MALÅ

ProEx - Professional Explorer Control Unit

Operating Manual v. 2.0

19-001030

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1 Introduction

Thank you for purchasing the MALÅ Professional Explorer (ProEx) Control unit. This fourth generation of control units from MALÅ Geoscience is designed for the demanding user, supporting all the MALÅ antennas available and prepared for customisation. The ProEx gives you a modular design with changeable antenna modules, enabling measurements in any mode, single or multi-channel. The ProEx, is run from the proven, easy-to-use, interfaces of GroundVision2 (for PC) and the MALÅ XV Monitor, both, by many, thought of as the best data collection interfaces available. Current users of MALÅ GPR systems will find themselves familiar in no time, and new users will be surprised by the short learning curve.

We at MALÅ Geoscience welcome comments from you concerning the use and experience of this equipment, as well as the contents and usefulness of this manual. Please take the time to read through the assembling instructions carefully and address any questions or suggestions to the following:

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1.1 Unpacking and Inspection

Great care should be taken when unpacking the equipment. Be sure to verify the contents shown on the packing list and inspect the equipment for any loose parts or other damage. All packing material should be preserved in the event that any damage occurred during shipping. Any claims for shipping damage should be filed to the carrier. Any claims for missing equipment or parts should be filed with MALÅ Geoscience.

1.2 Repacking and Shipping

If original packing materials are unavailable, the equipment should be packed with at least 80 mm of absorbing material. Do not use shredded fibres, paper wood, or wool, as these materials tend to get compacted during shipment and permit the instruments to move around inside the package.

1.3 Important information regarding the use of this GPR unit

According to the regulations stated in ETSI EN 302 066-1 (European Telecommunication Standards Institute):

- The control unit should not be left ON when leaving the system unintended. It should always be turned OFF when not in use.
- The antennas should point towards the ground, walls etc. during measurement and not towards the air.
- The antennas should be kept in close proximity to the media under investigation.

Note! As a rule of thumb, when the conductivity of a geological medium (soil, rock, concrete, etc.) is more than 20 mS/m (or resistivity is less than 50 Ohm-m), GPR is a less advisable method for investigations in that area. Less advisable areas can for instance be clay rich soils, areas with saline water infiltration and wet (i.e. ’new’) concrete.

2 The ProEx Control unit

The radar control unit ProEx is the main part of a MALÅ GPR system. As seen in Fig. 2.1, the ProEx is compatible with all current MALÅ antennas, both unshielded, shielded, borehole and high frequency antennas.

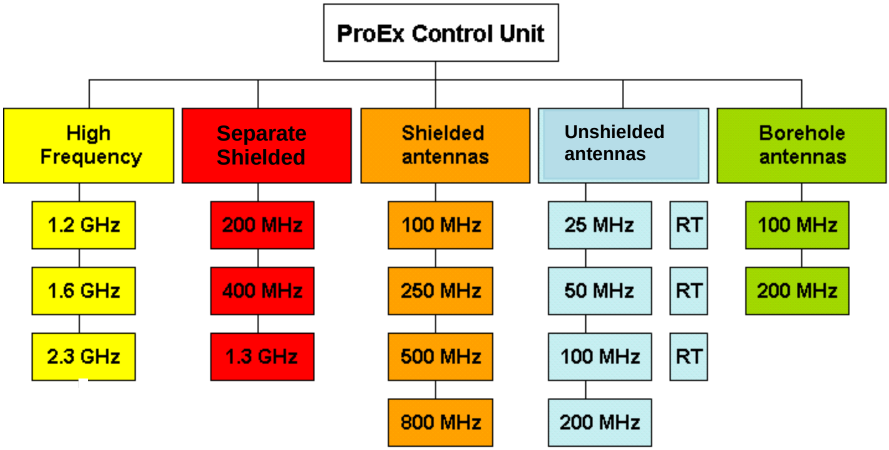


Fig. 2.1 An overview of all antennas that can be used together with the ProEx today. For latest update, go to the MALÅ Geoscience homepage; www.malags.com

The MALÅ ProEx is the administrator for the radar data collection. It consists of a power supply, an analogue section that generates the crucial control signals and internal computers. Three parallel 32-bit processor controls transmitter and receiver timing, sampling and trace intervals, stores raw radar data in a temporary buffer and data transfer to a PC interface or to the MALÅ XV Monitor. The three controllers communicate internally by means of fast, double port memories and externally by means of a high speed Ethernet link hence taking away bottlenecks common with older control units.

For safe and easy operation, the needed calibrations parameters are stored in the internal memory of the ProEx. The antenna configurations are stored in separate files in the XV or PC.

The main unit has (see Fig. 2.2 below):

- a 100MBit Ethernet link for XV Monitor or PC communication.
- connector for Master wheel (distance-measuring devices) (See Chapter 12).
- input power (See Chapter 13).
- connectors for the different antenna modules and auxiliary ports (see Chapter 4 and 11).
- connectors for expansion unit (see Chapter 10).
- 2 slots for antenna modules, see Chapter 4 to 9. Currently 3 different antenna modules are available.

The ProEx requires only short warm up time and is ready for data acquisition in just a few minutes.

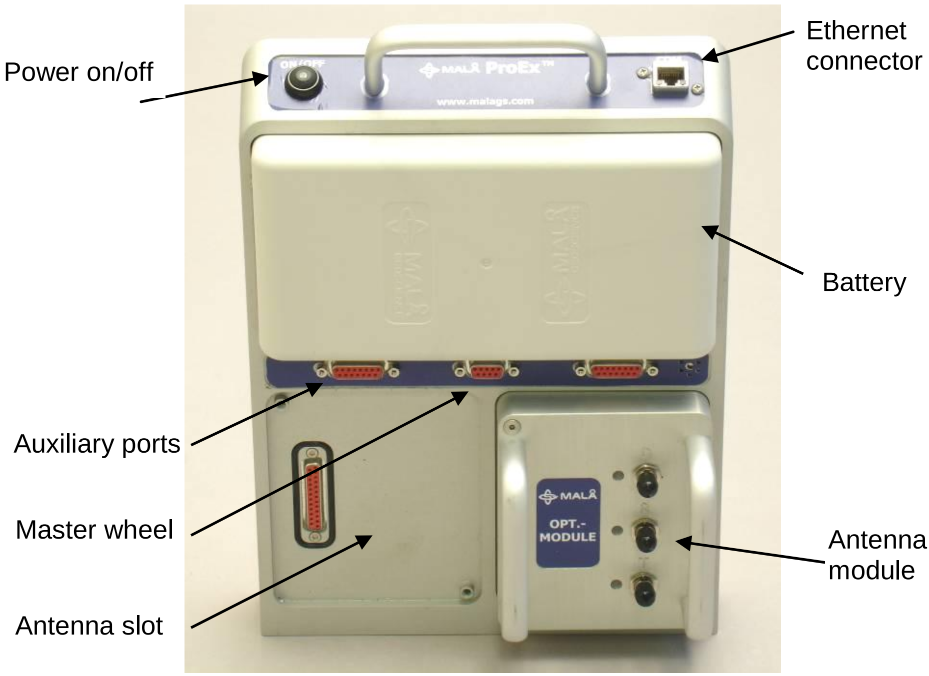


Fig. 2.2 The MALÅ ProEx Control unit.

The ProEx is designed for outdoor use. The unit is made in worked aluminium and is completely waterproof. The mechanics is designed to protect connectors and switches from physical damage.

During operation the ProEx is mounted on a backpack holder or used together with the MALÅ backpack. The ProEx can also be attached to the MALÅ RTC (**R**ough **T**errain **C**art), see Fig. 2.3.

Note! The backpack is not suitable if the HF-option is used.

Fig. 2.3 The MALÅ ProEx Control unit mounted in the backpack and on the RTC.

More information on assembling the ProEx to the different MALÅ antennas, see Chapters 5 to 9.

For fixed, mounted operations, as on a vehicle, there’s a power connector under the main battery as well as on each expansion unit. When the ProEx unit is used with one or more expansion units, it has to be connected to an external 12V power source; battery operation is not possible in these configurations.

Note that the firmware of the ProEx is upgradeable from a normal computer, to prevent the need for sending the unit back for upgrades or customizations.

3 The ProEx measurement modes

The ProEx in its origin form has two module slots, A and B, where the, currently, three different types of antenna modules can be connected (optical, coaxial and HF). See Fig. 3.1 and Chapter 4. To this base unit two more extension modules can be connected (See Chapter 10) which increases the number of slots up to a maximum of 8.

Fig 3.1. The ProEx and the name of the two different slots on the main unit.

Each of these slots with its antenna module can collect data on two different channels, 1 and 2 or also called Internal Tx and External Tx. Internal Tx means that the antenna measures as an ordinary antenna, with its transmitter and receiver part. External Tx means that the antenna connected will only function as a receiver. The transmitter is used on the antenna connected to the second slot in that slot pair.

For example:
Configured with only one optical module, the ProEx unit is, by functionality, identical to the older CUII unit and thus supports all antennas with optical interfaces, i.e. unshielded, RTA, borehole, and shielded antennas.

