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MineCat 140/230 KE Remote Control System Technical Manual

Operator Panel Unit

OPU

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WARNING

It is of uttermost importance that the operator doesn't start operating the machine only after reading this manual. Additional documentation on machine handling and operation procedures for demining must be properly understood first.

Follow the suppliers instructions regarding education and training of machine operators prior to using the machine.

Electrostatic discharge protection

Observe precautions against electrostatic discharge while working with the remote control system.

Avoid using synthetic clothing that may generate electrostatic discharge while working with electronic boards or inside an opened cabinet.

Open the cabinets and access the electronic boards only at suitable worksites. These sites should be free of synthetic carpets or similar and workbench should be covered by non synthetic, medium conductivity material, such as antistatic workstation mats or unpainted wood or cardboard. Synthetic or metallic surfaces are prohibited.

Personnel handling the electronic boards should be grounded prior to and during the handling, either by a discharge wrist strap or by touching grounded equipment.

During shipment or storage, the electronic boards should always be enclosed in an antistatic shielding bag. If no such shielding bag is available, the boards should first be wrapped in plain paper and then in aluminium foil for shielding.

Note that when handling boards with integrated batteries, the boards must be wrapped in cardboard of proper thickness to protect the aluminium foil from shorting the battery. Shorting the battery may otherwise lead to fire and damage to the board. Note that tracks carrying battery voltage may be distributed all around the board so that the whole board must be handled and isolated as if it was under power.

Never allow synthetic wrapping or material of any art to touch the board unless the board is protected by a electrostatic shielding bag or aluminium foil.

An antistatic field service kit with antistatic mat, wrist strap and antistatic shielding bags can be purchased from Novatron AS, part.no. NOV-5500.

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1. Introduction

The intention behind this manual is that it should provide a comprehensive documentation for the technical maintenance personnel regarding service and maintenance of the Operator Panel Unit (OPU).

The manual gives an overview of the controls on the operator panel, and describes the interface used by the operator during normal operations, as well as the technical menus. It also describes the meaning of the different local warnings produced by the OPU, and provides a description on the possible causes that may have triggered them. It will also provide an overview of possible actions to be taken to fix the problem and bring the OPU back to operational state again.

Schematics of internal wiring and descriptions of modules and status indicators are provided as a help to trace down any problems that may appear. The documentation do however only contain information for locating the problem to a certain module. It will not provide information for locating a problem within the modules as this demands specialized knowledge and equipment that is outside the scope of this manual.

Spare modules must be purchased from the supplier and faulty units may be returned to the supplier for repair.

It is however important to notice that this is primarily a description of the technical details regarding the operation, maintenance or service of the OPU. Even though there are references to possible causes generated by equipment outside the OPU and brief descriptions of the relationship with the rest of the system, these are only intended as “helpful” references, and not as accurate or comprehensive descriptions of other parts of the control system or the machine itself. These details must be found elsewhere.

2. Normal operation

The Operator Panel Unit (OPU) is the main tool for the operation of the MineCat 140 KE and MineCat 230 KE demining vehicles. The OPU is either carried in a chest harness by the operator, placed on a tripod, or fitted in an armoured vehicle or a mobile control tower.

It may be used on internal batteries that provides up to 10-12 hours operation, or it may be connected to an external supply, such as a 230VAC/13.2VDC supply, or directly to a car battery of 12 or 24VDC (voltage range: 10-30VDC). The panel is internally protected against accidental reverse polarity.

The radio communication uses the ¼ wavelength whip fitted on the OPU, or it may use an external antenna connected to the antenna TNC-connector through a 50 ohm coaxial cable. External antenna should be used if the panel is operated from within an armoured vehicle, from inside a car, or in any other location that may act as a shielding for the radio communication. Otherwise, a reduction in operational distance may be the result.

The OPU has a layout as shown on the fig.1.

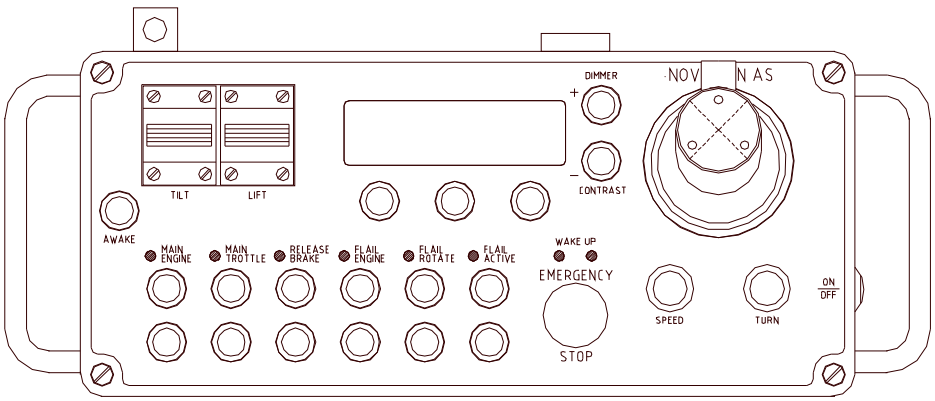


Figure1: Operator Panel Unit layout

2.1 ON/OFF switch and external connector

The OPU is switched ON or OFF by pressing the ON/OFF button on the right side. The button is protected against accidental hits by the stainless steel carrying handle. The button also has built in delay to discard short accidental hits. The combined external supply and umbilical connector is located just below the ON/OFF switch and not shown on fig.1. This connector must always have the dust cap fitted when it is not in use to stop dirt and water from getting into the connector.

2.2 Automatic switch off

To save power when not in use, the operator panel has a built in power saving feature. If the panel operates on internal batteries and doesn't receive a valid response from the machine within 10 minutes, the panel will issue a short "beep" and switch itself off.
This feature will save battery power if the operator switches off the machine main switch, but forget to switch off the operator panel at the same time. In this case, the panel will switch itself off 10 minutes later.
When operating on external supply, this feature will not be active as there is no need to save power.

2.3 Charging display

If the OPU is in the OFF state while being connected to external power, it will display either

```
CHARGING  94.7 %
0.75 A    8.12 V
```

or it will display

```
 FULLY  CHARGED

```

During charging, the values below indicates the total charging current being to the battery packages (0.75A) and the battery voltage (8.12V).

The value of 94.7% indicates that the panel is currently charging the internal batteries, and that the battery is charged to 94.7% of its nominal capacity, i.e. nearly fully charged.

While being connected to an external supply, the panel will not be completely switched off. In this state the internal electronics will be operational and handle the charging of the batteries. The display will show the charging state as shown above. Radio communication and "operational" functions will however be disabled until switched to ON state by pressing the ON/OFF button.

2.4 Display group

The display group consists of the 2 lines by 16 character LCD display (Liquid Crystal Display) and 5 buttons for menu navigation and display adjustment.

The two display adjust buttons are located on the right side of the display. They are used for adjusting the display to fit the viewing conditions, such as adjusting backlight and contrast. It may be necessary to adjust the backlight according to varying ambient light conditions, while the contrast may be necessary for adjusting the contrast to optimal viewing under varying temperature conditions.

Note that during low temperature conditions, the display will get slow and the “afterglow” may be annoying during menu operations and while looking at fast changing variables. In this case, it may be possible to optimise the display speed by adjusting the contrast a little up or down. It might improve the speed even if no change in contrast is observed.
It may also be a good idea to use the backlight in this case, even though the ambient lighting conditions are good. This is because the backlight will emit some heat that may increase the display speed a little (after some delay for the heating to take place).

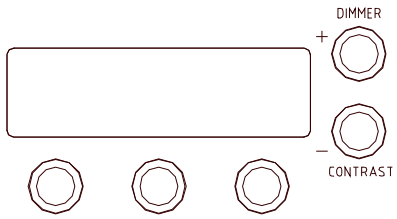


Figure 2: Display with display buttons

2.5 DIMMER button

The upper right button is the DIMMER button. By pressing this button, the display will enter the “Dimmer Adjust” mode and the DIMMER and CONTRAST buttons will now act as + and – buttons for adjusting the display intensity up or down. The buttons will return to normal functions after 2 seconds of inactivity.

In “Dimmer Adjust” mode, the display will show the following text:

```
   DIMMER
ADJUST:  5
```

The dimmer controls both the display backlight and the LED-indicators on the panel. Dimmer level 1 is the lowest intensity intended for night operation. Increasing values increase the intensity, even though the display intensity will reach its maximum already on step 4. From step 5-8, only the LED intensity will continue to increase. Level 9 is the daylight level. In this case, the display backlight is considered useless and is switched off to save power. The LED indicators change from steady light at full intensity (step 8) and to flashing light at full intensity (step 9). Flashing light is used to make it easier to observe in direct sunlight.

2.6 CONTRAST button

The lower right button is the CONTRAST button. By pressing this button, the display will enter the “Contrast Adjust” mode and the DIMMER and CONTRAST buttons will now act as + and – buttons for adjusting the display contrast up or down. The buttons will return to normal functions after 2 seconds of inactivity.

In “Contrast Adjust” mode, the display will show the following text:

```
   CONTRAST
ADJUST:  5
```

Normally a contrast setting of 5 will be optimal. Reducing the value will weaken the display contrast, and may even make the text totally invisible. Increasing the value will make the display darker, and finally it may be all dark. It may also go dark by itself at high temperatures which means that the contrast may have to be reduced as the temperature rises. Since the display will never be all blank (" -- ** -- " is the way the OPU indicates an empty display), a totally blank display must be regarded as too low contrast and one should then try increasing the value. Since the "help-text" on the display is invisible in this case, it might be a little confusing. It's therefore important that the operator makes himself familiar with how the DIMMER- and CONTRAST-adjust functions work, so that the buttons may be operated in the correct sequence even when nothing can be seen.

2.7 Softkeys

Below the display are three unspecified buttons, "softkeys". These buttons usually have functionality defined by the main control software in the Control Unit – CTU and details on these functions is described in the "Operator Manual" and "Control Unit – Technical Manual".

The softkeys is also used for navigating and adjusting parameters in the local panel-based calibration and status menues which are described later in this document

2.8 Tilt and Lift handles

The TILT and LIFT handles are located in the upper left corner of the panel. TILT and LIFT is used for controlling the TILT and LIFT cylinder or for adjusting software parameters. More details is found in the "Operator Manual".

2.9 The ON/OFF buttons

The group of 12 buttons in the lower left part of the display is the START/STOP buttons for controlling the status of the machine during operation. The function of each and one if these buttons are described in detail in the "Operator Manual". The yellow LED indicator above is used to signal back the state of the machine and these LED's are also described in detail in the "Operator Manual"..

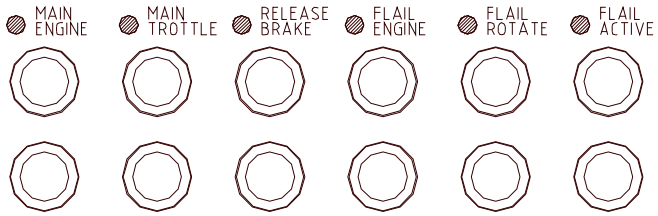


Figure 3: The ON/OFF button group

2.10 Prime mover control

The prime mover control group is used for driving and steering the vehicle. It consist of one hand operated, two axis joystick, and two additional knobs.

The joystick has one large "joystick enable" button in front. This button is used to sense when the operator puts his hand around the joystick and instructs the program to transfer control from the knobs and to the joystick. This button must be kept depressed as long as the joystick is used.

The joystick has also 4 buttons on top. It looks just like on big button, but pressing off centre in one of the four quadrants (see fig.4) will activate the corresponding button. The best result is usually obtained on pressing close to the rim. It is also important to press in centre of the quadrants, i.e. either straight backwards, 90 degrees right, 90 degrees left or straight forward.

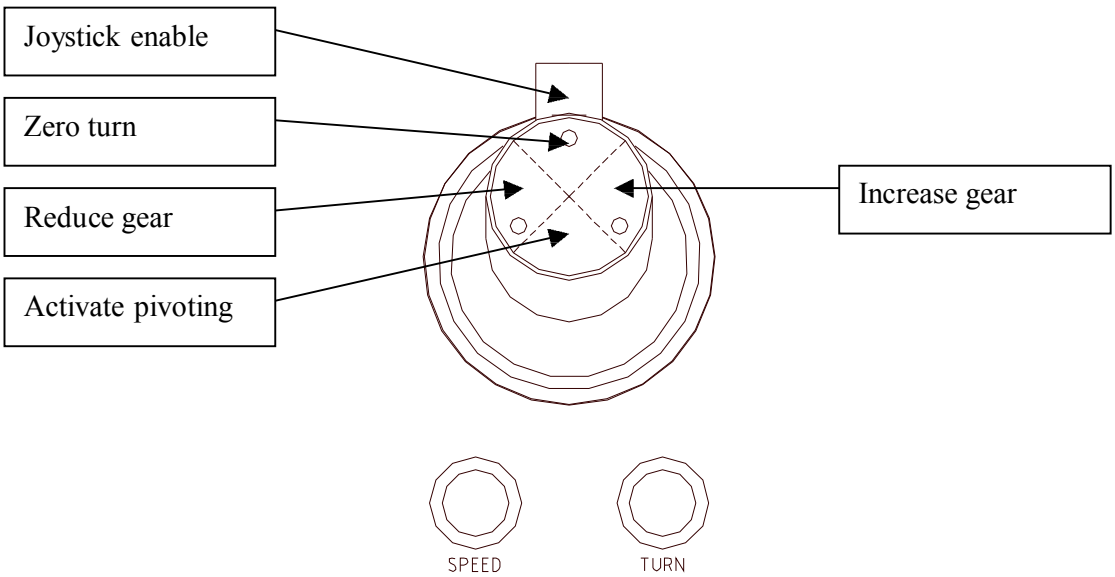


Figure 4: Prime mover control

2.11 Joystick operation

The joystick is for one hand operation of the machine and all software for handling the steering functionality is located in the Control Unit. See the “Operator Manual” for more details.

2.12 Gear selection

The MineCat 140 KE has 3 different “gears”, two physical gears (3 and 2) and a slow speed mode (1). The MineCat 230 KE has 2 different “gears” ”, a normal speed mode (2) and a slow speed mode (1).

The lowest “gear” – gear 1 – is the slow speed mode for both machines (MineCat 140 KE and MineCat 230 KE). In fact it is a low gear with a 25% limitation on the joystick speed . This means that full forward/backward movement of the joystick will only give +/- 25% speed to the tracks, thus reducing the risk of “overreacting” while manoeuvring in restricted spaces. The reduction of joystick speeds to 1/4 , giving maximum +/- 25% speed, is done locally in the OPU and the value transferred to the machine is therefore maximum +/- 25%.

The middle “gear” – gear 2 – is again the low gear (on MineCat 140 KE), but without any limitation on maximum speed. 100% joystick movement gives 100% speed. On the MineCat 230 KE this is the highest “gear” used for all types of operation, transport and flailing.

The top “gear” – gear 3 – is a true high gear available only on the MineCat 140 KE. It doubles the speed and reduces the available driving force on the tracks accordingly. This means that this gear is suitable for transportation along roads and on hard ground, but not suitable on muddy and soft ground due to the reduced track-force. There is an eminent risk of overloading or choking the main engine in this case. It is emphasized that this feature is only available with the MineCat 140 KE.

Changing gear must be done with a “double click” on the button. The first button activation will bring up the following message on the display:

```
CHANGE  "GEAR"
FROM 1 TO 2  ?
```

This display will stay for 1-2 seconds and within this time one has to press the button a second time to confirm the “gear” shift. When the gear switching is accepted by the system , the following message will appear for 2 seconds:

```
  "GEAR" No. 2
    SELECTED
```

Attempting to change to higher gear while already being in highest gear will give the following message:

```
HIGHEST "GEAR"
ALREADY IN USE
```

Attempting to change to lower gear while already being in lowest gear will give the following message:

```
LOWEST "GEAR"
ALREADY IN USE
```

Note:
When operating the MineCat 140 KE, gear 3 is not allowed during flailing due to the low traction force that may easily overload the main engine and disrupt the flailing operation that demands stable speed. Due to this limitation, changing to gear 3 is not allowed while the flail is rotating. The gear will also be automatically forced down to gear 2 in case gear 3 was selected prior to starting the flail. The messages displayed in these cases will be as shown:

```
HIGHEST GEAR = 2
 WHILE FLAILING
```

or

```
  FORCING GEAR
CHANGE: 3 -> 2
```

2.13 Zero turn button

In front of the joystick is a fourth button called "zero turn" which is intended for use when not operating the joystick. When operated, it sends an "clear turn" signal to the main software on the CTU, and the machine then stop turning and continue in a straight line.

