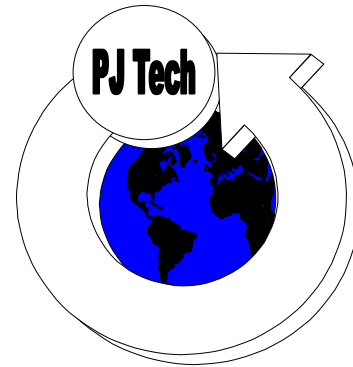


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OPERATING & MAINTENANCE INSTRUCTIONS MANUAL MINSEARCH-08 POSITION FINDING RECEIVER





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1 INTRODUCTION

1.1 Purpose of MinSearch-08

MinSearch-08 is an intrinsically safe device designed to be applied in underground mine workings in presence of methane and coal dust.

Main purpose of MinSearch-08 is to find positions of miners in mine workings by tracking their transmitters. As an M1 category device MinSearch-08 does not require turning off when explosion hazard occurs.

Transmitters which are built into miners' cap lamps, have nominal magnetic moment $0.08 \pm 30\%$ Am² and use 4000-6000 Hz frequency band (channels 05-40).

Complete MinSearch-08 device contains:

- *central unit* - microcomputer with keys and LCD display,
- *receiver* - main omni directional antenna,
- *spotter* - directional antenna for precise short-range searches,
- *power charger* - used for recharging device's battery.



Figure 1.1: MinSearch-08: Central unit with receiver antenna

1.2 Principles of operation

MinSearch-08 measures signal level in frequency band of current channel and uses the result to estimate distance between antenna and miner's transmitter. Analysis is based on amplitude characteristic (derived from FFT operation) of received signal, so levels can be measured for every channel separately. To decrease noise it is possible to perform more than one FFT operation and use averaged estimations (what makes measuring procedure longer).




Figure 1.2: MinSearch-08: Spotter

To increase accuracy of measurements in each channel, receiver is equipped with a set of five toggle-switched capacitors. These are used to set antenna's resonant frequency to the middle of channel's band. Every device requires a different configuration of switches, so antenna contains programmable signal generator which allows central computer to scan all possible settings and find the one most adequate for putting resonant frequency at desired value (this process is called „tuning” and is described in chapter 4.4).

Resonant frequencies cause that channels' amplitude characteristics are not flat. To avoid faulty distance estimations when transmitter's frequency is different from antenna's resonant, correction coefficients are applied. These coefficients' are found using antenna's built-in signal generator during the operation called „FFT correction” (see 4.4).

When distance between receiver and transmitter is very short (less than 2 meters), appliance of spotter is required. Spotter is a directional antenna which measures summarized level of signals received in all channels together and allows to find accurate transmitter's position (in point, where level is the highest).

2 TECHNICAL SPECIFICATIONS

Description	Data
Marking:	 I M1 Ex ia I
ATEX certificate:	FTZU 07 ATEX 0119X
International protection rating	IP54
Metrological parameters	
Range	0-30 m
Spotter range	0;1-2 m
Spotter Resolution	0.1 m
Measurement uncertainty: (direction measuring)	<ul style="list-style-type: none">• resulting from position of transmitter to receiver: $\pm 11;5\%$• resulting from dispersion of magnetic moment: $\pm 3;5\%$ at dispersion $\pm 10\%$ $\pm 10;5\%$ at dispersion $\pm 30\%$• resulting from processing by device: negligibly small
Total uncertainty:	<ul style="list-style-type: none">• $\pm 15\%$ at $\pm 10\%$ dispersion of magnetic moment (directional measuring)• $\pm 22\%$ at $\pm 30\%$ dispersion of magnetic moment



Power supply	
Battery	Li-ion LP277067 (Lishen)
Charge capacity	10 Ah
Current consumption	160 - 250 mA
Supplied voltage	3.2 – 4.2 V
Operating time	40 h (continuous measuring)
User interface	
Keypad	6 keys
Display	colour TFT-LCD 3,5" (resolution 320x240)
Temperature ranges	
Operating temperature	0°C to +40°C
Storing temperature	-25°C to +55°C
Transporting temperature	-25°C to +55°C
Dimensions	
Central unit	128 x 128 x 48 mm
Receiver antenna	Casing - Φ 98 x 90 mm Handle - Φ 40 x 110 mm
Length of spotter	0.5 m
Weight	
Central unit	990 g
Receiver antenna	675 g
Spotter	505 g

Table No.:2.1- Technical Specifications



"CE" marking is a declaration from the manufacturer that their product conforms to a specific Directive(s) adopted by the EEA (European Economic Area) and is a requirement for the product to be sold into any of the countries in this 18 member group. CE is an abbreviation for the French phrase *Conformité Européenne*, meaning European Conformance. Unlike hazardous location approvals, the manufacturers are solely responsible for ensuring their product's conformance to these Directives which were developed using IEC and Cenelec standards.



These are some of the recognized European approval agencies that have certified Viatran transmitters to Cenelec (European Committee for Electrotechnical Standardization) and/or IEC (International Electrotechnical Commission) standards for hazardous locations. Cenelec attempts to harmonize the electrical standards of its member countries. Generally, IEC standards are used. However, in certain instances where IEC standards are considered too vague, Cenelec defines more precise requirements.

3 USER INTERFACE

3.1 Keypad

MinSearch-08 is controlled with six keys. Their functions depend on working mode and are described in hints displayed on the screen. In general, keys' functions in all modes are similar:

- **ENTER** key - confirm choice, start an operation or enter next working mode,
- **ESC** key - cancel choice, stop an operation or return to previous working mode,
- **LEFT** context key - turn device on, start a measurement or move cursor left,
- **RIGHT** context key - start a measurement, move cursor right or start additional operation,
- **UP** and **DOWN** navigation keys - move cursor vertically or change settings.