A common, practical 2-channel configuration would be a HF-module in slot A and an optical unit in slot B. This configuration would be ideal for road measurements with a high frequency antenna (1.2, 1.6 or 2.3 GHz) connected to the HF module, measuring asphalt thickness and an 500/800MHz connected to the optical module, measuring the layers within the roadbed.

Adding a second optical module gives a system suitable for more advanced analysis such as continuous velocity sounding, multi-path analysis of structures etc. See Chapter 10.

4 Antenna modules

Since the early days of GPR, the number of different antennas and hence the interfacing have become much more diverse. In order to overcome this and to be able to support any future development, the ProEx Control Unit is made in a modular design with changeable antenna modules (Fig. 4.1 and 4.2).

Currently there are three different types of modules to make the ProEx compatible with all antennas; Optical, Coaxial and High Frequency modules. These modules can be combined in any way to enable different types of antennas to be run simultaneously, each antenna with their individual settings. Note that an individual processor controls each module and timing board, no switching takes place, giving each channel the best possible performance.

Fig 4.1. The ProEx and the three different antenna modules.

Fig 4.2. Mounting the antenna module on the ProEx main unit.

4.1 Optical module

This unit (Fig. 4.3) connects to all antennas with optical interface, including borehole, shielded and unshielded antennas. The main benefits of using optical interfaces are that no dependence on cable lengths is present and that the optical fibers do not interfere with the radar waves.

The connections on the module are marked with T (Transmitter), R (Receiver) and D (Data). Corresponding connections are found on the borehole, shielded and unshielded antenna electronics.

Supported antennas:
Shielded 100-800MHz, Unshielded 25-200MHz, RTA 30-100MHz, Borehole 20- 250MHz

Fig. 4.3 The optical module. In the picture the three different fibre optical connectors are seen, for T (transmitter), R (receiver) and D (Data).

For troubleshooting purposes, the module has a LED connected to each optical connector. The ones on the R and T connectors indicate that trig signals are leaving the module, when flashing. The one on the D-connector indicates that the module, when flashing receives data.

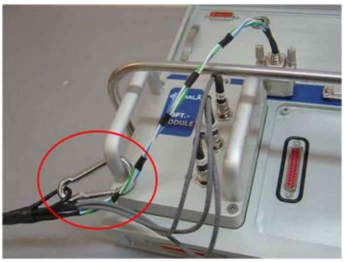
4.1.1 Optical fibres

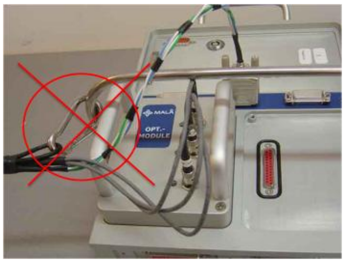
When using the optical module, the ProEx communicates with the transmitter and receiver antenna electronics through fibre optical cables. The data transfer rate through the fibres is 4 Mbytes/sec and they operate:

- Trig signals to the transmitter element from the ProEx
- Trig signals to the receiver element from the ProEx
- Data from the receiver element to the ProEx.

The antennas can be operated through the standard set of optical fibres for MALÅ GPR systems. These optical fibres come in a standard length of 3 m. They are also available in lengths up to 100 meters or more for applications such as CMP measurements or cross scanning where the two antennas have to be separated from each other.

For the shielded antennas MALÅ Geoscience have designed a special set of fibres housed in a plastic hose for convenience. This is to protect the fibres from damage when operating the antenna in e.g. rough environments. The attachment of the optical fibres to the antenna includes a metal cover over the optical connectors. This is in order to protect the connectors and the fibres at their attachment on the antenna.





Note! The safety hook should be fastened in the bow of the module and not the protective bow.

The bending of a trig fibre should be avoided because it can play an important role for the time displacement of the pulse in the time window.

For using the shielded antennas at longer distances from the ProEx than 3 m there is also a plastic hose of 20 m length available. Alternatively the standard optical fibres with lengths up to 100 m can be used.

All the fibre optic cables provided with the MALÅ GPR are reinforced with Kevlar™ and feature stainless steel and ceramic tip connectors. However, care should always be exercised when handling this type of cable. The light carrying fibre core is only 50 micrometer in diameter, which is less than the thickness of hair.

Note!

- Avoid excessive bending
- Keep cables protected against physical damage
- Keep connectors clean

4.2 Coaxial module

This unit makes the new separate shielded antennas available as well as the borehole winches. The separate shielded antennas combine some of the possibilities you have with the unshielded design with the less environmentally sensitive shielded designs. This includes possibilities to vary the polarization and R-T distance as well as to design any antenna configurations.

The connections on the module are marked with T (Transmitter), R (Receiver) and D (Data). Corresponding connections are found on the used antenna electronics.

Supported antennas:
200, 400 and 1.3 GHz receiver and transmitter, all borehole antennas operated with winch.

Fig. 4.4 The coaxial module. In the picture the three different coaxial connectors are seen, for T (Transmitter), R (Receiver) and D (Data).

For troubleshooting purposes, the module have LED connected to the each coaxial connector. The ones on the R and T connectors indicate that trig signals are leaving the module, when flashing. The one on the D-connector indicates that the module receives data.

4.3 HF module

The High Frequency module is used together with the high-resolution (HF) antennas, including the HF antennas with EM-option.

Supported antennas:
1.2 GHz, 1.2 GHz+EM, 1.6 GHz, 1.6 GHz+EM and 2.3 GHz

Fig. 4.5 The HF module. In the picture the connector for the HF antenna cable is seen.

As for the other modules, this one also have LED’s connected to the internal signals. Since the recorded data is digitised within the unit, no LED’ is indicating incoming data. Flashing R and T LED’s indicate that trig signals are leaving the module.

5 Unshielded antennas

The MALÅ GPR unshielded antennas give you a wide variety of frequencies for a number of different investigation purposes. The antennas and suitable areas of use are listed below, together with approximate depth penetrations and suitable target sizes (Tables 5.1 and 5.2).

These antennas are connected the ProEx control unit with the optical module.

It should be noted that unshielded antennas most often have a better depth penetration than the shielded correspondence, but to a greater extent also records, depending on the environment, so called air reflections.

Figure 5.1 An unshielded system with the 200 MHz antennas and handles with 0.6 m spacing.

Table 5.1 Unshielded antennas and suitable areas of use.

25 MHz	Made for deepest possible penetration depths. Commonly used for geological and stratigraphic surveys in open terrain.
50 MHz	Designed for moderately to deep measurements. Commonly used in geological and geotechnical applications, as bedrock and groundwater surface mapping.
100 MHz	A general-purpose antenna with good penetration and fair resolution. The application range is broad; used for river, landfill, karts studies, lake bottom mapping and deep pipe and bedrock detection.
200 MHz	Give a mid-range penetration depth with good resolution. Its application range is broad. It is used for utility detection, bedrock and cavity detection. The compactness of the antenna facilitates surveys in more vegetated terrain.

Table 5.2. Approximate depth ranges for different antenna frequencies.

Antenna frequency (MHz)	Approximate Radial Resolution @,c=100 [m/µs] , $\lambda_c/4$ [cm]	Approximate max penetration depth (m)
25	100	50
50	50	40
100	25	25
200	12.5	12

* In normal geological environment absent of material with low resistivity.

The unshielded antennas consist of separate transmitter and receiver electronics, to which the antenna elements are attached. A complete MALÅ GPR system is shown in Figure 5.1, where the antenna electronics are mounted to the antenna elements together with wooden handles.

The unshielded antennas can be used with antenna handles or an antenna sledge (see Section 5.3).

5.1 Antenna electronics

The unshielded antenna electronic unit for the transmitter (Figure 5.2) generates electromagnetic energy and transmits it to the attached antenna elements every time a trigger signal is received from the ProEx through an optical fibre (labelled **T**). These high amplitude pulses (typically 370 V) are fed to the antenna elements at a repetition rate of 100 kHz. The antenna element transforms these pulses into radar impulses at a centre frequency, which is dependent on the antenna dimensions. The unit has one optical connector for the transmitter trigger, a connector for a battery pack, a power switch and a LED.

When flashing, the LED on the transmitter electronic indicates trigger pulses are being received from the radar control unit used. No light indicates that no power is being received by the electronics. A steady light indicates that no Trig pulses are received from the radar control unit.

Note! As soon as the power switch is turned on with a battery connected the transmitter starts firing pulses. There is a short "warm-up" sequence of the antenna whereby it is recommended to turn the electronics on a few minutes before data collection starts. A good rule of thumb is to turn on the transmitter first, when preparing for a survey.

Figure 5.2 Unshielded Receiver (left) and Transmitter (right) electronics without any batteries mounted.

The receiver electronic (Fig. 5.2) digitises the received signals from the antenna to a 16-bit numerical integer value (0-32768 and +32767). These numerical values represent the amplitudes of the received radar signals. This digital collected data is transmitted to the control unit used via the fibre optic cable labelled **D**). A second fibre optic cable labelled **R** is used to receive the trigger signals from the radar control unit. There are also a connector for a battery pack, a power switch and two LEDs.