2.14 Speed and turn knobs

The speed and turn knobs can be used for controlling the machine when the main joystick is not in use.

The knobs are incremental, meaning that they have no absolute position. Turning these knobs produce a value between 0 and 1023 with increasing values when turning clockwise and decreasing values when turning counter clockwise.

When the value increase above 1023, it drops to 0 and starts increasing from 0 again.
When the value decrease below 0, it jumps to 1023 and starts decreasing from 1023 again.

All further manipulation of the turn/speed setting is done by the software in the CTU. See "Operator Manual" for more details.

2.15 Awake button – automatic system shutdown

The awake button is a safety feature. When any engine is started, this button has to be pressed at regular intervals to tell the control system that the operator is awake and in control of the machine. Any other button or knob activation will also do the job, and so will operation of the TILT and LIFT handles, but the AWAKE button is the button to use if there is no reason to press any of the others. The AWAKE button can easily be activated by the left thumb if one has the hand resting on the carrying handle.

If the button is not activated, the LED's above the EMERGENCY STOP button will start to flash, the first one after approx. 20 seconds, then both will start flashing. After 25 seconds there will be a single warning beep and after 35 seconds a continuous pulsed audible alarm will start with increasing intensity. Finally, if nothing has been done after 50 seconds, a system shutdown will take place, an automatically executed EMERGENCY STOP.

In case of an AWAKE timeout, the following message will appear:

```
 - NOT  AWAKE -
SYSTEM  SHUTDOWN
```

Pressing the AWAKE button or any other button will reset the system again.

This awake functionality, unless disabled on a specific system, will be controlled by the status of the two LED's "MAIN START" and "FLAIL START". When either of the LED's are lit, the system will automatically enter the "awake control mode" and issue the awake messages (flashing light and audible tones) unless the specified buttons are activated as described above.

A "SYSTEM SHUTDOWN" is a state similar to pressing the "EMERGENCY STOP" button, but executed automatically by then OPU. See "Operator Manual" for more details.

Note:
The AWAKE function may be disabled from the technical menu in cases where the technician need to concentrate on other issues. The possibility of disabling this safety feature must however be used with care and under safe conditions. See technical menu on machine equipment for more details on how to perform this operation.

The person disabling the AWAKE safety feature has the responsibility of ensuring that it may be done safe and without risk for personnel or equipment.

2.16 Emergency Stop

In case of an event that needs instant stop of engines and vehicle movement, the EMERGENCY STOP may be used. It can also be used for resetting the control routines as described in the "Operator Manual". Using the EMERGENCY STOP button should however only be used with care after observing the restrictions listed in the "Operator Manual".

Pressing the EMERGENCY STOP button will send an instant stop message to the vehicle and the OPU will then cut all communication after 1 second. The result is that all engines will be shut down instantly as a reaction to the stop message. If the stop message is lost due to noise or jamming, the machine will in any case stop any forward movement within 1 second as response to the loss of communication and then start a controlled shutdown. See “opertor Manual”.

Note that while the EMERGENCY BUTTON is being depressed, the communication will be switched off and the display will be locked to the text:

```
EMERGENCY STOP
 IS ACTIVATED
```

It will therefore not be possible to scroll through menus or do any other actions as long as the button is depressed. To enable communication with the machine and the CTU-based operator interface, it is necessary to release the button and start the communication again.

When pressing the EMERGENCY STOP button, it will lock in the depressed, active position. To release the EMERGENCY STOP button, turn the button and it will pop up to OFF position again.

3. Communication

The communications uses framed messages with checksums and a built in identifier code that is to be specific for each set of vehicle and operator panel. Running two systems with different identifier on the same channel will therefore not be possible. Neither of the vehicles will react to commands from the other panel and the operator panels will also tell the operator that it has detected other machines on the same frequency. See alarm description.

If the OPU detect a valid message frame with an invalid identifier code, the following message will appear:

```
AN OTHER MACHINE
ON THIS CHANNEL
```

Note: Operating the machine in this case of a "channel crash" is hazardous and should not be allowed as communication will be slow and delayed. Instead it is recommended to change frequency on one of the machines to avoid further channel conflict before commencing operations.

See the "MineCat 140 KE - Technical Manual – Machine Electronics" for more info on the procedures for changing frequency.

3.1 Communication sequence

All communication between OPU and machine (CTU) is controlled entirely by the OPU. The CTU is only a slave in this respect, responding to the commands from the OPU. So when the OPU stops transmitting, the CTU will also stop responding within less than one second.

For keeping track of what is happening in the communication between the OPU and the CTU, a brief description of a communication sequence, step by step, will be given. To be able to have full understanding of what happens, please refer to the drawings describing the status indicator LED's on the OPU electronic module, the OPU radio module, the CTU electronics module and the CTU radio module.

3.2 OPU transmits to CTU

A communication sequence is always initiated by the OPU electronic module. It will first send a message to the radio module by wire and this transmission will be signalled by flashing the RED "TRANSMIT" LED on the electronic module. The message will be received by the radio module which will start up the transmitter, and as soon as the transmitter is operational after some 10-20ms, the radio module will start sending the message out on the antenna. The transmission will then be signalled by the RED "TRANSMIT" LED on the radio module. A soon as the whole message has been sent, the transmitter will switch off and the RED "TRANSMIT" LED will go off.

On the CTU side, the message is received by the radio module which will flash the YELLOW "RECEIVE" LED to signal a data reception. The received data is then sent by wire to the CTU electronic module where the incoming message will be handled by the CTU software. If the software finds the data valid, the YELLOW "RECEIVE" LED on the CTU electronic module will be lit for 1 second to signal a valid reception. If it receives data which is found to be invalid, it will only give a rapid flashing light on the YELLOW "RECEIVE" LED.

Since the communication sends many packages each second and since valid data gives steady light for 1 second, a normal communication will give steady light in the YELLOW "RECEIVE" LED's on the electronic modules. The YELLOW "RECEIVE" LED on the radio modules will however only be active during the reception, meaning that this led will flash on and off for every received message.

If the electronic modules receives data that doesn't satisfy the security tests (framing error, checksum error or invalid id-code), it will only give a fast flashing signal on the YELLOW "RECEIVE" LED. A stable YELLOW light is thus an indication that the majority of the received messages are valid.

3.3 CTU transmits to OPU

As a response to the received message, the CTU will send a message to the radio module by wire and this transmission will be signalled by flashing the RED "TRANSMIT" LED on the CTU electronic module. The message will be received by the radio module which will start up the transmitter, and as soon as the transmitter is operational after some 10-20ms, the radio module will start sending the message to the antenna. The transmission will then be signalled by the RED "TRANSMIT" LED on the radio module. A soon as the whole message has been sent, the transmitter will switch off and the RED "TRANSMIT" LED will go off.

On the OPU side, the message is received by the radio module which will flash the YELLOW "RECEIVE" LED to signal a data reception. The received data is then sent by wire on to the OPU electronics module where the incoming message will be handled by the OPU software. If the software finds the data valid, the YELLOW "RECEIVE" LED on the OPU electronics module will be lit for 1 second to signal a valid reception. If it receives data which is found to be invalid, it will only give a rapid flashing light on the YELLOW "RECEIVE" LED.

Since the communication sends many packages each second and since valid data gives steady light for 1 second, a normal communication will give steady light in the YELLOW "RECEIVE" LED's on the electronic modules. The YELLOW "RECEIVE" LED on the radio modules will however only be active during the reception, meaning that this led will flash on and off for every received message.

If the electronic modules receives data that doesn't satisfy the security tests (framing error or checksum error), it will only give a fast flashing signal on the YELLOW "RECEIVE" LED. A stable YELLOW light is thus an indication that the majority of the received messages are valid.

3.4 Communication Overview

It has now been given a detailed description of a single OPU -> CTU -> OPU sequence. To understand completely how the two units communicate it is also necessary to have a knowledge of the overlaying communication structure.

Basically, the OPU will always send messages to the CTU and the CTU will send return messages to the OPU, even when nothing happens. The only time when there is no communication is when the OPU is switched off, when the EMERGENCY STOP is being depressed or when the "NOT AWAKE" shutdown has been activated. The only difference between full operation and an idle situation is that the transmission rate goes down from once every 150 ms to once every 450ms, i.e. that it only sends every third data frame to save power.

> ***Note: While using cable communication, the communication rate is 75 ms between each transmitted frame, regardless of idle-state. Therefore all reactions will be much faster by cable than by radio.***

The continuous communication is essential for the machine since the CTU will start a shutdown sequence if it looses communication for more than 1 second. The idle communication with at least one message every 0.5 seconds will prevent this from happening.

3.5 Retransmissions

In any type of communication, and especially in radio communication, there will also be loss of data due to noise and other factors. To ensure that no data is lost, a retransmission protocol is implemented. Any message being sent will therefore have to be acknowledged by the receiving part before the next 150 ms transmission window. If no acknowledge has been received within 150 ms from the previous transmission, the same data will be retransmitted once more. A second retransmission will be made if there is still no reply. After a third unsuccessful transmission attempt, the message is deemed obsolete and dropped.

If three messages are lost, interference will probably also block the next attempts and there is a risk of queuing up a lot of old data. Therefore the data is dropped after three attempts to "cool down" the communication and try re-establishing the communication. This means that the system may loose some button activations during longer pulses of noise interference, but this will be visible to the operator from the response given back (LED's and display) so that the button may be activated once more.

There are indicators on both the OPU and CTU electronics modules that show the retransmission status. The RED status LED called "RETRANSMIT" will normally be off, but it will start flashing for 1 second as soon as a retransmission has to be made. If data is dropped after three retransmissions, the LED will light steady for 1 second telling that the message has been dropped.

There is of course a possibility that the message has been received correctly, while the acknowledge message returned has been lost instead. In this case the sender will also give a retransmission, but double messages are easily detected by the receiver and will pose no problem.

3.6 Normal status LED behaviour

During normal communication, the radio module LED's are flashing in this sequence: OPU-RED, CTU-YELLOW, CTU-RED, OPU-YELLOW. This will go on continuously at a rate of twice a second in idle situation and 6 times a second in full traffic.
The GREEN status LED on the radio modules is just a radio-modem ON indicator and will flash all the time regardless off traffic.

On the OPU and CTU electronic modules, the RED "TRANSMIT" LED's will be flashing at regular intervals as messages are being sent, while the YELLOW "RECEIVE" LED's will light steady. The RED "RETRANSMIT" LED's will normally be off, with just a few flashes now and then when a retransmission takes place. If this LED starts lighting constantly for 1 second, it indicates a loss of data. If it lights continuously, it indicates that the communication has stopped completely.

A RED "RETRANSMIT" LED, signalling loss of communication may also be triggered by operator action, for example if the machine main switch is switched off, if the emergency stop is activated, and so on. The communication is correctly enough lost, but it is not due to any noise or error in this case.

The green flashing LED on the OPU electronics module is the "processor OK" indicator.

4. Local Operator Panel Menus

For additional information to help the technician in fault finding, two local technical menus have been added to the OPU. These are **OPU Status Menu** and **Joystick Calibration Menu**. Both menus are accessible through the display group without any need for additional tools.

4.1 OPU Status Menu navigation

The OPU Status Menu can be entered at any time, also when machine operation is going on. This enables supervision of certain values, while at the same time be able to observe the link to the machine behaviour. This can be very useful when tracing down the source of a problem.

The OPU status menu is entered from the normal state by simultaneously pressing the DIMMER and CONTRAST buttons and keeping them depressed for more than 5 seconds.

The following message will then appear on the display indicating that the local status menu has now been entered:

```
  PANEL STATUS
<<    HOME    >>
```

The display will now be showing the local status and thus mask out the messages sent from the machine. Also, the button input from the display group during this situation will not be sent over to the machine.

Except from the display group, all other buttons and status LED's will function as normal, unaffected by the local display of status information.

This index is shown only the first time when the menu is entered, and will never reappear as long as one stays within the menu. The different indexes can be thought of as being side by side on a circle and can be navigated by the left and right button as shown by the arrows. By moving right through all indexes, the first index will reappear. The same will happen after moving left through all indexes. Indexes on the end of the list should therefore be easier to access from the back using the left button instead of going right through the whole list.

-(34)-**(PANEL STATUS)-(1)-(2)(3)-(4) - - - - - - - (31)-(32)-(33)-(34)**-

(1)

```
 OPU VERSION
HW: 3.1  SW: 3:0
```

Displays the version numbers of the hardware and software in the OPU electronics module.

This information is useful when support from the manufacturer is necessary. By passing over these version numbers, the manufacturer will know exactly which version of the system that is in use and can thereby give more correct support.

The electronic module is the module fitted in the bottom of the panel, as opposed to the Operator Panel Front electronic board that is fitted in the top of the panel. The version number of the later is only accessible by visual inspection.

The hardware version number (HW) consists of a main version number (3.) which is the number of the physical revision of the PCB (printed circuit board) and a sub version number (.1) which only indicates revisions of the component list.

For the software, the main version number indicates larger fundamental revisions of software functionality, while the sub version number only indicates minor revisions of modules within the program.

(2)

```
PANEL BATTERY
7.8V -0.65A  75%
```

Displays the battery and charging status of the internal battery packs.
The first value indicates the battery voltage, i.e. the mean value of the 3 battery packs with the highest voltage. On or two damaged battery packs will thus not affect the measured voltage.
The second value show the total current going in and out of the battery packs. In this case, the negative value indicates that the battery packs are being discharged with 0.65 A. A positive value means charging.
The third value indicates the estimated battery level calculated from the measured charge and discharge currents and specified in percentage of nominal battery capacity.

(3)

```
TOP TEMP :  45°C
CPU TEMP :  55°C
```

Displays the temperature measured within the OPU. Top temperature is the temperature measured on the Operator Panel Front PCB fitted in the top of the OPU. This can be regarded as a measurement of the OPU internal temperature, which will be almost the same as the battery temperature and the radio modem temperature while operating on batteries.

During charging, battery temperature may be higher, especially at the end of the charging.

The CPU temperature is the temperature measured on the OPU electronic module in the bottom. During charging, this temperature will be considerably higher than the top temperature due to heat dissipation in the voltage down converter and charge control circuits.

During discharge, it will just be slightly higher than the top temperature, unless the top is directly heated by sunlight. In the last case, top temperature may be observed to be higher, at least until an equilibrium has been reached.

(4, 5, 6, 7 and 8)

```
BATTERY PACK #1
7.8V -0.15A  75%
```

Displays the battery and charging status for each of the 5 internal battery packs in the OPU.
The value to the right on the upper line shows the battery pack number,
The first value on the lower line indicates the voltage on the battery pack.
The second value show the current going in and out of the battery. In this case, the negative value indicates that the battery is being discharged with 0.15 A. A positive value means charging.
The third value indicates the estimated battery level calculated from the measured charge and discharge currents and specified in percentage of nominal battery capacity.

By going through all 5 battery packs, it will be possible to see if any of the 5 battery packs is faulty or has significantly different values from the rest. A battery pack that is found to be worse than the others is an indication that the battery packs is starting to get worn out and should be replaced.

Always replace all 5 battery packs at the same time. This is easily done as all 5 battery packs are supplied as one unit with one common connector.

(9)

```
EXTERNAL VOLTAGE
SUPPLY :  12.5 V
```

Displays the voltage on the external supply. This value should be above 13V for an optimal charging. A voltage dropping well below this value may reduce the possible charging current and thus increase the necessary charging time. The supplied DC-adapter delivers 13.2V DC for optimal conditions.

(10)

```
TOTAL BATTERY
CAPACITY : 102%
```

Displays the measured total battery capacity in the OPU, shown as percentage of total nominal battery capacity. With fresh battery packs, values above nominal can be seen. The values will drop as time goes on and until it reaches a level where they should be replaced.

The level where replacement should be done may vary depending on the duration of daily operation compared to available recharge time. One obstacle might however be that the internal resistance in the battery packs increase with age so that the voltage drop at peak current consumption may set the limit even though the measured capacity is still enough.

(11, 12, 13, 14 and 15)

```
BATTERY PACK #1
CAPACITY : 102%
```

Displays the measured capacity for each of the 5 internal battery packs in the OPU. Measured capacity is displayed as percentage of nominal battery pack capacity. With fresh battery packs, values above nominal can be seen. The values will drop as time goes on and until it reaches a level where they should be replaced.
If the measured capacity for the different battery packs in the OPU is differing a lot, this may be a good indication that the batteries are reaching the end of their life and that the battery pack should be replaced.

