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MineCat 230
Remote Control System
Technical Manual

Machine Units
CTU-IFU-PDU-DSR

NOV-9112-R0

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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 to provide a comprehensive documentation for the technical maintenance personnel regarding service and maintenance of the machine mounted parts of the remote control system and the electrical wiring. This includes details on CTU, IFU, PDU, DSR and wiring.

In addition to giving an overview of the machine mounted units and electrical wiring, it describes the complete menu system with focus on the submenus used technician supervision. It also provides guidelines and suggestions on how to handle problems that may occur and to bring the system back to operational state.

Additional details on the machine wiring may be found in the cable manufacturers manual "Cable Harness Documents".

Schematics of internal wiring in the Control Unit (CTU) and Interface Unit (IFU) cabinets are provided. Descriptions of the electronic modules and status indicators are provided as a help to trace down any problem that may appear. The documentation do however only contain information for locating the problem to a certain module. It is not intended to 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. Epoxy filled components such as the DSR are however not intended for repair and has to be replaced by new components.

It is important to notice that this is primarily a description of the technical details regarding the operation, maintenance or service of the machine mounted equipment, the CTU, IFU, PDU, DSR and electrical wiring. Even though there are references to possible causes generated by the OPU or sensors, actuators and other electrical or non-electrical equipment on the machine, these are only intended as "helpful" references and must not be regarded as accurate or comprehensive descriptions of these parts or the machine itself. These details must be found elsewhere in the machine documentation.

2. Normal operation

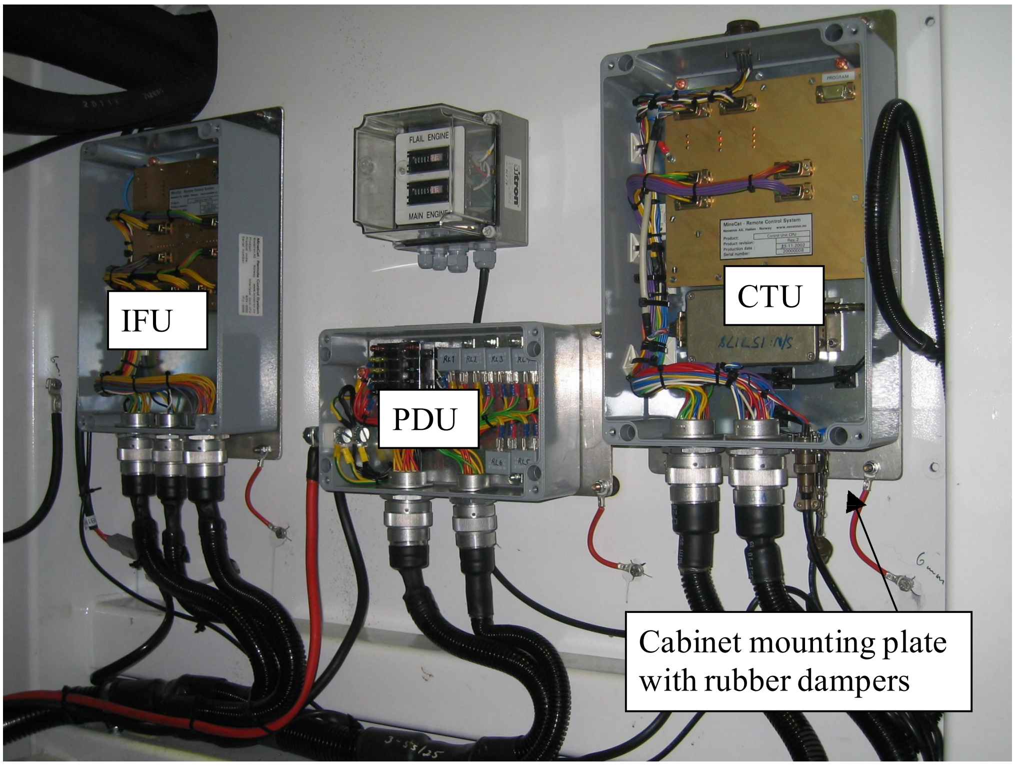
The Control Unit (CTU) and Interface Unit (IFU) are mounted on a vibration damped bracket fitted inside the hinged main engine cover in the back of the machine. The Power Distribution Unit is located on the left side between the flail oil cooler and the fuel tank, just beside the main switch. The Dual Smart Relay's are located near the starter motor on each engine.

The system operates from the machine's 12V DC battery system. Power is feed from the battery and through a main switch that enables total switch off of all power consuming parts when the machine is not in use.

Generator output is connected on the battery side of the switch to eliminate damage generated by transients in case of accidental switch-off with a running engine. Disconnecting a generator under load could otherwise lead to damaged electronics and rectifier diodes.

Communications with the Operator Panel Unit is handled by the Control Unit (CTU) and the radio signals goes by coaxial cable from the CTU cabinet and up to the ¼ wavelength whip fitted on a socket in the top cover. The socket has a male FME connector on top enabling easy replacement of the whip in case of damage. Damage may happen once in a while if the whip is hit by a falling stone thrown up by the flail or a mine explosion.

Please note that in most cases, the radio system will have enough signal strength to be able to operate even with a partly damage antenna. It will therefore in most cases be possible to take the machine out of the minefield by remote control for repair.



Picture 1: Cabinet mounting inside engine compartment

2.1 Emergency Stop

In case of an event that needs instant stop of engines and machine movement, an EMERGENCY STOP command may be sent from the Operator Panel Unit. This will instruct the control system to make a instant shutdown of all functions, both the hydraulic power for the tracks and flail and also the engines themselves.

In addition to the software controlled shutdown, a hard wired EMERGENCY STOP button is mounted on the back left side of the machine. Pressing this button will cut the voltage to the fuel valves on both engines and thus bring these engines to an instant stop regardless of the control system state. This action will however not cut any of the other signals so an EMERGENCY STOP procedure should also be executed on the OPU afterwards to reset all functions to the EMERGENCY STOP state. This should be done before releasing the hard wired EMERGENCY STOP.

The hardwired emergency stop may be used in case a serious problem occur that makes the use of the OPU based EMERGENCY STOP more difficult. It may also be used by any person close to the machine if an emergency situation occurs that is not properly recognized by the remote operator.

WARNING: Operating the machine with persons close by should not be done if the operator is at distance or if the operator is standing in such a way that there are persons in the "dead viewing angle" as seen from the operator. The operator must have full visibility and control of the situation at any time. If not, STOP and WAIT until the situation is under full control, before commencing operation.

2.2 Alternative Emergency Stop

Remember that the machine control system will demand communication from the OPU at an interval not exceeding 1 second. If the 1 second limit is exceeded, the control unit will command the left and right side pump actuators to idle position and thus stop any further forward movement of the machine. It will also start a controlled shutdown of the machine after 5-10 seconds.

This feature may also be used as a backup EMERGENCY STOP for the OPU in case of button failure since an emergency stop can then be initiated by just stopping the communication. This can be done simply by pressing the ON/OFF button and thus switching off the panel.

3. Communication

The communications uses framed messages with checksums and a built in identifier code that is to be specific for each set of machine and operator panel. Neither of the machines will react to commands from panels with different identifier code and the operator panels will also notify the operator that it has detected other machines on the same frequency. See the "230 MineCat - Remote Control System - Operator Manual" and the "140/230 MineCat - Remote Control System – Technical Manual – Operator Panel Unit - OPU".

WARNING: Even though the machines only reacts to commands from its own panel, 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.

See the Special Menu description 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 electronics 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 electronics 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 electronics 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 on to the CTU electronics 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 electronics module will be lit for 1 second to signal a valid reception. If it receives data which is found 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 electronics 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 electronics 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 electronics 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 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 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 electronics 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 electronics 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, ie. 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 also essential for the machine since the CTU will start a shutdown sequence if it looses communication for more than 1 second. The idle communication 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 being used. 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 bursts of noise or 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 "Retransmitting message to …" 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, but that the acknowledge message returned has been lost instead. In this case the sender it will also give a retransmission, but double messages is easily detected by the receiver and discarded and will therefore pose no problem.

3.6 Normal status LED behaviour

During normal communication you will see that 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 electronics 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 retransmission 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.

Please note that 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 but instead due to operator interaction.

The green flashing LED on the CTU electronics module above the communication LED’s is the “processor running)” or “processor OK” indicator.

4. Processor Watchdog functionality

As a precaution against uncontrollable operation in case of equipment failure, a multiple watchdog functionality is built into the system. This system allows the OPU to supervise the IFU and the IFU to supervise the CTU. Both units may independently command the machine to stop in case it detects a critical failure on the other part. In addition, both units will supervise the communication with the OPU and react to loss of communication.

As described elsewhere, the CTU is the main controlling processor and the CTU is therefore the unit that will first react to a communication failure. It will then stop the movement within 1 second after loss of communication with OPU. At the same time, the CTU will supervise the communication running between the CTU and the IFU and make a similar action if the response from the IFU is lost.

To understand this handling better, it is important to have a look at system structure:

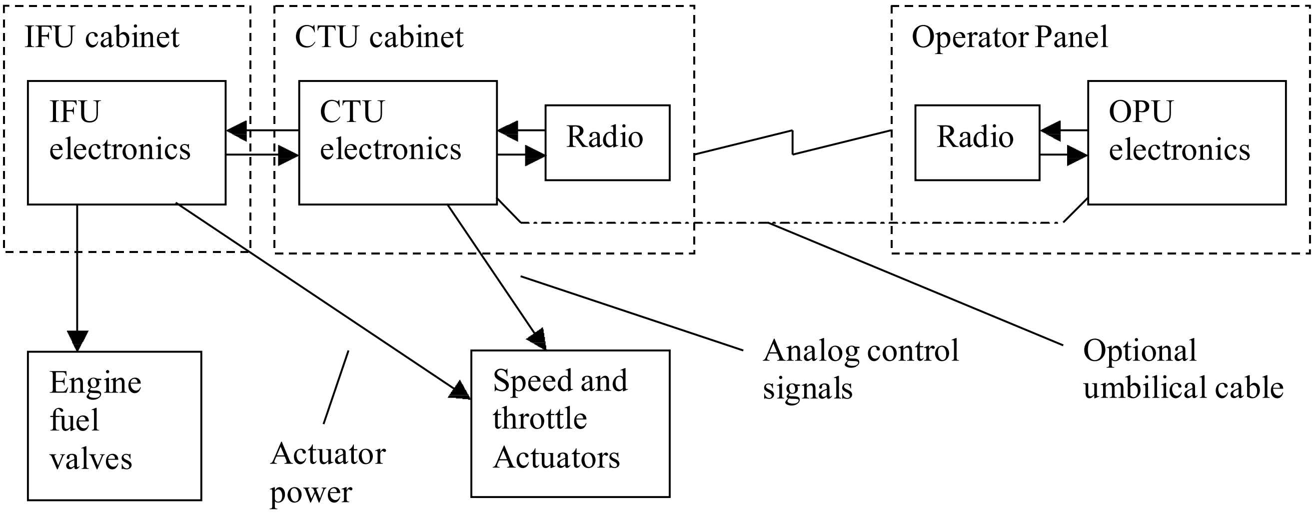


Figure 1: System communication overview

As shown above, the CTU is the most central part of the control system where all messages passes by. A failure in the CTU would therefore be considered critical.

4.1 IFU failure

In case a failure occur in the IFU, it is difficult to predict what the output state of the digital outputs might be. A processor failure may give many different reaction patterns and different digital output setting, depending on the type of failure that occur. One possibility is that it dies with the outputs locked in the current output pattern or it might start doing things that it is not programmed to do. In any case, such a behaviour would be detected by the watchdog on the IFU electronics board, which would in turn try to restart the processor and get it onto the correct track again. If it’s just a transient situation, this may prove fruitful. If not, the processor may not be possible to start, or it might start but soon fail again.

Regardless of what the result will be, this happenings will be detected by the CTU due to loss of communication with the IFU or by irregularities in the communication. This will again tell the CTU to take appropriate actions, mainly by pulling all analogue output signals to idle state to stop machine movement and throttle down the engines. So, even though it may not be able to command the IFU to stop the engines, it can command the actuators to the least harmful position, no movement and idle throttle setting.

4.2 CTU failure

In case a failure occur in the CTU, there is again difficult to predict what the reaction will be. The possibilities are many. In any case, such a behaviour would be detected by the watchdog on the CTU electronics board, which would in turn try to restart the processor and get it onto the correct track again. If it's just a transient situation, this may prove fruitful. If not, the processor may not be possible to start, or it might start but soon fail again. Any such irregularities would normally be detected by the IFU as the IFU expect a regular communication with the CTU. A loss of communication for more than 1 second will automatically command the IFU to switch off all outputs and thus bring both engines to halt.

There is also a possibility that the CTU could be partly failing but still be able to communicate with the IFU in a correct manner. This might be the most critical situations off all as the CTU could now do a lot of harm without the IFU being able to detect the situation and start the shutdown procedure. The CTU might not react to messages from the OPU at all or react wrongly to the commands sent.

This crucial situation is handled by a second watchdog functionality built into the IFU. In addition to monitoring the regularity in the CTU communication, it also monitors part of the OPU to CTU communication that is relayed through to the IFU by the CTU. This is details that is just copied from the OPU-communication and relayed transparently through to the IFU without any modification. Due to this precaution, the IFU should be able to detect whether the CTU is just feeding garbage or if it is still under command from the OPU.

Let's assume a situation with a failing CTU that is still communicating and keeping the IFU happy, but otherwise reacting in an uncontrolled manner. These uncontrolled reactions would of course be observed by the operator who would then press the EMERGENCY STOP button. This would in turn cut the communication within a second.

As reaction to this, the IFU would not receive any more valid signals relayed through from the OPU and as a result, the IFU would start its own shutdown and after 20 seconds switch off all outputs and stop all engines and activities. The longer reaction in this case is to give the CTU the possibility to make a normal controlled slow shutdown first to prevent engine damage. But if the CTU doesn't do this, it will anyhow be overridden by the IFU and brought to a full stop within 20 seconds.