All functions are summarized in table 5.8.

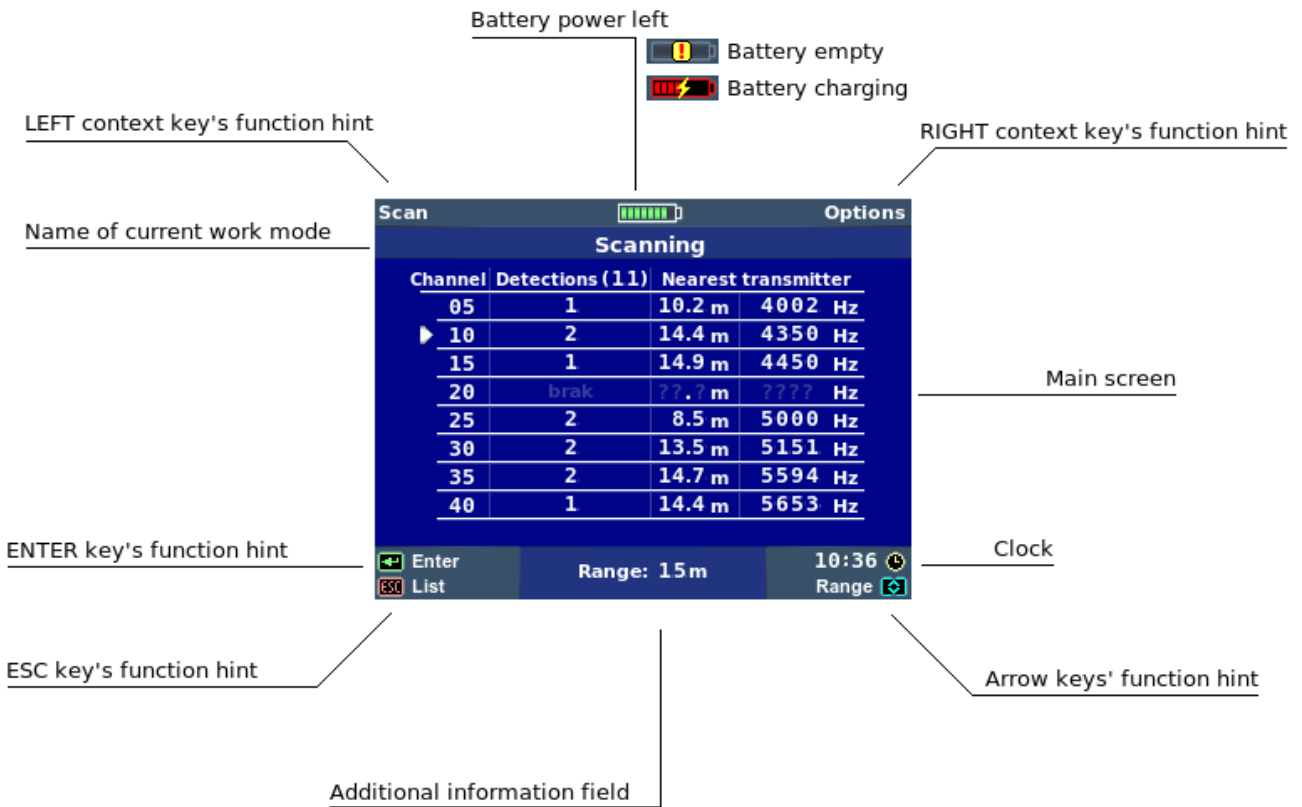


Figure 3.1: Screen elements

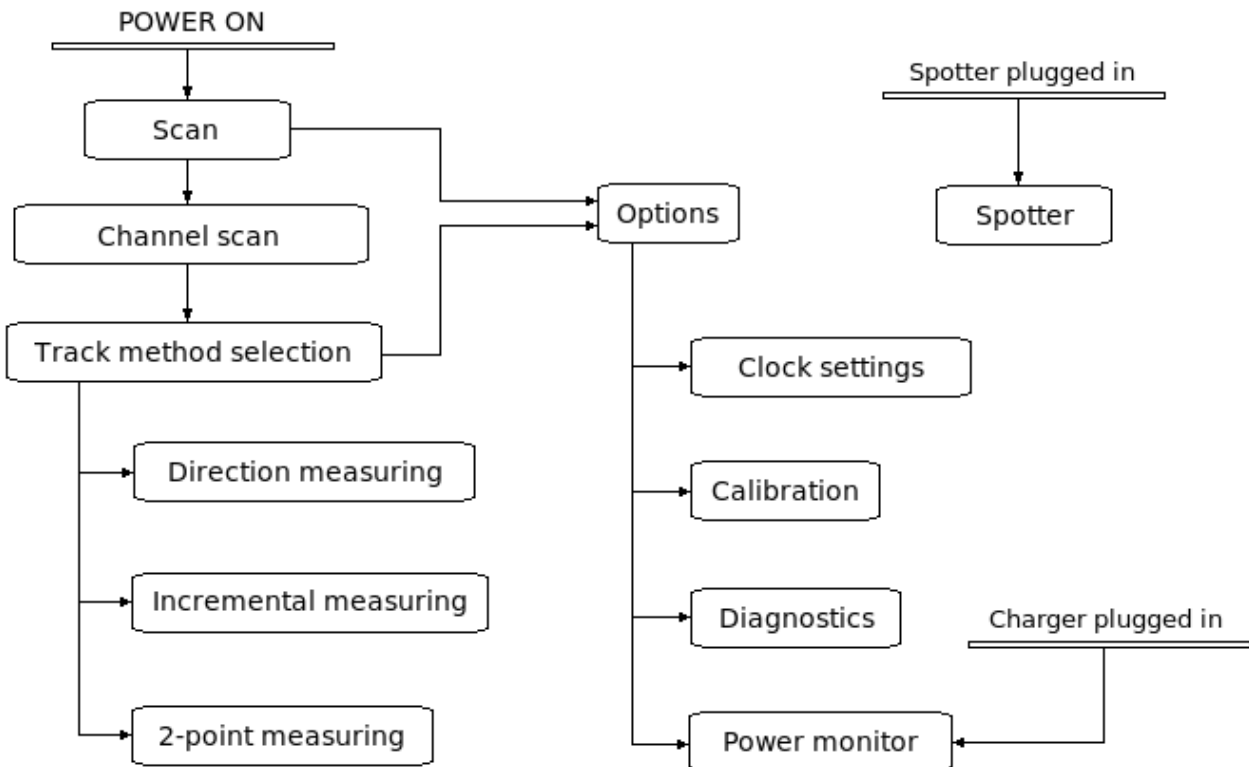


Figure 3.2: Map of working modes



3.2 Turning on and off

To turn on the device press **LEFT** context key and wait until welcome screen appears. MinSearch-08 will be turned off automatically after 5 minutes of idleness. To do it manually go to „Scanning” working mode and press **ESC** and **DOWN** keys simultaneously.

3.3 Screen

Basic elements of screen are described on Figure 3.1.

3.4 Working modes

Device’s functions are organized into working modes. User can switch between them by pressing proper control keys (exception is „Spotter” mode which starts up automatically). Map of working modes is shown on Figure 3.2.

4 FINDING POSITIONS OF TRANSMITTERS

4.1 Introduction

Transmitter finding process is divided into following phases:

- scanning the surroundings for signals in all channels and determining searching range,
- accurate single-channel scanning, searching for transmitters and estimating correctness of detections,
- finding exact position of selected transmitter using three available tracking methods,
- using spotter if necessary.

4.2 Scanning the surroundings

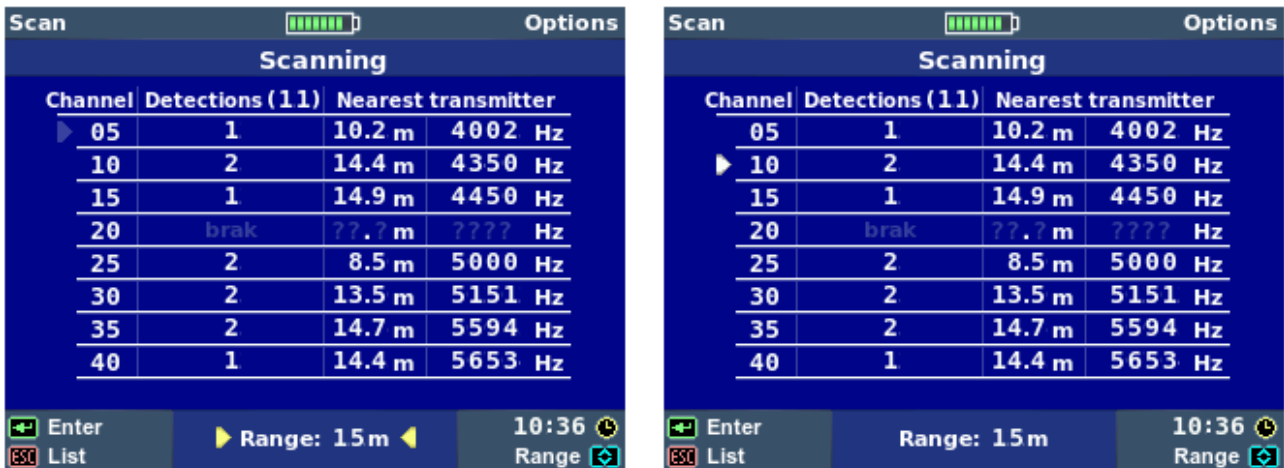


Figure 4.1: „Scanning” working mode
 a) adjusting searching range, b) selecting a channel for accurate scan

„Scanning” working mode is started automatically when device is turned on. After performing basic surroundings scan user may eliminate influence of noise by decreasing searching range (Figure 4.1a). Table in main part of the screen shows following information:

- number of channel,
- number of detected transmitters in channel (if too many transmitters were detected, exclamation mark is shown figure 4.2),
- distance to nearest detected transmitter,
- frequency of nearest detected transmitter’s signal.



Total number of detected transmitters is displayed in table's heading (channels with exclamation mark are not included). Table's content is updated on every change of searching range.

ESC key switches navigation (function of **UP** and **DOWN** keys) between range adjusting and moving cursor up and down the channel table. Figure 4.1b shows „Scanning” working mode while cursor is used to select a channel for accurate scanning.

Keys' functions in „Scanning” mode:

- **ENTER** - show list of transmitters in selected channel,
- **ESC** - switch navigation mode,
- **LEFT** - start scanning of the surroundings,
- **RIGHT** - enter „Options” working mode,
- **UP** and **DOWN** - depending on navigation mode: set range or move cursor.

Current key functions are described in on-screen hints.

While scanning is performed, a progress bar is shown in additional information field. Operation can be stopped anytime by pressing **ESC** key.

IMPORTANT NOTE

During scanning operation receiver must be held stable in one point.