(16)

```
BATTERY TYPE :
NiMH  7.5 Ah  LT
```

Displays the selected battery configuration. As the panel is only intended for NiMH batteries, the first parameter will always be "NiMH".

The second parameter show the selected total battery capacity within the panel. This value should match the physical capacity of the installed batteries (the total sum of all 5 batteries) to within 0.25 Ah.

The last parameter indicates the temperature class of the batteries:

- LT : batteries with a charging temperature of up to +55ºC.
- MT : batteries with a charging temperature of up to +60ºC - +65ºC.
- HT : batteries with a charging temperature of up to +70ºC or above.

(17)

```
TILT HANDLE
TEST :    55 %
```

Displays the value from the TILT handle as +/- 0-100%. Pushing the handle forward gives negative values. Pulling it backwards gives positive values.

(18)

```
LIFT HANDLE
TEST :    -5 %
```

Displays the value from the LIFT handle as +/- 0-100%. Pushing the handle forward gives negative values. Pulling it backwards gives positive values.

(19)

```
SPEED JOYSTICK
TEST :   -25 %
```

Displays the speed value from the two axis joystick as +/- 0-100%. Pushing the joystick forward gives positive values. Pulling it backwards gives negative values.

(20)

```
TURN JOYSTICK
TEST :     0 %
```

Displays the turn value from the two axis joystick as +/- 0-100%. Moving the joystick sideways to the right gives positive values. Moving the joystick sideways to the left gives negative values.

(21)

```
SPEED KNOB
TEST :    1023
```

Displays the value from the rotary speed knob.

The knob is incremental, meaning that it has no absolute position. Turning this knobs produce a value between 0 and 1023 with increasing values when turning clockwise and decreasing values when turning counter clockwise.

When the value increase above 1023, it drops to 0 and starts increasing from 0 again.
When the value decrease below 0, it jumps to 1023 and starts decreasing from 1023 again.

(22)

```
TURN KNOB
TEST :    1023
```

Displays the value from the rotary turn knob.

The knob is incremental, meaning that it has no absolute position. Turning this knobs produce a value between 0 and 1023 with increasing values when turning clockwise and decreasing values when turning counter clockwise.

When the value increase above 1023, it drops to 0 and starts increasing from 0 again.
When the value decrease below 0, it jumps to 1023 and starts decreasing from 1023 again.

(23)

```
BUTTON TEST
  -  WAIT  -
```

or

```
BUTTON TEST
ONLY WHEN OFF
```

Index used for testing the functionality of the buttons. As pressing the buttons for test is not recommended when operating the machine, this test feature is only available when the operator panel is switched OFF and not in control of the machine. Since a panel operated on internal batteries is completely dead when being switched off, this test must be done with external supply, i.e. when the panel is in “charge mode”.
When going through this index in operational mode, the lower line says “ONLY WHEN OFF” to tell that the panel must be switched off before this feature may be used.
When going through this index in “panel OFF - charge mode”, the message
" - WAIT - " will display on the lower line. To test the buttons, wait until the present text disappear and the button status appears on both lines.

```
O OOOOOO O   O O
  OOOOOO    OOO
```

The “O” indicates an inactive button. When a button is depressed, the value will change to “X” instead. Please observe that there may be a little delay before the change is displayed.

Upper line buttons:
First letter is AWAKE button. The next group of 6 letters are the 6 green ON buttons. Then comes the EMERGENCY STOP button, the ZERO TURN button and finally the JOYSTICK ENABLE handgrip-button.

Lower line buttons:
The first group of 6 letters are the 6 red OFF buttons. Then follows the REDUCE GEAR, ACTIVATE PIVOTING and INCREASE GEAR.

(24)

LED TEST GN1-GN6 RD1-RD2	or	LED TEST ONLY WHEN OFF

Index used for testing the functionality of the LED's. As this affects the LED status and the buttons used for machine operation, this feature is only available when the operator panel is switched OFF and not in control of the machine. Since a panel operated on internal batteries is completely dead when being switched off, this test must be done with external supply, i.e. when the panel is in "charge mode".

When going through this index in operational mode, the lower line says "ONLY WHEN OFF" to tell that the panel must be switched off before this feature may be used.

When going through this index in "panel OFF - charge mode", the text "GN1-GN6 RD1-RD2" will appear on the lower line. This indicates that the green buttons no. 1-6 should be used for testing the corresponding yellow LED's, while the red buttons 1 and 2 should be used for testing the orange and red LED's above the EMERGENCY STOP button.

The LED's will go on when the corresponding button is pressed and off when the corresponding button is released.

(25)

AUDIO TEST GN1 GN2 GN3 GN4	or	AUDIO TEST ONLY WHEN OFF

Index used for testing the audio alarm. As this affects the audio and the buttons used for machine operation, this feature is only available when the operator panel is switched OFF and not in control of the machine. Since a panel operated on internal batteries is completely dead when being switched off, this test must be done with external supply, i.e. when the panel is in "charge mode".

When going through this index in operational mode, the lower line says "ONLY WHEN OFF" to tell that the panel must be switched off before this feature may be used.

When going through this index in "panel OFF - charge mode", one will get the text "GN1 GN2 GN3 GN4" on the lower line. This indicates that the green buttons no. 1-4 should be used for testing the different audio signals.

Button 1 gives the lowest volume and most relaxing tone. Intensity increases on button 2 and 3. Button 4 gives maximum intensity and the more intense vibrating sound intended to be

recognizable even in very noisy environments. The audio goes off when the buttons are released.

(26)

```
SYSTEM IDENTITY
CODE :    1007
```

Displays the value of the system identity code programmed into the panel. This code must be identical to the machine code for the radio communication to work.

If the identity code in the CTU and the OPU differ, the following message will appear when radio communication is attempted:

```
AN OTHER MACHINE
ON THIS CHANNEL
```

See the "MineCat 140 KE – Technical Manual – Machine Electronics" for details on how to reprogram the system identity code.

(27)

```
RADIO FREQUENCY
    440.600 MHz
```

Displays the current operating frequency programmed into the panel. The OPU frequency must be identical to the machine (CTU) frequency for the radio communication to work. If the frequency differ, no communication will be observed.

See the "MineCat 140 KE - Technical Manual – Machine Electronics" for details on how to reprogram the system frequency.

(28)

```
 RADIO VERSION
HW: 3.0  SW: 3.5
```

Displays the version numbers of the internal radio modem hardware and software.

The radio modem hardware and software versions are also printed on the back of the radio modem module inside the OPU.

This information is useful when support from the manufacturer is necessary. By passing over these version numbers, the manufacturer will know exactly which version of the system that is in use and can thereby give more correct support.

The hardware version number (HW) consists of a main version number (3.) which is the number of the physical revision of the PCB (printed circuit board) and a sub version number (.1) which only indicates revisions of the component list.

For the software, the main version number indicates larger fundamental revisions of software functionality, while the sub version number only indicates minor revisions of modules within the program.

(29)

```
 RADIO VOLTAGE
 7.05V    7.15V
```

Displays the voltage delivered to the radio modem module from the radio voltage regulator in the OPU electronic module. There are two values, showing the lowest measured value on the left and the highest measured value on the right. This low and high values should normally not differ more than 0.1 – 0.2 V.

The min/max values are reset each time this index is entered and it will accumulate low and high values as long as the index is selected.

(30)

```
SIGNAL STRENGTH
 RSSI :   1.55V
```

Displays the radio signal strength indicator – RSSI signal output by the radio modem module. This is a non calibrated value that may provide an indication of the available receive signal strength on the antenna. The value is also not linear and will just give a rough indication of the signal strength, nothing more.

Voltage at –110 dBm : approx. 0.6 V
Voltage at –60 dBm : approx. 2.1 V

(31)

```
TRANSMIT COUNTER
 <<   RESET  >>
```

Used for resetting the internal transmit test counter used in the following indexes. Pressing the centre button will clear the counter. The centre button will thus not work as a HOME button in this index.

(32)

```
TRANSMITTED
  13025
```

Displays the number of messages sent out by the OPU after startup or after the last reset (see index 30). It only counts new messages, not retransmitted ones.

(33)

```
RETRANSMITTED
  131    1.00%
```

Displays the number of messages that had to be retransmitted by the OPU after it was turned on or after the last reset (see index 30). The number of retransmitted messages is shown both as an absolute number and as percentage of the total number of transmitted messages.

Note that this value is calculated from received acknowledge messages from the CTU. Due to this, the value may be higher than what is actually lost from OPU to CTU, as it may be the returned acknowledge that was lost, not the message itself. As an indication of the total OPU -> CTU -> OPU sequence failure rate, it will however give a correct figure.

The communication usually looses some messages shortly after the system is switched on and before the OPU and CTU has established contact. The value might therefore be high shortly after the system is turned on, even if there is nothing wrong. This is especially the case when the OPU is turned on first and tries sending to a CTU that is still not switched on. The best communication test is therefore to let the system establish contact and then reset the counters (see index 30)

(34)

```
LOST MESSAGES
   13    0.10%
```

Displays the number of messages that has been dropped by the OPU after it was turned on or after the last reset (see index 30). The number of lost messages is shown both as an absolute number and as percentage of the total number of transmitted messages.

Note that this value is calculated from received acknowledge messages from the CTU. Due to this, the value may be higher than what is actually lost from OPU to CTU as it may be the

returned acknowledge that was lost, not the message itself. As an indication of the total OPU -> CTU -> OPU sequence failure rate, it will however give a correct figure.

The communication usually looses some messages shortly after the system is switched on and before the OPU and CTU has established contact. The value might therefore be high shortly after the system is turned on, even if there is nothing wrong. This is especially the case when the OPU is turned on first and tries sending to a CTU that is still not switched on. The best communication test is therefore to let the system establish contact and then reset the counters (see index 30)

5. Joystick and Handle Calibration

The OPU Joystick Calibration menu can be entered only when the OPU is switched off and not in control of the machine. Since a panel operated on internal batteries is completely dead when being switched off, this test must be done with external supply, i.e. when the panel is in "charge mode".

The OPU Joystick Calibration menu is entered from "charge mode" by simultaneously pressing the all 5 display buttons (the three "softkey" buttons and the DIMMER and CONTRAST buttons) and keeping them depressed for more than 5 seconds.

The following message will then appear on the display indicating that the Joystick Calibration menu has now been entered:

```
JOYSTICK CALIB.
 <<    HOME    >>
```

This index can be returned to by using the left and right buttons, and this is the only place where the calibration menu may be aborted (by pressing HOME). The different indexes can be thought of as being side by side on a circle and can be navigated by the left and right button as shown by the arrows.

-(TURN) - **(JOYSTICK CALIB) - (TILT) - (LIFT) - (SPEED) - (TURN)** - **(BATT.CAP)** - **(BAT.CHG.TEMP)** - (TILT)-

5.1 TILT Calibration

First, move sideways with the left or right button until the following display appears:

```
TILT CALIBRATE
 <<    CALIB   >>
```

By pressing the centre button, the TILT calibrate function is entered, and the following message appear:

```
PUSH DOWN SLOWLY
           ABORT
```

Now take a firm grip on the TILT handle and try supporting the rest of the hand on the top of the panel to avoid unintentional movements. Then push the handle slowly downwards, i.e. push it towards the back of the panel. Do it slowly and with a steady and smooth movement!! Finally, when the system senses that the handle is passing the out of the neutral zone, the signal from the handle is saved and will be used as negative zero value. Now a new message appears:

```
TO END AND BACK
           ABORT
```

Now, one just moves the handle towards the end until it stops, keeps it there for a second and returns it slowly to zero. It will recognize the maximum value from this movement and save it as the negative full scale value.
It is not critical to do this part of the operation with the same slow speed as the first one.
When the joystick gets back to idle (zero) position, a new message will appear:

```
 PULL UP SLOWLY
           ABORT
```

Now take a firm grip on the TILT handle again and try supporting the rest of the hand on the top of the panel to avid unintentional movements. Then pull the handle slowly upwards, i.e. pull it towards the front of the panel. Do it slowly and with a steady and smooth movement!!

Finally, when the system senses that the handle is passing the out of the neutral zone, the signal from the handle is saved and will be used as positive zero value. Now a new message appears:

```
TO END AND BACK
           ABORT
```

Now, one just moves the handle towards the end until it stops, keeps it there for a second and returns it slowly to zero. It will recognize the maximum value from this movement and save it as the positive full scale value.
It is not critical to do this part of the operation with the same slow speed as the first one.
When the handle gets back to idle (zero) position, a new message will appear:

```
VERIFY:   -45 %
SAVE       ABORT
```

One now moves the joystick slowly from end to end to check that the joystick will provide all values from 1% to 100% and from –1% to –100%. It is especially important to verify that the handle really start on +/- 1. If the lowest available values are higher than +/- 1, the handle has probably been moved to fast during the first part of the calibration. If so, press the right button to abort the calibration and repeat it once more with slower movement.

It the values has been satisfactory verified, press SAVE to transfer the calibration values to the internal FRAM memory for long term storage.

5.2 LIFT Calibration

First, move sideways with the left or right button until the following display appears:

```
LIFT CALIBRATE
 <<   CALIB  >>
```

By pressing the centre button, the LIFT calibrate function is entered an the following message appear:

```
PUSH DOWN SLOWLY
           ABORT
```

Now take a firm grip on the LIFT handle and try supporting the rest of the hand on the top of the panel to avid unintentional movements. Then push the handle slowly downwards, i.e. push it towards the back of the panel. Do it slowly and with a steady and smooth movement!!
Finally, when the system senses that the handle is passing the out of the neutral zone, the signal from the handle is saved and will be used as negative zero value. Now a new message appears:

```
TO END AND BACK
           ABORT
```

Now, one just moves the handle towards the end until it stops, keeps it there for a second and returns it slowly to zero. It will recognize the maximum value from this movement and save it as the negative full scale value.
It is not critical to do this part of the operation with the same slow speed as the first one.
When the handle gets back to idle (zero) position, a new message will appear:

```
 PULL UP SLOWLY
           ABORT
```

Now take a firm grip on the LIFT handle again and try supporting the rest of the hand on the top of the panel to avid unintentional movements. Then pull the handle slowly upwards, i.e. pull it towards the front of the panel. Do it slowly and with a steady and smooth movement!!

Finally, when the system senses that the handle is passing the out of the neutral zone, the signal from the handle is saved and will be used as positive zero value. Now a new message appears:

```
TO END AND BACK
           ABORT
```

Now, one just moves the handle towards the end until it stops, keeps it there for a second and returns it slowly to zero. It will recognize the maximum value from this movement and save it as the positive full scale value.
It is not critical to do this part of the operation with the same slow speed as the first one.
When the handle gets back to idle (zero) position, a new message will appear:

```
VERIFY:   -45 %
SAVE       ABORT
```

One now moves the handle slowly from end to end to check that the handle will provide all values from 1% to 100% and from –1% to –100%. It is especially important to verify that the handle really start on +/- 1. If the lowest available values are higher than +/- 1, the handle has probably been moved to fast during the first part of the calibration. If so, press the right button to abort the calibration and repeat it once more with slower movement.

It the values has been satisfactory verified, press SAVE to transfer the calibration values to the internal FRAM memory for long term storage.

5.3 SPEED Calibration

First, move sideways with the left or right button until the following display appears:

```
SPEED CALIBRATE
 <<   CALIB  >>
```

By pressing the centre button, the SPEED calibrate function is entered an the following message appear:

```
PUSH FORW SLOWLY
           ABORT
```

Now take a firm grip on the main handle and try supporting the rest of the hand on the top of the panel to avid unintentional movements. Then push the handle slowly forwards, i.e. push it towards the back of the panel. Do it slowly and with a steady and smooth movement!! Try avoiding too much sideway movement during this calibration.

Finally, when the system senses that the joystick is passing the out of the neutral zone, the signal from the joystick is saved and will be used as positive zero value. Now a new message appears:

```
TO END AND BACK
           ABORT
```

Now, one just moves the joystick handle towards the end until it stops, keeps it there for a second and returns it slowly to zero. It will recognize the maximum value from this movement and save it as the positive full scale value.
It is not critical to do this part of the operation with the same slow speed as the first one.
When the joystick gets back to idle (zero) position, a new message will appear:

```
PULL BACK SLOWLY
           ABORT
```

Now take a firm grip on the main handle again and try supporting the rest of the hand on the top of the panel to avid unintentional movements. Then pull the handle slowly backwards, i.e. pull it towards the front of the panel. Do it slowly and with a steady and smooth movement!! Try avoiding too much sideway movement during this calibration.