4.3 OPU failure

The third possible failure is with the OPU, but a total failure of the OPU will normally be detected by the CTU due to the loss of communication and a shutdown will be initiated.

There are of course possibilities that only the buttons on the OPU-front may be affected so that the CTU doesn't detect the correct button and EMERGENCY STOP signals from the panel. A dead button input will however be detected by the operator within seconds after a command is given and the machine doesn't respond.

Panel button failure may be a single button failure or a total panel front failure. Since all devices in the panel front runs through the panel board, such a situation is a possibility, though not very likely since the EMERGENCY STOP signal doesn't run through the same electronic circuits as the rest of the buttons.

There is however a way around this problem also if the worst possible should happen. The important thing is that the operator knows about the possibility and is trained enough to remember to use it in a real situation. The clue is to use the ON/OFF button instead and simply switch off the panel power. Since this button is mounted in the bottom part of the panel, it isn't connected through the front board an it's therefore less likely to experience a simultaneous problem.

Switching off the OPU power will effectively stop transmission and force the CTU to make a stop within 1 second. At distance, disturbing the communication by disconnecting the antenna will have similar effect.

5. Speed Stabilizer

The speed stabilizer is a subsystem used to keep the machine speed as constant as possible under varying conditions (uphill, downhill, climbing over a small rock, soft soil, hard soil). Keeping a stable speed is essential for low speed operation as the prime mover hydraulic system is working in the lower end of its operating range during flailing operations. In this case, the pressure dependant internal leaks in the hydraulic motors may drain away all the oil from the pumps in case of an increased load and thus bring the machine to a stop even though the hydraulic pumps still deliver the specified oil flow to the hydraulic motors. These hydraulic motor characteristics will make it a tiresome job to manually keep the speed at the stable low speed that is needed for a satisfactory flailing operation.

To solve these speed variation problems, a speed stabilizer system has been fitted to ensure that the speed can be kept stable within a reasonable deviation form the optimal speed.

The speed stabilizer senses the speed through two incremental encoders connected to the forward track guidance wheels by flexible shafts.

The encoders send speed information back to the control Unit (CTU) in the rear of the machine. Here the actual speed measured will be compared with the speed requested by the operator and appropriate signals will be sent to the two prime mover pumps to reduce the difference between requested and actual speed.

This stabilizing circuitry will however only work as intended if all parts of the control loop works correctly, ie. that both the control system, the speed sensing encoders and the actuators controlling the prime mover pumps, is working correctly. Otherwise it may not react at all, or even worse, it may overreact and give erratic behaviour. To be able to recognise problems related to the speed stabilizing system, a detailed description of the functionality will be given to give the technician a possibility to interpret an observed situation and from this behaviour be able to locate the source of the problem.

5.1 Speed Stabilizer Operation

To visualize what happens inside, it is recommended to go to the TEST DISPLAY in the \ TECH MENU. This display shows two lines with four numbers on each line.

The upper line is the LEFT side. The lower line is the RIGHT side.

When you make a manoeuvre with a combination of speed and turn, either from joystick or speed/turn knobs, this will result in a speed setting for the right and left belt.

When the machine not moving, the speed setting is 0 for each belt. When driving in a straight line, the speed setting are equal for both belts. If the machine turns right, the left belt will have a higher speed setting than the speed value, and the right belt will have a lower setting than the peed value, thus the machine will turn right. This is similar to what happens mechanically in car with differential, while turning. The inner wheel will then go slower and the outer wheel will go faster when the car turns even though the engine rpm is kept constant. The only difference to the MineCat is that the “differential” function is done electronically by the control system

The speed setting is shown in the leftmost column. It is the speed the operator want the belts to have, calculated from the joystick and speed/turn-knob operations.

The rightmost column is the value actually sent to the actuators operating the left and right hydraulic pumps.

With the speed stabilizer disabled, the value sent to the valves are the value commanded by the operator. But this doesn't necessarily mean that the belt will go at that speed, due to internal leaks and other factors. As a result, it is difficult to keep a stable speed in this case, especially at low speed when the internal leaks can be quite large compared to the actual hydraulic flow.

If 50% of the oil flow is lost in internal leaks, the machine will obviously have a problem. But internal leaks are pressure dependant, meaning that the leak will increase under heavy load and may even leak 100% of the oil flow, giving nothing left for propulsion. Hence, the machine may stop in an uphill situation even though it worked well on even ground. This is where the speed stabilizer comes into play. (Note that internal leaks mentioned here are in fact quite normal internal leaks in hydraulic motors. It is collected by the outer motor enclosure and feed back to the hydraulic tank. It’s no leak to the outside world)

The second column is the actual speed measurement from the speed sensors. The sensor is calibrated to match the valve opening at full trottle. So 50% valve opening (forward speed) at full trottle will give a sensor reading of 50. This is for the mathematics to work.

But when you run at less than full trottle, 50% valve opening will not give you 50% speed any more. If the engine RPM is only 50% of full trottle, then 50% valve opening will only give 25% in speed. This is what you experience with the second column on low trottle.

But for the control loops to work, the sensor reading has to match the valve opening. Therefore, the speed reading is corrected by calculating a compensated speed reading = sensor input * (full trottle RPM / actual trottle RPM)

In the 50% RPM case, the sensor reading will be multiplied by 2.

The compensated values are shown in column 3. Due to the compensation, the colum 3 senor reading should, with the speed stabilzer disabled, be comparable to the command input in column 1 and with the valve output in column 4 (1 and 4 should be equal). One may observe a difference of up to 10-20% in the values between column 1/4 and column 3 at full speed. On lower speeds, the difference will increase until you may see that the column 3 finally goes down to zero and the machine stops, even though there is still a speed setting greater than zero (column 1 and 4).

With the speed stabilizer enabled and operating correctly, column 1 and 3 should have almost equal values, but usually not 100% equal. They values should follow each other also at low speed.

The be able to understand the reaction a more close study of the calculations done within the control loop is necessary:

The operator gives the system a setpoint i.e. what the operator likes the speed to be (column 1). The sensor senses the actual speed (column 2) and compensates for reduced trottle to give a value that match the setpoint (column 3). Bear in mind that column 1 is not a true speed setting but a valve opening setting. If 50% speed is selected with the joystick, it means 50% of whatever speed can be obtained at your current trottle setting (which may be less than full trottle). I does so by opening the pump for 50% flow.

Now comes the clue. By comparing column 1 (requested speed value) and column 3 (actual measured value) the system will detect whether the belt goes at desired speed, faster than desired speed or slower. The detected discrepancy will then be multiplied with a factor and feed as a correction to the valve.

The formula will then be:

valve output = speed setpoint + ((speed setpoint - compensated speed measurement) * factor).

The factor may vary between 7 and 12, lowest at high speed, highest (12) at flailing speed.

I you are flailing and command it to be 10%, the compensated speed measurement may not be more than 7. The difference which is 10-7 = 3 will then be multiplied by 12, thus giving a valve setting of 10 + (10-7)*12 = 46%

But as the belt speed increases due to the high valve output, the difference will drop and the valve setting will do the same until an equilibrium point is found where the difference is just big enough to give the necessary valve output when multiplied by 12.

5.2 Erratic operation

The description above shows what happens in a working condition. The problem is when something goes wrong and the control system is unable to operate the machine correctly.

Imagine that the machine is at rest with a faulty sensor giving only zero reading.

Zero setpoint and zero reading gives a valve output of: 0 + (0-0)* 12 = 0, so nothing happens and that is good. But imagine what happens when one try to start driving the machine and the sensor doesn’t give a correct speed reading.

With 5% setpoint and a fault sensor, the formula will give a valve output of: 5 + (5 - 0)*12 = 65%

So a 5% speed setting will in fact give 65% valve output on the belt with the faulty sensor.

So if one tries to drive forward at 5% speed with a faulty sensor on left side, the machine will end up with 65% valve opening on left and around 5% on the right. The machine will then turn hard to the right and possibly hitting any obstacles in its way. If this is observed, **use the EMERGENCY STOP button**.

Such a happening is often thought to be caused by the control electronics, but the fact is that the electronics and the program works correct, but it gives a bad result because it has bad sensor readings. In the computer world there is a saying: “Garbage in gives garbage out”. If you feed faulty values or signals into a program, you'll get faulty signals out of it.

Similar behaviour may also happen if one by accident switches the sensor cables after having them disconnected. In this case, one may get the left sensor reading fed into the right side control loop and vice versa and with disastrous results on the machine control.

Switching the sensors all together (both cable and sensor) may also give a situation where the sensor is on the correct side, but giving negative speed while driving forward and positive speed while driving backwards.

This will usually give both belts locked inn 100% forward, both in 100% backward or one in 100% forward and one in 100% backward (roundabout). You have no control in this case - **use the EMERGENCY STOP button**.

The most tricky one is where the sensor gives partly a sensible signal and partly an erratic signal. Then it may drive steady for 10-20 cm, the suddenly make a jerk, then going steady for 10-20cm and then a new jerk. Normally this gives a jerk for every complete revolution of the sensor shaft. If one get jerks that correlate with the sensor shaft revolution, its most likely a sensor failure.

One other possibility is a slippery sensor to guidance wheel connection giving a lower speed reading than what is actually the case. This may give a machine that has a tendency to turn at a certain rate even though the turn setting tells the machine to drive in a straight line. If this is the case, the flexible shaft should be adjusted or replaced.

The combinations are many, but the sensors are often the cause of the problem in case of problems with the speed stabilizer. Either it is the sensor itself, the cables, the connectors, the electronic circuit that handles the sensor input or a slipping sensor belt.

Switching off the speed stabilizer will eliminate any erratic behaviour created by the sensors. If there is still erratic behaviour, the problem must be with either the electronics, or more likely, with the electro/hydraulic actuators. Check the TEST DISPLAY to find any discrepancy between valve output and actual actuator behaviour.

6. Analogue and digital I/O

6.1 Analogue 4-20mA sensors

Analogue[1] measurements is done mainly with 4-20 mA sensors, a type of sensors that has been an industry standard for analogue process interface. Sensors from different suppliers can be used as replacement for each other as long as they are calibrated for the same measuring interval and have a suitable fitting. The only thing to bear I mind when using a second source sensor is that it has to be two wire sensors and able to operate at voltages down to around 10V DC or lower.

Normally there are two major problems that may occur with the 4-20mA sensors. First, one may have a bad connection between the sensor and control system giving a current of 0mA. The second is an internal sensor fail which will normally lead to a current of 22-25mA which is the way the sensor electronics signal an error situation (may vary with type of sensor). Typical sensor failure may be electronic failure, loss of calibration and in the case of temperature sensors, a wire break between the sensing element and the current converter (the donut-shaped unit inside the temp-sensor housing).

The control unit is programmed to regard currents below 3.5mA and above 20.5mA as error conditions which will generate a SENSOR WARNING. To be able to tell the type of failure, it is necessary to go into the MINECAT-menu and read the sensor current. Please observe that the control electronics are designed for maximum 21-22mA so that currents above this level will still look like 21-22mA. To establish the exact current, one has to connect an AVO-meter (Ampere-Volt-Ohm meter) and measure the current flowing.

Please note that when a sensor fails and a sensor-fail WARNING is issued, all other WARNING and ALARMS based on this sensor is discarded. You will therefore not get any temperature or oil pressure alarms or warnings if the corresponding sensor has been found to have failed. This makes it possible to operate the machine with a sensor failure without having a lot of false temperature or oil pressure alarms and subsequent automatic engine shutdown.
Only proceed with great care and with extra supervision as sensor failure will camouflage any engine overload that this sensor will protect from. The risk of damaging the engines is therefore eminent. As a result of this, operating the machine with a faulty sensor is done on the operators own risk and may make the warrant void for damage caused by this action (see supplier warranty conditions).

---

[1] *Analogue measurements are measurements giving a value proportional to the measured parameter. These are used for variable temperature, pressure and voltage measurements.*

On the other hand, digital measurements are done by simple sensors signalling whether you are above or below a fixed value. These are typically level, temperature or filter clogged switches.

The third type used is digital sensors which gives an analogue value by measuring the time between each on/off signal. This is the case with the speed sensing encoders and to some extent the rpm pickup coils.

6.1.1 Checking the 4-20mA sensor input

To check whether the sensor input on the control system is working correct in case of a problem, just insert a mA-meter in series with the sensor. It is normally safer to insert it in series with the sensing cable going between the sensors minus connector and the control system input. Connecting to the + terminal increases the risk of short-circuit. When connecting to the minus terminal, you may short circuit to ground without any danger as the sensor will always limit the current to the measuring value.

Most AVO-meters can measure DC mA. Often, one has to move the positive (red) measuring cables to a special connector for mA measurement.

!!! Take precaution and do not connect the AVO-meter to any voltage source in this case as this will give a short circuit and may blow a fuse or even destroy the instrument.

When the instrument has been connected, check the measured value against the SENSOR VALUE shown in the MINECAT-menu. They should match within 1-2%, depending on calibration and instrument accuracy.

6.1.2 Sensor function

A 4-20mA sensor gives a current of 4mA for the lowest specified input and 20mA for the highest specified input. For example a 0-40 Bar sensor will give 4mA at 0Bar, 12mA at 20Bar and 20mA at 40Bar. Pressures above 40Bar will still give 20mA

For the temperature sensors, a –25 to +130 degrees C sensor will give 4mA at –25 degrees C or below, 12mA at 52.5 degrees C and 20mA at 130 degrees C and above. In between the current will vary proportional with the value.

The following formula can be used to calculate the measured value from the measured current.

Measured value =
(((current[mA] – I4) / I16) * (max.sensor val. – min.sensor val.)) + min sensor val.