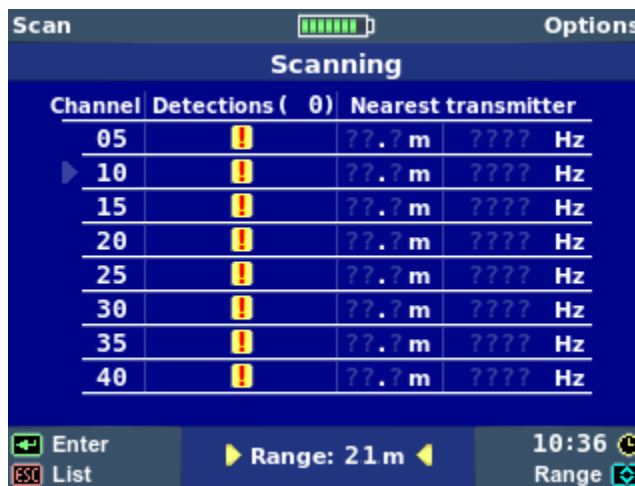


Figure 4.2: „Scanning” working mode: too many transmitters in all channels

4.3 Scanning for transmitters in channel

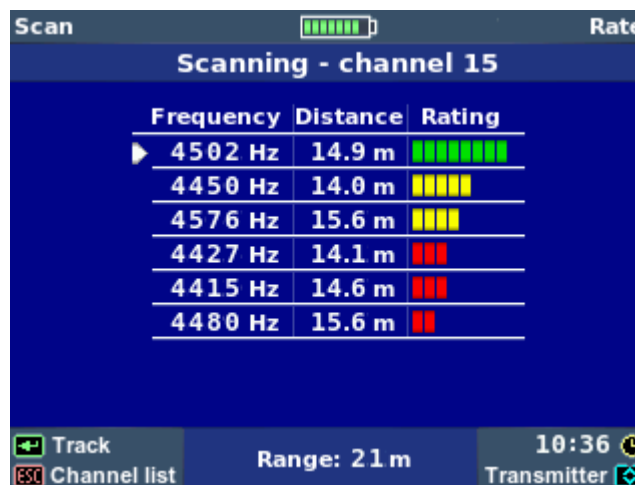


Figure 4.3: List of detected transmitters with detection correctness ratings



Figure 4.3 presents screen that shows up after pressing **ENTER** key in „Scanning” working mode. Table contains information about detected transmitters:

- transmitter’s signal frequency,
- distance between antenna and transmitter,
- graphic presentation of detection correctness (after finishing correctness rating operation).

During correctness rating scanning of the surroundings (in current single channel) is performed eight times and after every next scan occurrences of each transmitter signal are counted. Highest correctness rate indicates that transmitter’s signal was detected in every scan. Transmitters detected only once are not displayed, so after rating number of shown transmitters may change.

Key’s functions in this working mode:

- **ENTER** - start tracking selected transmitter,
- **ESC** - return to channels table and range setting,
- **LEFT** - scan surroundings in single channel,
- **RIGHT** - start detection correctness rating,
- **UP** and **DOWN** - move cursor.

4.4 Selecting track method



Figure 4.4: Track method selection screen

After selecting transmitter to track, user can choose one of available tracking methods (direction measuring, incremental measuring or 2-point measuring). Additional information field shows current transmitter identified by it’s channel number and signal frequency (Figure 4.4). Key functions:

- **ENTER** - start to track transmitter with selected method,
- **ESC** - return to „Scanning” working mode,
- **LEFT** - not used,
- **RIGHT** - enter „Options” working mode,
- **UP** and **DOWN** - move cursor.



4.5 Finding direction to transmitter

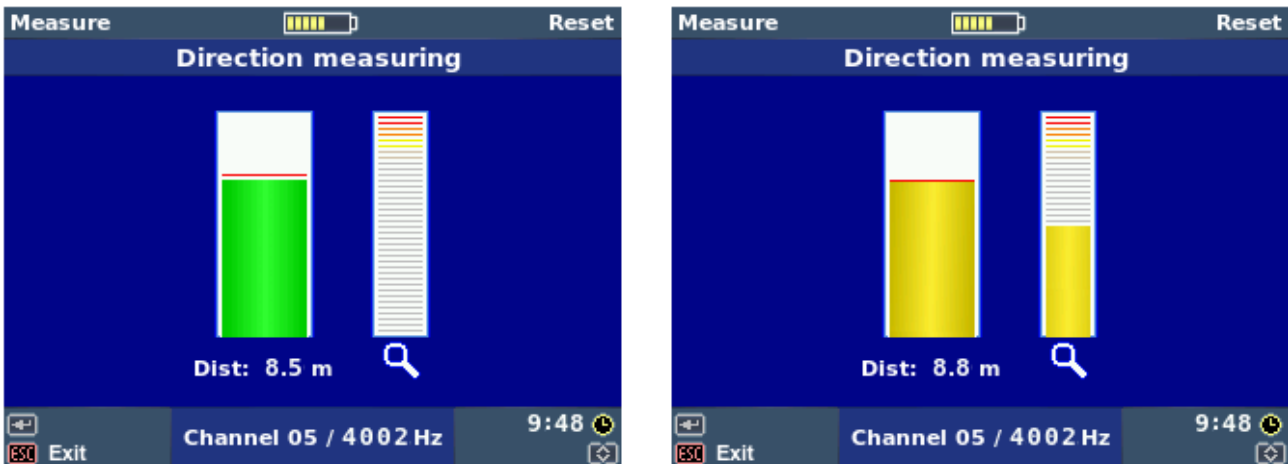


Figure 4.5: Direction measuring mode

To enter this working mode press **ENTER** key on „Direction measuring” position in „Track method selection” mode (after choosing tracked transmitter in „Scanning” mode). To find direction to transmitter:

- place a stand or anything that can be used as reference point,
- move the receiver around the stand in constant distance to it and measure signal level every short period of time,
- direction to transmitter is designated by segment bounded by stand and point where signal level is the highest.

