Multi-Electrode Survey Systems for 2D & 3D

Number of electrodes	Up to 81, using internal electrode selector Up to 16384, using external electrode selectors
Switching matrix	Internal 10x64, divided into four blocks for effective use of all receiver channels available
Roll-along	Full coverage, both 2D and 3D
Pre-installed array types	Multiple Gradient, Dipole-Dipole, Wenner, Schlumberger, Pole-Dipole and Pole-Pole
Remote electrodes	2 remote electrodes in addition to inline electrodes
Electrode test	Estimates contact resistance on all electrodes currently in use



Receiver

Number of channels	Up to 12 (+ 2 for transmitter monitoring)
Isolation	All channels are galvanically separated
Input voltage range	Up to ± 600 V
Range	Depending on model ± 2.5 V, ± 15 V, ± 600 V
Input impedance	200 M Ω (± 2.5 V range), 30 M Ω (± 15 V range), 20 M Ω (± 600 V range)
Precision	0.1 %
Accuracy	0.2 %
Resolution	Up to 3 nV at 1 sec integration (theoretical)
Linearity	0.005 %
Flat frequency response	Better than 1 % up to 300 Hz
Full waveform recording	Depending on model Built-in monitoring of all input channels

Transmitter

Maximum output power	Up to 250 W
Current transmission	Constant current transmitter
Maximum output current	Up to 2500 mA
Maximum output voltage	Up to ± 600 V, 1200 V peak to peak
Current accuracy	0.2 %
Current precision	0.1 %
Instant polarity changer	Yes
Self diagnostics	Monitoring of temperature and power dissipation
Safety	Easily accessible safety switch
Full waveform recording	Depending on model, built-in monitoring of current and voltage output



Specifications per model

Model Configuration	Basic 2/48	Standard 2/48	Standard 2/81	Advanced 4/48	Advanced 10/48	Advanced 4/81	Advanced 8/81	Advanced 12/81
Number of channels	2	2	2	4	10	4	8	12
Max. number of electrodes	48	48	81	48	48	81	81	81
Input voltage range	± 15 V	± 15 V	± 15 V	± 600 V	± 600 V	± 600 V	± 600 V	± 600 V
Input impedance (± 2.5 V)	-	-	-	200 M Ω	200 M Ω	200 M Ω	200 M Ω	200 M Ω
Input impedance (± 15 V)	30 M Ω	30 M Ω	30 M Ω	30 M Ω	30 M Ω	30 M Ω	30 M Ω	30 M Ω
Input impedance (± 600 V)	-	-	20 M Ω	20 M Ω	20 M Ω	20 M Ω	20 M Ω	20 M Ω
Theoretical resolution	22.5 nV	22.5 nV	22.5 nV	3 nV	3 nV	3 nV	3 nV	3 nV
Max. output power	100 W	200 W	200 W	250 W	250 W	250 W	250 W	250 W
Max. output current	1000 mA	2000 mA	2000 mA	2500 mA	2500 mA	2500 mA	2500 mA	2500 mA
Max. output voltage	400 V	500 V	500 V	600 V	600 V	600 V	600 V	600 V
Full waveform recording	No	No	No	Yes	Yes	Yes	Yes	Yes
IP using 100% Duty cycle	No	No	No	Yes	Yes	Yes	Yes	Yes