I4 = 4.000 mA value
I16 = 16.000 mA value

The calibration values for the sensor, such as minimum and maximum sensor value can either be fixed from factory or be programmable so that one standard sensor can be tailored to any application by adjusting the calibration values, either by adjusting small potentiometers on the converter module (old sensors that needed to be adjusted in a test-bench) or by connecting a PC with a special setup program. See sensor manufacturer data for more information on sensor adjustment.

6.2 Digital Outputs

The MINECAT-menu gives access to checking the digital data sent out from the program to the digital output drivers on the Interface Unit

The display will look like:

```
 DIGITAL OUTPUT
    ooAooooAooAo
```

The lower line will show the status of the different signals as sent to the IFU.
"o" is inactive signal (floating) , while "A" is active signal (+12V out)

If one has problems with a non functioning output, check first if it is a fuse or relay problem. This only applies to those signals that runs through relays, fuses and smart-relays, which is half of the outputs. The rest goes directly to the devices they control.

The first test is to check the fuse. If the fuse looks OK, open the IFU cover and look at the indicator light on the specific output. If the light goes on, but there is no reaction, its probably a faulty relay or bad contact in the fuse. Use a AVO-meter to trace the problem.

If there is no light, check the status against the DIGITAL OUTPUT status described above. If the status is "A" on the specific output but the light is off, then its either an electronic fault on the digital output or the digital output has gone into protective switch-off due to some overload situation. Check the OUTPUT FAIL status to verify this – an "F" should now occur on the specific output. Disconnect the wire from the interface unit to output device and see if the light comes on. If still no reaction, switch off the main switch for 5 minutes and try again. If still no reaction, its probably an electronics module failure. Replace with a new electronics board or send the board back to the manufacturer for repair.

6.3 Active Low Digital Input

The display will look like:

```
DIG.INPUT ACT.LO
        oooLooLo
```

"L" in the display corresponds with LIGHT in the corresponding status LED.

"L" means that there is an active connection to chassis ground on the machine. Whether this is a normal or "warning" situation varies from signal to signal. See the menu description for more details on this issue.

6.4 Active High Digital Input

The display will look like:

```
DIG.INPUT ACT.HI
        oooHooHo
```

“H” in the display corresponds with LIGHT in the corresponding status LED.

“H” means that there is an active +12V input signal on this input. These signals are mainly sense signals from the output of relays and fuse to verify if the output is operational. See the menu description for more details on this issue.

6.5 RVAR Sense Input

These inputs are used for sensing variable resistance sensors on the machine. There are 3 such sensors on the 230 MineCat, 1 tank level sensors that are interfaced to the IFU and 2 hydraulic oil temperature sensors that are interfaced to the CTU.

The measured resistance is converted to level and temperature values by the software based on internal calibration tables. Values outside the table boundaries will automatically generate warnings and signal the converted values as “INVALID”.

For the CTU input, both current and voltage on the sensor can be monitored together with the calculated resistance, while only the calculated resistance is available on the IFU inputs.

7. Technical Menus

For accessing information about the technical behaviour and status of the machine, a number of technical menus are implemented that enable the technician to select and supervise a number of internal measuring variables and status parameters. The technician also has access to some adjustable parameters and system control flags (function enable/disable).

The easily accessible information are mainly split into two sub menus, the MINECAT menu and the SYSTEM menu.

The MINECAT menu contain all parameters and details regarding the physical implementation on the machine such as sensor input, actuator output, digital input, digital output and flail parameters. It can be thought of as the menu describing the interaction between the CTU and IFU boxes and the equipment and sensors on the machine, i.e. the signals going between the machine and the boxes.

The SYSTEM menu contain information about the control system itself and contain only system specific information, version numbers, communication status and so on. It will therefore be the menu that best informs the technician about the "health" of the control system, as opposed to the MINECAT menu that inform about the "health" of the machine equipment.

The third menu is called the SPECIAL menu and contains special information that is only to be accessible for technical personnel with special clearance. The two menus above contain only status information and parameters that can be changed temporarily without risk or where modification will be easy to verify. The SPECIAL menu, on the other hand, contains calibration values that can affect the accuracy of the system if they are modified in a wrong way. These modifications may also be difficult to detect without calibration equipment. In addition, this menu contains the frequency selection and the identifier code, parameters that need special attention. Due to all these restrictions, the SPECIAL menu is protected by password, making it inaccessible for unauthorized personnel.

Operational data are located in the MAIN menu which is not considered a part of the technical menu. This menu is described in detail in the Operator Manual.

7.1 Entering the technical menus

Technical menus 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 menu is entered from the normal state by simultaneously pressing the three display buttons and keeping them depressed for more than 5 seconds.

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

```
SELECT TECHNICAL
SPES   HOME   TECH
```

This is the top or "root" of the technical menu structure. The menu now branches into the three menus, with the protected SPECIAL menu on the left and the two "open" menus on the branch marked "TECH" on the right.

Pressing the left button will lead to the password protected SPECIAL menu which is described more in detail under the chapter "Special Menu".

By pressing the right button, a new display appears with additional branches:

```
SELECT TECH INFO
SYST   HOME   MCAT
```

Pressing the left button will lead to the SYSTEM menu with the information on the control system itself, while pressing the right button will lead to the MINECAT menu with information on the machine related information. See the chapters "System Menu" and "Minecat Menu" for more details on these menus.

Pressing the centre button at any time will bring control one step back towards the "root" of the menu structure and finally out of the technical menus altogether.

7.2 Minecat Menu

This index below is shown only the first time when the MINECAT 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. If one goes right through all indexes one suddenly gets back to the first index again and the same will apply if one goes right. After passing the first index, one will get to the last one again. Knowing where on the list the wanted value is to be found will be of help when finding the easiest way. Indexes on the end of the list should therefore easiest be accessed from the back using the left button instead of going right through the whole list.

```
 SELECT MINECAT
 <<    HOME    >>
```

(Select Minecat)

```
     /   \
-(19)-(1)-(2)(3)-(4)-(5)-(6)-(7)- - - - - - - - -  (16)-(17)-(18)-(19) -(1)-
```

(1)

```
SPEEDSTAB DIS/EN
 <<  CHANGE  >>
```

Enables the technician to temporarily disable speed stabilizer. The speed stabilizer enable/disable parameter always default to “enabled” when system is switched on. It will therefore have to be disabled manually when there is a need to run the machine without the speed stabilizer in use, a situation that may happen if a failure occur on one of the speed sensing tachometer units. In this case, it may be necessary to temporarily switch off the speed stabilizer function until the problem has been fixed. Otherwise, the machine may be quite impossible to control.

After pressing the middle button, the display will show one of the following:

```
SPEDSTAB ENABLED
 DIS  HOME   EN
```

or

```
SPEDSTAB DISABLE
 DIS  HOME   EN
```

The upper line shows the current state while the lower line shows the possible actions. Pressing DIS(ABLE) or EN(ABLE) will change the status and the text on the upper line accordingly.

After having selected the desired mode, return to the menu is done by pressing the centre button. Control is then transferred back to the “SELECT MINECAT” index and any new index has to be selected from there.

(2)

```
AUTOSTOP  DIS/EN
 <<  CHANGE  >>
```

Enables the technician to temporarily disable the automatic stop functionality. The autostop enable/disable parameter always default to “enabled” when system is switched on. It will therefore have to be disabled manually when there is a need to run the machine without the automatic stop protection in use.

Autostop is a function that will automatically stop the affected engine or engines if the lubrication oil pressure drops below a critical value. Something similar happens for cooling temperature above critical value, but in this case a stop is not recommended. Instead, the engines will automatically throttle down in a controlled manner and the engine is then left running on idle speed to keep the cooling system operational without producing too much excess heat. The operator may then decide to stop it entirely if this action proves insufficient.

After pressing the middle button, the display will show one of the following:

```
AUTOSTOP ENABLED
 DIS  HOME   EN
```

or

```
AUTOSTOP DISABLE
 DIS  HOME   EN
```

The upper line shows the current state while the lower line shows the possible actions. Pressing DIS(ABLE) or EN(ABLE) will change the status and the text on the upper line accordingly.

After having selected the desired mode, return to the menu is done by pressing the centre button. Control is then transferred back to the “SELECT MINECAT” index and any new index has to be selected from there.

(3)

```
 FLAIL  DIS/EN
 <<  CHANGE  >>
```

Enables the technician to temporarily switch off the flail system and instead use the auxiliary hydraulic output. The flail enable/disable parameter always default to “enabled” when system is switched on.

The FLAIL ACTIVE buttons will in this case OPEN and CLOSE the auxiliary hydraulic output instead of STARTING and STOPPING the flail control routine. The FREE FLOAT/FORCE CONTROL selection will not have any meaning in this case.

After pressing the middle button, the display will show one of the following:

```
 FLAIL  ENABLED
 DIS  HOME   EN
```

or

```
 FLAIL DISABLED
 DIS  HOME   EN
```

The upper line shows the current state while the lower line shows the possible actions. Pressing DIS(ABLE) or EN(ABLE) will change the status and the text on the upper line accordingly.

After having selected the desired mode, return to the menu is done by pressing the centre button. Control is then transferred back to the “SELECT MINECAT” index and any new index has to be selected from there.

(4)

```
FLAILPUMP OUTPUT
PRESS. : 185 Bar
```

Display the pressure measured by the flail pump high pressure side. This value is the basis for the calculation of the flail pressure used by the FORCE FLAIL control loops. The flail pressure (flail motor differential pressure) is proportional to the energy output on the flail and is calculated as the difference pressure between the high pressure output and the low pressure input side of the pump. The low pressure side is not measured directly but is almost equal to the pilot pressure.

(5, 6, 7, 8, 9 and 10)

```
 4-20 mA INPUT
VALUE #1 : 12.54
```

Displays the sensor input current measured on the selected channel (1-6). This value can be compared against the value measured by the sensor or against the actual current as measured with an AVO-meter. See “Analaog 4-20mA Sensor” description for more details on this issue.

The value number will change according to the selected channel.

The input current value has an upper limit of 21-22 mA due to limitations in the input amplifier and A/D-converter. Even though the actual current may be larger, as will be the case if the sensor signals an error condition, the value displayed will still not be larger than 21-22mA. This is normal and sufficient for detecting the error condition which is defined as any value below 3.5mA or above 20.5mA.

(11 and 12)

```
 CTU  -  RVAR 1
6.3V  15mA  420R
```

Displays the value measured value on the variable resistance sensing input number 1 and 2 on the Control Unit (CTU). To the lower left is the voltage measured across the sensor. In the lower middle is the current flowing through the resistor. To the lower right is the final result, the resistance value calculated from the measured voltage and current based on Ohms-law:

R [ohm] = U [V] / I [A]. With the value sin the example, the formula will be:

R = 6.3 / 0.015 = 420 [ohm] . Bear in mind that the measured current is in [mA] whereas the formula needs the current in [A], thus making it necessary to convert the current from [mA] to [A] by dividing with 1000, before putting it into the formula.

The sensor control circuitry will however try to keep the sensor voltage and current within certain limits. A current above 100mA or a voltage below 1.9V or above 8.2V may indicate that something has happened to the sensing circuitry. Contact factor for more details.

CTU – RVAR 1 is the sensor used for measuring main hydraulic temperature
CTU – RVAR 2 is the sensor used for measuring flail hydraulic temperature

(13 and 14)

```
IFU  -  RVAR 1
VALUE :    420R
```

Displays the value measured value on the variable resistance sensing input number 1 and 2 on the Interface Unit (IFU).

No Sensor voltage and current is available fro these sensors, only the calculated value. The measuring circuitry on the IFU are however almost similar to the circuitry on the CTU, even though the values are not available.

IFU – RVAR 1 is the sensor used for measuring fuel tank level
IFU – RVAR 2 is not in use on the 230 Minecat

(15)

```
DIG.INPUT ACT.LO
        oooLooLo
```

Displays the status of the digital active low input signals. These are signals that are regarded as active in the LOW state, i.e. where the corresponding indicator LED's are lit while the inputs are low. These are used for sensing status switches connected to ground, such as filter clogged indicators, low oil level indicators and so on.

Even though these inputs are regarded as active low due to their construction, there is no rule as to which stat that is the normal switch state. Some switches are closed in normal state (NC) while others are open in normal state (NO). A normal operational state (filters OK, oil level OK and so on) will therefore give a mixture of "o" and "L". To determine any irregularities, one has to check the normal state of each signal. Unused signals will of course be detected as inactive and displayed as "o". "L" is active low state:

The different signals have the following functions. Counting from the right (8 7 6 5 4 3 2 1)

1)	MINI 140 SENSE		Not connected on 230MineCat
2)	FLAIL OIL LEVEL	(NO)	Low level signal from sensor in flail oil tank
3)	Not used		
4)	MAIN AIR FILTER	(NO)	Filter clogged signal from pressure sensor in filter
5)	Not Used		
6)	MAIN OIL FILTER	(NC)	Filter clogged signal from pressure sensor in filter
7)	MAIN OIL LEVEL	(NO)	Low level signal from sensor in main oil tank
8)	Not used		

(16)

```
DIG.INPUT ACT.HI
        oooHooHo
```

Displays the status of the digital active high input signals. These are signals that are regarded as active in the HIGH state, i.e. where the corresponding indicator LED's are lit while the inputs are high. These are used for sensing voltages, primarily for sensing the outputs from external relays, smart relay drivers and fuses. These signals should follow the corresponding digital output signal if everything is OK. "H" is active high state.

The different signals have the following functions. Counting from the right (8 7 6 5 4 3 2 1)

1)	Not used	
2)	Not used	
3)	COOLING_FAN_SENSE	Flail cooling fan fuse/relay sense
4)	FLAIL_STARTER_SENSE	Flail starter fuse/relay sense
5)	FLAIL_GLOW_SENSE	Flail glow plug fuse/relay sense
6)	FLAIL_VALVE_SENSE	Flail fuel valve fuse/relay sense
7)	MAIN_STARTER_SENSE	Main starter relay/fuse sense
8)	MAIN_GLOW_SENSE	Main glow plug fuse/relay sense

(17)

```
 DIGITAL OUTPUT
    ooAooooAooAo
```

Displays the status of the digital active high output signals. These are signals that are regarded as active in the HIGH state, i.e. where the corresponding indicator LED's are lit while the inputs are high. These are used for driving loads, either directly or through external smart relays to boost the current delivering capacity and reduce voltage drops.