There are two bars on the screen in „Direction measuring” mode. Left bar indicates current signal level, horizontal lines in it's background indicate highest measured signal level. Right bar (with magnifying glass icon) shows zoomed surrounding of highest measured level and is helpful when user wants to place receiver again in point with biggest signal.

Key functions in this working mode:

- **ENTER** - not used,
- **ESC** - return to track method selection menu,
- **LEFT** - start measuring,
- **RIGHT** - reset bars and forget highest measured signal level,
- **UP** and **DOWN** - not used.

Green colour of bars indicates that current measured signal level is higher than previous. Orange colour indicates that current level is smaller than previous.

IMPORTANT NOTE

During scanning operation receiver must be held stable in one point

4.6 Finding distance to transmitter

Purpose of incremental measuring method is to precisely estimate distance between given point and transmitter. Result is derived from signal level measurements in two points (named A and B) placed at a known distance on line containing transmitter's location.

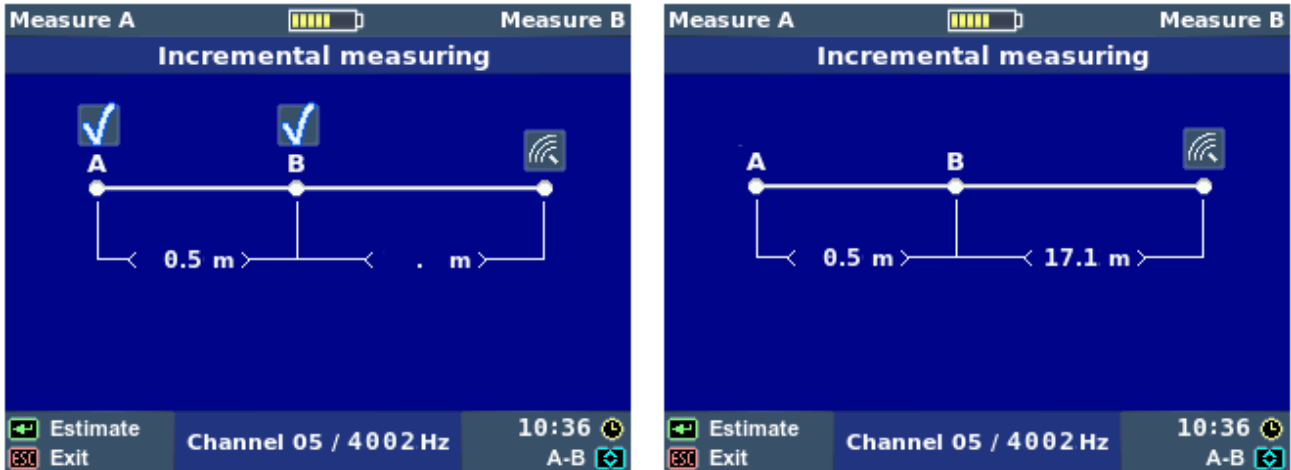


Figure 4.6: Incremental measuring mode

Key functions in „Incremental measuring" working mode:

- **ENTER** - estimate distance to transmitter (after measuring signal levels in two points),
- **ESC** - return to track method selection menu,
- **LEFT** - measure signal level in point A,
- **RIGHT** - measure signal level in point B,
- **UP** and **DOWN** - adjust known distance between A and B.

Point with measured signal level is marked with \checkmark . After estimation result can be corrected by adjusting A-B distance.

IMPORTANT NOTE

During scanning operation receiver must be held stable in one point

4.7 2-point measuring

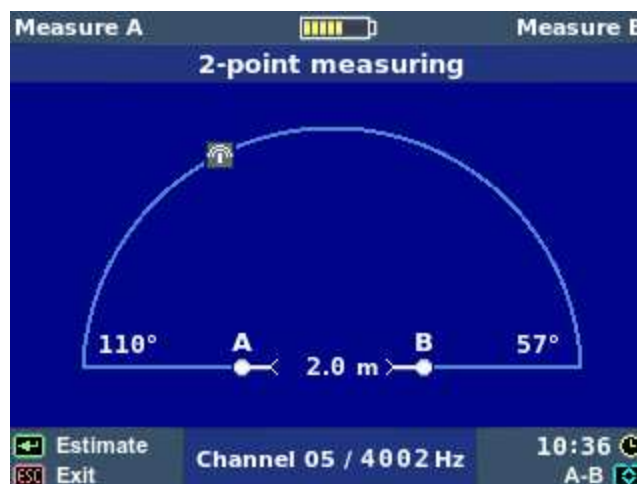


Figure 4.7: 2-point measuring mode

2-point measuring is an alternative way of obtaining direction to transmitter. In this method result is derived from signal level measurements in two points placed at a known distance on any line (line containing transmitter's location is not required).

As a result of operation (after measuring signal levels in points A and B and pressing ENTER key) two angle values are shown on screen. These are degree values of two angles of a triangle with



vertices in A, B and transmitter's location point. Graphical presentation of transmitter's location also is displayed.