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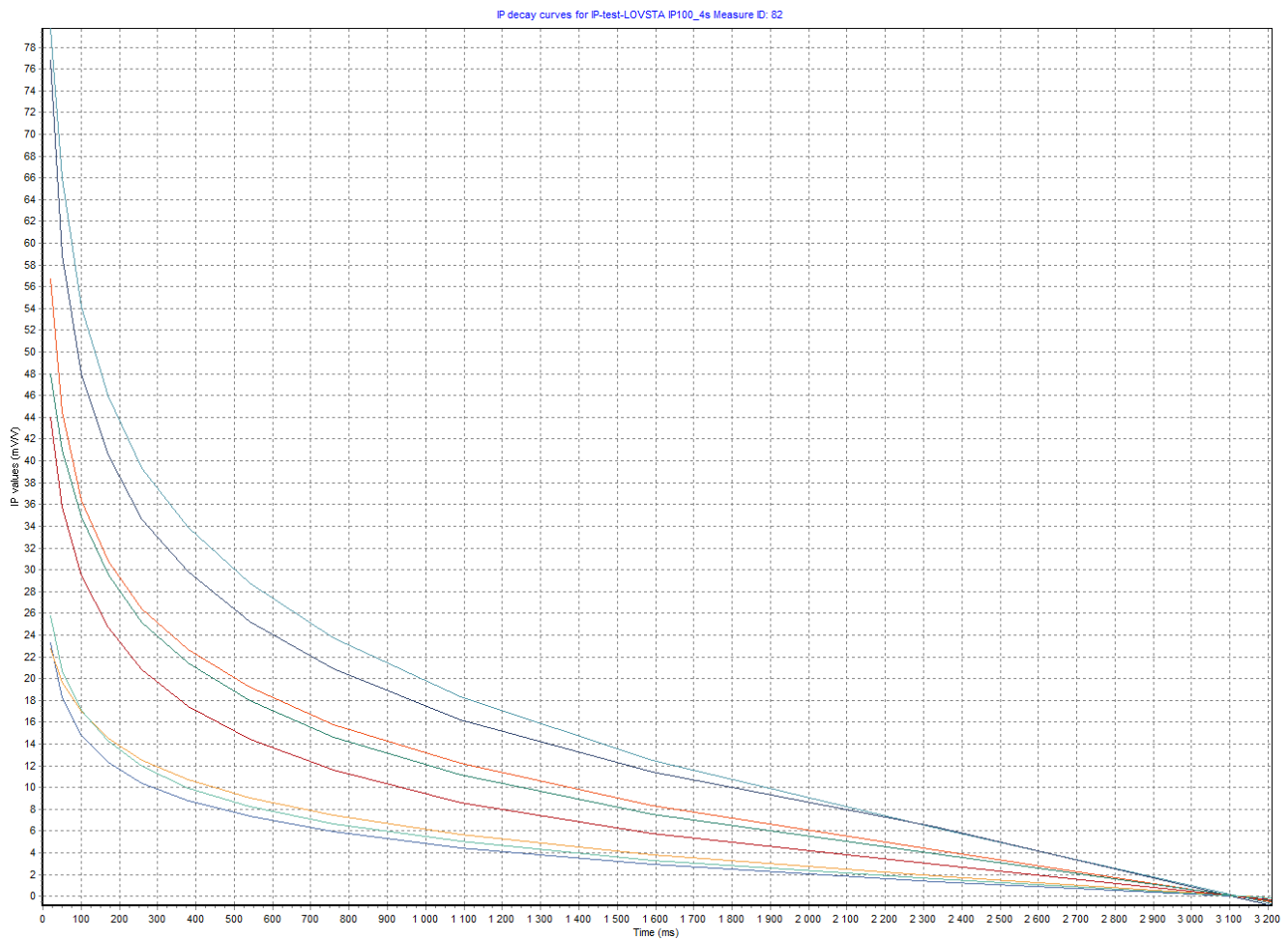
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IP using 100 % Duty Cycle



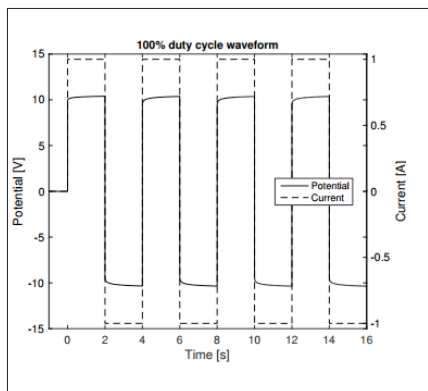
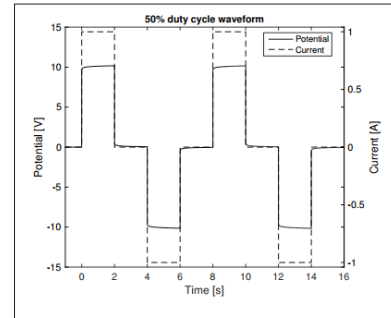
Author: Fredrik Nyqvist