The different signals have the following functions. Counting from the right
(12 11 10 9 8 7 6 5 4 3 2 1).
DIR indicates outputs that drive loads directly.
EXT indicates outputs with external relay/fuses or smart relays.

1)	FLAIL ENG GLOW PLUGS	EXT	Flail engine glow plug smart-relay control
2)	FLAIL ENG STARTER	EXT	Flail engine starter smart-relay control
3)	FLAIL ENG FUEL VALVE	EXT	Flail engine fuel valve via h.w.em.stop
4)	EXTRA HYDRAULIC VALVE	DIR	Extra hydraulic output valve
5)	FLAIL FLOAT VALVE	DIR	Flail free float bypass valve
6)	FLAIL COOLING FAN	EXT	Flail cooling fan
7)	PARK BRAKE HOLD	DIR	Park brake release output (optional)
8)	ACTUATOR TACHO POWER	DIR	Power supply to actuators and sensor
9)	MAIN GENERATOR FIELD	DIR	Power to alternator field input
10)	MAIN ENG GLOW PLUGS	EXT	Main engine glow pl. smart-relay control

11)	MAIN ENG STARTER	EXT	Main engine starter smart-relay control
12)	MAIN ENG FUEL VALVE	DIR	Main engine fuel valve via h.w.em.stop

(18)

```
DIG. OUTPUT FAIL
    oooooooFoooo
```

Displays the fail status of the digital active high output signals. These signals indicates that an error situation has occurred on the corresponding digital output and that the output has been switched off as a protective measure. The output will be operational again as soon as the signal is switched OFF. "F" indicates a fail situation on the specific output.

The different signals have the following functions. Counting from the right (12 11 10 9 8 7 6 5 4 3 2 1).

1)	FLAIL ENG GLOW PLUGS	Flail engine glow plug control failed
2)	FLAIL ENG STARTER	Flail engine starter control failed
3)	FLAIL ENG FUEL VALVE	Flail engine fuel valve control failed
4)	EXTRA HYDRAULIC VALVE	Extra hydraulic output valve failed
5)	FLAIL FLOAT VALVE	Flail free float bypass valve failed
6)	FLAIL COOLING FAN	Flail cooling fan output failed
7)	PARK BRAKE HOLD	Park brake release output failed
8)	ACTUATOR TACHO POWER	Power supply to actuators and sensor failed
9)	MAIN GENERATOR FIELD	Power to alternator field input failed
10)	MAIN ENG GLOW PLUGS	Main engine glow pl. smart-relay control failed
11)	MAIN ENG STARTER	Main engine starter smart-relay control failed
12)	MAIN ENG FUEL VALVE	Main engine fuel valve control failed

(19)

```
 TEST DISPLAY :
```

or

```
L-55 -65 -65 -25
R 90 100 100  80
```

Displays the test values for the speed stabilizer control loop. See the "Speed Stabilizer" section for more details on this issue. Upper line is left side (L), lower line is right side (R).

7.3 System Menu

This index below is shown only the first time when the SYSTEM 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. If one goes right through all indexes one suddenly gets back to the first index again and the same will apply if one goes right. After passing the first index, one will get to the last one again. Knowing where on the list the wanted value is to be found will be of help when finding the easiest way. Indexes on the end of the list should therefore easiest be accessed from the back using the left button instead of going right through the whole list.

```
 SELECT  SYSTEM
 <<   HOME   >>
```

(Select System)

```
    /   \
-(13)-(1)-(2)(3)-(4)-(5)-(6)-(7)- - - - - - - - -  (10)-(11)-(12)-(13) -(1)-
```

(1)

```
OPU CPU VERSION
 HW:3.1  SW:3.3
```

Displays the version number of the hardware and software in the Operator Panel Unit (OPU). The hardware number refer to the hardware number of the CPU electronic module.

The first digit of the hardware version number is the PCB layout version, while the second digit separates different component versions (differing component values or hardware modifications on the board)

With the software version, the first digit is the main version signalling larger structural modifications to the software, whereas the second digit lists bugfix version and minor modifications.

(2)

```
OPU TOP T:  45 C
OPU CPU T:  58 C
```

Displays the temperature measured inside the Operator Panel Unit (OPU).

The TOP temperature is the temperature measured at the front interface board in the top of the OPU enclosure. This will give a reasonable good indication of the temperature inside the operator panel.

The CPU temperature is the temperature measured at the processor board in the two board sandwich CPU module. During normal operation, it will be similar to the TOP temperature, whereas it will be higher during charging or external supply due to the heat generated by the down converter and charge control electronics.

The radio modem module mounted alongside the CPU module will have a temperature somewhere between the two. The radio modem module is the electronic part inside that will "feel" the temperature first, in addition to the batteries.

The radio modem is not guaranteed to work properly above 70°C, even though it is thought to be operational up to between 75 and 80°C due to the fact that it is only transmitting intermittent and with reduced power. This way of operation reduces internal heat and enables it to work in higher ambient temperature.

All other electronics is using industrial grade components that has a guaranteed operational temperature span of –25 to + 85°C.

(3)

```
CTU CPU VERSION
 HW:3.1  SW:3.3
```

Displays the version number of the hardware and software in the Control Unit (CTU). The hardware number refer to the hardware number of the CPU electronic module.

The first digit of the hardware version number is the PCB layout version, while the second digit separates different component versions (differing component values or hardware modifications on the board)

With the software version, the first digit is the main version signalling larger structural modifications to the software, whereas the second digit lists bugfix version and minor modifications.

(4)

```
CTU VOLT: 13.5 V
CTU TEMP:   54 C
```

Displays the voltage measured at the input to the Control Unit (CTU) and the temperature measured on the CTU electronics module.

The CTU VOLT indicates the voltage measured at the input of the CTU board supply and after the polarity protection diode. It is used to sense that the voltage supplied to the CTU is sufficient. It will normally be just 0.5 – 1 V below the battery voltage.

The CTU TEMP is the temperature measured at the CTU board
This will give a reasonable good indication of the temperature inside the CTU enclosure itself.

The radio modem module mounted below the CPU module and will have a temperature that is somewhat equal to the CPU temperature.

The radio modem is not guaranteed to work properly above 70°C, even though it is thought to be operational up to between 75 and 80°C due to the fact that it is only transmitting intermittent and with reduced power. This way of operation reduces internal heat and enables it to work in higher ambient temperature.

All other electronics is using industrial grade components that has a guaranteed operational temperature span of –25 to + 85°C.

(5)

```
IFU CPU VERSION
 HW:3.1  SW:3.3
```

Displays the version number of the hardware and software in the Interface Unit (IFU). The hardware number refer to the hardware number of the IFU electronic module.

The first digit of the hardware version number is the PCB layout version, while the second digit separates different component versions (differing component values or hardware modifications on the board)

With the software version, the first digit is the main version signalling larger structural modifications to the software, whereas the second digit lists bugfix version and minor modifications.

(6)

```
IFU VOLT: 13.5 V
IFU TEMP:   54 C
```

Displays the voltage measured at the input to the Interface Unit (IFU) and the temperature measured on the IFU electronics module.

The IFU VOLT indicates the voltage measured at the input of the IFU board supply and after the polarity protection diode. It is used to sense that the voltage supplied to the IFU is sufficient for proper operation. This is the voltage that determines when the IFU drops all outputs to prevent total battery voltage collapse if the batteries are weak. It will normally be just 0.5 – 1 V below the battery voltage.

The IFU TEMP is the temperature measured at the IFU board
This will give a reasonable good indication of the temperature inside the IFUU enclosure itself.

All electronics is using industrial grade components that has a guaranteed operational temperature span of –25 to + 85°C.

(7)

```
RADIO VERSION
HW:3.1  SW:3.3
```

Displays the version number of the hardware and software in the Radio Modem Module (RMM). The hardware number refer to the hardware number of the RMM electronic module.

The first digit of the hardware version number is the PCB layout version, while the second digit separates different component versions (differing component values or hardware modifications on the board)

With the software version, the first digit is the main version signalling larger structural modifications to the software, whereas the second digit lists bugfix version and minor modifications.

(8)

```
TILT JOYSTICK
TEST :      0 %
```

Displays the value received from the one axis TILT joystick as +/- 0-100%. Moving the joystick forward (away from the operator) gives negative values, moving the joystick backwards gives positive values.

(9)

```
LIFT JOYSTICK
TEST :      0 %
```

Displays the value received from the one axis LIFT joystick as +/- 0-100%. Moving the joystick forward (away from the operator) gives negative values, moving the joystick backwards gives positive values.

(10)

```
SPEED JOYSTICK
TEST :      0 %
```

Displays the SPEED value received from the two axis joystick as +/- 0-100%. Moving the joystick forward (away from the operator) gives positive values, moving the joystick backwards gives negative values.

(11)

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

Displays the TURN value received 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.

(12)

```
SPEED KNOB
TEST :    1023
```

Displays the value received 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.

(13)

```
TURN KNOB
TEST :    1023
```

Displays the value received 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.

7.4 Special Menu

Since the special menu contains parameters and information that should not be accidentally modified or modified without proper knowledge about the results of the modification, access to this menu is restricted. Only personnel that has been properly trained and knows the details behind these parameters should be given access to this part of the menu system.

To restrict the access, entering this menu is performed by entering a 4 digit access code. It is up to the supervisor to limit the distribution of this code.

The first display that will appear after selecting the SPECIAL menu is:

```
ENTER ACCESSCODE
      HOME ENTER
```

The operator now has two choices, either return back to the menu selection or to proceed to code entry display. Pressing the centre button return control to the menu selection, while pressing the right button starts the code entry mode.

```
CODE:       _0000_
INCR DIGIT ENTER
```

The three buttons below now has the following function:

The left button (INCR) is the increment button used to increment the selected digit. After "9", the digit starts on "0" again and goes on with the sequence 0-1-2-3-4-5-6-7-8-9-0-1-2…

The centre button (DIGIT) is used to select the digit to modify. On the display above, no digits are selected yet.

By pressing DIGIT, the first digit is selected for modification as shown below:

```
CODE:       _0_000
INCR DIGIT ENTER
```

Now , use the INCR button to set the first direct according to the access code. The press DIGIT and do the same with the next digit.

When all 4 digits are set correctly, press the right button (ENTER) to continue. The system will now check the value against the internally stored access code and if there is a mismatch, the "ENTER ACCESSCODE" message reappear. It the code is correct, the following message appear:

```
 SELECT SPECIAL
<<   HOME    >>
```

This index above is shown only the first time when the SPECIAL menu is correctly entered and will never reappear, except when returning from a subindex. 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. If one goes right through all indexes one suddenly gets back to the first index again and the same will apply if one goes right. After passing the first index, one will get to the last one again. Knowing where on the list the wanted value is to be found will be of help when finding the easiest way. Indexes on the end of the list should therefore easiest be accessed from the back using the left button instead of going right through the whole list.

```
(Select Special)
    /   \
-(13)-(1)-(2) (3)-(4)-(5)-(6)-(7)- - - - - - - - -  (10)-(11)-(12)-(13) -(1)-
```

(1)

```
CHANGE ACC.CODE
 <<   ENTER  >>
```

This index allow the supervisor to change the access code if necessary. By pressing the centre button (ENTER), the following display appear:

```
ACC.CODE: _1234_
INCR DIGIT ENTER
```

Now, the access code is set to the new code in the same way as the access code was entered earlier, by using the left (INCR) and centre (DIGIT) buttons.

When the new value has been entered, just press the right button (ENTER). A new display appears:

```
ACC.CODE: _1234_
ACCEPT     ABORT
```

Now, one has to press either the left button (ACCEPT) or the left button (ABORT) to either accept and save the new code to memory or just abort without saving anything. Please note that the ACCEPT button is on the opposite side compared to the previous display. This is to avoid accidentally save the value by just pressing twice. To save the value, the user now has to follow the instructions on the display and move his finger to the opposite button to accept. In case the entered value was wrong or the user changed his mind halfway, the sequence can thereby be aborted in a safe manner.

After leaving, control is transferred back to the “SELECT SPECIAL” display.

(2)

```
 CHANGE ID CODE
 <<   ENTER  >>
```

This index, **which may only be entered during cable communication**, allow the supervisor to change the identifier code if necessary. By pressing the centre button (ENTER) , the following display appear:

```
ID-CODE : _1234_
INCR DIGIT ENTER
```

Now, the identity code can be set to the new code in the same way as the access code was entered earlier, by using the left (INCR) and centre (DIGIT) buttons.

Note:
The identifier code is a code that identifies the machine and operator panel as belonging together and that only these two units are allowed to communicate. It is therefore important that the identifier used is unique for each machine/panel and not used by any other system. The safest code to use in this case might be to just simply use the 4 digit CTU serial number which is unique for every CTU.

When the new value has been entered, just press the right button (ENTER). A new display appears:

```
ID-CODE : _1234_
ACCEPT     ABORT
```

Now, one has to press either the left button (ACCEPT) or the left button (ABORT) to either accept and save the new code to memory or just abort without saving anything. Please note that the ACCEPT button is on the opposite side compared to the previous display. This is to avoid accidentally save the value by just pressing twice. To save the value, the user now has to follow the instructions on the display and move his finger to the opposite button to accept. In case the entered value was wrong or the user changed his mind halfway, the sequence can thereby be aborted in a safe manner.