5.2 Antenna elements

Each unshielded antenna frequency consists of a pair of transmitter and receiver antenna elements. See Fig 5.3. These elements are connected to their respective unshielded electronic units via a D-sub connector. The connectors have different genders for the transmitter and receiver antenna elements to eliminate the possibility of incorrect connections.

A rubber O-ring is fitted to the connecting metal plate in the D-sub for water resistance and should be inspected periodically. The antenna elements must be fitted to the electronics by properly locking the metal clips. See Fig. 5.2

The antenna elements are also sealed to be water-resistant; however, they are not guaranteed to be waterproof and should never be submerged in water.

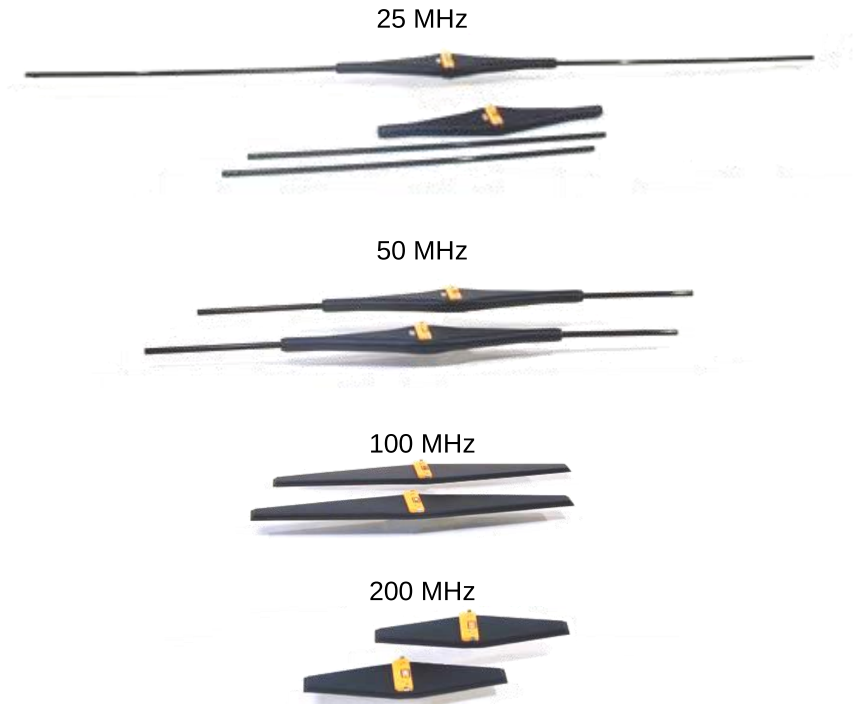


Figure 5.3 Unshielded antenna elements

The 25 and 50 MHz antenna elements consist of a central element with detachable end pieces. When mounting these pieces it is important that they are properly fitted so that the double O-rings at their ends seal properly against moisture and that the electrical connection is proper. The 100 and 200 MHz antenna elements are in one piece. See Figure 5.3 above.

5.3 Accessories

The wooden antenna handles (see Fig. 5.1 or 5.4) are used for carrying the unshielded antennas and stabilizing the antennas during measurements.

The handles are mounted together using the set of 8 screws and nuts. Mounting both horizontal bars for maximum stability is strongly recommended. The bars come in 0.6, 1.0 and 2.0 meters lengths for use with the 200, 100, 50 MHz antennas respectively. These are only recommended antenna separations. The operator is however free to select other transmitter/receiver offsets as desired.

The handles attach to the antenna electronics using the metal locks on each side. It may be necessary to adjust the metal hooks on the electronics for firm attachment. The handle tops are intended for use when the antennas are moved individually without the horizontal bars. This is the case when performing e.g. CMP or WARR type of surveys.

Note! If antenna separations other than the standard ones mentioned are used it will be necessary to edit the header file for correct depth scales to be displayed by the software.

Wooden separators on the 25 MHz antennas are not practical because the recommended antenna separation for this frequency is 4 meters. Instead a 4 m long strapping is provided for this purpose.

The unshielded 100 and 200 MHz antennas can also be attached on the MALÅ Soft Sledge for smooth operation and movement on especially flat terrain. See Fig. 5-below. The Soft Sledge is a tough plastic mat with fastening devices for both 100 and 200 MHz antennas and stabilising tubes for the edges. The Hip Chain is used as measuring device attached to the operator’s belt.

Figure 5.4 Unshielded 200 MHz antennas on the Soft Sledge.

6 Rough Terrain Antennas (RTA)

The MALÅ Rough Terrain Antenna (RTA) is a one-piece unshielded radar antenna (Figure 6.1) where the antenna elements are mounted in an in-line configuration. The antennas are commonly used for deep geological investigation (groundwater/soil layers/bedrock surface) and most suitable in very rough terrain. The RTA is available with 100, 50 and 30 MHz frequency.

These antennas are connected the ProEx control unit with the optical module.

Fig. 6.1 The RT antenna in field (above). The three different antenna frequencies; 100, 50 and 30 MHz (below).

As all other unshielded MALÅ GPR antennas the RTA communicates with the control unit through fibre optic cables. The fibre optic cables within the RTA are reinforced with Kevlar™ and feature stainless steel and ceramic tip connectors. The connecters should always be handled with care, keep them clean for best possible data flow and protect them against physical damage.

6.1 Start up

When initialising RTA measurements the following easy steps are made to connect and start up the whole GPR system:

- Make sure that the batteries are fully charged, both for the RT antenna (see Section Batteries) and for the ProEx.
- Connect the ProEx to the Ethernet port on an external PC or on the XV monitor.
- Connect the fibre optic cables between the control unit and the RT antenna. See Figure 6.2. The T corresponds to transmitter, R to receiver and D to data. One extra fibre is also provided as a spare.

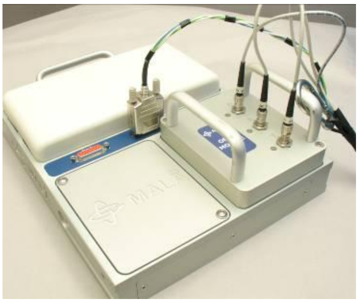


Fig. 6.2. Connection to the ProEx.

Note! It is essential to attach the strain relief (the snap-hook) to the ProEx or the towing belt in order to protect the optical fibres and connectors. Failure to do so, will likely result in damaged cables.

- Attach an appropriate length-measuring device and connect it to **Wheel** (on the ProEx) (See chapter 12 for more information).
- Make sure that the batteries are correctly mounted on the antenna electronics. They are attached with a snap-lock on the end part of the electronic unit. Push the on/off bottom on the back of the units to turn the power on. A firm light indicates power, and a flashing light a correct connection with the control unit. See Figure 6.3.

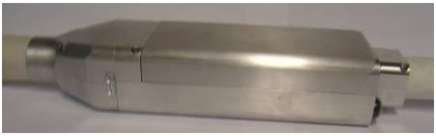
 

Fig 6.3 Left: Electronic unit with battery. Right: The on/off button is seen at the left side and the snap-lock for the battery on the right side.

- Mount the skid plates around the antenna electronics. See Figure 6.5.

Fig. 6.5. Skid plate mounted around the electronic unit.

- Turn on the power on the control unit. Turn on the PC or the MALÅ XV Monitor. Your RTA is now ready for operation.

6.2 Using the RTA

The RTA concept is a very light and compact GPR system. The weight, for a RTA 50 MHz system is for example less than 14 kilos (including Monitor and ProEx), and will thus enable measurements in also the roughest terrain.

Depending on the character of the investigations site (dense vegetation or accessible tracks) the RTA can be mounted on a towing belt or the ProEx backpack to be manually operated or on a vehicle. In each case, make sure that the snap-hook (strain relief on the RTA) is properly connected.

The RTA is used together with the standard MALÅ Geoscience distance measuring hip-chain, which is most suitable to mount close to the ProEx. A measuring wheel can also be used if the RTA is mounted on a vehicle (See Chapter 12 for more information).

Of course the RTA concept is also compatible with a GPS system directly connected to the Monitor XV or measurements can by done by time or manually trigged.

Note! An appropriate time interval when measuring with RT antennas and time is 0.15-0.5 seconds giving 2-4 traces (measuring points)/second.

Note! The measurements point on the RT antenna is located in-between the two antenna electronic parts. If a GPS is used and attached to the back-pack, remember this offset when interpreting the results.

The MALÅ RTA is developed to stand the demands of IP65. This means that the antenna is completely safe to use during rain and on wet ground conditions, and can be occasionally be lowered under water, but it should not be used for longer underwater investigations.

7 Shielded antennas

The MALÅ GPR shielded antennas are available in a variety of frequencies, as seen in the Table 7.1 and 7.2. Different shielded High Frequency antennas (above 1 GHz) are also available; see Chapter 9.

These antennas are connected the ProEx control unit with the optical module.

The construction of the MALÅ GPR shielded antennas makes them most suitable for urban investigations or at sites with a lot of background noise.

Table 7.1. Shielded antennas and suitable areas of use.