100 % Duty Cycle

Using a new measurement mode for IP (100 % duty cycle), data collection will be twice as fast and have twice the signal to noise ratio compared to the conventional IP method (50 % duty cycle) using the same settings.

Time-efficient IP measurements using 100 % duty cycle

The previous ABEM Terrameter LS, as most field resistivity/IP instruments, uses the time domain method to collect IP data. This method has traditionally used what is called a 50 % duty cycle - this means that measurement periods are divided into two equal parts. During the first part, the ON time, current is transmitted into the ground to charge it. During the second part, the OFF time, no current transmission is made, instead the instrument measures how the voltage decays as the ground discharges. During the ON time resistivity data are measured and during the OFF time IP data are measured. *To the right, a 50 % duty cycle measurement using two stacks (repetitions) can be seen.*



With the new ABEM Terrameter LS 2 it is possible to measure IP using 100 % duty cycle. This means that there is no OFF time, and that current is always transmitted into the ground. Instead of measuring IP when the ground is discharging, IP will now be measured during the early part of the ON time as the ground is being charged. With this new measure mode both resistivity data and IP data will be measured during the ON time, and the OFF time is not needed. By removing the requirement for an OFF period, it is now possible to measure IP twice as fast as with the traditional IP method. *To the left is a 100 % duty cycle measurement using the same ON time as the example above but, eight pulses can now be measured in the same time that only 4 pulses were achieved with the 50 % duty cycle.*

Increased data quality by super-positioning the signal

During resistivity and IP measurements the current transmission polarity is switched in order to remove ground SP (spontaneous potential) effects, which could otherwise cause an offset in recorded voltage values.

For IP using 50 % duty cycle, one cycle will consist of a positive ON time, an OFF time, a negative ON time and an OFF time. It is assumed that the ground has been completely discharged after the OFF time so, after each polarity switch, the charge-up effect is starting from zero. The voltage values in the IP decay are typically very small and can, in some situations, be difficult to differentiate from background noise.

IP using 100 % duty cycle has no OFF time, and one cycle will consist of a positive ON time, a negative ON time and a positive ON time. This means that at the polarity switch (positive to negative, and negative to positive) the ground will be discharged and charged at the same time. By super-positioning the discharge and charge-up (summing up the two effects) the result is a bigger IP response. With this bigger IP response, the signal to noise ratio (SNR) is increased, producing better data quality as it becomes easier to differentiate the IP decay from the background noise.

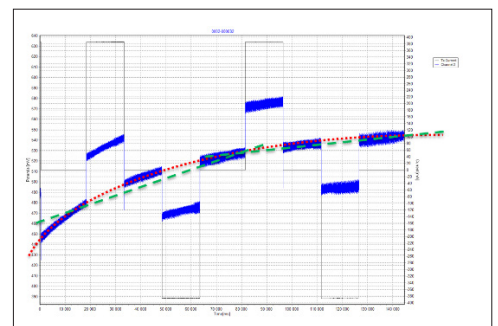
Exponential SP background removal for increased accuracy

Uncorrected SP effects can introduce errors in the calculation of resistivity and IP data. For that reason resistivity/IP meters normally use what is called linear SP trend removal. This means that before and after each measurement stack, SP samples are taken and any changes in the SP values can be detected. If the SP value has changed, the SP effect will be removed by using the two SP samples from the start and the end of the measurement cycle to create a linear background trend that is used to estimate the zero level when integrating the results.