After having pressed the ACCEPT button, the CTU updates the identifier code and waits for OPU to signal back that it has detected the new code an successfully updated the identifier location in the non volatile memory. While this exchange of code and memory update takes place, the display will show the following text:

```
  --  WAIT  --
      HOME
```

This indicates that the system is currently busy updating the identifier code and that the operator should wait for the process to be completed. When this process is successfully completed, the following display appear:

```
  ACKNOWLEDGED
      HOME
```

It is then time to press the centre button (HOME) and return to the Special menu. In case something goes wrong and the ACKNOWLEDGE message never appears, it is also possible to return during the WAIT state. However, as it is impossible to know the state of the identity-codes in CTU and OPU in this case, it is a great risk that the radio communication will be non functional after returning from the WAIT state. It is advised to make a new ID-CODE update in this case before returning to radio communication.

After leaving, control is transferred back to the “SELECT SPECIAL” display.

NOTE:
Please note that the identity code may only be changed while the panel is connected to the CTU by umbilical cable. This is because the ID-CODE is crucial for whether the CTU accept or discard the messages from the OPU by radio. Changing the ID-CODE while communicating by radio could therefore lead to loss of communication in the middle of the update sequence and this possibility has there for been blocked. While communicating by cable, ID-CODE checking is discarded, as it is impossible for two systems to be connected by the same cable.

Pressing ENTER for “CHANGE ID-CODE” while communicating by radio will instead just give the following warning, telling that the function is only accessible by cable:

```
  ONLY BY CABLE
      HOME
```

(3)

```
FREQ: 442.500MHz
 <<  CHANGE  >>
```

This index, **which may only be entered during cable communication**, allow the supervisor to change the frequency of communication if necessary. By pressing the centre button (ENTER) , the following display appear:

```
FREQ: 442.500MHz
LESS  MORE ENTER
```

Now, the new frequency may be selected by pressing the left (LESS) or right (MORE) buttons. This will change the frequency selected, one channel at a time. Each channel is 0.025MHz wide (25kHz). When reaching the lowest or highest available channel, the corresponding button will stop working.

Note:
The radio communication may interfere with other equipment and it is therefore crucial that the system only use frequencies that are not allocated for other types of communication. Following local regulations and lists of safe frequencies is therefore of uttermost importance to avoid interference and possible risk of damage or injury to equipment and personnel that this interference may lead to.

When the correct frequency has been entered, just press the right button (ENTER). A new display appears:

```
FREQ: 442.500MHz
ACCEPT     ABORT
```

Now, one has to press either the left button (ACCEPT) or the left button (ABORT) to either accept and save the new code to memory or just abort without saving anything. Please note that the ACCEPT button is on the opposite side compared to the previous display. This is to avoid accidentally save the value by just pressing twice. To save the value, the user now has to follow the instructions on the display and move his finger to the opposite button to accept. In case the entered value was wrong or the user changed his mind halfway, the sequence can thereby be aborted in a safe manner.

After having pressed the ACCEPT button, the CTU updates the frequency and waits for OPU to signal back that it has received the new frequency setting and successfully updated the frequency in the non volatile memory. While this exchange of frequency data and succeeding memory update takes place, the display will show the following text:

```
  --  WAIT  --
      HOME
```

This indicates that the system is currently busy updating the frequency data and that the operator should wait for the process to be completed. When this process is successfully completed, the following display appear:

```
  ACKNOWLEDGED
      HOME
```

It is then time to press the centre button (HOME) and return to the Special menu. In case something goes wrong and the ACKNOWLEDGE message never appears, it is also possible to return during the WAIT state. However, as it is impossible to know the state of the frequency setting in CTU and OPU in this case, it is a great risk that the radio communication will be non functional after returning from the WAIT state. It is advised to make a new FREQUENCY update in this case before returning to radio communication.

After leaving, control is transferred back to the “SELECT SPECIAL” display.

Note that the frequency may only be changed while the panel is connected to the CTU by umbilical cable. This is because the frequency selection is crucial for whether the CTU may communicate with the OPU by radio. Changing the frequency while communicating by radio could therefore lead to loss of communication in the middle of the update sequence and this possibility has there for been blocked. Changing frequency may only by safely done while communicating by cable.

Pressing ENTER for “FREQUENCY” while communicating by radio will instead just give the following warning, telling that the function is only accessible by cable:

```
  ONLY BY CABLE
      HOME
```

(4)

```
RESTRICTED FREQ
 <<  CHANGE  >>
```

or

```
EASY FREQ ACCESS
 <<  CHANGE  >>
```

Gives the supervising technician the possibility to decide whether to keep the frequency selection hidden or to give the ordinary operator access to the frequency selection without any need for access codes.

> **NOTE:** It must be considered carefully whether local telecom regulations and risk of interference to other equipment can justify giving the operator free access to the frequency selection. In many countries, these frequency bands are restricted and a licence must be obtained for every single frequency to be used.

(5, 6, 7, 8, 9 and 10)

```
CALIB 4-20mA #1
<<   ENTER  >>
```

This index allow access to calibration values for the six 4-20mA sensor inputs. These parameters allow fine calibration of the 4mA value and the 20mA value used by the input routines for calculating the measurement value. The measurement value may be pressure in [Bar] or temperature in [°C]

The calibration values are predefined to nominal values in the software, but these parameters allow corrections to the 4mA value in the size of +/- 5% or corrections to the 20mA values in the size of +/- 2%. This is sufficient to cancel out any hardware inaccuracy due to resistor tolerances and other component tolerances within the CTU. Larger discrepancies due to sensor improper sensor calibration or similar can however not be corrected. Such errors must be corrected at the source.

The limitation to +/-5% and +/-2% are made to allow for correction of maximum allowed internal component tolerance, but not more. Even though these values are accidentally set at wrong values, it will still not be able to give discrepancies larger than a few percent of full scale, discrepancies that will not seriously affect the operation of the machine. Discrepancies in the range of a few [Bar] or [°C] will hardly be noticeable by the operator.

The sensor calibration refer to the following formula:

Measured value =
(((current[mA] – I4) / I16) * (max.sensor val. – min.sensor val.)) + min sensor val.

The values I4 and I16 are the values affected by this calibration:

I4 = factory default 4.000mA value * ((100 + 4mA correction) / 100)

I16 = (factory default 20.000mA value * ((100 + 20mA correction) / 100)) – I4

When pressing the centre button (ENTER), the following display appear:

```
CALIB 2: 12.45mA
 4mA  HOME  20mA
```

This display shows the sensor current that is calculated from the measured input current and according to the current 4mA and 20mA corrections. If this value differs from the value actually measured by a calibrated 4-20mA measuring device (a loop calibrator, precision AVO-meter or similar), then the 4mA and 20mA values has to be corrected.

The optimal procedure for calibrating the sensor input is to first input a current equal to 4.000mA.

Pressing the left (4mA) button brings up the following display:

```
#2  4mA  : +0.5%
LESS  HOME  MORE
```

By pressing the left or right buttons, one may now change the 4mA-correction between –5.0% and +5.0% according to the difference that was detected. By pressing the centre (HOME) button, the control is transferred back to the display showing the measured current. If it still isn’t equal to the calibration current, the process is repeated.

When the 4mA value is correct, then apply an input current equal to20.000mA and go to the 20mA adjustment display:

```
#2 20mA  : -1.2%
LESS  HOME  MORE
```

By pressing the left or right buttons, one may now change the 20mA-correction between -2.0% and +2.0% according to the difference that was detected. By pressing the centre (HOME) button, the control is transferred back to the display showing the measured current. If it still isn't equal to the calibration current, the process is repeated.

Finally, if both the 4mA and 20mA calibrations are correct, the calibration may be finished by pressing the centre button (HOME) from the display showing the calibration current.

See the Sensor description for more details.

Note: If the calibration values fetched from internal memory were invalid, as will be the case when a new system is switched on and before the first calibration or if a memory failure has occurred, this will be signalled by the following display:

```
#2  4mA  INVALID
LESS  HOME  MORE
```

An invalid calibration is handled internally as if the calibration value was 0.0%, i.e. that the nominal 4mA or 20mA values will be used, giving a discrepancy of less than 1% due to internal component tolerances. A total failure of the calibration data will thus not seriously affect the operation of the system and will hardly be visible to the operator at all.

(11)

```
CALIB VOLT SENSE
<<   ENTER  >>
```

This index allow access to calibration values for the voltage sense input. This parameter allow fine calibration of the gain value used by the input routine for calculating the measurement voltage.

The calibration values are predefined to nominal values in the software, but these parameters allow corrections to the gain value in the size of +/- 5%. This is sufficient to cancel out any hardware inaccuracy due to resistor tolerances and other component tolerances within the CTU.

The limitation to +/-5 are made to allow for correction of maximum allowed internal component tolerance, but not more. Even though these values are accidentally set at wrong values, it will still not be able to give discrepancies larger than a few percent of full scale, discrepancies that will not seriously affect the operation of the machine. Discrepancies in the range of a few tenths of a [V] will hardly be noticeable by the operator.

The voltage sense calibration refer to the following formula:

Measured value = voltage sense input * volt sense gain volt sense gain = factory default volt sense gain * ((100 + gain correction) / 100)

When pressing the centre button (ENTER), the following display appear:

```
CALIB VS: 12.5 V
      HOME  GAIN
```

This display shows the voltage that is calculated from the measured input voltage and according to the current GAIN corrections. If this value differs from the value actually measured by a calibrated AVO-meter, then the GAIN value has to be corrected.

The optimal procedure for calibrating the sensor input is to input a voltage of around 13.0V.

Pressing the right button (GAIN) brings up the following display:

```
VS GAIN   : +2.5%
LESS  HOME  MORE
```

By pressing the left or right buttons, one may now change the GAIN-correction between –5.0% and +5.0% according to the difference that was detected. By pressing the centre (HOME) button, the control is transferred back to the display showing the measured voltage. If it still isn't equal to the measured voltage, the process is repeated.

Finally, if GAIN calibration is correct, the calibration may be finished by pressing the centre button (HOME) from the display showing the calibration voltage.

Note: If the calibration value fetched from internal memory was invalid, as will be the case when a new system is switched on and before the first calibration or if a memory failure has occurred, this will be signalled by the following display:

```
VS GAIN  INVALID
LESS  HOME  MORE
```

An invalid calibration is handled internally as if the calibration value was 0.0%, i.e. that the nominal GAIN values will be used, giving a discrepancy of less than a few percent due to internal component tolerances. A total failure of the calibration data will thus not seriously affect the operation of the system and will hardly be visible to the operator at all.

(12 and 13)

```
CALIB CTU RVAR1
 <<   ENTER  >>
```

This index allow access to calibration values for the variable resistor sense inputs on the CTU, i.e. the hydraulic temperature sensors. These parameter allow fine calibration of the gain value used by the input routine for calculating the measurement resistance values.

The calibration values are predefined to nominal values in the software, but these parameters allow corrections to the gain value in the size of +/- 10%. This is sufficient to cancel out any hardware inaccuracy due to resistor tolerances and other component tolerances within the CTU.

The limitation to +/-10 are made to allow for correction of maximum allowed internal component tolerance, but not more. Even though these values are accidentally set at wrong values, it will still not be able to give discrepancies larger than a few percent of full scale, discrepancies that will not seriously affect the operation of the machine. Discrepancies in the range of a few [°C] will hardly be noticed by the operator.

The sensor calibration refer to the following formula:

Measured resistance = rvar sense input * rvar gain

rvar sense gain = factory default rvar gain * ((100 + rvar correction) / 100)

When pressing the centre button (ENTER), the following display appear:

```
CALIB RV1: 124 R
      HOME  GAIN
```

This display shows the resistance that is calculated from the input measurements and according to the current GAIN corrections. If this value differs from the value of the resistor that is connected during the test, then the GAIN value has to be corrected.

The optimal procedure for calibrating the sensor input is to connect a resistor of around 50-100 ohm and read the value. Allow time for value to stabilize.

Pressing the right button (GAIN) brings up the following display:

```
#1 GAIN   : +3.5%
LESS  HOME  MORE
```

By pressing the left or right buttons, one may now change the GAIN-correction between –10.0% and +10.0% according to the difference that was detected. By pressing the centre (HOME) button, the control is transferred back to the display showing the resistor value. If it still isn't equal to the test resistance, the process is repeated.

Finally, if GAIN calibration is correct, the calibration may be finished by pressing the centre button (HOME) from the display showing the calibration resitance.

Note: If the calibration values fetched from internal memory was invalid, as will be the case when a new system is switched on and before the first calibration or if a memory failure has occurred, this will be signalled by the following display:

```
#1 GAIN  INVALID
LESS  HOME  MORE
```

An invalid calibration is handled internally as if the calibration value was 0.0%, i.e. that the nominal GAIN values will be used, giving a discrepancy of less than a few percent due to internal component tolerances. A total failure of the calibration data will thus not seriously affect the operation of the system and will hardly be visible to the operator at all.

The temperature sensors also have a non linear resistance/temperature function giving larger resistance variations than the actual temperature variations to be measured. This reduces the effect of resistance measurement inaccuracies to a minimum.

8.0 Machine Equipment Maintenance

During use, the CTU and IFU should have a regular maintenance too keep it operational all the time.

8.1 General cleaning

First it is important to clean it from dirt, especially before opening the cabinets. Water may be used for a cleaning, but only running water. Pressurized water should not be used as this may be squeezed through the sealing and into the cabinets.

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.

8.2 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 all the connectors with spirit and dry with pressurized air before closing the connectors if they have been full of dirt. Replace the connector if it is damaged. Check that the connector sockets are free of dirt. Try spraying with water or spirit in a syringe to get the dirt away. In case water is used for cleaning, dry thoroughly with a hear dryer or hot air gun (not too hot) to evaporate any excess water. Remaining water trapped in the connector may lead to corrosion.

After cleaning, spray the connector with an isolating, anti corrosive and protective spray designed for electrical use.

Inserting the plug with dirt in the sockets may make insertion impossible and also compacting the dirt and making it even worse to remove later. Replace the connector if necessary.

8.3 Antenna

The quarter wavelength whip on top of the machine 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 cable is temporarily removed, 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 umbilical connector if it gets dirty.

!!! To avid the needle scraping up the connector surface and damaging it, it is suggested that one cut the needle 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 to feed the spirit into narrow places.