100 MHz	The shielded 100 MHz antenna is the lowest shielded antenna frequency commercially available. It is use for medium to low resolution. Suitable for geological and geotechnical applications.
250 MHz	The shielded 250 MHz antenna is a general-purpose antenna. It is used for medium penetration depth and medium resolution. It is commonly used for utility detection, Underground Storage Tanks and void detection.
500 MHz	The shielded 500 MHz antenna is probably the most popular general purpose GPR antenna ever built. It delivers medium to shallow penetration and good resolution. Most commonly used for utility detection, road surveys and archaeological investigations.
800 MHz	The shielded 800 MHz antenna delivers very good resolution for shallow investigations. The interchangeable electronics makes the 800 MHz antenna an economically good alternative to the high resolution 1 GHz antenna. Commonly used for road mapping and concrete investigations.

Note! The 800 MHz antenna needs some warm-up time prior measurements are started, around 10 minutes.

Table 7.2. Approximate depth ranges for different antenna frequencies.

Antenna frequency (MHz)	**Approximate Radial Resolution** @,c=100 [m/μs] , $\lambda_c/4$ [cm]	**Approximate max penetration depth (m)**
100	25	25
250	10	8
500	5	6
800	3	2.5

* In normal geological environment absent of material with low resistivity

A shielded type of antenna means that most of the energy is only transmitted in one direction. It is also insensitive to radiation from all directions except from the bottom part of the antenna where the receiving antenna element is located. The shielded antenna element comprise both transmitter and receiver antenna elements in one single housing. These consist of a modified bow-tie antenna construction with the receiver element at the front end and the transmitter element at the back of the housing.

Note! Even though the antenna is shielded, air reflections can occur in the data.

The front of the antenna is equipped with a hook for attaching a tow handle or strap. A fastening device at the back of the housing accommodates the distance-measuring wheel. This wheel operates as a triggering device instructing the MALÅ GPR system to collect traces at operator pre-set distance intervals (see Operating Manuals for GroundVision2 or XV Monitor). See Figure 7.1.

Note! That the detachable wear plates (also called skid plates) should always be used to insure a long antenna life.

Figure 7.1 Shielded antennas. Top: 100 MHz (left) and 250 MHz (right). Bottom: 500 MHz (left) and 800 MHz (right)

7.1 Antenna electronics

When shielded antennas are used with the ProEx control unit they are used with shielded electronics units (see Figure 7.3 and 7.4). The Shielded Electronics Unit contains both the transmitter and the receiver electronics.

Power to the electronics is provided by a standard MALÅ GPR battery or externally from the MALÅ standard 12 V battery pack. Communication with the control unit is managed via three optical fibres and a cable for a distance-measuring wheel (see also Chapter 12). These cables provided are in a protective housing.

Figure 7.3 Shielded antenna electronic unit without the optical fibre cable. The connector for the external battery is seen at the front, right-hand side.

Figure 7.4 The cable hose to the shielded electronic unit (left), and the electronic unit with battery and mounted cable (right).

As in the unshielded electronics the LED-indicators show the status of communications between the shielded electronics unit and the ProEx control unit. When flashing, the **T** and **R** trigger pulses are being received from the control unit. No light indicates that no power is being received by the electronics. A steady light indicates that no trig pulses are received from the control unit.

When flashing, the LED labelled **D** indicates that data are sent to the control unit. No light indicates no power is being received by the electronics. A steady light indicates that no data are being transmitted to the control unit.

As seen, a steady light on a LED indicates an interruption in the optical communication. This means either that a fibre optic cable has failed or, the fibre optic connectors need to be cleaned (easily managed with the compressed air can provided with the system). When none of the LED's is blinking a power failure to the electronics unit has occurred. Replace or recharge the battery. If the electronics still do not function with a fresh battery then there is an internal failure in the shielded electronics unit.

To mount the shielded electronic on a shielded antenna, perform as follows;

- Place the shielded electronics unit on the antenna with facing the cable hose towards the antenna front.

Note! Do not try to mount the electronics in the reverse direction. This will damage the electronic unit.

- See to that the unit is firmly attached to the antenna before you fasten the two black mounting screws.
- Mount a battery pack to the electronic unit.
- When appropriate mount the survey wheel at the antenna rear and connect the signal cable to the electronics unit.
- Attach the cable hose to the backpack as a strain relief.
- Connect the optical fibres libelled **T**, **D** and **R** to the control unit.
- Connect the signal cable from the survey wheel to the control unit.

Note! Two rubber O-rings are fitted on the connecting metal plate in the D-sub connectors on the antenna for water resistance and should be inspected periodically.

7.2 Accessories

The 250, 500 and 800 MHz shielded antennas can be used together with the RTC, Rough Terrain Cart, as seen in Fig. 7.5.

Figure 7.5 The RTC for shielded 250, 500 and 800 MHz antennas.

The RTC is assembled by first attaching the pulse encoder on one of the back wheels, as seen in Fig. 7.6.

Note! Before the wheel with the encoder is attached the O-ring has to be threaded over the axle, as seen in Fig. 7.7.

Figure 7.6 The pulse encoder on the back wheel. The screw below is for the wheel axles.

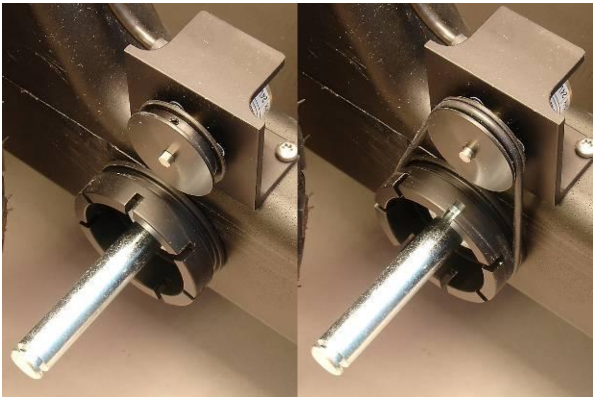


Figure 7.7 The O-ring attached to the wheel axes.

When this is done the wheels can be attached, see Fig. 7.8. And the finally the handle inserted and secured (Fig. 7.5)

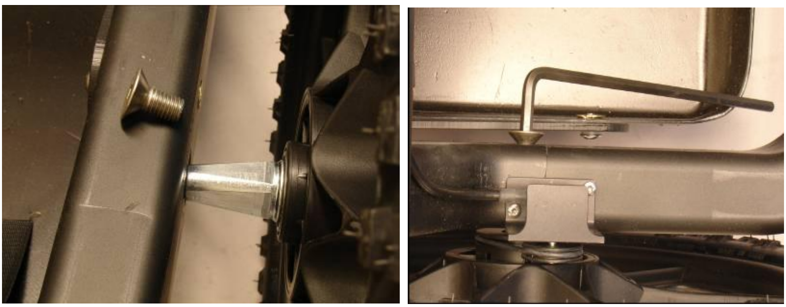


Figure 7.8 Attachment of wheel.

8 Separate T and R shielded antennas

MALÅ shielded antennas are also available as separate shielded transmitter (T) and receiver (R) antennas. The MALÅ Separable Shielded antennas are available with frequencies of 200, 400 and 1300MHz.

These antennas are connected the ProEx control unit with the coaxial module.

Separate transmitter and receiver antenna units enable different types of tomographic measurements and velocity analysis as CMP (Common Mid Point) etc.

Note! The 1.3 GHz antennas need some warm-up time prior measurements, around 10 minutes.

The transmitter antenna unit have one power connector and one trig connector, while the receiver antenna unit also have a connector for the digital data communication. See Fig. 8.1.

For each trig connector on the antenna unit there’s a LED, when blinking, tells that trig signals is received by the electronics inside the antennas. Similarly there’s a LED telling that digital data is leaving the antenna, when blinking.

The separate shielded antennas are connected to the coaxial module used with the ProEx control unit with coaxial cables, which are available in variable lengths.

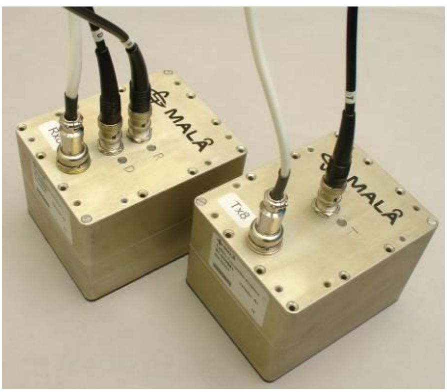


Figure 8.1 Separate T (right) and R (left) shielded antennas with the frequency of 1.3 GHz.

9 High Frequency antennas

MALÅ High Frequency (HF) antennas are available with frequencies of 1.2, 1.6 and 2.3 GHz. The 1.2 and 1.6 GHz antennas also have an EM (Electromagnetic) option, giving a GPR antenna with a 50/60 Hz EM-locator.

These antennas are connected the ProEx control unit with the coaxial module.

Note! The High Frequency antennas need some warm-up time prior measurements, around 10 minutes.

The HF antennas are most suitable for investigations were high resolution is important, as for construction/concrete investigation, asphalt mapping, ice thickness etc. See also Table 9.1.

Table 9.1. Approximate depth ranges for different antenna frequencies.