Finally, when the system senses that the joystick is passing the out of the neutral zone, the signal from the joystick is saved and will be used as negative zero value. Now a new message appears:

```
TO END AND BACK
           ABORT
```

Now, one just moves the joystick handle towards the end until it stops, keeps it there for a second and returns it slowly to zero. It will recognize the maximum value from this movement and save it as the negative full scale value.
It is not critical to do this part of the operation with the same slow speed as the first one.
When the joystick gets back to idle (zero) position, a new message will appear:

```
VERIFY:   -45 %
SAVE       ABORT
```

One now moves the joystick slowly from end to end to check that the joystick will provide all values from 1% to 100% and from –1% to –100%. It is especially important to verify that the joystick really start on +/- 1. If the lowest available values are higher than +/- 1, the joystick has probably been moved to fast during the first part of the calibration. If so, press the right button to abort the calibration and repeat it once more with slower movement.

It the values has been satisfactory verified, press SAVE to transfer the calibration values to the internal FRAM memory for long term storage.

5.4 TURN Calibration

First, move sideways with the left or right button until the following display appears:

```
TURN CALIBRATE
 <<   CALIB  >>
```

By pressing the centre button, the TURN calibrate function is entered and the following message appear:

```
MOVE LEFT SLOWLY
          ABORT
```

Now take a firm grip on the main handle and try supporting the rest of the hand on the top of the panel to avid unintentional movements. Then move the handle slowly to the left. Do it slowly and with a steady and smooth movement!! Try avoiding too much forward/backward movement during this calibration.

Finally, when the system senses that the joystick is passing the out of the neutral zone, the signal from the joystick is saved and will be used as negative zero value. Now a new message appears:

```
TO END AND BACK
          ABORT
```

Now, one just moves the joystick handle towards the end until it stops, keeps it there for a second and returns it slowly to zero. It will recognize the maximum value from this movement and save it as the negative full scale value.
It is not critical to do this part of the operation with the same slow speed as the first one.
When the joystick gets back to idle (zero) position, a new message will appear:

```
MOVE RIGHT SLOW
          ABORT
```

Now take a firm grip on the main handle again and try supporting the rest of the hand on the top of the panel to avid unintentional movements. Then move the handle slowly right. Do it slowly and with a steady and smooth movement!! Try avoiding too much forward/backward movement during this calibration.

Finally, when the system senses that the joystick is passing the out of the neutral, the signal from the joystick is saved and will be used as positive zero value. Now a new message appears:

```
TO END AND BACK
          ABORT
```

Now, one just moves the joystick handle towards the end until it stops, keeps it there for a second and returns it slowly to zero. It will recognize the maximum value from this movement and save it as the positive full scale value.

It is not critical to do this part of the operation with the same slow speed as the first one. When the joystick gets back to idle (zero) position, a new message will appear:

```
VERIFY:   -45 %
SAVE       ABORT
```

One now moves the joystick slowly from end to end to check that the joystick will provide all values from 1% to 100% and from –1% to –100%. It is especially important to verify that the joystick really start on +/- 1. If the lowest available values are higher than +/- 1, the joystick has probably been moved to fast during the first part of the calibration. If so, press the right button to abort the calibration and repeat it once more with slower movement.

It the values has been satisfactory verified, press SAVE to transfer the calibration values to the internal FRAM memory for long term storage.

5.5 Battery Capacity

First, move sideways with the left or right button until the following display appears:

```
BATTERY CAPACITY
 <<  ADJUST  >>
```

By pressing the centre button, the Battery Capacity Adjust function is entered and the following message appear:

```
BATTERY:  7.5 Ah
LESS  SAVE  MORE
```

The total panel battery capacity may now be adjusted in steps of 0.5 Ah (500mAh) from 5.0 Ah and up to 15.0 Ah. This makes it easy to adjust the charge controller in the panel so that it may handle any battery capacity in an optimal way.

Typically, it will be easy to increase battery capacity setting when new and better batteries becomes available on the market. Or it will be equally easy to the reduce capacity setting whenever that may be necessary, for example in connection with use of high temperature batteries that – due to their construction – will have lower capacity than standard batteries.

Note that the battery capacity setting is the total capacity in the panel, i.e. the sum of the 5 individual battery packs.

When the desired capacity has been selected and the centre button (SAVE) is pressed, the following display appears:

```
BATTERY:  7.5 Ah
SAVE       ABORT
```

This gives a chance to abort the modification without saving the new value, simply by pressing the right button (ABORT).

By pressing the left button (SAVE), the new capacity setting is transferred to the internal FRAM memory for long term storage.

5.6 Battery Charge Temperature

First, move sideways with the left or right button until the following display appears:

```
BATTERY CHG.TEMP
 <<  ADJUST  >>
```

By pressing the centre button, the Battery Charge Temperature Adjust function is entered and the following message appear:

```
CHARGE TEMP: LO
LESS  SAVE  MORE
```

Standard batteries designed for a charging temperature of up to +55ºC should use the LOW temperature setting.

Medium temperature batteries designed for a charging temperature between +55ºC and + 65ºC should use the MEDIUM temperature setting.

High temperature batteries designed for a charging temperature up to + 70ºC should use the HIGH temperature setting.

When the desired temperature setting has been selected and the centre button (SAVE) is pressed, the following display appears:

```
CHARGE TEMP: LO
SAVE       ABORT
```

This gives a chance to abort the modification without saving the new setting, simply by pressing the right button (ABORT).

By pressing the left button (SAVE), the new temperature setting is transferred to the internal FRAM memory for long term storage.

6. Local OPU Warnings

Warnings are messages that pops up during operation, informing the operator about situations detected by the OPU which may affect the operation of the machine. The most common message in this respect is the LOW BATTERY warning, event though all the different messages may be observed.

Some warnings disappear automatically, some may be acknowledged/silenced by pressing the centre display button, but this may differ between the different messages.

```
   RADIOMODEM
SETUP FAIL :  0
```

May appear when the panel is switched on to signal a problem with the radio modem. A value of "0" indicates that the operator panel cannot get a valid response from the OPU radio module. Check the GREEN "RUN" LED on the radio modem to see if the modem is operational. Also check the connection between OPU Electronics and the radio modem.

Any other value is an error status from the radio modem and should be reported to the system manufacturer for advice.

```
MEMORY RESTORE
  BLOCK FAIL
```

```
MEMORY RESTORE
 DATA INVALID
```

```
MEMORY RESTORE
  FRAM ERROR
```

May appear when the panel is switched on or anytime during use. Indicates that the processor has encountered a problem during restore of information from FRAM backup or during updating of variables in the same memory. The problem may be temporary or fatal, depending on the cause.

The first message, "MEMORY RESTORE – BLOCK FAIL", indicates that an error was encountered in one of the data blocks that was fetched from the FRAM. It will however have found additional healthy data blocks so that no data will be lost. The block that failed will also automatically be refreshed with healthy data. This error will therefore not have any influence on the system and operation may be continued as usual. If the message appear very often, it might be an indication that there is a reliability problem with the FRAM , and a replacement should be considered during the next service stop of the machine.

The second and third message do however indicate an unrecoverable error, and the OPU will then use default values instead of the lost calibration values.

It is recommended to first make a recalibration of the joysticks as described under “Joystick Calibration” and then to check the system Id code. If the system works fine afterwards, it may just have been a transient problem and it may never reappear.

If these messages reappear often, it could indicate that the memory has some kind of problem and that the OPU electronic module should be sent for repair at the next service. Please remember to write in detail the source of the problem, the actual message shown, and when it occur during the operating sequence (during start of the OPU, during operation, during charging, ….)

```
EMPTY  BATTERY
 RECHARGE NOW
```

May appear when the OPU is switched on. Indicates that the operator panel ran out of power last time and that the OPU hasn’t been recharged yet. The charging indicator may give wrong indication. In any case, using the panel without charging first is not possible as it will run out of power again almost instantly.

```
  LOW  BATTERY
```

May appear anytime during use. Indicates that the battery voltage is about to reach a level where loss of communication soon may happen. Stop and connect to an external supply before commencing, if possible.

```
AN OTHER MACHINE
ON THIS CHANNEL
```

May appear anytime during use. Indicates that the operator panel detects data from an other machine with different identity code. Shut down system and see the “MineCat 140 KE - Technical Manual – Machine Electronics” for description on how to change frequency.

```
SWITCH TO RADIO
 COMMUNICATION
```

May appear during use if the operator panel need to switch from cable to radio communication, for example when the umbilical is disconnected.

It may also switch after some time even if still connected to the umbilical. In this case there must be something wrong with the umbilical cable or the communication circuits in either end.

When connected to an external source, it may also try communication by cable before switching to radio and establishing radio contact. This is due to the OPU sensing the voltage on the external connector, believing it's connected by an umbilical cable, something which is not the case.

```
SWITCH TO CABLE
 COMMUNICATION
```

May appear during use if the operator panel need to switch from radio to cable communication, for example when the umbilical is connected. When the CTU detects that there is something connected to the umbilical connector, it will stop radio communication instantly and start trying to establish communication by cable. The OPU will however not switch until after it has tried re-establishing the communication for 20-30 seconds.

The message may also appear if the panel looses contact with the vehicle by radio while being supplied from an external power source. It will then soon try to switch back to radio again, as cable communication is impossible, and it will continue switching back and forth until contact by radio is re-established. This may happen during periods of strong radio interference or jamming.

```
  JC100  ERROR
```

This message indicates that the OPU has detected a failure situation on one of the lift or tilt handles, most possibly the one that is currently being operated.

The handles have both potentiometer function, and switches that tells when the handles are moved out of idle position, either in positive or in negative direction. The error message is issued if the electronics senses impossible potentiometer and switch combinations.

The cause of the error may be faulty switch, damaged wiring or electronic failure.

```
  JC600  ERROR
```

This message indicates that the OPU has detected a failure situation on one of the main joystick axes. Try one axis at the time to determine the source of the problem.

The joystick have both potentiometer function, and switches telling when the joystick is moved out of idle position on one or both axes, either in positive or in negative direction. The

error message is issued if the electronics senses impossible potentiometer and switch combinations.

The cause of the error may be faulty switch, damaged wiring or electronics failure.

7. OPU Maintenance

During use, the OPU should have a regular maintenance to keep it operational all the time.

7.1 General cleaning

First it is important to clean it from dirt. Water is good for cleaning combined with using the hand or a cloth to wipe away the dirt. Wiping away dry dirt without water is not recommended as it will wear down the surface and make it dull, especially the acrylic front panel where it may be more difficult to read the text. Use enough water for a safe cleaning, but DO NOT use pressurized water.

Add some mild detergent if the dirt is difficult to remove. For oil and, asphalt and other types of hydrocarbon based dirt, it might be necessary to use spirit. If so, limit it to the area in question, and wash with running water afterwards.

7.2 Cable connector

Also make sure that the dust cap on the umbilical connector is fitted. Replace it as soon as possible if it is lost. Clean the inside of the connector with spirit before replacing the new connector if it has been full of dirt. Check that the pins are straight. Try straighten them if they are bent. Don't force the cable connector onto a damaged connector with bent pins as this will only make things worse. Replace the connector if necessary.

7.3 Audio transducer

The audio transducer used for alarms is located on the back. It has an open grid so water and dirt may get into it. The transducer itself is IP65, so nothing will get into the panel, but particles or water that gets into the grid may reduce the movement of the metal membrane and strongly reduce the audible volume.

To fix this problem, try keeping the panel with the back down and try shaking the panel slightly to get loose particles out. Then spray a little water in with a syringe or similar to wash out mud (DON'T USE THE NEEDLE). Let it dry.

7.4 Antenna

The quarter wavelength whip on top may be bent or damaged and if so, it should be replaced instantly as a fault antenna may drastically reduce the operational distance.

If the antenna is removed and a cable for external antenna is fitted, make sure that dirt or water doesn't get into the connector. Clean it out if necessary, use spirit. It is very important that the centre hole doesn't get filled with dirt. If this is suspected, try cleaning it with a small syringe filled with spirit and with a thin needle to get the spirit into the hole to wash out the dirt. This may also be used on other contacts, such as the female umbilical connector if it gets dirty.

To avoid the needle scraping up the connector surface and damaging it, it is suggested that one cut the need in 90 degrees angle an round the edges with a small file. It is no need for a sharp needle to penetrate but a just a blunt one.

7.5 Inside

Check the inside of the panel once in a while to ensure that it is clean and dry. Any traces of water or leaks must be checked and the source of the problem must be fixed. Check sealing around buttons, handles and joystick. Also check that the main seal on the top part of the operator panel is undamaged and in place.

Only open the panel in a dry and cool place to avoid trapping too much moisture inside. Opening the panel on a hot and damp day with high moisture in the air may lead to condensing as the temperature drops. If risk is eminent, try putting a dried silica gel pack inside.

If the 4 top panel screws doesn't move easily, put some silicone fat or similar lubrication on the threads to avoid the screws from getting stuck.

7.6 Battery packs

The battery packs should be replaced when necessary, i.e. when the operational time for a fully charged panel gets too short for the work to be done. See the status menu description for additional details about battery supervision.

Since the NiMH batteries may vary in capacity between different types and suppliers, it is recommended to only use the standard battery packs. Using other types of batteries may lead to reduced charging, overcharging, short circuit or other problems.

Warranty is void when operated with other than the factory supplied battery packs.

7.7 Battery Storage

To keep the battery packs operational for as long as possible, it is important to store the OPU and the battery packs at a low temperature.

The best is to store the operator panels and spare batteries in a cool and dry place. Often, it can be difficult to store them in a cool place due to the environment in which the demining operations take place. But at least, try storing panel and batteries in a place where the temperatures doesn't rise too high.

Storing the battery equipment in a container exposed to sunlight at an ambient temperature of 50 °C will easily give an equipment temperature of in excess of 70 °C inside, a temperature that will effectively reduce the lifetime of the batteries and even make them useless within a few months. Then, it is better to find a ventilated place where the temperature will not rise above the ambient temperature.

7.8 Battery test

To check the health of the batteries, there are some test features that can be used to measure the battery capacity.

A complete test procedure will be as follows:

First discharge the battery packs completely. This is best done by leaving the panel switched on, without any external supply, until it runs empty and switches itself off.

Normally, this has to be done with the machine switched on as the panel will otherwise switch itself off automatically after 10 minutes without communication. If one doesn't want to have the machine switched on and draining the batteries, or if the distance between panel and machine is too long, then the auto shutdown has to be overridden. This is simply done by entering the status menu and leave it there as the automatic shutdown function is disabled when the status menu is active.

After the battery packs has run empty, put the panel on charge again and leave it until it is fully charged.

Then switch on the panel and let it run empty again.

When putting it on charge again, go into the status menu and check the battery capacity indicators. During the discharge from full battery, the OPU electronics measure the discharge current and time and calculates the battery charge taken out from each of the 5 battery packs in the OPU. These values can now be accessed.

The total battery capacity shows the measured capacity in percentage of nominal battery capacity. For new battery packs it should be around 100%. The capacity on each of the 5 battery packs should also be relatively equal. If the capacity starts dropping well below 100% or if the capacity starts varying a lot between the different battery packs, then this a strong indication that something has happened to the battery packs and that a battery replacement should be considered. Just a capacity reduction may not be a problem, depending on the intensity of use. Big differences in individual battery capacity may however indicate that some of the battery packs are about to end its life. Sudden reductions in capacity or other problems may the then appear in the near future as the different battery packs fail.

Failed battery packs may have single cells that has reversed and this is a situation that may lead to overheating and possibly gas production in the long run. Therefore, battery packs showing this kind of behaviour should be replaced instantly. At least, consider to temporarily cut away faulty battery packs since they will not have any positive effect anyhow. Do however remember to just cut one wire at a time to avoid short circuit and isolate open ends.

The remaining battery packs should then be replaced by a new battery packs as soon as possible.

8. Fault finding

Problems originating within the OPU may affect the whole machine and lead to unusual behaviour on affected functions. To isolate and bypass problems with the OPU, it is essential to locate the source of the problem so that the proper action may be taken.