8.4 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 that the main seal on the cover 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 a high moisture content 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 front cover screws doesn't move easily, put some silicone fat or similar lubrication on the threads to avoid the screws from getting stuck.

WARNING !!!

Open the cover carefully and disconnect the voltage stabilizer before removing the cover.

If testing is to be done with the cover removed, bypass the stabilizer by plugging the short strap wire into the voltage stabilizer plug between the red and yellow wires. Otherwise the electronic module will not receive power.

When putting the cover back on, remember to remove the strap wire and connect the voltage stabilizer before closing the cover. Also remember to fasten the loose end of the voltage stabilizer contact/cable with the speed-strap to keep the connector properly fixed under heavy vibration.

9. Fault finding

Problems affecting the operation of the machine may be of either mechanical, hydraulic or electrical nature. This chapter discuss possible problems of electrical nature with special focus on the control system related problems.

Many of the electrical related problems can be located outside the remote control system itself. Even though this document refers to possible causes generated by equipment outside the remote controls system, such as starters, actuators and sensors, and brief descriptions of the relationship with the rest of the system is given, 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 in the machine documentation.

9.1 Problems not related to the Remote Control System

Failure situations detected by the remote control system and reported as warning or error messages from the CTU (shown as “> WARNING XX <” or as “>> ALARM XX <<”), are problems detected by the remote control system, but which are mostly caused by problems outside the control system, except for the indexes 90-93 which are control system related messages.

The messages given will however give a good indication of the initial problem and may give the operator a hint to the real cause and provide a tool for deciding whether the problem is of serious nature that need instant attention or just something that can be dealt with during the next service stop.

9.2 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 between the OPU and the CTU. The warnings listed in the “MineCat 140/230 - Remote Control System – Technical Manual – Operator Panel Unit – OPU” 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 the section 5. “Speed stabilizer” for more details on this issue.

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 the “CTU fault finding” section for more details on this issue.

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

Check the “MineCat 140/230 - Remote Control System – Technical Manual – Operator Panel Unit – OPU” for more details on radio interference and possible solutions.

If the problem has been located to the radio communication, open the CTU cower 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 YELLOW RECEIVE LED signal detected incoming signals. Check that the antenna looks undamaged, that the antenna cable looks undamaged and that the connector is properly fastened to the connector on the CTU-cabinet. Also check the internal antenna connectors and the cable connecting the radio modem with the CTU electronics board.

If the RED TRANSMIT LED on the radio modem unit is flashing, this indicates that the CTU is responding to incoming messages from the OPU and sends reply messages back. If this is the case and still no response is detected on the OPU, the problem most likely is with the return message from the CTU to the OPU. This may again be due to a faulty transmitter in the CTU radio modem or in the receiver part of the OPU radio modem. Interference close to the OPU may also block the OPU from receiving the messages correctly.

9.2.1 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.

9.3 CTU fault finding

The CTU is the central part of the system and problems related to the CTU will therefore normally have critical effect on the whole machine. Fatal errors will normally stop the CTU processor and lead to no response. This will in turn make the IFU shut down the engines within a few seconds.

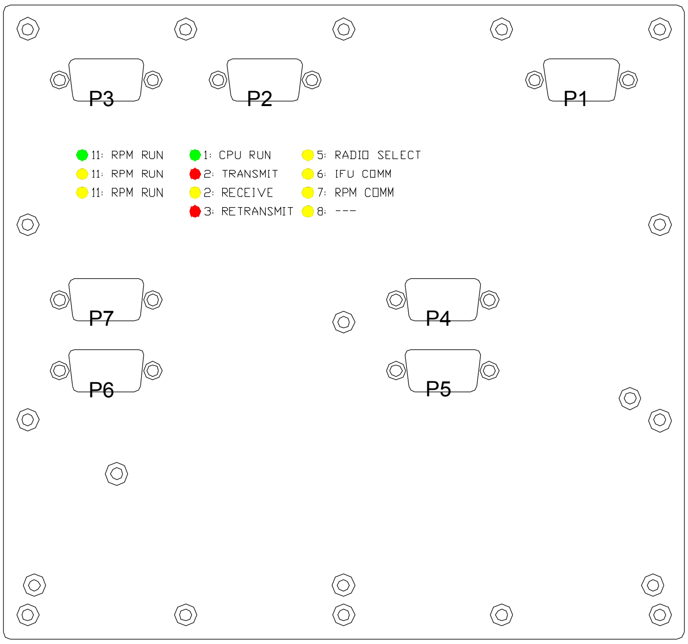


Figure 2: CTU electronics module layout with status LEDs

The more tricky problems to trace are those that only give partly failure and where multiple error sources may exist. To narrow in on the actual problem source, the status indicators on the CTU electronics module may provide a good indication. A detailed list of the different indicators and the information gathered from the appearance will provide a good indication on the different possibilities.

Indicator 1: Main processor running (green)

Signals whether the main processor is running properly and executing the program. The normal appearance will be regular flashing with approx. 3 short green flashes pr. second. Steady green light or no light at all indicates that the processor has stopped or that the program isn't running as it should. An irregular flashing pattern also signals something wrong in the program execution.

Indicator 2: Transmitting to OPU (red)

Signals that the CTU is sending a message packet to the OPU. The flash will normally be short and may be repeated at a rate of 3-6 flashes each second depending on the traffic. During periods of menu navigation or machine manoeuvring, 5-6 flashes each second should be observed. During idle periods, just a few flashes should be observed each second.
No flashes at all may indicate that the CTU doesn't receive any messages from the OPU and therefore has no reply to send. This is normal if the OPU is switched off or if there is interference.
A steady red light is a non valid situation and indicates CTU failure.

Indicator 3: Receiving from OPU (yellow)

Signals that the CTU is receiving data from the OPU. Short flashes indicates received messages which are rejected due to improper framing, improper checksums or other invalid content.
A long flash of one second indicates the reception of a valid message. A stream of valid messages with intervals less than 1 second, as will be the case in a normal communication sequence, will thus give a continuous steady light.
No light at all may indicate that the CTU doesn't receive any messages from the OPU. This is normal if the OPU is switched off or if there is interference.

Indicator 4: Retransmitting message to OPU (red)

A short flash signals that the CTU retransmits a message because it has not received a valid acknowledgement from the OPU on the previous message.
A long flash of 1 second signals that the CTU has retransmitted the message the maximum number of times without a valid acknowledgement from the OPU and that the message is deemed obsolete and discarded.
A short flash signalling retransmission may be seen once in a while, especially during high traffic, due to noise spices that may corrupt random frames. This has no effect as the system is designed to handle single lost messages.
The long flash do however indicate serious problems with the communication, for example long burst of interfering signals from other sources. Such long communication losses will normally also be seen as intermittent stops on the movement of the machine. Se more details under section 3. "Communication".

Indicator 5: Radio communication selected (yellow)

Lights when communication by radio is selected. If the CTU detects that an OPU is connected by umbilical cable (by sensing the current going to the panel), the light will go off inn 2 seconds indicating that the CTU has switched to cable communication. This light will be either steady on or off. Flashing or blinking light is an invalid situation and indicates CTU failure.

Indicator 6: Communicating with IFU (yellow)

Indicates status on communication with IFU. A flashing light indicates received data with invalid framing or checksums. A steady light indicates reception of valid data from IFU.

Since the communication with the IFU goes by twisted cable over a distance of not more than 1-2 meter, communication error occur very seldom. This light should therefore be lit continuously. Any interruptions occurring during operation therefore indicates problems that should not occur, possibly bad connections in the cable or electronic problems on either IFU or CTU.

Indicator 7: Receiving RPM data form RPM processor (yellow)

Indicates that the main processor on the CTU module is receiving data from the RPM sensing processor on the CTU module. This light should be steady on. A flashing light or no light at all indicates that no data is received. Either it is an internal communication problem or most likely a faulty RPM processor.

Indicator 8: Not in use (yellow)

May sometimes be used for factory testing and any light pattern observed should be discarded .

Indicator 9: Receiving RPM signal from Flail Engine (yellow)

Indicates that the RPM processor detects valid RPM signals form the Flail Engine.

Indicator 10: Receiving RPM signal from Main Engine (yellow)

Indicates that the RPM processor detects valid RPM signals form the Main Engine.

Indicator 11: RPM processor running (green)

Signals whether the RPM processor is running properly and executing the program. The normal appearance will be regular flashing with approx. 3 short green flashes pr. second. Steady green light or no light at all indicates that the processor has stopped or that the program isn't running as it should. An irregular flashing pattern also signals something wrong in the program execution.

Problems with the RPM processor will only affect the RPM measurements and the hydraulic temperature readings so the machine may be operated with a dead processor until a replacement of the CTU electronics module can take place, provided that the hydraulics temperature is properly monitored by other means.

9.4 IFU fault finding

The IFU is the unit controlling all digital input and output signals in addition to the pulse width modulated (PWM) flail pump current and the fuel tank measurements.

To simplify locating problems that may occur, status indicators has been provided on the IFU electronics module to show the exact status of main functions and individual input- and output-ports. A detailed list of the different indicators and the information gathered from the appearance will provide a good indication to the different problems.

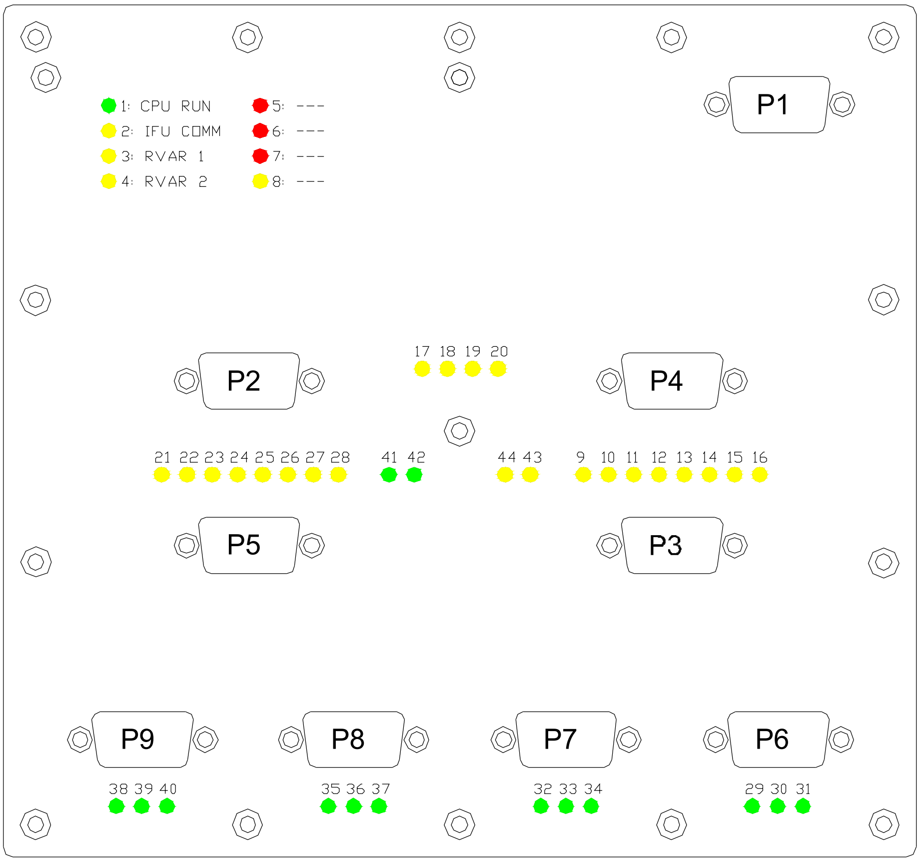


Figure 3: IFU electronics module layout with status LEDs

Indicator 1: Main processor running (green)

Signals whether the main processor is running properly and executing the program. The normal appearance will be regular flashing with approx. 3 short green flashes pr. second. Steady green light or no light at all indicates that the processor has stopped or that the program isn't running as it should. An irregular flashing pattern also signals something wrong in the program execution.

Indicator 2: Communicating with CTU (yellow)

Indicates status on communication with CTU. A flashing light indicates received data with invalid framing or checksums. A steady light indicates reception of valid data from CTU.

Since the communication with the CTU goes by twisted cable over a distance of not more than 1-2 meter, communication error occur very seldom. This light should therefore be lit continuously. Any interruptions occurring during operation therefore indicates problems that should not occur, possibly bad connections in the cable or electronic problems on either IFU or CTU.

Indicator 3: Detecting valid sense on channel 1 (yellow)
Indicates that the IFU detects a tank level sensor on channel 1 (main fuel tank). This light should be steady on. If not, check the connection to the tank level sensor.

Indicator 4: Detecting valid sense on channel 2 (yellow)
Indicates that the IFU detects a tank level sensor on channel 2 (second fuel tank). Since there is no second tank on the 230 MineCat, this light should be steady off.

Indicator 5-8: Not in use (red and yellow)
May sometimes be used for factory testing and any light pattern observed should be discarded .

Indicator 9: Main Glow relay/fuse sense (yellow)
Indicates the state of the output from the fused Main Glow relay output on the PDU. If this indicator is OFF while the corresponding output should be ON, this indicates either a blown fuse (most likely) or a faulty relay.
Note that this output only controls the Smart Relay, not the actual Glow Plugs.

Indicator 10: Main Starter relay/fuse sense (yellow)
Indicates the state of the output from the fused Main Starter relay output on the PDU. If this indicator is OFF while the corresponding output should be ON, this indicates either a blown fuse (most likely) or a faulty relay.
Note that this output only controls the Smart Relay, not the actual Starter Motor.

Indicator 11: Flail Fuel Valve relay/fuse sense (yellow)
Indicates the state of the output from the fused Flail Fuel Valve relay output on the PDU. If this indicator is OFF while the corresponding output should be ON, this indicates either a blown fuse (most likely) or a faulty relay.