Key functions in this working mode:

- **ENTER** - calculate position of transmitter (after measuring signal levels in two points),
- **ESC** - return to track method selection menu,
- **LEFT** - measure signal level in point A,
- **RIGHT** - measure signal level in point B,
- **UP** and **DOWN** - adjust known distance between A and B

Point with measured signal level is marked with \surd . After estimation result can be corrected by adjusting A-B distance.

IMPORTANT NOTE

During scanning operation receiver must be held stable in one point

4.8 Spotter

MinSearch-08 enters „Spotter” working mode (Figure 4.8) automatically after plugging spotter antenna in. To return to previous working mode simply unplug the antenna.

Spotter should be used when finding accurate position of transmitter which is placed at a small distance (less than 2 meters) is required. Its antenna measures signal level continuously and two vertical bars are drawn in a way similar to „Directional measuring” mode. The closer to transmitter antenna is put, the taller bars are displayed (signal level is higher). In additional information field channel number and frequency of currently detected transmitter are shown.

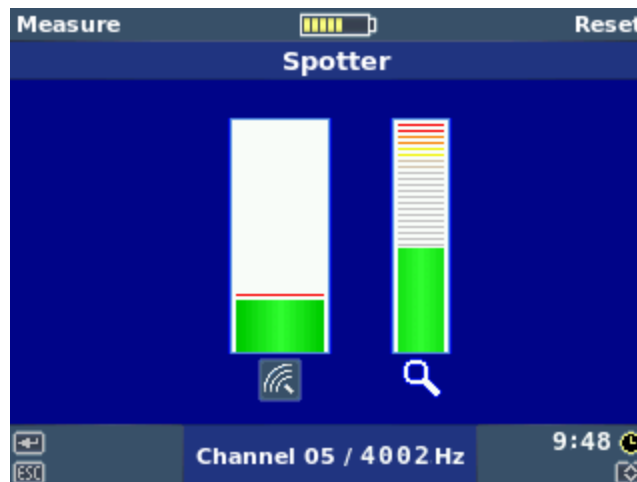


Figure 4.8: Spotter

Keys' functions in „Spotter” working mode:

- **ENTER** - not used,
- **ESC** - stop continuous measuring,
- **LEFT** - begin continuous measuring,
- **RIGHT** - reset bars and forget highest measured signal level,
- **UP** and **DOWN** - not used.

Green colour of bars indicates that current measured signal level is higher than previous. Orange colour indicates that current level is smaller than previous.

IMPORTANT NOTE

Bars are updated with about one-second delay, so do not move the spotter antenna too fast.



5 CONFIGURING DEVICE

Table 5.1: Key's functions depending on working mode

MODE	KEY				
	LEFT	RIGHT	ENTER	ESC	UP/DOWN
Scanning	Start measuring	Enter options menu	Scan selected channel	Toggle cursor/range	Move cursor or adjust range
Channel Scanning	Start measuring	Rate detection correctness	Track selected transmitter	Return to „Scanning” mode	Move cursor
Track method selection	Return to „Scanning” mode	Enter options menu	Start selected track method	Return to „Scanning” mode	Move cursor
Directional measuring	Start measuring	Reset results	Not used	Return to track method selection	Not used
Incremental measuring	Start measuring in point “A”	Start measuring in point “B”	Estimate result	Return to track Method selection	Adjust “A” to “B” distance
2-point measuring	Start measuring in point “A”	Start measuring in point “B”	Estimate result	Return to track Method selection	Adjust “A” to “B” distance
Options	Not used	Not used	Change option or enter selected mode	Return to previous mode	Move cursor
Clock settings	Move cursor to the left	Move cursor to the right	Save settings	Return to options menu without saving	Change value under cursor
Calibration	Start measuring signal level	Change channel	Calibrate	Return to options menu without calibrating	Adjust distance to transmitter
Diagnostics	Start capacitor switches tuning	Start FFT correction coefficients search	Save results	Return to options menu without saving	Toggle displayed information
Power monitor	Not used	Not used	Start battery discharging	Return to previous mode	Not used
Spotter	Start continuous measuring	Reset results	Not used	Stop continuous Measuring	Not used

5.1 Options

„Options” working mode is used to change device’s configuration and monitor its parameters. To enter options menu press RIGHT key in „Scanning” or „Track method selection” mode. Available menu items:

- Averaging - number of FFT operations used in averaging (more FFTs averaged make whole measuring process longer and results more accurate),
- Clock settings - enter „Clock settings” mode,
- Calibration - enter „Calibration” mode,



- Diagnostics - enter „Diagnostics” mode,
- Power monitor - enter power supply monitoring and forming mode,
- Store settings - save current settings and parameters to memory (will not be lost after turning device off),
- Restore defaults - delete current settings and calibration and restore factory defaults.

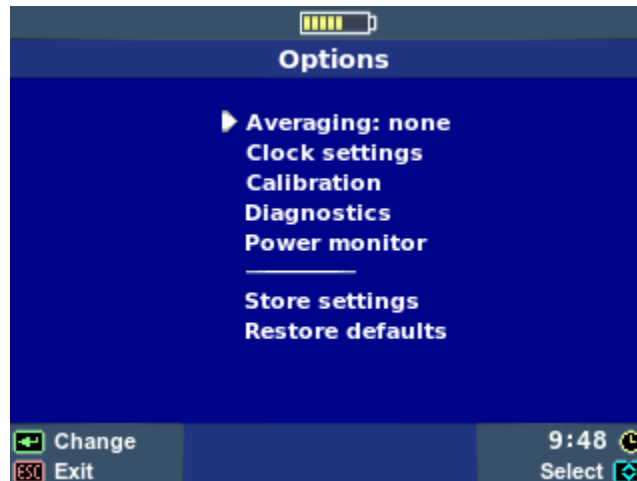


Figure 5.1: Options menu

Keys' functions in „Options” working mode:

- **ENTER** - enter working mode depending on cursor position or change averaging setting,
- **ESC** - return to previous working mode,
- context keys - not used,
- **UP** and **DOWN** - move cursor.