Antenna frequency (GHz)	**Approximate Radial Resolution** @,c=100 [m/μs] , $\lambda_c/4$ [cm]	**Approximate max penetration depth (cm)**
1.2	2.1	100
1.6	1.6	50
2.3	1.3	40

* In normal geological/construction environment absent of materials with low resistivity.

The HF antennas are one-piece radar antennas where the antenna elements are contained in a small handheld, shielded box, which in turn can be mounted in a wheel carriage, the HF cart. See Fig 9.1 to 9.3.

Figure 9.1 The HF antenna without the wheel carriage (1.2 GHz with the EM option).

Figure 9.2 The HF antenna (1.6 or 2.3 GHz) in a wheel carriage, the HF cart.

Figure 9.3 Mounting the HF antenna in the HF cart. The antenna is attached on two sides, see black arrows.

The HF antennas are attached to the ProEx control unit through a 4 m long cable, allowing a flexible and mobile data collection. A 10 m extension cable is also available.

If the antenna is used without the HF Cart, the skid plate (attached with screws underneath the antenna box) should be changed when worn, to insure a long lifetime of the antenna.

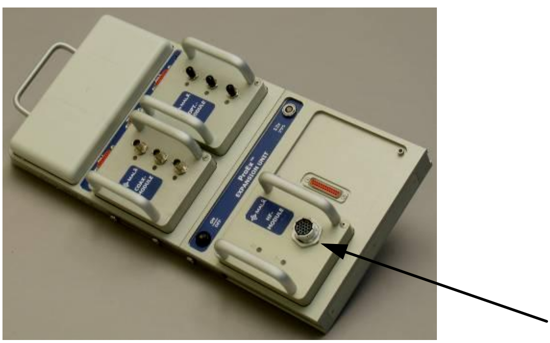
The antennas can also be used with a single wheel encoder, see Fig. 9.4 below, instead of the small wheel carriage (See also Chapter 12).This is quite convenient if the investigation surface is rough and uneven or if the HF antenna is to be used in another measurement direction, for instance to investigate polarization effects.

Figure 9.4 The single wheel encoder (top) and attached to a HF antenna (below) in two directions.

9.1 Start up

Before starting up the ProEx radar system the following connections are made:

- Mount the battery for the ProEX. This battery also supplies the HF antenna with power if the HF module is mounted on the ProEx main unit, otherwise the antenna is powered by the external power supply for the extension module.
- Connect the HF module to one of the slots on the ProEx unit and connect the antenna data cable to the HF module.



- Connect the ProEx to the XV Monitor or an external PC with an Ethernet cable.

- When using the wheel carriage or single wheel encoder to the antenna, the encoder cable is connected to the antenna (recommended). If using a separate encoder wheel or hip chain this is connected to the ProEx.
- Turn on the ProEx and the XV Monitor or PC. Your HF system is now ready for operation.

9.2 Using the HF antennas

When the HF antennas are used with the XV Monitor to create Grid Projects, the data collection is controlled by the two buttons on the handle of the antenna (Fig. 9.5). The button on the right hand side of the handle (black, button 1) starts and stops data collection of the current profile and the left hand button (red, button 2) begins a new profile.

Figure 9.5 1.6 GHz antenna with the right (black) and left (red) hand buttons visible.

Figure 9.6 Extension pole. On the handgrip the two buttons are seen, the one on the top (red) starts a new profile.

When using the extension pole, as seen in Fig. 9.6 above, the two buttons are located on the hand grip, with one button underneath the grip starting and stopping the data collection, and the other one on the handle top starting a new profile.

Note! US-models only! One of the buttons, the black, both on the antenna itself and on the extension handle also functions as a “kill-switch”, which means it must be pressed at all times during measurements. If the button is released the transmitter of the antenna will stop transmitting within 10 seconds. It restarts when the button is pressed again.

The extension handle, with the control buttons, is mounted on the wheel carriage and the extension handle cable is connected to the connector at the back of the High Frequency antenna. See Fig 9.7.

Figure 9.7 Mounting of the extension handle.

If measuring single profiles, the buttons on the antenna or the extension handle are not in use. Note however the kill-switch on US-models.

As an option a switch box is provided to the High Frequency antennas (Fig. 9.8). With this switch box it is possible to measure with only the receiver in one HF antenna and only the transmitter in the other HF antenna. This enables different types of tomographic measurements and velocity analysis as CMP (Common Mid Point). The data cables from the two antennas are connected to the switch box and the switch box to the ProEx.

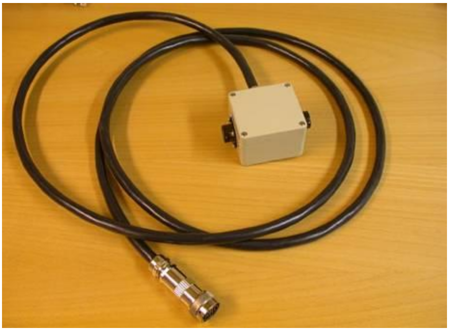


Figure 9.8. Switch box for two High Frequency antennas.

When the HF antennas are operated together with the XV Monitor, you have access to the fully integrated data collection tool, 2.5D analysis tool and Migration Wizard.

10 Expansion unit

In the basic mode the ProEx control unit supports two individual antennas connected simultaneously, but in order to increase the number of physical channels, expansion units can easily be connected to the ProEx (see Fig. 10.1 to 10.3). Each expansion unit enables two extra antenna module slots, which can be used in any antenna module combination.

The slots are named A to H (see Fig. 10.2) on the ProEx and this prefix is also used for the name convention of files. See Operating Manual for GroundVision2 and Operating Manual Monitor XV.

Note! The slots work in pairs, A and B, C and D, E and F and G and H. The slots can communicate within the pair but not with other pairs.

A maximum of three expandable units can be connected to the main ProEx, which results in a total of eight totally independently configurable antenna modules.

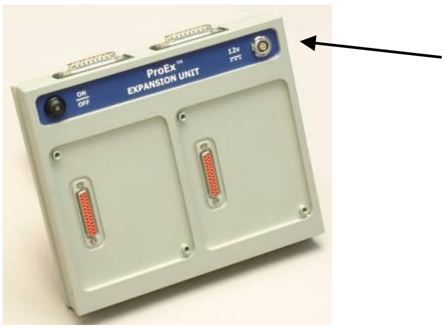


Fig. 10.1 The expansion unit, with the possibility to connect two different antenna modules.

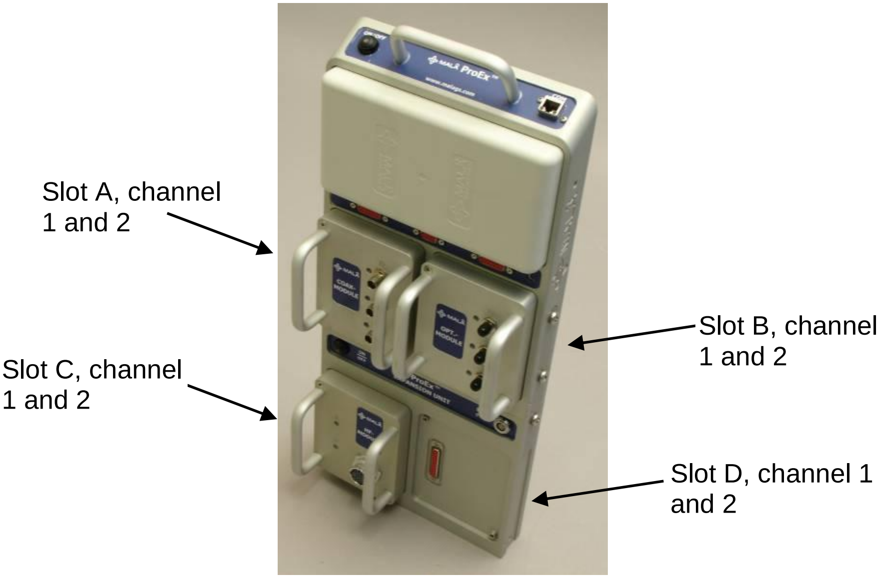


Fig 10.2 The ProEx with one expansion unit and three antenna modules. To this set up two more expansion units can be connected.

Fig. 10.3 The expansion unit is connected and secured with 3 screws and a metal plate on each side.

When the ProEx is used with expansion units, the system is considered to be a fixed installation; meaning that we believe it will be used installed in a vehicle or in laboratories. An example of application is seen in Fig. 10.4 where the ProEx and one expansion unit is used for snow thickness and water content investigations, including two separate transmitter antennas and four separate receiver antennas.

The expansion units have to be powered trough the power connector on each unit. See Fig. 10.1. It’s not possible to “daisy-chain” units.

Note! Even though the units are protected internally against reversed polarity, we recommend you to use MALÅ cables only.

Note! In order for the main unit to identify and properly set the system up, you need to power on the expansion units prior turning on the main unit. The main unit gives a beep for each of the slots detected when booting, regardless of if there’s a module attached to the slot or not.

Fig. 10.4 The ProEx unit installed on a snowmobile, using one expansion unit and 4 different antennas.