Indicator 12: Flail Quick Start heater relay/fuse sense (yellow)
Indicates the state of the output from the fused Flail Quick Start relay output on the PDU. If this indicator is OFF while the corresponding output should be ON, this indicates either a blown fuse (most likely) or a faulty relay.
Note that this output only controls the Smart Relay, not the actual heater.

Indicator 13: Flail Starter Motor relay/fuse sense (yellow)
Indicates the state of the output from the fused Flail Starter Motor relay output on the PDU. If this indicator is OFF while the corresponding output should be ON, this indicates either a blown fuse (most likely) or a faulty relay.
Note that this output only controls the Smart Relay, not the actual Starter Motor.

Indicator 14: Flail Cooling Fan relay/fuse sense (yellow)
Indicates the state of the output from the fused Flail Cooling Fan relay output on the PDU. If this indicator is OFF while the corresponding output should be ON, this indicates either a blown fuse (most likely) or a faulty relay.

Indicator 15-20: Various unspecified input signals (yellow)
Not in use.

Indicator 21: Main Oil Temp Switch (yellow)
Obsolete – not in use.

Indicator 22: Main Oil Level Switch (yellow)
Normally ON. Signals low level in main hydraulic oil tank when light goes OFF.

Indicator 23: Main Oil Filter Switch (yellow)
Normally ON. Signals clogged oil filter in main hydraulic circuit when light goes OFF.

Indicator 24: Not in use (yellow)
No light.

Indicator 25: Main Air Filter Switch (yellow)
Normally ON. Signals clogged air filter on main engine when light goes OFF.

Indicator 26: Flail Oil Temp Switch (yellow)
Obsolete – not in use.

Indicator 27: Flail Oil Level Switch (yellow)
Normally ON. Signals low level in flail hydraulic oil tank when light goes OFF.

Indicator 28: Not in use (yellow)
No light.

Indicator 29: Flail cooling fan (green)
Signals active flail cooling fan when lit.

Indicator 30: Flail float bypass valve (green)
Signals open tilt cylinder bypass valve when lit.

Indicator 31: Extra cooling module – hydraulic fan valve (green)
Signals open valve for hydraulic cooling fan when lit

Indicator 32: Flail fuel valve (green)
Signals open flail engine fuel valve when lit.

Indicator 33: Flail engine starter motor (green)
Signals activation of flail engine starter motor when lit. This is a control signal to the DSR (smart relay) controlling the starter.

Indicator 34: Flail engine quick start (green)
Signals activation of flail engine quick start heater when lit. This is a control signal to the DSR (smart relay) controlling the quick start heater.

Indicator 35: Main fuel valve (green)
Signals open main engine fuel valve when lit.

Indicator 36: Main engine starter motor (green)

Signals activation of main engine starter motor when lit. This is a control signal to the DSR (smart relay) controlling the starter.

Indicator 37: Main engine glow plugs(green)
Signals activation of main engine glow plugs when lit. This is a control signal to the DSR (smart relay) controlling the glow plugs.

Indicator 38: Main alternator field supply (green)
Signals that power to the alternator field input is switched on.

Indicator 39: Actuator, Tacho and Sensor Power (green)
Signals that power to the actuators, tachometers and sensors has benne switched on.

Indicator 40: Park brake hold (green)
Signals release of park brake. Unless an optional park brake is fitted, this signal is not in use.

Indicator 41: Flail pump PWM output A (green)
Flail pump PWM control signal A (active during normal rotation). This signal is a proportional signal going between dark and medium intensity in small steps during FLAIL START/STOP in normal direction. OFF while in reverse direction

Indicator 42: Flail pump PWM output B (green)
Flail pump PWM control signal B (active during reverse rotation). This signal is a proportional signal going between dark and medium intensity in small steps during FLAIL START/STOP in reverse direction. OFF while in normal direction.

Indicator 43: Not in use (green)
No light.

Indicator 44: Not in use (green)
No light.

9.5 PDU fault finding

The PDU is the unit distributing power to all major components. The CTU and IFU get their power supply through separate fuses and in addition, most power consuming devices are supplied from relays and fuses in the PDU. The relays are in turn controlled by outputs on the IFU which then has to supply only the control current for the relay and not the total load current.

On the new upgraded systems, the most power consuming devices such as starter motors and glow plugs are also supplied from local electronic smart relays (DSR) mounted close to the starter motor on each engine. This ensures as short power wiring as possible and hence as little voltage loss as possible during high load situations such as glowing and starter motor engagement.

In case of function failure possibly caused by fuse or relay fail in the PDU, first check the fuse according to the fuse list. If the fuse seems OK, measure the voltage at the relay output to verify that the rely is functioning properly. See the PDU internal wiring schematic for additional information on this issue. If the voltage is present at the relay output and the internal wiring looks OK, check the voltage on the device side of the cable harness. If there is voltage present at the connector, but still no reaction, it might be a bad connection inside the connector or a faulty device.

First disconnect the connector on the device and measure the resistance between device pins. For valves, this should be a value of typically less than 10 ohm.

If there is voltage at the relay output, but not at the device, disconnect all connectors in the cable harness and clean the affected pins. Also look for external damage to the cable harness.

10. Technical Specifications

10.1 Control Unit (CTU) – Technical data

The control Unit is delivered ready to be fitted on a shock-absorbing mounting plate. Shock absorbing devices is not included with the unit. The Unit has circular contacts that mate with the contacts on the cable harness.
It has a separate connector for the OPU cable and an TNC connector for the antenna cable.

Size:	width:	230mm
	depth:	110mm
	height including contacts:	370mm

Weight: approx. 4.kg

Ambient Temp.: -25 to +60 ºC.

Environmental protection: IP65 with mated connectors

The Control Unit, part.no. NOV-2000, includes the control unit cabinet itself and one of each of the listed accessories.

Part numbers

Control Unit cabinet, complete	NOV-2000
Accessories:	
4m antenna cable with FME chassis mount and TNC-conn.	NOV-6000
1/4 wave antenna whip with FME-connector	NOV-6001

10.2 Interface Unit (IFU) – Technical data

The Interface Unit is delivered ready to be fitted on a shock-absorbing mounting plate. Shock absorbing devices is not included with the unit. The Unit has circular contacts that mate with the contacts on the cable harness.

Size:	width:	230mm
	depth:	110mm
	height including contacts:	350mm

Weight: approx. 4.kg

Ambient Temp.: -25 to +60 ºC.

Environmental protection: IP65 with mated connectors

Part numbers

Interface Unit cabinet, complete	NOV-3000

10.3 Power Distribution Unit (PDU) – Technical data

The Interface Unit is delivered ready to be fitted on a shock-absorbing mounting plate. Shock absorbing devices is not included with the unit. The Unit has circular contacts that mate with the contacts on the cable harness.

Size:	width including contacts:	290mm
	depth:	110mm
	height including contacts:	185mm

Weight: approx. 3.5 kg

Ambient Temp.: -25 to +60 ºC.

Environmental protection: IP65 with mated connectors

Part numbers

Power Distribution Unit cabinet, complete	NOV-4000

10.4 DSR – Technical Specifications

The Dual Smart relay is delivered as a compact, epoxy filled and maintenance free unit.
The DSR has two independent, short circuit proof outputs, one with a nominal rating of 70A intended for starter engine control and one with a nominal rating og 140A, intended for glow plugs.
One yellow (red/green) LED indicates when power is present, while two bicolour LED's indicate the Smart Relay state on either channel.
Yellow indicates a healthy activated output. It should be either yellow or off.
Red indicates an activated output that has been switched off by protection circuitry or an output that has been damaged. It gives no output voltage!
Green indicates a deactivated output which has voltage present at the output. Despite the fact that the light is green, it is not a normal situation.

Size:	DSR width including brackets:	77 mm
	DSR depth (cables not included):	50 mm
	DSR height:	30 mm
	Length of control cable (DSR to plug):	250 mm
	Length of plug:	45 mm
	Length of supply wire (red 6 mm^2):	900 mm
	Length of ground wire (black 2.5 mm^2):	900 mm
	Length of starter wire (l.blue 4 mm^2):	900 mm
	Length of glow wire (brown 6 mm^2):	1900 mm
Weight:	DSR with cables:	0.5 kg
Supply voltage:	8 – 18 VDC	
Output current:	Starter motor, nominal load:	max. 70A
	Starter motor, short circuit trip current:	65-180A
	Glow plugs, nominal load:	max. 140A
	Glow plugs, short circuit trip current:	130-360A
Activation time:	Recommended under nominal load:	max. 15 s.
Protection:	Overvoltage protection	
	Overcurrent protection	
	Overtemperature protection	
Ambient Temp.:	-40 to +85 ºC.	
Environmental protection:	IP65, epoxy filled housing.	
Part number:		NOV-4050

11. Spare Parts List

11.1 CTU – Spare Parts List

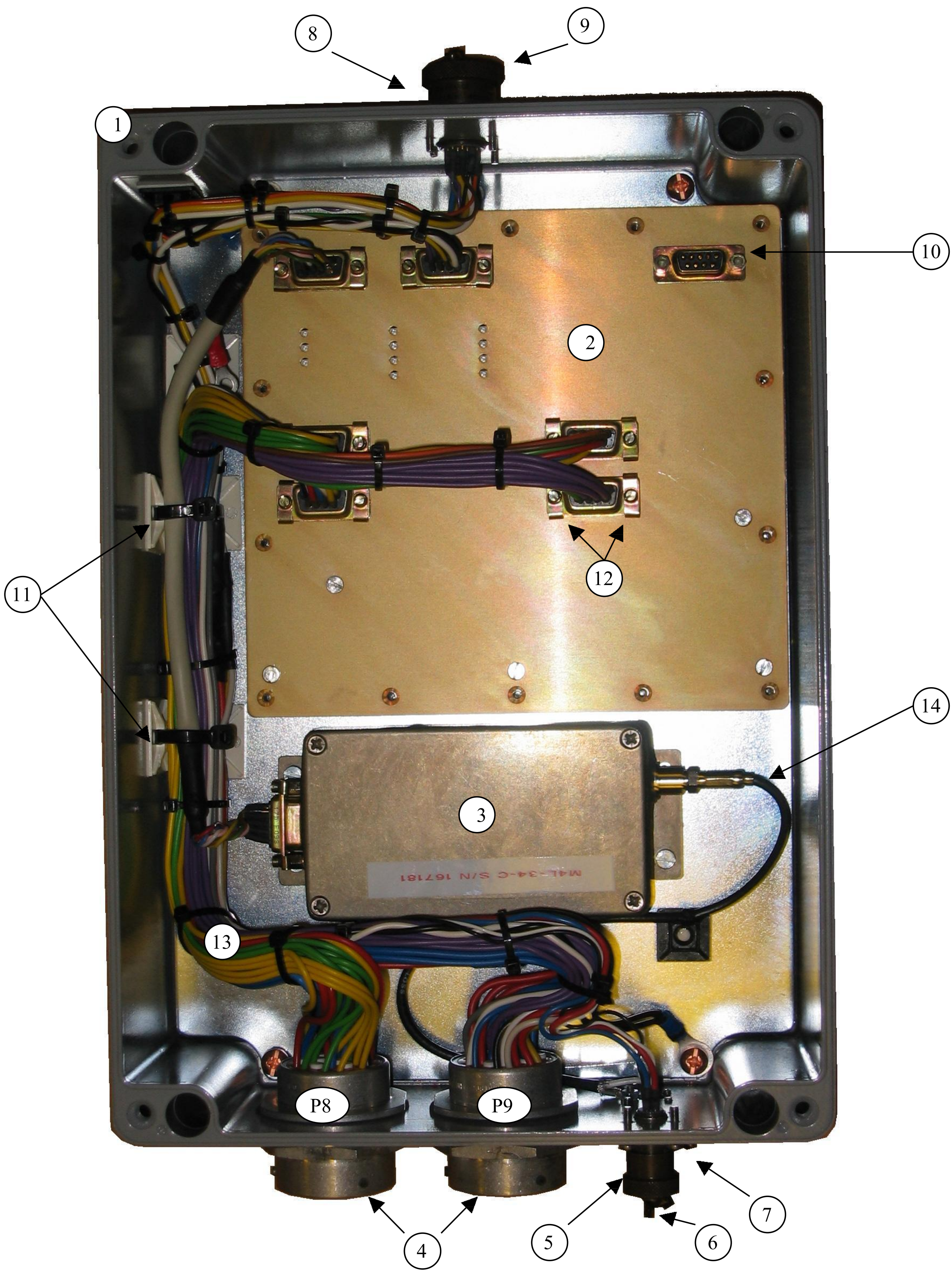
The following items may be supplied as standard spare parts for local replacement.

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 CTU Electronics Module and Radio Modem Module.