5.2 Clock settings



Figure 5.2: „Clock settings” working mode

Enter this working mode to set up proper time and date for device's onboard real time clock. Use context keys to move cursor and navigation keys to adjust value under cursor.



Functions of keys in this mode:

- **ENTER** - set up clock and return to options menu,
- **ESC** - cancel setting up clock and return to options menu,
- context keys - move cursor,
- **UP** and **DOWN** - change value under cursor.

5.3 Receiver calibration

To calibrate main antenna place the transmitter at given distance from it, adjust the distance value in device (using **UP** and **DOWN** keys) and perform single measurement of signal level. Ensure that transmitter's frequency is in scanned channel. After measuring your signal value will be shown, it's the value directly from receiver, before calculating the distance.



Figure 5.3: „Calibration” working mode

Functions of keys in „Calibration” mode:

- **ENTER** - calibrate receiver and return to options menu,
- **ESC** - cancel calibration and return to options menu,
- **LEFT** - measure signal level,
- **RIGHT** - change channel,
- **UP** and **DOWN** - adjust known distance between antenna and exemplary transmitter.

IMPORTANT NOTE

During measuring operation receiver must be held stable in one point. It is recommended to set receiver antenna at 45° angle to measuring axis and its magnetic moment to be $0:08 \pm 5\% \text{ Am}^2$. After calibration it is necessary to set up other parameters using „Diagnostics” working mode.

5.4 Diagnostics

„Diagnostics” mode allows to perform two important operations essential to proper device's functionality:

- tuning - finding capacitor switch combinations for each channel's proper resonant frequency,
- FFT correction - estimating FFT correction coefficient to assure flat amplitude characteristic (should be performed after tuning capacitors).

During tuning operation antenna's built-in generator emits signal with channel's middle-band frequency and searches for capacitors configuration at which received signal is the strongest. Process is performed automatically for every channel. Last tuning's result is shown as a „table of switch codes” displayed on the screen (use **UP** and **DOWN** to change displayed information).

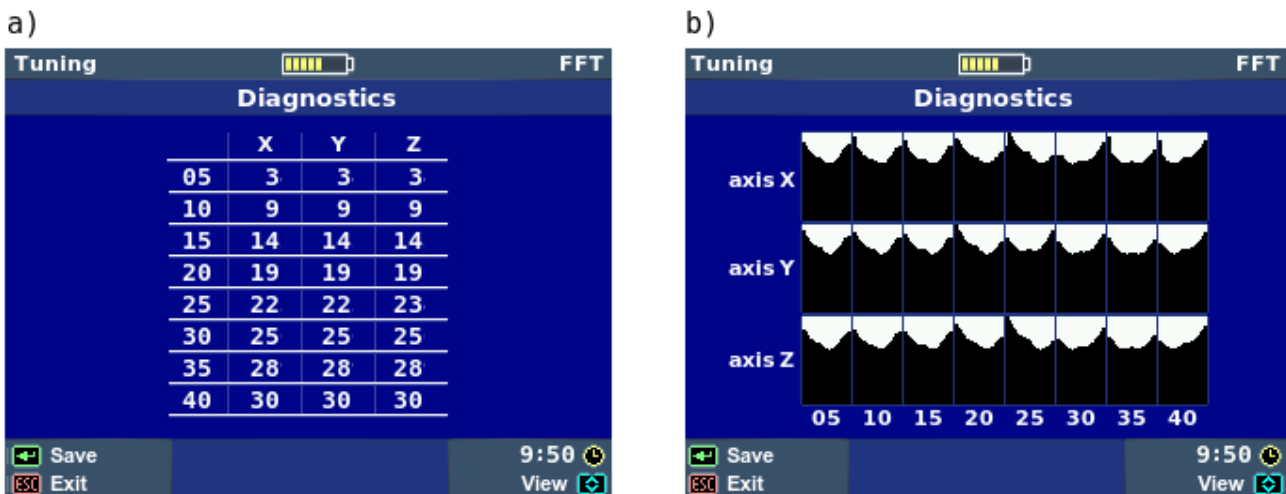


Figure 5.4: „Diagnostics” mode: a) capacitor switches table; b) FFT correction graph.

Searching for FFT correction coefficients begins with setting proper capacitors configuration for scanned channel (tuning should be performed before). After that, antenna's built-in generator emits signals with frequencies changing through whole channel's band by 1 Hz step and every time new signal measurement is performed. Basing on those results MinSearch-08 estimates amplitude-frequency characteristics of every band and calculates correction coefficients to make these characteristics flat. Approximated values of coefficients are presented on FFT correction graph.

Keys' functions in „Diagnostics” mode:

- **ENTER** - save results and return to options menu,
- **ESC** - return to options menu without saving,
- **LEFT** - start capacitor switches tuning,
- **RIGHT** - start FFT correction coefficients search,
- **UP** and **DOWN** - change displayed information (tuning table or FFT correction graph).

While one of operations is performed, receiver should lie motionless in room with possibly low environmental noise level. It is recommended to perform all calibration activities in following order:

1. calibration of receiver antenna,
2. capacitor tuning,
3. FFT correction.