11 Auxiliary ports

The ProEx control unit is equipped with two versatile auxiliary ports (Fig. 11.1). The functionality of these ports is to be defined by the customer and have to be ordered on a case-by-case basis.

The auxiliary connectors include serial ports for communication with external devices, analogue inputs for sampling of other than radar data, digital input/output etc. These extras are to tailor the unit to any specific needs which may arise.

Note that the firmware of the ProEx is upgradeable from a normal computer, to prevent the need for sending the unit back for upgrades.

Contact MALÅ Geoscience AB for further information, addresses are found in Chapter 1.

Fig. 11.1. The two auxiliary ports.

12 Trigger devices

The most efficient method of radar data acquisition is to use a distance-measuring wheel or profile encoder (a so called hip chain) to control the collection of radar data. Data is acquired at user defined distance intervals so that the position of each trace along a survey line is given by the position of a radar trace in the data file. This simplifies data processing procedures and positioning of identified targets.

The ProEx works with all standard MALÅ encoders and the connector is located at the front, easily reached, see Fig. 12.1. Each module also have it's own distance encoder, which is used together with the HF-antennas, so no cable to the external wheel connector is necessary when these antennas are used.

If several HF-antennas are used, the operator have to select which wheel are to be used as trigger device, its possible to use any of the wheels on the antennas or the master, external, wheel.

Fig. 12.1. The encoder connector.

Note! The precision of the encoder wheel is not infinite and depending on several factors as; the measurement surface, the pressure applied on the wheel and possible wear. If you are unsure of the encoder wheel precision a re-calibration should be made.

The **hip chain** can be used when scanning from a sled or when the transmitter and receiver are mounted on carrying handles. The hip chain comes with cotton string at a length of 2800 meters in a roll. The string is made of pure cotton that decomposes in nature. Its greatest advantage is in trackless and undulating terrain where it would be impractical to use a measuring wheel.

The **measuring wheel** (Figure 12.2) may be more appropriate to use for distance control for surveys on flat terrain or in urban areas (for shielded antennas). The measuring wheel is attached directly on the shielded antennas.

Fig. 12.2 Two different types of measuring wheels (Ø150mm, Ø300mm).

All distance-measuring devices for the MALÅ GPR use an optical encoder that transmits electrical pulses to the ProEx. A distance calibration file is used to convert the number of pulses to the correct distances. The operator can create calibration files or use those supplied with the installation disk/CD.

These calibration files for different length encoders contain information about both the numbers of pulses that are counted per meter and the rotation direction in which it will calculate the optical pulses correctly. The triggering of readings from the GPR will ONLY be done in the positive direction of rotation. Thus, you can move the wheel back-wards without any readings being made. However, if the wheel needs to be rotated constantly in the opposite direction this can be accomplished by changing acquisition direction in the GroundVision2 software or in the MALÅ XV Monitor.

Note! When using both devices you should keep accurate record of your calibration files for the devices so the right one is selected for the device used at each measurement occasion.

Note! The distance interval when using a measuring wheel should be set to a value greater than 0.003 m. The measuring wheel counts about 427 pulses/m, which is less than one pulse/2mm. A distance <0.003 m will correspond to zero pulses and cause the antenna to start collecting data immediately at full speed.

13 Power supply

The ProEx is powered by a 12V Li-Ion battery (Fig. 13.1). The ProEx can also be powered externally, with the power connector found on the battery slot. The unit is protected internally for power surges and wrong polarities but it is recommended for all users to use MALÅ cabling only.

Fig. 13.1 The ProEx without and with a mounted battery. The connector for external power is marked.

The batteries are mounted by simply placing the battery compartment with the lid on the rear short side under the corresponding groove in the electronic units. The front end or the battery pack has a locking tab on the plastic housing. See Fig 13.2.Gently press on the front end of the battery until the lid is released from the groove before removal.

Fig. 13.2 Mounting the battery

The battery should always be stored fully charged to maximize the lifetime of the battery.

The operating time of the system is dependent on the charge cycle history of the batteries as well as the modules in use. Normally, maximum operating time is not reached until the batteries have been fully charged and discharged 3-5 times. Optimum performance is achieved through fully discharging and recharging the battery packs.

The expansion units are powered externally, with 12V AC/DC or any 12 V battery or with MALÅ standard Li-Ion Batteries, see Fig. 13.3.

Fig. 13.3 MALÅ battery pack and battery bag. Internal of the battery bag (left) and the connectors on the outside (right). **Note!** Before use, open the battery bag and connect the battery to the outside connectors.

For the unshielded system or the shielded system with electronic antenna units each electronic component in the system is powered by the same type of battery as for the ProEx control unit, shown in Fig. 13.1.

The unshielded RT antenna has specially designed batteries. The batteries have to be disconnected from the electronic units before charging. The battery charger is then connected to the round connection beside the serial port (D-sub) on the battery unit. See Fig. 13.4.

Fig. 13.4 Battery pack for the RT antennas.

The MALÅ battery chargers are an automatic quick charger designed for Li-ion batteries. Recharging the first 80% of the full capacity goes very quickly. However, it is recommended to keep the battery charging until it is fully charged. The battery charger then automatically begins to maintain the charge.

The indicator lamp on the charger gives the following information:

- Red: charged < 80%
- Yellow: charged 80-100%
- Green: maintenance charging

Note! Before charging it is important to reset the internal memory of the charger by reconnecting it to the mains supply and wait until the indicator lamp turns off.

Note! The batteries lose efficiency in cold temperatures. So insulating the electronics and battery packs in cold climates will prolong the battery life as the electronic units generate internal heat during operation.

14 Start up of your MALÅ ProEx

In order to operate the system, the following items are required:

- MALÅ ProEx control unit
- Antenna module (Optical, Coax or HF)
- The antennas chosen; shielded, unshielded, borehole, HF, or separate T and R units.
- Optical fibres, Coaxial cables or HF antenna cable.
- Power supply for the ProEx and the antennas.
- Ethernet data cable for communication between the ProEx and the computer or XV Monitor.
- Data collection software (GroundVision2 for ProEx) installed if using an external PC.

In addition the above mentioned there exists different length measuring devices, pulling and carrying handles which are regarded as accessories.

14.1 Connecting the system components

- Mount the antenna electronics if unshielded or shielded antennas are used.
- Connect the ProEx to the XV Monitor or an external PC with an Ethernet communication cable.
- Connect appropriate fibre optic cables between the ProEx and the antenna electronics as follows:

  For unshielded systems: Single fibre optic cable from the fibre optic connector labelled **T** on the ProEx to the Transmitter Electronics. Dual fibre optic cable from the fibre optic connectors labelled **D** and **R** to their respective connectors on the Receiver Electronics

  Note! It is essential to attach the strain relief to the ProEX in order to protect the optical fibres and connectors. Failure in doing so will likely result in damaged cables.

  For shielded systems: Fibres labelled **T**, **D** and **R** should be attached to their respective fibre optic connectors on the ProEx optical module.

  For separate shielded systems: Cable labelled T should be attached between the transmitter antenna and the coxial module on the ProEx. Cables labelled D and R should be attached between the receiver antenna and the coxial module on the ProEx.

For HF systems: The HF cable should be attached to the HF antenna and to the HF module on the ProEx

- Attach the appropriate Measuring Device and connect to the port labelled **Wheel** on the ProEx. **Note!** The precision of the encoder wheel is not infinite and depending on several factors as; the measurement surface, the pressure applied on the wheel and possible wear. If you are unsure of the encoder wheel precision a re-calibration should be made.

- Turn on the power on the antennas, the extension units and on the ProEx. Turn on the XV Monitor or the PC and start the data acquisition program GroundVision2. Your MALÅ GPR system is now ready for operation.

15 Trouble shooting

As with all electronic equipment it is important to handle the ProEx with great care and to avoid harsh handling and bumps against the electronics. During transport of the equipment the ProEx should be packed properly and firmly in a transport box.

Care should also be taken for the optical fibres (when used) so they are protected against dust and dirt. When finishing a survey the equipment should be checked and packed properly in the transport case. Batteries should be kept charged if possible and if stored away for longer time they should be charged now and then.

The most common types of problems you will find listed below together with our recommended actions. If you do not succeed following these actions we recommend you please contact your closest MALÅ Geoscience sales representative.

Most of the troubles occurring with optical fibres can be resolved with the help of the LED's on the modules, please refer to the appropriate section in this manual for further reading.

An error messages appear on the computer screen when taking a reading, Communication problem:

Cause	**Action**
Communication problem between the XV Monitor or the PC and the ProEx	Check the data cable
	Check that control unit is on
	Check battery for control unit
	Check communication set up in the data acquisition programme

Only a straight line appears on screen when taking a reading:

Cause	Action
The transmitter is not turned on	Turn the transmitter on
Signal search has not been performed	Perform signal search
The transmitter is not triggered by the ProEx	Check the LED located on the transmitter unit. If it blinks the electronics receives a correct trig signal from the ProEX If the LED does not blink: Check for dirt in the optical connector in the Transmitter
The ground is too conductive for a GPR survey	Check the system by collecting a trace with the antenna above the ground.

No traces are collected when survey starts:

Action
Check Trig set-up and calibration with measuring wheel file.
Move the antenna in the correct direction.