8.1 Problems not related to the OPU

If problems are detected by the machine electronics and reported as warning or error messages from the CTU (shown as "> WARNING XX <" or as ">> ALARM XX <<"), the problems are most likely not related to the OPU. Refer to the warning and alarm descriptions in the "MineCat 140 KE – Operator Manual" or the "MineCat 140 KE – Technical Manual – Machine Electronics". These documents describe all different types of warnings and alarms that originate from the machine or machine electronics and which are not OPU related.

Problems that are not detected by the system or problems of such a nature that it prevents the system from reporting the problem correctly are more difficult to trace. There are however some general rules to follow.

8.2 Communication related problems

As listed in the warning and alarm section, there are a few possibilities where interference from other machines or other types of equipment can affect the communication. The listed warnings will help tracing some of the problems. However, there may still be external interference that affects the communication without being detected as such, and hence, it will not be reported by the system.

Normally, communication interference may be seen as slow response on commands given. This will give unusual long delays from the activation of buttons, knobs and joystick and until the response is observed. There is a 1 second timeout on communication in the machine electronics, so in case the machine is manoeuvring, the movement will automatically be halted after 1 seconds loss of communications. During communications losses of more than 1 second, a jerky movement will thus be observed as the machine will move and stop at irregular intervals. Short stops simultaneously on both tracks at irregular intervals is in most cases an indication of problems with the communication. Regular, jerky movement, that mostly affects only one track, is most likely not a communication problem. See "MineCat 140 KE – Technical Manual – Machine Electronics" for more details.

One good test to verify communication problems, is to go into the main menu (by pressing the centre display button) and then move through the menu fast with the left or right buttons. If the text on the display is updated in a normal way (within a few tenths of a second), then the communication is most likely not the cause.

If communication error is found to be the most likely cause, connect the CTU and OPU by umbilical cable and repeat the test. After the cable has been connected, the system may need up to 30 seconds before switching communication. The switching will be signalled on the display by the following message: "SWITCH TO CABLE COMMUNICATION".

If there is a problem establishing communication, the OPU will switch back and forth between CABLE and RADIO. In this case, it is probably a faulty CTU and not related to the OPU at all. See “MineCat 140 KE – Technical Manual – Machine Electronics” for more details.

If communication works OK while using the umbilical cable, then there is obviously a radio related problem.

Try connecting the OPU to an external power source through the charger cable, either from a car lighter output, directly from a 12V car battery, or from the supplied charger. Any voltage from 10 to 30V will do the job. If external power solves the problem, the problem is probably related to the internal battery packs in the OPU. See section 7. for more details and test procedures to locate the problem.

It is however perfectly safe to continue operation with an external power source until new batteries may be replaced.

If the problem has been established to be radio related, but no improvement can be seen with external power applied, then radio interference may be the cause.

Try to find out whether the interference is broadband or narrowband. Broadband interference may be due to deliberate jamming or to noise from engines or electronics with unsatisfactory noise suppression. First check if there might be any petrol driven machinery nearby with a faulty noise suppression on the spark plugs. This type of noise will usually also be detectable as a crackling sound on ordinary radio receivers and can be found all over the frequency band.

In cases where the machine is in the middle of a minefield and there is difficult or unsafe to test communication by umbilical cable, it is recommended to test with an external supply first and then check for noisy equipment in the vicinity. If equipment that is suspected to generate noise can be located in the vicinity, try switching it off before commencing operations.

If the problem has been located to the radio communication, open the OPU and check the status LED’s on the radio modem unit and verify that the GREEN RUN LED is flashing at regular intervals and that the RED TRANSMIT LED is also flashing. Check the YELLOW RECEIVE LED for detected incoming signals. See section 3. for more details on communication sequence and fault finding. Also check that the antenna connector is properly fastened and that the DSUB-connector locking screws is properly fixed. Also check the antenna and the internal antenna cable for damage.

8.2.1 Radio modem – electrical measurements

If radio communication is found to be the problem, the possible causes include the radio modem interface on the “OPU Electronics module”, the cable connection to the radio modem, the radio modem itself, radio based interference to the communication or problems on the Minecat electronic modules.

Problems related to the electronics inside the OPU can to some extent be verified by measuring the signals going between the radio modem and the “OPU Electronics module” with an oscilloscope or AVO meter. An oscilloscope can be used for measurements during

operation, while an AVO meter limits the measurements to a verifying the idle levels during transmission stops, i.e. with the emergency stop button depressed.
The signals and voltage levels are listed below with reference to the 9 pin DSUB connector. Since the cable between electronics and modem are a 1:1 cable, measurements may be done at either end. Normally, the connector on the top of the "OPU Electronics module" is the easiest point to perform the measurement

Signals are referenced to pin number and the direction of the signals are listed as I (Input on "OPU Electronics module" – output on radio modem) or O (Output on "OPU Electronics module" – input on radio modem)

Pin 1:	I	Carrier Detect – Signal from radio modem indicating incoming radio signal that open the receiver squelch. Idle = -5.5V. Active = +5.5V.
Pin 2:	I	Receive Data from radio modem. Idle = -5.5V. Active = +5.5V.
Pin 3:	O	Transmit Data to radio modem. Idle = -7.5V. Active = +7.5V.
Pin 4:	O	Power supply to radio modem. Approx. 6.5V DC
Pin 5:	O	Power ground to radio modem. Approx. 0.0V DC
Pin 6:	--	PC configuration input on radio modem only. Not wired
Pin 7:	O	Request To Send signal. Always +7.5V
Pin 8:	O	Mode. Pulled low when commanding the radio modem during parameter setup and frequency change. Idle = +3.0V. Active = 0.0V.
Pin 9:	I	RSSI – radio signal strength indicator. 0.5 V – 2.5 V.

Measurements that fail to comply with the values listed will indicate a possible source to the problem. In case a deviating value is found, the problem will most likely lie at the source of the signal, even though failure on the input can disrupt the signals in some cases.

8.3 Display visibility problems

The display may be difficult to read at low temperatures (below 0 ºC) or it may even go completely black during high temperatures. In this case, using the contrast adjustment might help increase the visibility. See section 2.6 "Contrast Button" for more information on this issue.

The display of the OPU will not be totally empty while in use, as an empty display without text will automatically be replaced by the " --**--" string to avoid confusion about whether the contrast setting is out of range. A totally blank display will therefore indicate that the OPU is either switched off, or has an incorrect display contrast setting.

8.3.1 Display visibility – electrical measurements

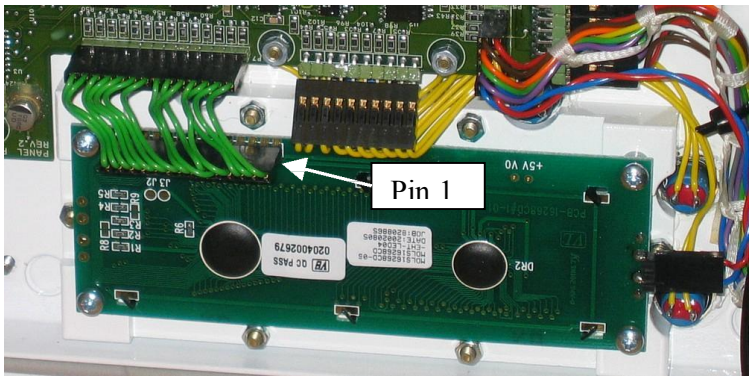
In case the display problem cannot be fixed by adjusting the contrast setting, the following measurements can be done with an oscilloscope to verify the cause of the problem.

In case the problem lies with the display interface, the display will often end up in a state where the display controller is not initialised. This is usually recognized as a display filled with solid rectangles, often with only the upper line filled while the lower line is empty. In this case, it is either a faulty display, bad interconnection or a failure on the electronic boards.

If the problem only affects the display, it is most likely limited to the “OPU Front panel PCB”, the display interconnection or the display itself.

By measuring the different signals listed below, it is possible to get an indication on whether it is the “OPU Front panel PCB” that fail to output signals or if it is the display that fail to respond to the signals.

If the display accidentally goes into the non-initialised state during operation, especially when touching the front of the panel, the cause is most likely an electrostatic discharge that affects the OPU due to bad electrical connection between the front of the OPU-cabinet and the back off the OPU-cabinet. Normally, there will be good electrical contact through the four corner screws and the internal ground wire. Check the internal ground wire that runs between the front and back, then check the four screws for corrosion and may act as an insulator.



Picture 1: LCD display with connector

The display interconnection is organized as follows:

Pin 1:	Display GND - 0.0V
Pin 2:	Display supply - 5.0V
Pin 3:	Contrast control - between 2.0V and –5.5V, depending on contrast setting Default value on contrast setting 5 is –3.5V.
Pin 4:	Register select – changes between low (0V) and high (5V). Idle high.
Pin 5:	Read / Write select – Read is high (5V) – Write is low (0V). Idle high.
Pin 6:	Display Enable clock signal –active high (5V). Idle low.
Pin 7-14:	Data bits 0-7 – toggles between low (0V), high (5V) and floating. Idle high.

If any of the lines seems to be dead or on a different level than specified, the output from the “OPU Front panel PCB” is the most likely cause. If all signals appears to be healthy, the display itself is the most likely cause of the problem.

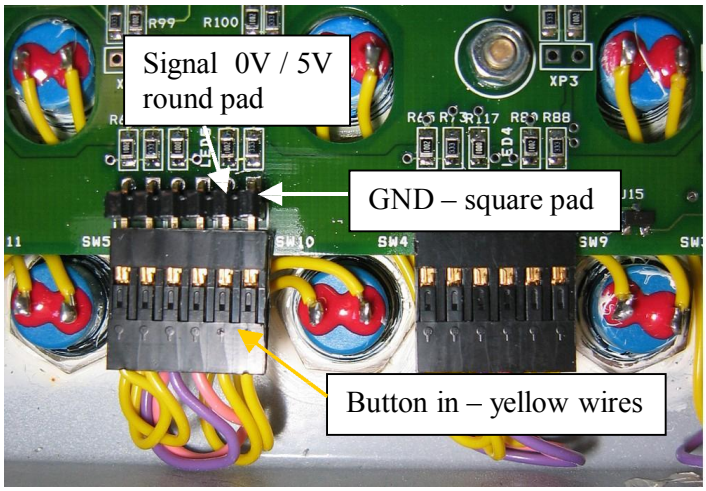
8.4 Button failure

If problems occur with one of the buttons, either one of the ON/OFF buttons or one of the joystick buttons, go to the button test index in the “local status menu” and test the response of

the buttons. If this test shows that all buttons are working correct, the button itself is most likely not the problem. Check “MineCat 140 KE – Technical Manual – Machine Electronics” for more details on possible causes that may prevent the selected operation from taking place.

8.4.1 Buttons - electrical measurements

To verify the true cause of the problem, additional measurements must be carried out with an AVO-meter. Measure the voltage across the button when it is not depressed. The voltage should then be 5.0V. When activating the button, the voltage will drop to 0.0V. Also check the resistance between the pins and OPU chassis with the power switched off. One pin should have connection to OPU chassis.



Picture 2: Button connections

If both measurements indicates that the button is working correctly, the problem will most likely be located to one of the electronic boards. If the failure only affects one button or the neighbour buttons on the left or right while all other functions work correctly, the problem is most likely located to the “OPU Front panel PCB”. A failure affecting more than a group of 1-4 buttons can be located to either the “OPU Front panel PCB”, the “OPU Electronics module” or in the cable between them.

Note that the emergency stop button works opposite of all other buttons, i.e. that the switch is closed while the button is released and open when the button is depressed or locked in depressed state. As a result of this, a faulty (broken circuit) emergency stop switch or a disconnected switch will automatically stop the machine.

8.5 Joystick and handle failure

Problems with one of the two handles, or with the main joystick, can be tested with the handle and joystick test indexes found in the “local status menu”. If these tests show that the handle/joystick is working correctly, then the handle or joystick is most likely not the problem.

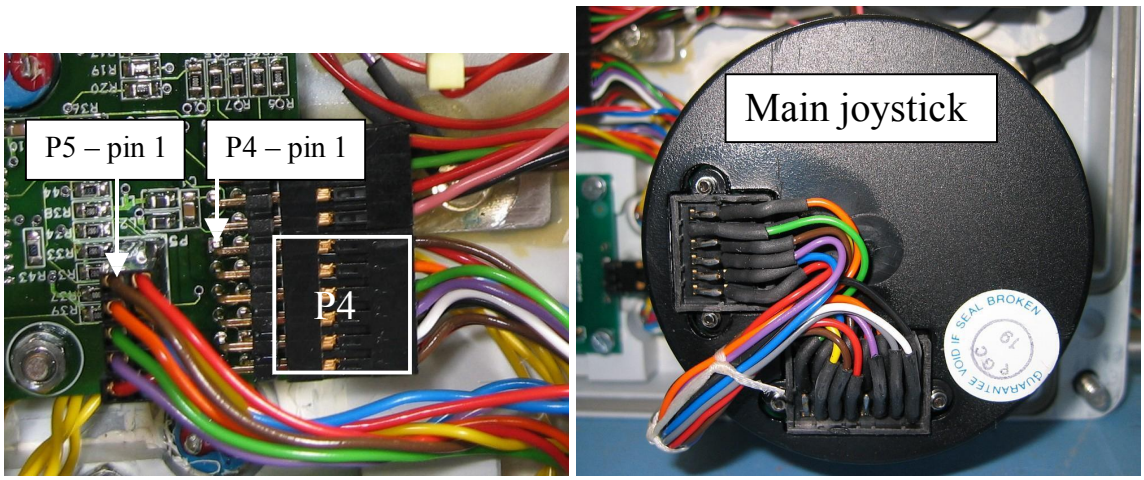
Check “MineCat 140 KE – Technical Manual – Machine Electronics” for more details on possible causes that may prevent the selected operation from taking place. The technical menu, SYSTEM section, as described in the above manual, also allows testing of the handle and joystick signals as they are received by the CTU. If these readings also indicates that the device is giving a correct value, it can be ruled out completely that the problems originates within the OPU. It must then be due to problems located on the machine.

If any of these test indicates a wrong response on any of the handles or the main joystick, then careful recalibration of the affected device is recommended. See the “Joystick Calibration Menu”. If the problem was due to a bad calibration, the problem may now be solved. If the problem is still there, or if it proves difficult to execute the calibration procedure, then it is most likely a hardware failure with either the handle/joystick or a failure in one of the OPU electronic boards or modules.

For the two handles, a simple test is to just switch the cables from the handles so that each handle is connected to the opposite input (both have equal connections). If the problem moves with the handle, then the handle is the cause. If the problem stays with the same input regardless of switching the handles, then it must be an electronic problem. Similar test cannot easily be done with the main joystick.

8.5.1 Main joystick - electrical measurements

The main joystick may be tested with an AVO meter according to the following procedure. The signals described in the text are referenced by their connector number and pin number on the form “P5 – pin 4” See pic. X and fig. X that describes the location of the different connectors and the position of the pins within each connector.



Picture 3: Main joystick connections

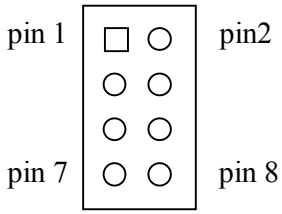


Figure 5: Pin numbering sequence on double row connectors

P4 connects to the X-axis and Y-axis position sensors, while P5 connects to the thumb operated buttons and the handgrip switch on the main joystick handle.

The X- and Y-axis joysticks are connected to P4 as follows:

P4 - pin 1: X-axis (turn) positive potentiometer supply – approx. 4.7V
P4 - pin 2: X-axis (turn) potentiometer sense signal – between 0.6 and 4.3V
P4 - pin 3: X-axis (turn) negative potentiometer supply – approx. 0.3 V
P4 - pin 4: X-axis (turn) positive direction switch. Idle 4.9V. Active 0.05V.
P4 - pin 5: X-axis (turn) negative direction switch. Idle 4.9V. Active 0.05V.
P4 - pin 6: Common GND for X-axis direction switches (through 100 ohm resistor)
P4 - pin 7: Y-axis (speed) positive potentiometer supply – approx. 4.7V
P4 - pin 8: Y-axis (speed) potentiometer sense signal – between 0.6 and 4.3V
P4 - pin 9 Y-axis (speed) negative potentiometer supply – approx. 0.3 V
P4 - pin 10: Y-axis (speed) positive direction switch. Idle 4.9V. Active 0.05V.
P4 - pin 11: Y-axis (speed) negative direction switch. Idle 4.9V. Active 0.05V.
P4 - pin 12: Common GND for Y-axis direction switches (through 100 ohm resistor)

The potentiometer sense signals should be approx. 2.5V in neutral position. When operated towards positive direction (speed -> forward or turn -> right), the value should increase up to approx. 4.3V at maximum tilt. When operated towards negative direction (speed -> backward or turn -> left), the voltage should drop down to approx. 0.6V at maximum negative tilt. The direction switches are normally open, thus giving voltage levels of approx 5.0V on the direction switch pins. When the joystick is moved out of its neutral position, the corresponding direction switch will be activated and the direction signal will drop to approx 0.05V.