5.5 Battery monitoring and forming

Battery level is displayed as a number of bars inside the „battery” icon at the top of the screen (with a small „plug” when a charger is connected to device). Empty icon with exclamation mark indicates that battery is empty and device may turn off suddenly (Figure 3.1). During charging „battery” icon turns red. Icon becomes full when battery charge exceeds 10000 mAh.

Device „knows” battery charge level because of measuring and counting incoming (while charging) and outgoing (while discharging or normal use) current. Supplied voltage is also continuously measured - when it drops below 3.1 V battery is marked as empty, when it gets over 4.2 V battery is marked as full and charging stops. For proper recognition of battery charge device should be discharged completely (to find „empty battery” level) and then fully charged. This operation is called battery forming (Figure 5.6).



Figure 4.5: „Power monitor” working state

To check battery parameters or perform battery forming use „Power monitor” working mode. Following information is displayed in this mode:

- Power left - battery charge in mAh,
- Supplied voltage - voltage supplied by batter (its dropping below 3.1 V indicates that battery is empty and device will suddenly turn off, its getting over 4.2 V indicates that battery is fully charged),
- Consumed current - current consumed from battery (outgoing),
- Charging current - current incoming into battery while charging.

Forming of the battery is essential to proper power monitoring. To start discharging press ENTER key, MinSearch-08 will automatically start to charge battery when voltage gets below 3.1 V (ensure to have charger plugged in). You can stop discharging anytime by pressing ESC.

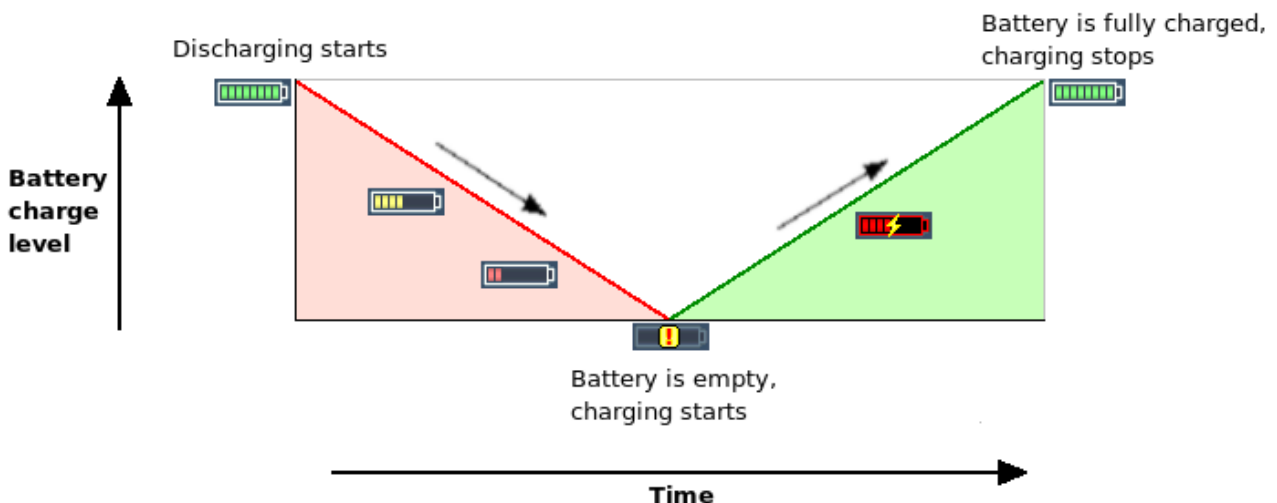


Figure 5.6: Battery forming process

„Power monitor” will start up automatically after connecting charger to device. It can also be entered by pressing **ENTER** on proper item in options menu.

Keys’ functions in this mode:

- **ENTER** - start battery discharging,



- **ESC** - stop discharging or return to options menu,
- context keys - not used,
- navigation keys - not used.

On device's front panel there's a light emitting diode placed between **LEFT** and **ENTER** buttons. Green colour of this diode indicates that device is operating normally and current is consumed from battery. Red colour indicates charging of battery.

Device can not be powered from charger, so when battery becomes full, charging will stop (diode will turn green) and device will start normal operation consuming battery's current. Then if charger is not disconnected, battery will become partially discharged and when its voltage drops below 4 V - charging will start again.

6 WARRANTY

PJ Tech MinSearch-08 is warranted against defects in workmanship and materials for period of 12 months from date of delivery. This warranty does not cover failures due to misuse, neglect, abuse, improper handling, alteration, improper maintenance or accident, and PJ Tech shall not be liable for any direct, indirect, consequential or incidental damages from use, results of use or inability to use this product. Within the warranty period, the faulty product will be repaired or replaced by PJ Tech free of charge. Except as mentioned above, no other warranty expressed or implied applies.

7 TRANSPORTING

MinSearch-08 should be transported in covered vehicle and kept in factory container during conveyance. It should be protected from moving, Temperature should be between -25°C and +55°C.

8 STORAGE

MinSearch-08 device should be stored in factory container in closed, free from fumes and corrosive gases room. Storing temperature should be between -25°C and +55°C, relative humidity should not exceed 95%.

9 HOW TO ORDER

The orders should be sent to the below:

Company Name	:	PJ TECH
Registration Number	:	CK94/30139/23
V.A.T. Number	:	4240179202
Contact Details	:	Tel.: +27 (011) 704-7088/9 Fax: +27 (011) 704-7019 e-mail: sales@pjtech.co.za www: www.pjtech.co.za
Physical Address	:	Mini Factory 2 Northlands Business Park North Riding Johannesburg Republic of South Africa

When placing orders, please provide the below part number: **PJT-MINSEARCH-08**