Traces disappear during survey and only a straight line appears intermittently:

Action
Check Tx fibre connection at the antenna.

16 GPR technique in brief

16.1 General description of the GPR Technique

GPR is an electromagnetic method that detects interfaces between subsurface materials with differing dielectric constants. Your GPR system basically consists of the ProEx control unit, antenna elements (transmitter and receiver in a shielded box) and a monitor or external PC, which processes the received signal and produces a graphic display of the data.

The transmitter radiates repetitive short-duration electro-magnetic signals into the earth as the antenna moves across the surface. Electromagnetic waves are reflected back to the receiver by interfaces between materials with differing electrical properties (See Figure 16.1).

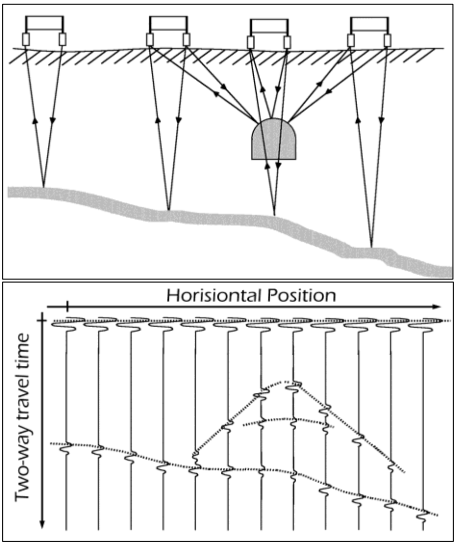


Fig. 16.1 The GPR technique with wave propagation from transmitter antenna (Tx) and reflection to the receiver antenna (Rx).

The intensity of the reflected signal is, primarily, a function of the contrast in the dielectric constant at the interface, the size and shape of the target, the target depth and the conductivity of the material, which the wave is travelling through.

Subsurface features, which may cause such reflections, are for instance:

- Man-made objects including all types of utilities of various material types such as plastic, ductile iron, terracotta, concrete, underground storage tanks, building foundations, trench boundaries, buried waste and more.
- Natural geologic conditions such as changes in soil composition, supporting layers, ice, groundwater level, bedrock, boulders, cobbles, voids etc.

In GPR context the following terminology is often used:

Sample:
Instant, digital value of recorded radar signal at one specific time.

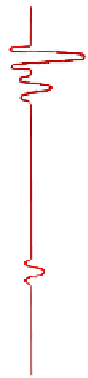
Stacks:
Number of averages for each trace

Trace:
The recorded radar signal from one channel at one point. An envelope built up by a certain number of samples.

Point distance:
Distance between each trace collected for all individual channels.

Profile:
A collection of traces along a line or transect.

Direct wave:
This is the part of the energy that travels the shortest distance between the transmitter and the receiver.


A trace or scan

And in short the ProEx carries out measurements as follows:

When collecting a sample, the ProEx sends a timing signal (a control signal) to the transmitter and receiver antenna respectively. After the transmitter has received the signal, it generates and transmits radar pulses through the antenna. The pulse then propagates through the medium. Reflections occur from underground objects, structures and materials where there is a change in the electrical property.

Once the receiver has detected the control signal, it collects a sample and passes it to the ProEx. By repeating this process at very finely controlled intervals, the ProEx can collect all the samples in a trace. The ProEx places each incoming sample in its correct position in the current trace.

When the trace is complete, it is sent to the computer where it is saved on the hard disk and displayed on the computer monitor.

During data collection, the whole system is transported along the line to be investigated, while collecting and recording traces at defined distance or time intervals. The result is a continuous profile, a record of subsurface conditions along that line (see Fig 16.2), a so-called radargram.

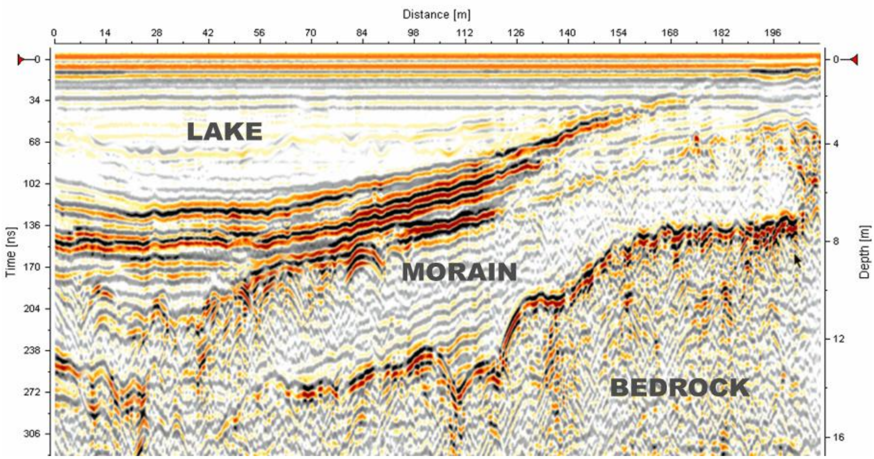


Figure 16.2 An example of a continuous record of radar traces, a so-called radargram.

16.2 Basic information in investigation depths and velocities

The problem of range (depth) versus resolution is well known for the type of investigations that GPR represents. Sufficient penetration depth may be achieved but it may require a low frequency which reduces the resolution, the ability to distinguish two targets from each other or to detect it at all. . There often is a compromise regarding the choice of antenna frequency for a particular application at a specific site.

The depth penetration with different frequency antennas varies greatly depending on local soil conditions. Primarily the depth/resolution requirements and the soil conditions at the site determine the choice of antenna frequency. The table below is hoped to be of assistance when selecting antenna frequency based on the depth interval of interest.

A comparison of three different antenna frequencies is shown in Fig 16.3.

Table 16.1. Approximate depth ranges for different antenna frequencies.

Antenna frequency (MHz)	**Approximate Radial Resolution** @,c=100 [m/μs] , $\lambda_c/4$ [cm]	**Approximate max penetration depth (m)**
25	100	50
50	50	40
100	25	25
250	10	8
500	5	6
800	3	2.5
1200	2.1	1
1600	1.6	0.5
2300	1.3	0.4

* In normal geological environment absent of materials with low resistivity.

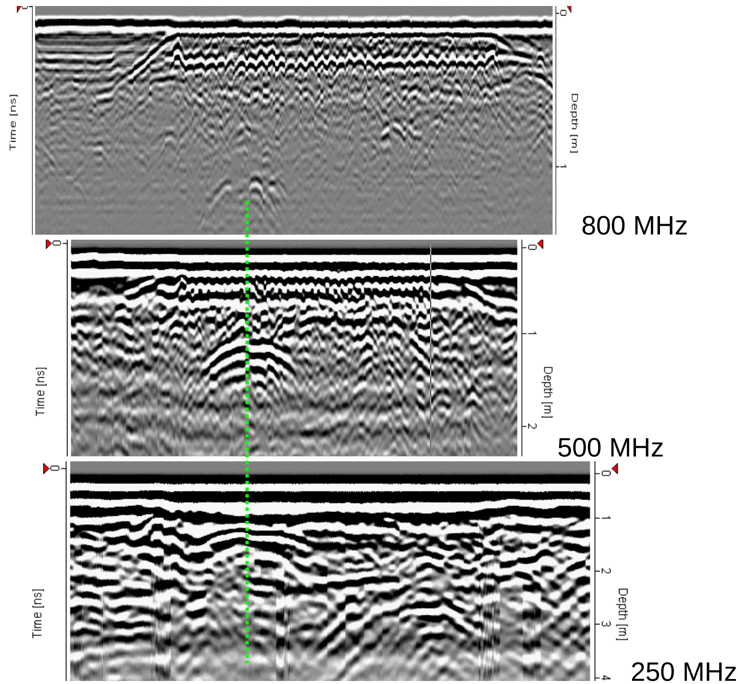


Fig. 16.3 Comparison of three different antenna frequencies. The green line marks the position of the same object in the three radargrams, at a depth of approximately 1 m. The number of equally spaced hyperbolas at ground surface, seen with the 500 and 800 MHz antennas, is due to electrical wires in the ground.

For the interpretation of the radargram, the velocity of different geological environments is needed to achieve the best possible depth estimation of the identified layers and objects.

The velocities (in Table 16.2) can be used as guidance. These values given, are only approximate, and can vary greatly with the water content in the medium. The larger value given for velocity applies to unsaturated conditions.

Table 16.2. Approximate values of ε_r (relative permittivity) and the corresponding velocity. ε_r varies to a great extent with the water content in the medium. The larger value given for velocity applies to unsaturated media.

Medium	**ε_r**	**Velocity [m/µs]**
Air	1	300
Fresh water	81	33
Limestone	7 - 16	75 - 113
Granite	5 - 7	113 - 134
Schist	5 - 15	77 - 134
Concrete	4 - 10	95 - 150
Clay	4 - 16	74 - 150
Silt	9 - 23	63 - 100
Sand	4 - 30	55 - 150
Moraine	9 - 25	60 - 100
Ice	3 - 4	150 - 173
Permafrost	4 - 8	106 - 150

16.3 GPR Performance

The GPR performance is primarily affected by the conductivity and dielectric permittivity of the mediums intended for operation. Conductivity is a measure of the ability to carry an electrical current; it causes the radar signal to attenuate exponentially. Dielectric permittivity is a measure of the ability to store charge; it governs the velocity at which the radar wave is travelling through the media.