The thumb buttons connected to P5 is connected as follows:

P5 - pin 1: Left thumb button – “change gear down”. Released = 5.0V. Pressed = 0.05V.
P5 - pin 2: Right humb button – “change gear up”. Released = 5.0V. Pressed = 0.05V.
P5 - pin 3: Rear thumb button – “pivoting”. Released = 5.0V. Pressed = 0.05V.
P5 - pin 4: Forward thumb button – “clear turn”. Released = 5.0V. Pressed = 0.05V.
P5 - pin 5: Thumb buttons – common GND connection (through 100 ohm resistor)
P5 - pin 6: Grip switch signal. Released = 5.0V. Pressed = 0.05V.
P5 - pin 7: GND connection for grip switch (through 100 ohm resistor)
P5 – pin 8: Not used

When a button is open, the corresponding input should be close to 5.0V (referenced to OPU chassis). When operated, the voltage will drop to approx 0.05V.

Allow for variations of +/- 0.1V on indicated values.
A signal that is not on 5.0V level in released state indicates either a permanently closed button (button failure) or an internal failure in the "OPU Front panel PCB". Disconnect the plug and use the AVO-meter (in resistance mode) to verify the functionality of each button.

If the signal doesn't drop to 0.05V when a button is pressed, it indicates either a faulty GND connection or a faulty button. First check that the GND pins (5 and 7) stays below 0.1V when the buttons are activated. If not, there may be a faulty ground connection on the "OPU Front panel PCB". If the voltage on the GND pins looks correct, disconnect the plug and use the AVO-meter (in resistance mode) to verify the functionality of each button.

8.5.2 Flail control handles - electrical measurements

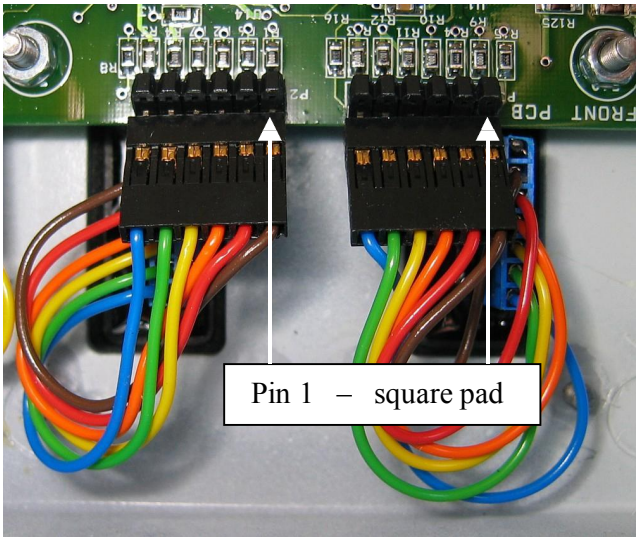
The flail control handles may be tested with an AVO-meter according to the following procedure. The signals described in the text are referenced by their connector number and pin number on the form "P2 – pin 4" .

P2 connects to the left flail control handle as listed below:

P2 - pin 1: Left handle positive potentiometer supply – approx. 4.8V
P2 - pin 2: Left handle potentiometer sense signal – between 0.1 and 4.8V
P2 - pin 3: Left handle negative potentiometer supply – approx. 0.1 V
P2 - pin 4: Left handle positive direction switch. Idle 4.9V. Active 0.1V.
P2 - pin 5: Left handle negative direction switch. Idle 4.9V. Active 0.1V.
P2 - pin 6: Common GND for left handle direction switches (through 100 ohm resistor)

P3 connects to the right flail control handle as listed below:

P3 - pin 1: Right handle positive potentiometer supply – approx. 4.8V
P3 - pin 2: Right handle potentiometer sense signal – between 0.1 and 4.8V
P3 - pin 3 Right handle negative potentiometer supply – approx. 0.1 V
P3 - pin 4: Right handle positive direction switch. Idle 4.9V. Active 0.1V.
P3 - pin 5: Right handle negative direction switch. Idle 4.9V. Active 0.1V.
P3 - pin 6: Common GND for right handle direction switches (through 100 ohm resistor)



Picture 4: Handle connectors

The potentiometer sense signals should be approx. 2.5V in neutral position. When operated towards positive direction (speed -> forward or turn -> right), the value should increase up to approx. 4.8V at maximum tilt. When operated towards negative direction (speed -> backward or turn -> left), the voltage should drop down to approx. 0.1V at maximum negative tilt. The direction switches are normally open, thus giving voltage levels of approx 4.9V on the direction switch pins. When the joystick is moved out of its neutral position, the corresponding direction switch will be activated and the direction signal will drop to approx 0.1V.

8.6 Speed and turn knob failure

Problems with one of the two knobs can be tested with the knob test indexes found in the "local status menu". If these tests show that the knob is working correctly, then the handle or joystick is most likely not the problem.

Check "MineCat 140 KE – Technical Manual – Machine Electronics" for more details on possible causes that may prevent the selected operation from taking place. The technical menu, SYSTEM section, as described in the "Technical Manual", also allows testing of the knob signals as they are received by the CTU. If these readings also indicates that the knob is giving a correct values, it can be ruled out completely that the problems originates within the OPU. It must then be due to problems located on the machine.

If these tests indicates a problem with one of the knobs, then it is most likely a hardware failure with either the optical incremental encoder or a failure in one of the OPU electronic boards/modules.

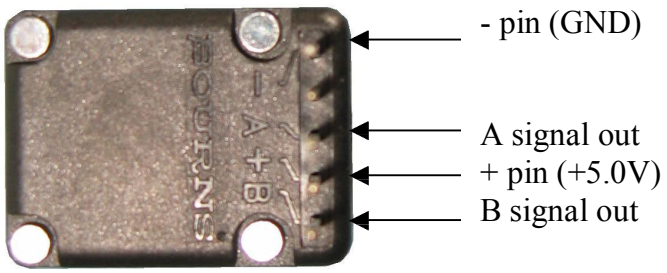
For the two knobs, a simple test is to just switch the cables from the knobs so that each knob is connected to the opposite input (both have equal connections). If the problem moves with the knob, then the knob is the cause. If the problem stays with the same input regardless of switching the knobs, then it must be an electronic problem.

8.6.1 Speed and turn knob - electrical measurements

To be able to better verify the true cause of the problem, additional measurements must be carried out with an AVO-meter, or even better, with an oscilloscope.

The signals from the rotary optical encoders are quadrature signals, i.e. two pulse trains where one signal is 90 degrees delayed compared to the other. The total increment is detected by counting the number of pulses, and the direction of rotation is detected by sensing the phase between the signals.

The optical encoder has 4 connections, +, -, A and B. The Supply voltage of 5.0V is connected to the + terminal, while the – terminal is at GND level (same as OPU chassis +/- 0.1V). The two quadrature outputs have voltage levels below 0.1V (low level) or above 4.9V (high level).



Picture 5: Rotary optical encoder connections

Test with an AVO meter will be limited to checking whether the voltage levels are below or above the specified low and high limits. Turn the encoder shaft slowly to make the output levels change so that both high and low levels may be verified.

Test with an oscilloscope should include inspection of the waveform to verify that the signals are clean and without noise spikes or other disturbances. The best would be to use a 2 channel oscilloscope so that both channels may be viewed at the same time. The relationship between the two outputs may then be checked at different turn rates. See Fig. X.

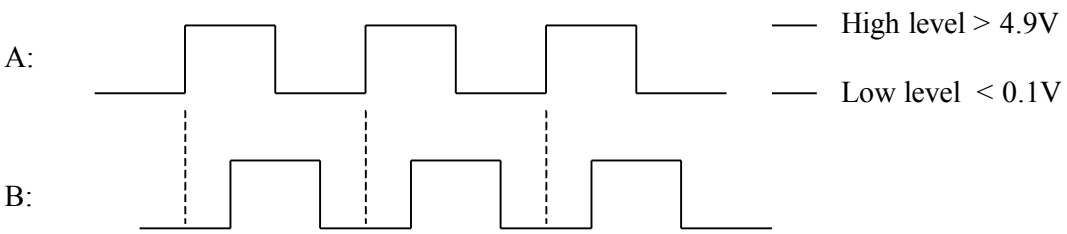


Figure 6: Quadrature output – signal waveform for an ideal and healthy encoder

The problems can be grouped in three main type of errors:

- The first problem is loss of power. If the + or – voltage levels are wrong, this is most likely due to a failure on the electronic boards. If only one encoder is affected, the problem is most likely located on the "OPU Front panel PCB". If the "OPU Electronics module" or the cable between the front and electronic module are the cause, then all front panel functions should be affected.

- The second type of problem is an encoder that has power but gives no reaction in the test menu. Turn the encoder slowly and verify that both signals change as shown in the figure and that the voltage levels are within specifications. If both signals looks fine, but no reaction is observed in the test menu, then it might be a failure in the "OPU Front panel PCB". This is the most likely cause if the second knob works fine. If both knobs are affected, the problem may also be located in the "OPU Electronics module" or in the cable between the front and electronic module.

- The last type of problem is when the test menu gives a erratic and unstable result when the encoder is turned. This problem is known to occur with incremental optical encoders if there is damage to the shaft bearings so that the rotation axis change with respect to the internal optical sensors. It can then be observed that the 90 degree delay between the A and B signals may change a lot and that it gives a very irregular appearance. This makes it hard for the sensing circuits to correctly detect a stable rotation and may instead lead to a very erratic change in value. I erratic behaviour is detected only on one knob, or if an irregularity on the signals can be seen, then it is most likely a incremental encoder problem, and the encoder should be replaced.

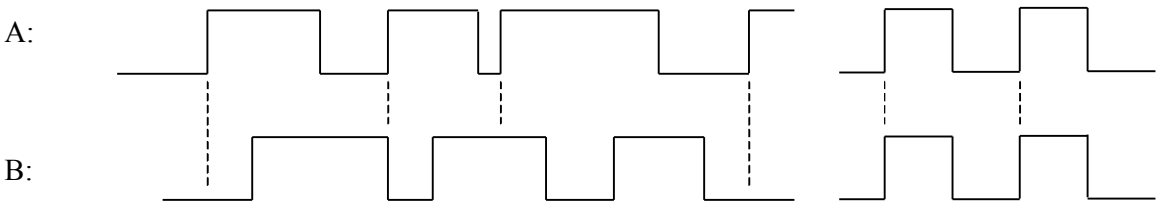


Figure 7: Quadrature output – possible erratic waveforms from a faulty encoder

8.7 LED failure

If one of the LED's doesn't' seem to be working, it may be tested with the LED test index found in the "local status menu". If these tests show that the LED is working correctly, then the OPU is not the problem.

Check "MineCat 140 KE – Technical Manual – Machine Electronics" for more details on possible causes that may prevent the selected LED from being lit. Check that the action connected to the LED status is changing. If both the LED and the connected action (such as ENGINE START) is not responding, the problem is most likely not the LED, but the function controlling the LED.

8.7.1 LED - electrical measurements

First, select intensity setting 8. This gives LED's with max intensity without any blinking. Lower intensity values will give a more difficult value to measure with an AVO meter due to pulse width modulation (PWM) of the current. Level 9 will give a blinking ON/OFF situation which may also be difficult to measure.

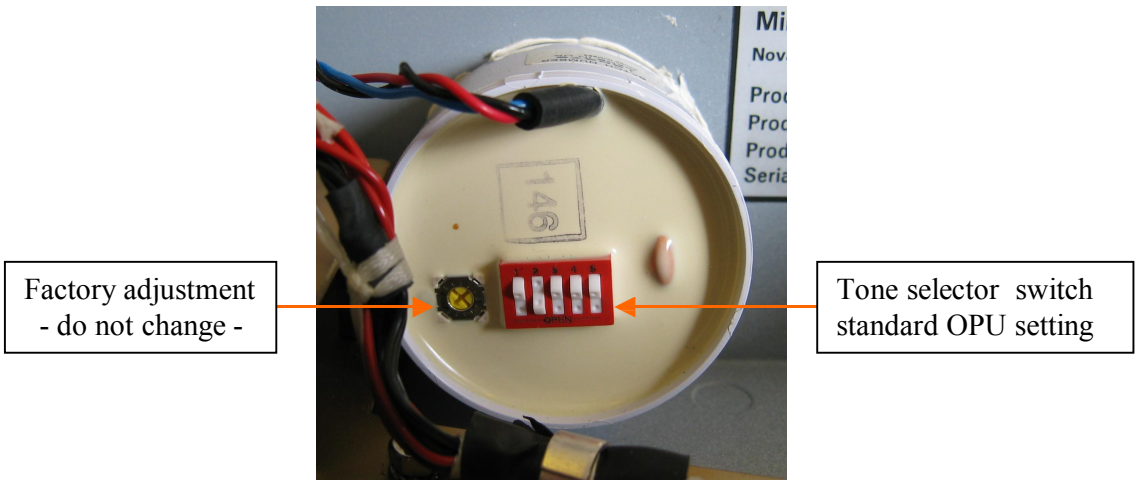
First measure the voltage on the anode of the LED (pink wire). This voltage should be 5.0V +/- 0.25V as measured with reference to OPU chassis.

Then measure the voltage between the anode side (pink wire) and the cathode side of the LED (violet wire). This voltage should be around 2.0V +/- 0.2V, when the LED is lit. If this voltage is less than 1.5 V, the LED should not be lit. This might be due to electronic failure or just simply that the CTU has commanded it to be off. If the voltage is higher than 2.5V without the LED being lit, then it is a either a bad connection in the wires leading to the LED or a failure in the LED itself. Check the connector and wires and replaced the LED if necessary.

If the test indicates an electronic board failure, check whether all other LED's and all other functions seems to be OK. If there is a problem only with one single LED, the "OPU Front panel PCB" is the most likely cause of the problem. If the problem affects a group of up to 4 LED's, the "OPU Front panel PCB" is also the most likely cause. A failure affecting more than a group of 1-4 LED's, can be located to either the "OPU Front panel PCB", the "OPU Electronics module" or in the cable between them.

8.8 Audio transducer failure

If the alarm signals doesn't sound as they should, the most likely cause is that the membrane chamber of the alarm transducer has been filled with dirt or water. Try shaking out any loose particles and try cleaning it as described under OPU-maintenance, section 7.3, Audio transducer.



Picture 6: Audio transducer with tone selector switch

Use the audio test index in the “local status menu” for testing the different tones and intensity levels. If the sound still doesn’t sound right, check the “tone selector switch” setting on the back of the transducer. If this setting has been accidentally changed, a different sound or sound pattern may be heard. Check the setting against the setting shown in the schematic to ensure that nothing has been accidentally altered.

If still nothing helps, the transducer will most likely have to be replaced.

8.8.1 Audio transducer - electrical measurements

If the audio is dead or gives a poor signal, measure the voltage on the red wire (pin 1 on the 9 pin connector) with the AVO meter. In off position, the voltage should be approx 8.5V, and it should be the same when testing level 1 (button GN1). When testing level 2 (button GN2), the voltage should rise to approx 13.5V and finally, the voltage should rise to 21.5V on level 3 and 4 (buttons GN3 and GN4). Allow for 0.5-1 V variation in these measurements. All measurements are done with reference to OPU chassis.

On level 1, 2 and 3, the blue wire (pin 6 on the connector) is pulled to GND and thus giving a voltage reading close to 0.0V. The voltage on the black wire will then be above 0.7V.

On level 4, the black wire (pin 7 on the connector) is pulled to GND and thus giving a voltage reading close to 0.0V. The voltage on the blue wire will then be above 0.7V.

If the voltages on the red wire doesn’t match the listed values, try disconnecting the audio transducer and measure the voltages directly on the connector pin while performing the test. If the voltages measured now matches the listed values, the problem most likely is due to a faulty audio transducer that overloads the audio supply line. Try replacing the transducer with a new one.