The linear SP trend removal works very well if the SP changes are small, or vary at a steady rate. But if the SP changes are non-linear or larger in size, the linear SP trend removal will not be ideal and will result in a difference between the integrated and the actual resistivity/IP value. The measured IP signals are typically very small, and introducing this error in the calculated IP value can have a big effect on the reliability of the final model.

In the new IP measure mode an exponential SP trend removal has been implemented. This means that non-linear SP changes can be measured much more precisely and will be incorporated in the resistivity and IP integration for a more accurate result.

In the figure to the right full waveform data from a measurement can be seen. The blue line represents the measured input voltage, and it is strongly affected by non-linear SP effects. The green dashed line represents how the linear SP trend removal would have been used to estimate the zero level and there is a distinct difference from the actual SP variation and the calculated SP effect, especially in the first part of the measurement. The red dotted line represents the exponential SP trend removal, and as can be seen it has a much better fit to the actual SP effect.



Input channel filters optimized for IP

The input channels of the new ABEM Terrameter LS 2 have been changed in order to give a higher bandwidth for IP data. The new filter design allows for inclusion of more low and high frequency IP components in the calculations than the previous Terrameter LS. This means that the Terrameter LS 2 can start measuring IP decays earlier after current turn off, and that measurements are improved during very long IP times.

Additional IP parameters and processing features available with Aarhus Workbench

Traditionally IP data have been processed and inversed as an integral IP data set. This means that even if multiple IP windows have been used for increased decay information when measuring, the modelling software will handle the data as if only one, very long, IP window was used. This severely limits the scope for quality evaluation as well as the processing and interpretation possibilities. This 'simplification' of the IP decay may also negatively impact upon the end result in terms of model accuracy.

Using Aarhus Workbench with the ERT/IP modules the full decay data, using all IP windows, will be analyzed. This gives a much better view and understanding of the data quality. The IP decay is represented graphically, showing each IP window. In the data processing it is possible to exclude an entire decay curve or, if only parts of the IP decay are affected, individual IP windows can be excluded whilst good segments can still be used.

In all other modelling software for time domain IP data, the IP result can only be represented as chargeability. For frequency domain IP (sometimes called spectral IP) two additional parameters, C and Tau, have been used to fit the IP signal and model the data. These parameters have previously only been available from frequency domain IP data, but Aarhus Workbench is currently the only commercially available software offering this capability for time domain IP data by using Cole-Cole parametrization. Applications for Tau and C values are currently the subject of much research, but potential uses include gaining additional information about the geology, such as grain size and fluid conductivity.

The advantages with IP using 100 % duty cycle

The three biggest advantages are:

1. Using a 100 % duty cycle, IP data can be collected twice as fast as when using the 'standard' 50 % duty cycle.
2. As the signal to noise ratio is twice as high using the new method, IP data quality will be much better than before.
3. Exponential SP trend removal makes the IP calculations more accurate.

These are important factors which strengthen the argument that external high power transmitters are not always necessary.

The advantages with Aarhus Workbench ERT/IP for IP data

- Better quality control as the entire IP decay can be seen
- Better processing possibilities as individual sections (IP windows) can be excluded if necessary
- Uses Cole-Cole or Constant Phase Angle analysis for better IP modelling
- Two additional IP parameters, C and Tau (if using Cole-Cole parametrization)

To make full use of the advantages with the new measure mode in the ABEM Terrameter LS 2, Aarhus Workbench is a great tool. The other commercially available inversion software cannot process and model IP data in the same way.

References

IP using 100 % duty cycle along with the additional processing are methods and processes that have been developed by Aarhus University and Lund University. The work done by Guideline Geo is to implement parts of the new methods in the ABEM Terrameter LS 2. For more information and research papers we refer to publications of Aarhus University and Lund University.

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For a full list of publications see Aarhus University and Lund University web sites

Aarhus University

<http://geo.au.dk/forskning/enheder-og-centre/hydrogeophysics-group/publications/new/>

Lund University

<http://www.tg.lth.se/english/research/selected-publications/>

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