Depth of investigation of the GPR signal is highly site specific, and is limited by attenuation (absorption) of the radar signal in the subsurface materials. Clay soils attenuate GPR signals strongly, as do brackish or salt groundwater. GPR signals in some soils may be completely attenuated whereby the method cannot be used.

In addition, in some cases the presence of reinforcement bars in concrete structures may severely attenuate the GPR signal such that objects below the slab may be undetectable.

GPR works best in sandy or gravely soil types/mediums. Ideal conditions are silica sands and other mediums such as fresh water, ice, and most solid rocks with low conductivity.

Note! As a rule of thumb, when the conductivity of a geological medium (soil, rock, concrete, etc.) is more than 20 mS/m (or resistivity is less than 50 Ohm), GPR is a less advisable method for investigations in that area.

Note! It should be remembered, that a contrast in electrical properties between the target object and the surrounding material is needed to create a clear radar signature, the larger the contrast the stronger reflections.

In Figure 16.4 a radargram collected in favourable soil conditions is shown, which can be compared to the radargram in Figure 16.5, measured in poor soil conditions. The reality is normally somewhere between these two examples.

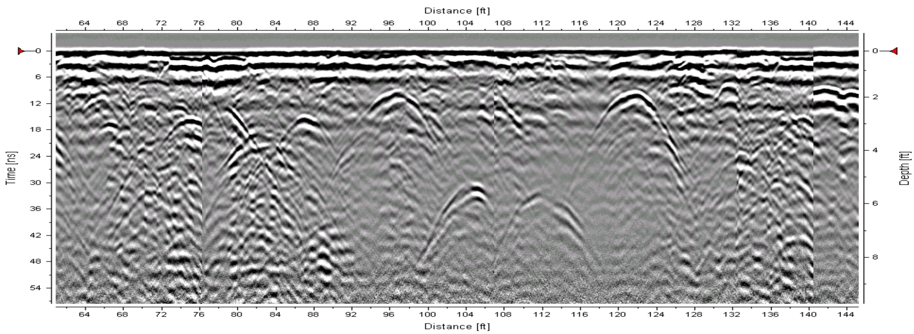


Fig. 16.4 Example of a good radargram in low conductive soils (Note the multiple targets detected).

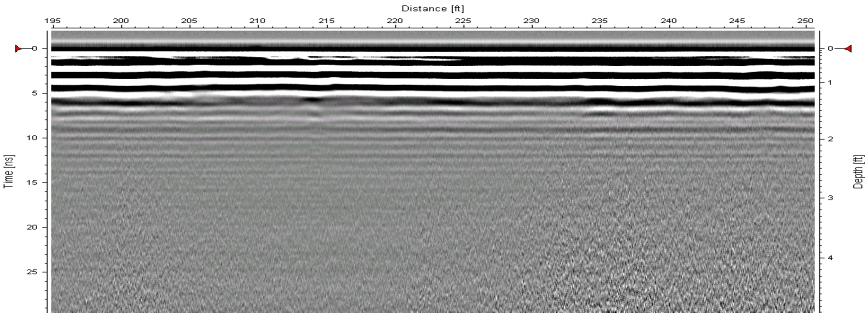


Fig 16.5 Example of a poor quality radargram in highly conductive soils. Please note the snow or noise in the lower section and banding or ringing in the upper section.

16.4 Running a survey

Starting a survey routine is a simple task with the MALÅ ProEx system. The ProEx offers you a fast way of parameter choice through the "Pre-set" parameter settings. Factory default and user selected parameters can be saved for later use. First-time GPR users will find the default settings to be helpful in setting up their system parameters.

During data collection the radar data and other information are displayed on the XV Monitor or on the computer screen. Once data collection is in progress modifications to display functions, screen colours, gain settings can be performed without affecting the start parameters or the recorded data. The data collection can be interrupted and resumed at any time. This feature facilitates the entry of field notes and comments. For more information see GroundVision2 for ProEx software manual and Operating Manual for the XV Monitor for ProEx.

The ProEx offers you three different ways of acquiring data:

- By the use of a distance measuring device (distance triggered)
- Through the XV Monitor (by pressing the turn-push button) or an external PC keyboard (by pressing the SPACE button)
- By taking readings at fixed time intervals

We recommend measurements to be performed using some kind of distance measuring control. This way you can relate the results to a fixed geographic location. Using time triggering is as an alternative for lake, river and wetlands surveys where the equipment may be set-up in a boat or raft or, for studies where a GPS may be deployed for positioning control. For More information on GPS see the Operating Manual for XV Monitor for ProEx or GroundVision2 for ProEx.

17 Technical Specifications ProEx

Pulse repetition freq.	100, 200 kHz, not interleaved
Data bits	16
Nr. of samples/trace	128-2048, in standard configuration, other on request
Nr. of stacks	1 – 32768 and auto stacking
Samplings frequency	0.2 – >400 GHz
Signal stability	<70ps
Communication interface	Ethernet
Communication speed	100Mbit/s
Data transfer rate	Antenna dependent
Acquisition modes	Distance/time/manual
Power supply	12V MALÅ standard battery / external battery
Operating time	Typically 5 hours, antenna dependent
Software	GroundVision2 for ProEx, XV-monitors
Antennas	All MALÅ manufactured
Wheel inputs	1 master, 1 for each HF-unit
Operating temp.	-20°C to +50°C
Environmental	IP 65

Power requirements @ 12VDC

Main unit	Expansion unit	Optical module	HF-module	Coaxial module
0.9A		0.4A	0.9A	0.4A

Auxiliary port configuration

Analogue input	Digital output	Digital input	Latched input	Communication
6	8	3	4	RS232, I^2C

Number of recording channels and physical antennas in different configurations

	Default	1 expansion unit	2 expansion units	3 expansion units
Recording channels	4	8	12	16
Physical antennas	2	4	6	8

Dimensions

Item	Height[cm]	Width[cm]	Depth[cm]	Weight[kg]
Base unit	32.50	22.20	4.20	1.9
Modules (all)	12.00	9.90	6.40	0.4
Base unit with 2 modules and battery	32.50	22.20	9.70	3.3
Expansion unit	16.10	22.20	4.20	1.25
	Imperial units			
Base unit	12.80	8.74	1.65	1.9
Modules (all)	4.72	3.90	2.52	0.4
Base unit with 2 modules and battery	12.80	8.74	3.82	3.3
Expansion unit	6.34	8.74	1.65	1.25

18 Technical Specifications Antennas

Antenna type	Weight	Dimensions
Unshielded		
25 MHz	3.85 kg (each)	4.06 x 0.20 x 0.07 m
50 MHz	2.65 kg (each)	2.06 x 0.20 x 0.07 m
100 MHz	1.10 kg (each)	1.04 x 0.16 x 0.04 m
200 MHz	0.55 kg (each)	0.54 x 0.16 x 0.04 m
RTA 30 MHz	7.8 kg (incl. batteries)	13.06 m long Tx-Rx distance: 6 m
RTA 50 MHz	7.0 kg (incl. batteries)	9.25 m long Tx-Rx distance: 4 m
RTA 100 MHz	6.0 kg (incl. batteries)	6.56 m long Tx-Rx distance: 2 m
Shielded		
100 MHz	25.5 kg	1.25 x 0.78 x 0.20 m
250 MHz	8.0 kg	0.78 x 0.44 x 0.16 m
500 MHz	5.0 kg	0.50 x 0.33 x 0.16 m
800 MHz	2.6 kg	0.38 x 0.20 x 0.12 m
Separate 1.3 GHz	1.5 kg (each)	90 x 114 x 85 mm
Separate 400 MHz	2.1 kg (each)	230 x 165 x 160 mm
Separate 200 MHz	4.2 kg (each)	455 x 255 x 250 mm

19 Technical specifications HF Antennas

Centre frequency	1.2, 1.6 and 2.3 GHZ
Bandwidth	> 100 %
Time window	> 50 ns
Repetition rate	100 kHz
EM option	50 Hz or 50/60 Hz sensors (sensitivity 300 uV, 14 bits)
Dimension	160x90x110 mm (1.6 GHz and 2.3 GHz) and 190x115x110 mm (1.2 GHz, 1.6+EM and 1.2+EM)
Weight	0.6 kg: 1.6 GHz and 2.3 GHz 1.0 kg: 1.2 GHz 1.2 kg: 1.6+EM and 1.2+EM
Cable length	4 m
Operating time	3 hours (with 12V battery)
Operating temperature	-20 to + 50 ^{0}C
Control Unit	CX Main unit or ProEx control unit
Data acquisition	CX Main unit or XV Monitor (both preferred) or other laptop (with MALÅ GroundVision2 Software)
Environmental	IP65
Options	Wheel cart, single wheel encoder, Extension handle, 10 m extension cable, split box for tomography applications

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