8.9 Locating electronic module failure

The sections above describe fault finding on different input/output devices such as display, LED’s, audio transducer, buttons, knobs, handles and joystick.

In many cases, the fault may be located to be with the electronic modules. Inside the OPU, there are two electronic modules, the “OPU Electronics module” and the “OPU Front panel PCB”. Even though some hints are given to simplify the location of the failure source, there are still cases where it may be difficult to locate whether the failure is located in the “OPU Electronics module” or in the “OPU Front panel PCB”. To help tracking down the source of the fault and to locate it to the correct module, some additional information is provided.

This information includes description of failures that may only be located to the “OPU Electronics module” and description of the interface between the two modules.

8.9.1 OPU Electronics module failure

The “OPU electronics module” is the central part of the OPU and contains the OPU processor, the umbilical cable interface, the radio modem interface, the power supply circuits, the battery charger and the audio driver.

Thus, failures only affecting the umbilical or radio modem interface, the battery charger or the audio circuits, can only originate from the “OPU electronics module”. As long as the menu system and the operator interaction devices on the front panel works as normal, the “OPU Front panel PCB” can be ruled out as the source of the failure in these cases.

8.9.2 Failures that may originate from either module

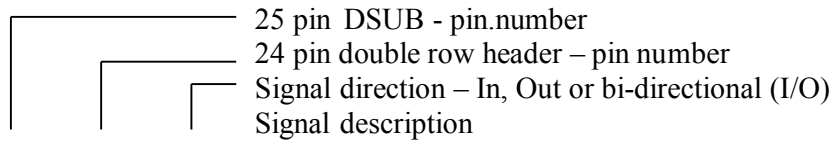
The more difficult failures to locate is the ones that may originate from either of the two electronics modules. The sections above give some clues on how to locate the failure more specific, and as a “rule of thumb” it can be said that failures affecting only one single signal or device is most likely to be located to the “OPU Front panel PCB”. Failures affecting a limited group of signals or devices, such as one handle or a limited group of buttons is also likely to be located to the “OPU Front panel PCB”.

Failures affecting all or most of the devices on the front panel is however most likely located to the “OPU electronics module”. It may also be due to damage of the interconnecting cable, even though the probability of this kind of damage is much lower. If the cable has been damaged in any way, for example if it has been squeezed between the OPU cabinet bottom and the OPU panel front, then cable damage may be a likely problem source. Therefore, checking the cable and connectors for damage is the obvious place to start.

If none of these general hints locates the problem, a more thorough investigation may be carried out with help of an oscilloscope. By checking the signals pin by pin with a an oscilloscope, it may be possible to verify on which side of the cable that the failure source is located. The signal list also show the direction of the signal. O (Output) indicates signals originating from the “OPU electronics module”. I (Input) indicates signals originating from the “OPU Front panel PCB”. I/O are bidirectional bus signals.
The failure is most likely located to the originating end.

The signals are listed with reference to the connector pin number in either end. Figure 8 show the numbering sequence used on the 25 pin DSUB connector on the “OPU Electronics module”. The 24 pin double row header on the “OPU Front panel PCB” uses the same numbering sequence as previously shown in figure 5.

The signals on the interconnection cable are as follows:



1	1	O	Display backlight cathode - pulsed low depending on intensity. 0-2V.
2	3	O	Logic GND supply for front PCB
3	5	O	PWM dimmer signal for LED driver – depending on intensity. 0-5V.
4	7	I/O	Multiplexed data and address bus – bit 0 – low, high or floating
5	9	I/O	Multiplexed data and address bus – bit 2 – low, high or floating
6	11	O	Address strobe – active high – strobes address into front PCB. Idle low.
7	13	I	Emergency stop – signal from switch hardwired through the front PCB
8	15	O	Logic 5.0V supply for front PCB
9	17	O	Analogue minus supply for handle and joystick position potentiometers
10	19	I	Analogue input sense 1 – right flail control handle
11	21	I	Analogue input sense 3 – main joystick y-axis – speed signal
12	23	I	Front panel PCB temperature sensor – GND reference
13	--	--	Not in use
14	2	O	Display backlight anode – approx. 5 VDC
15	4	O	Logic GND supply for front PCB
16	6	O	Reset signal – active low signal resetting the LED drivers
17	8	I/O	Multiplexed data and address bus – bit 2 – low, high or floating
18	10	I/O	Multiplexed data and address bus – bit 3 – low, high or floating
19	12	O	Data strobe – active high – strobes data from bus into front PCB
20	14	O	Contrast control for LCD display – hardwired to LCD pin 3 – via L4
21	16	O	Logic 5.0V supply for front PCB
22	18	I	Analogue input sense 0 – left flail control handle
23	20	I	Analogue input sense 2 – main joystick x-axis – turn signal
24	22	O	Analogue plus supply for handle and joystick position potentiometers
25	24	I	Front panel PCB temperature sensor – temperature signal (20ºC = 2.2V)

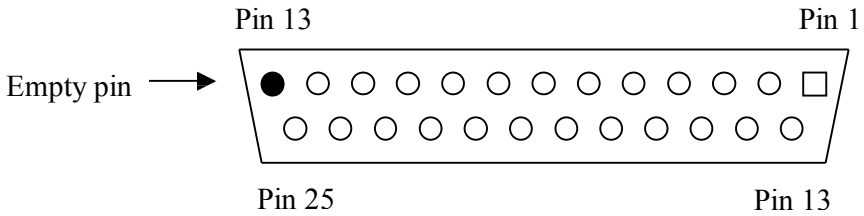


Figure 8: Pin allocation on 25 pin DSUB connector

9. Technical Specifications

The Operator Panel Unit is delivered as a complete free standing panel fitted with a 1/4 wave whip antenna. It has NiMH rechargeable battery packs which is automatically charged when the panel is connected to either the by the umbilical cable or to a 13.2 VDC power source, either the battery charger NOV-5001 or some other 13.2 V DC-supply.

Size:	OPU width including handles:	425 mm
	OPU depth:	180 mm
	OPU height to top of joystick:	270 mm
	carrying frame width:	400 mm
	carrying frame depth:	230 mm
	carrying frame height:	345 mm
Weight:	OPU with antenna:	6.2 kg
	carrying frame with harness:	2.0 kg
	OPU with frame and harness:	8.2 kg
Supply voltage:	10 – 30 VDC with reverse polarity protection	
External supply current at 12VDC / 24V DC:		
	Operation - no backlight - no charging:	0.3 A / 0.2 A
	Operation - backlight on - no charging:	0.5 A / 0.3 A
	Operation - backlight on - charging on:	1.6 A / 0.8 A
Charging time:	10-13 h from empty battery (at 13.2 V supply)	
Battery pack:	7.2V, 7.5Ah, NiMH	
Antenna:	1/4 wave whip antenna with BNC	
Ambient Temp.:	-10 to +50 ºC. some degradation of display visibility and response at min./max. temp.	
Radio frequency:	440.000 – 449.975 MHz	
Channel separation:	25 kHz	
No. of channels:	400	
Transmit power:	approx. 150 mW	
Receiver sensitivity:	-107 dBm	
Communication rate:		
	By cable:	38.2 kBaud at 75 ms transmission interval (RS485)
	By radio:	19.2 kBaud at 150 ms transmission interval
Communication safety:		
	Forward error correction on radio communication Machine identification and dual checksums for message verification	
Environmental protection:	IP65	

10. OPU – Spare Parts List

The following items may be supplied as standard spare parts for local replacement.

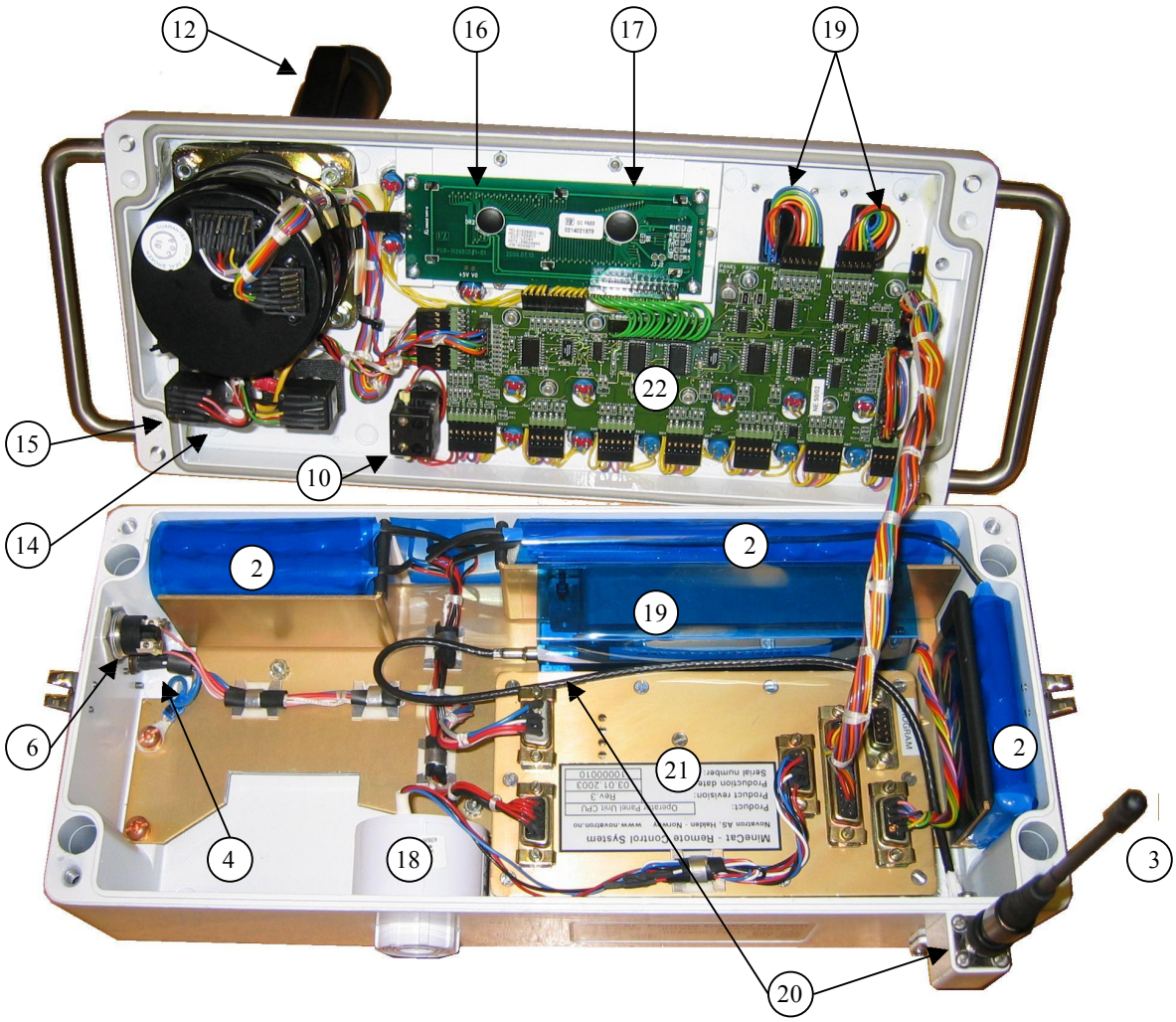
Parts not listed is normally not available as spare parts. The whole unit should then be returned for repair, as is the case with the OPU Electronic Module and Front Panel PCB.

Please observe that replacing parts should only be done by personnel with the necessary knowledge and equipment to do so. Repair done by unskilled personnel may damage the panel and make warranty void.

Part	Part description	Number of Items	Part number
1	Complete Operator Panel	1	NOV-1000
2	Battery pack, 7.2V, 7500 mAh	1	NOV-1005
3	¼ wave antenna whip	1	NOV-1002
4	Panel mounted umbilical connector with cables	1	NOV-1030
5	Dust cap for umbilical connector	1	NOV-5020
6	Main ON/OFF switch	1	NOV-1031
7	Green button with silicone cap and wire	7	NOV-1032
8	Red button with silicone cap and wire	6	NOV-1033
9	Black button with silicone cap and wire	5	NOV-1034
10	Emergency stop button with wire	1	NOV-1035
11	Tilt/Lift joystick with cables	2	NOV-1036
12	Main joystick with cables and sealing	1	NOV-1037
13	Speed/Turn knob, 22mm, black	2	NOV-1038
14	Speed/Turn knob, IP65 shaft sealing	2	NOV-1039
15	Speed/Turn incremental encoder with cables	2	NOV-1040
16	Laminated front glass for display with sealing	1	NOV-1041
17	Display with backlight	1	NOV-1042
18	Audio transducer with cables and sealing	1	NOV-1043
19	Radio modem unit (specify version)	1	NOV-5050
20	Antenna cable and antenna socket with sealing	1	NOV-1045
21	OPU Electronics module (specify which version)	1	NOV-1046
22	OPU Front panel PCB.	1	NOV-1047
23	Umbilical cable	1	NOV-1001
24	Cable for charger and external supply	1	NOV-5002
25	Charger 230V, 50-60Hz / 13.2V, 5A	1	NOV-5001
26	Chest carrying frame with harness	1	NOV-1070
27	Spare harness for carrying frame	1	NOV-1071

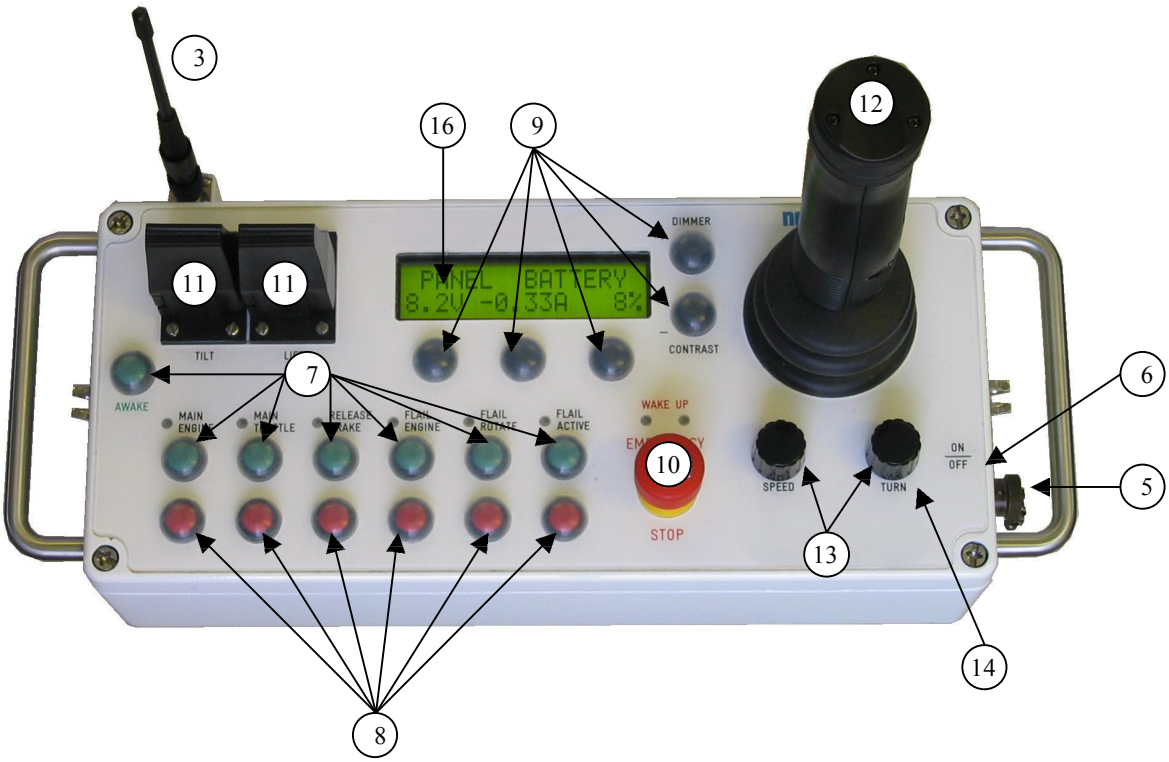
11. Spare Part Assembly

11.1 Spare Part Assembly – Part 1

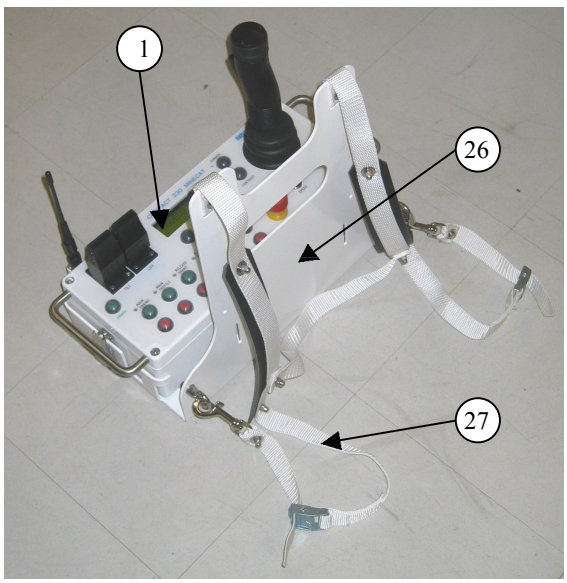


Picture 7: Operator panel - internal view

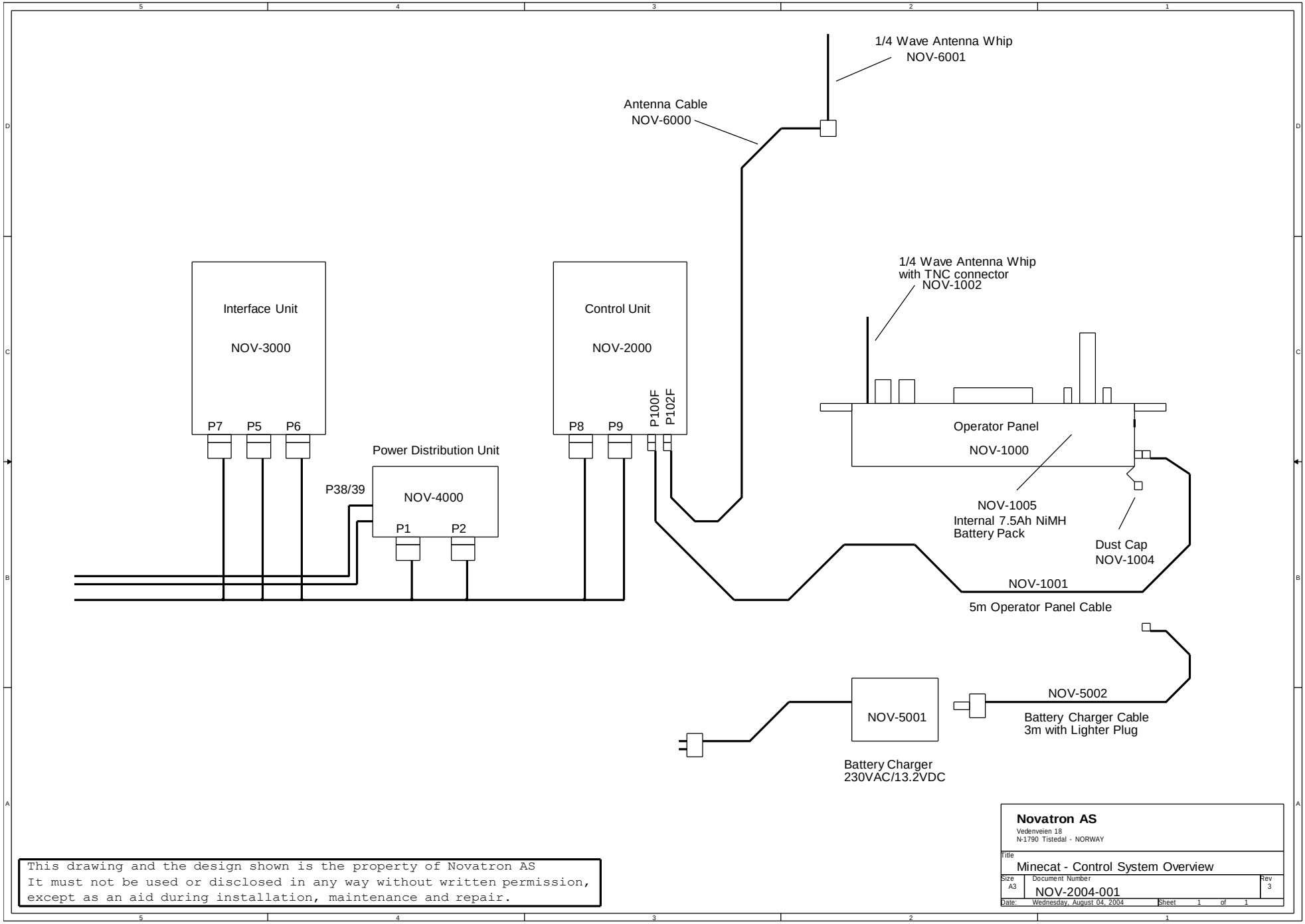
11.2 Spare Part Assembly – Part 2



Picture 8: Operator panel – top view



Picture 9: Operator panel with harness



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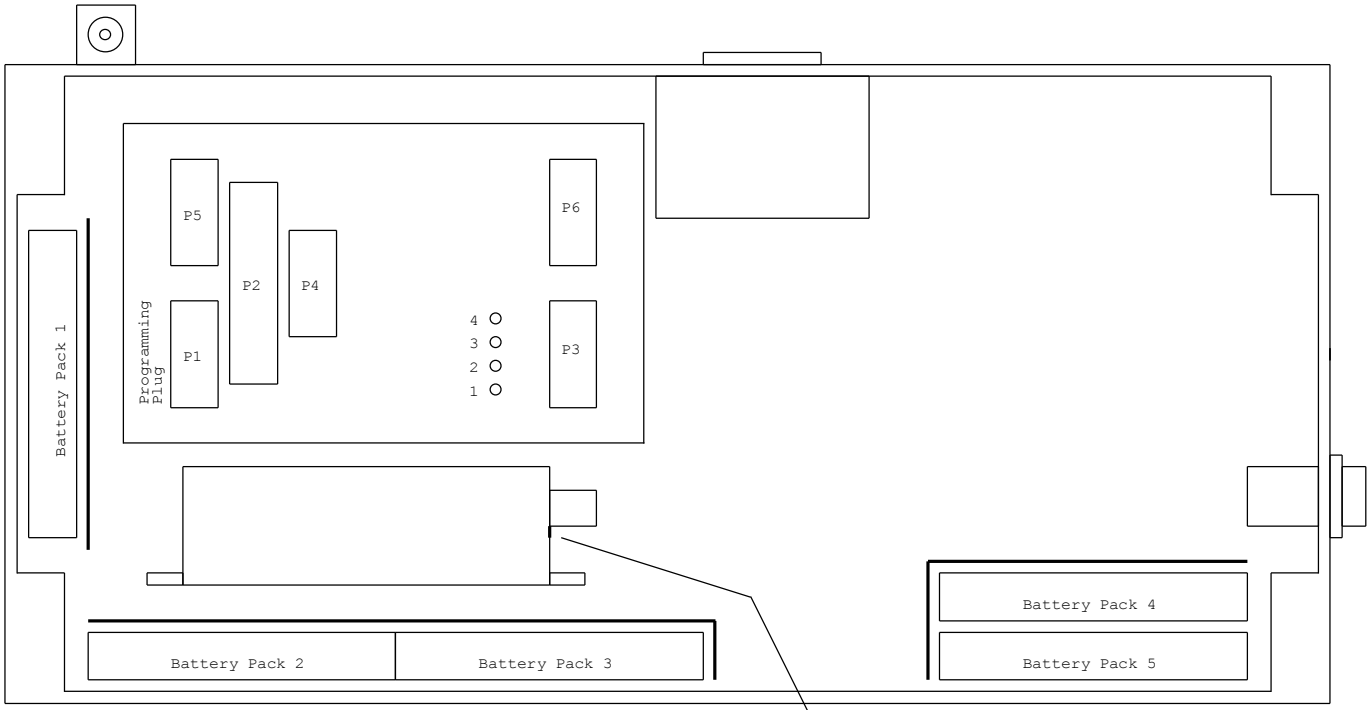
Title: Minecat - Control System Overview
Size: A3 | Document Number: NOV-2004-001 | Rev: 3
Date: Wednesday, August 04, 2004 | Sheet 1 of 1

Operator Panel Unit - Internal layout



LED No.	Colour	Description
1	Green	Main processor running
2	Red	Transmitting to Control Unit
3	Yellow	Receiving from Control Unit
4	Red	Retransmitting message to Control Unit

LED No.	Colour	Description
R1	Green	Radio Modem power
R3	Yellow	Radio Modem receiving
R2	Red	Radio Modem transmitting

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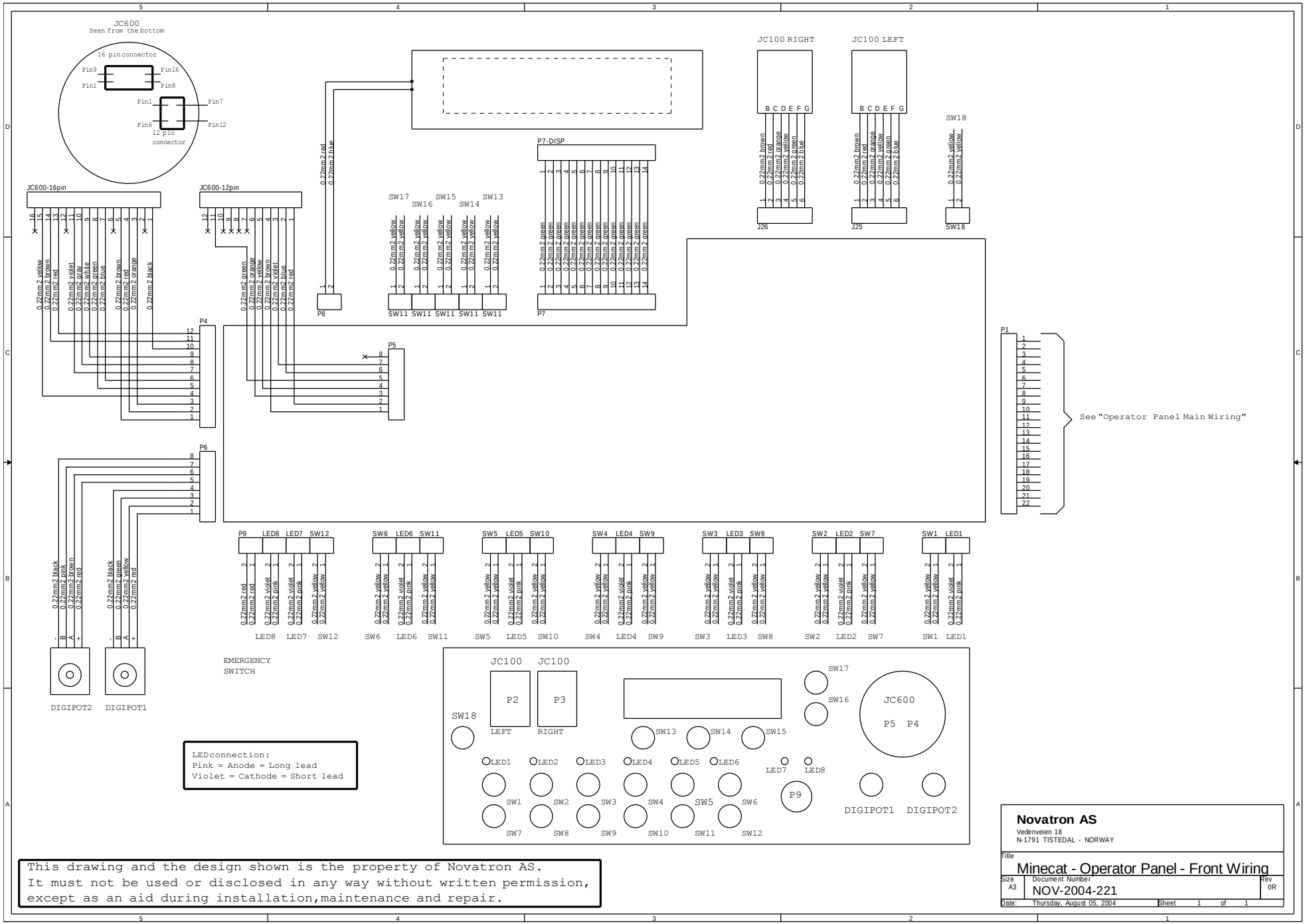
Title: Minecat - Operator Panel Unit

Size: A3 | Document Number: NOV-2004-004 | Rev: 1

Date: Wednesday, August 04, 2004 | Sheet 1 of 1



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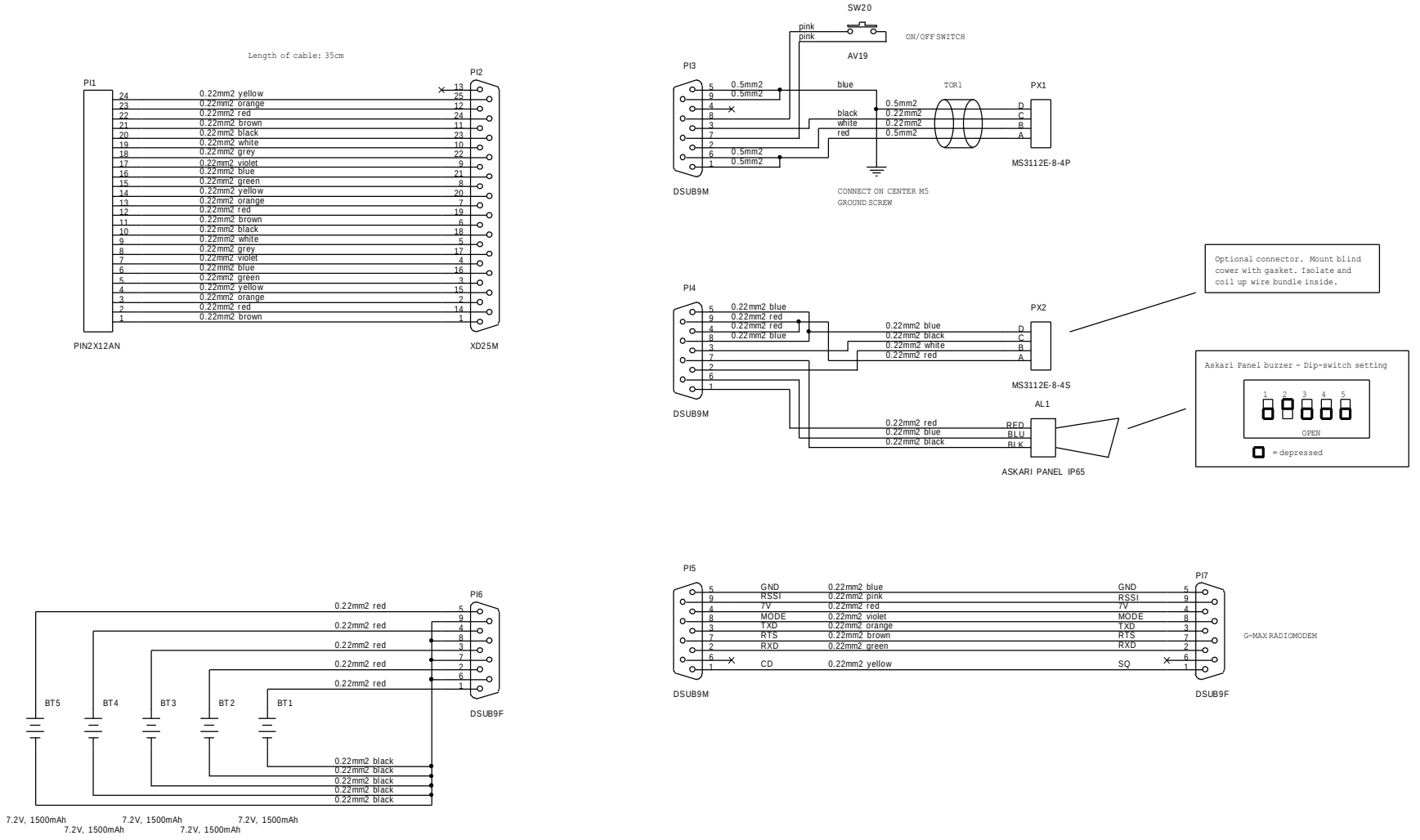
Title: Minecat - Operator Panel - Front Wiring

Size: A3 | Document Number: NOV-2004-221 | Rev: 0R

Date: Thursday, August 05, 2004 | Sheet 1 of 1



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Title: Minecat - Operator Panel - Main Wiring

Size	Document Number	Rev
A3	NOV-2004-222	0R

Date: Thursday, August 05, 2004 Sheet 1 of 1