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 Control Unit	1	NOV-2000
2	CTU Electronics module	1	NOV-2010
3	Radio Modem Unit (specify version)	1	NOV-5050
4	Circular chassis connector – 31 pin - female	1	NOV-5010
5	Circular chassis connector – 4pin – female	1	NOV-5013
6	Dust cap for umbilical connector	1	NOV-5020
7	TNC chassis connector - solder	1	NOV-5014
8	Circular chassis connector – 10pin – female	1	NOV-5015
9	Dust cap for 10pin connector	1	NOV-5021
10	Programming socket cap	1	NOV-5030
11	Cable ties and pad set	1	NOV-2021
12	DSUB locking screw set	12	NOV-5031
13	CTU Internal wiring	1	NOV-2020
14	CTU internal coaxial cable	1	NOV-2022
15	Voltage stabilizer module	1	NOV-5040

11.1.1 CTU – Control Unit - Spare Part Assembly



Picture 2: CTU - Control Unit – internal view

11.2 IFU – Interface Unit - Spare Parts List

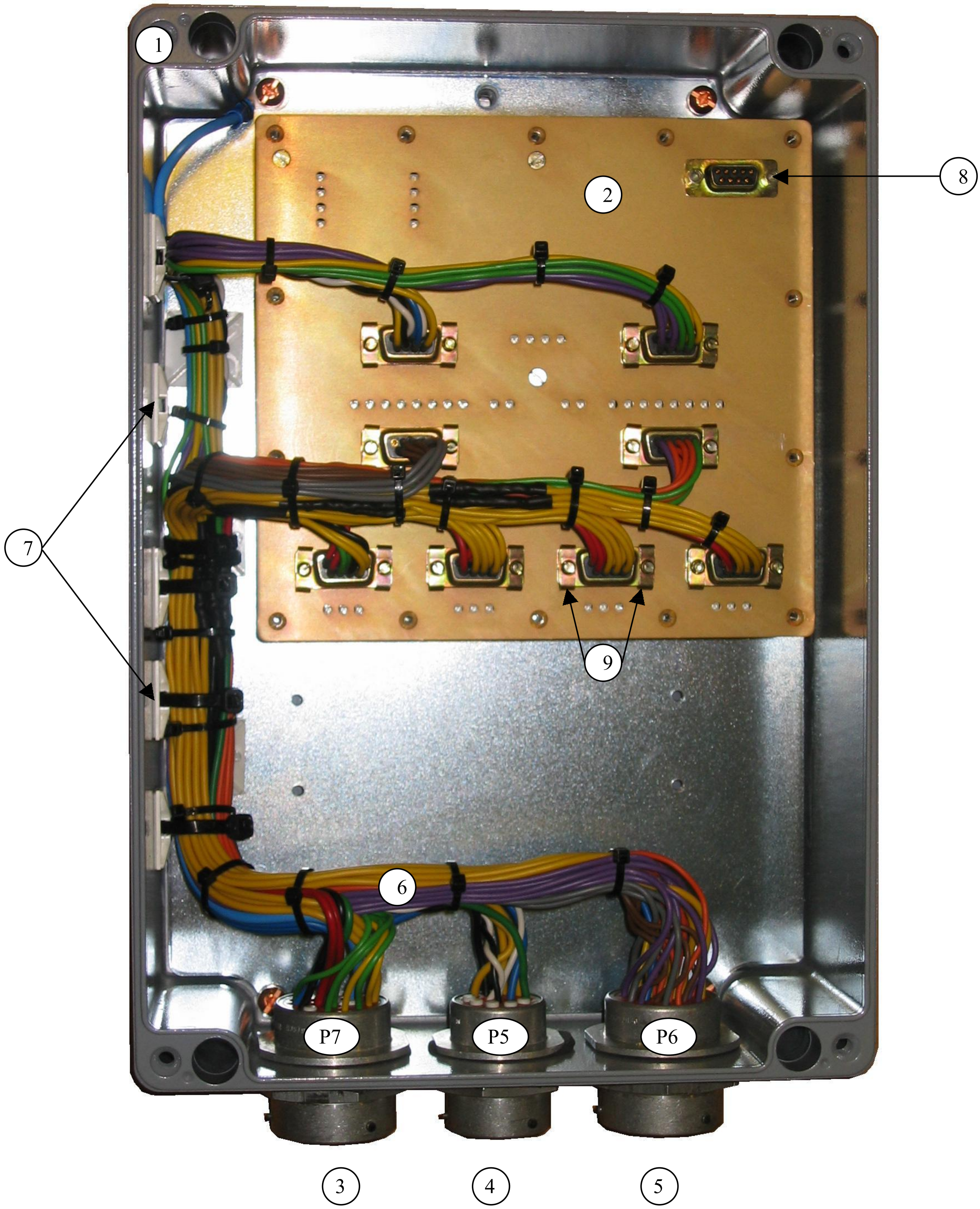
The following items may be supplied as standard spare parts for local replacement.

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 IFU Electronics Module.

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 Interface Unit	1	NOV-3000
2	IFU Electronics module (specify version)	1	NOV-3010
3	Circular chassis connector – 21 pin - female	1	NOV-5011
4	Circular chassis connector – 14 pin - female	1	NOV-5012
5	Circular chassis connector – 31 pin - female	1	NOV-5010
6	IFU Internal Wiring	1	NOV-3020
7	Cable ties and pad set	1	NOV-3021
8	Programming socket cap	1	NOV-5030
9	DSUB locking screw	16	NOV-5031
10	Voltage stabilizer module	1	NOV-5040

11.2.1 IFU – Interface Unit - Spare Part Assembly



Picture 3: IFU - Interface Unit – internal view

11.3 PDU & DSR – Power Distribution Unit with DSR - Spare Parts List

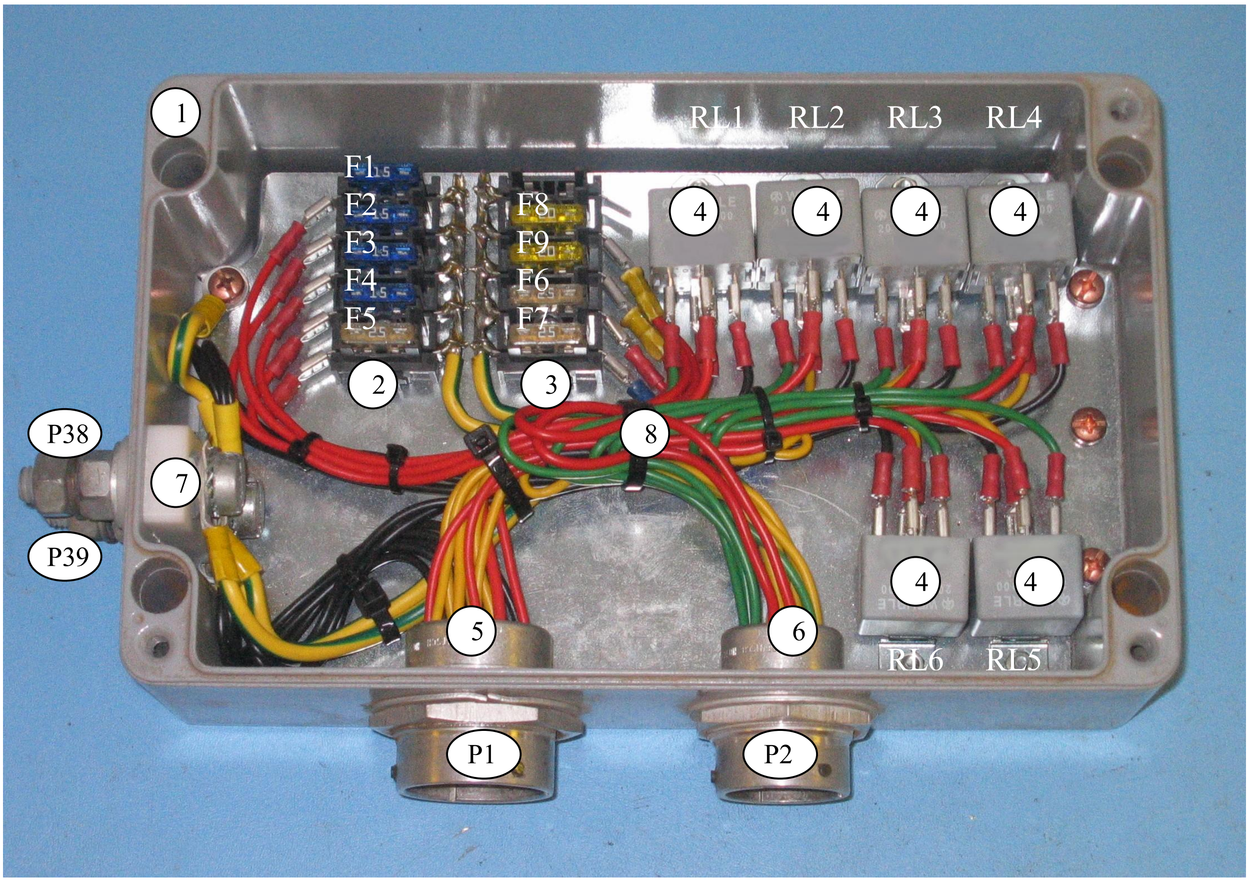
The following items may be supplied as standard spare parts for local replacement.

Parts not listed is normally not available as spare parts.

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.

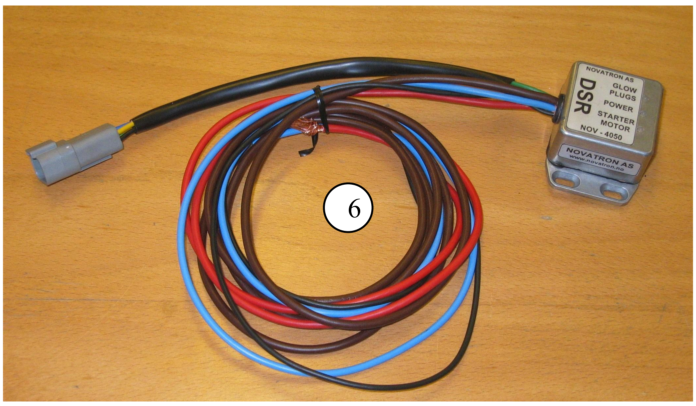
Part	Part description	Number of Items	Part number
1	Complete Power Distribution Unit	1	NOV-4000
2	Fuse holder with right rail	1	NOV-4010
3	Fuse holder with left rail	1	NOV-4011
4	Relay, 12V/30-40A	6	NOV-4012
5	Circular chassis connector – 21 pin - female	1	NOV-5011
6	Circular chassis connector – 14 pin - female	1	NOV-5012
7	POM feedthrough w/accessories	1	NOV-4013
8	PDU internal wiring	1	NOV-4014
9	DSR - Dual Smart Relay	2	NOV-4050

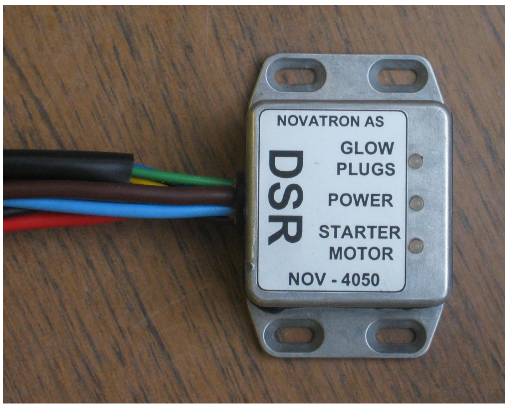
11.3.1 PDU – Power Distribution Unit - Spare Part Assembly



Picture 4: Power Distribution Unit

11.3.2 DSR – Dual Smart Relay





Picture 5: DSR - Dual Smart Relay

Picture 6: DSR - Dual Smart Relay

11.4 Voltage stabilizer module

Picture 7: Voltage stabilizer module

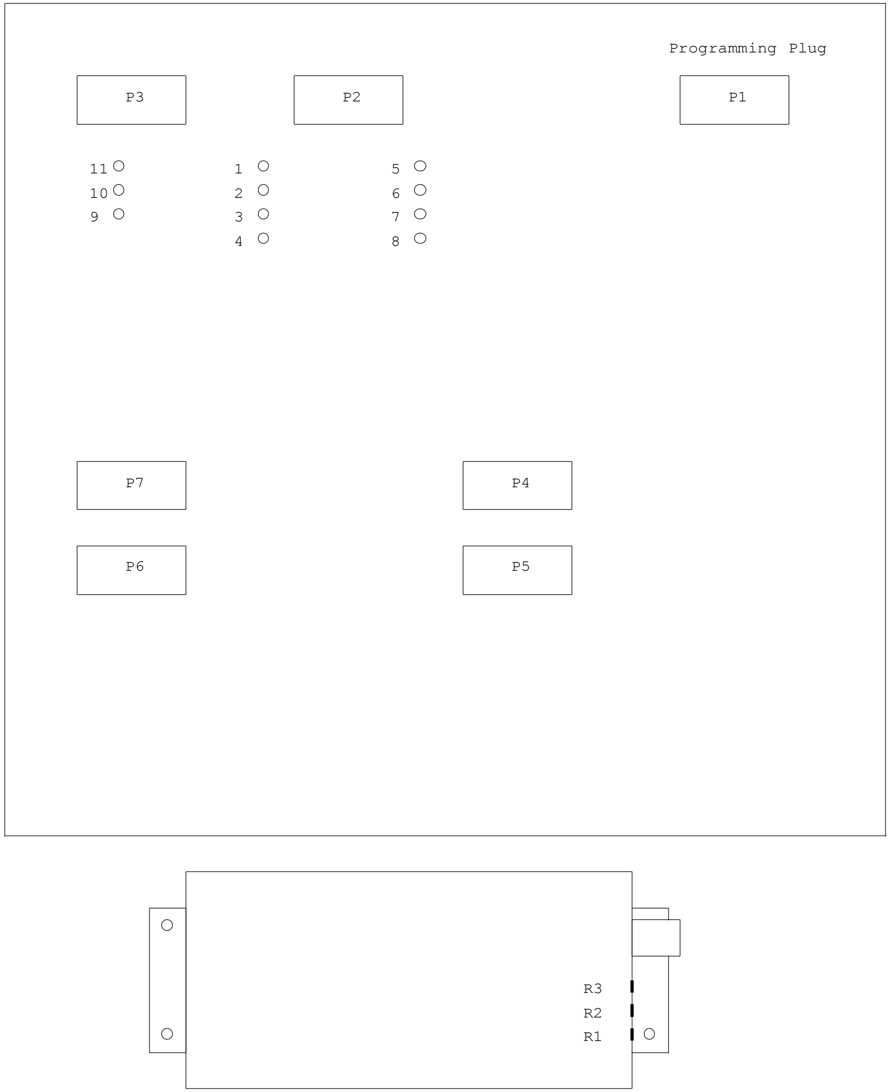
This module act as a battery and stores energy to supply the electronic modules in the CTU and IFU during low voltage situations.

Without a voltage stabilizer, starting the main engine in cold climates or with a poorly charged battery can be a problem. When the starter motor is engaged and starts turning the engine, the current consumption is so high that the battery voltage may drop down to a level where the control electronics may stop operating and the program execution be restarted. This happens at a voltage between 5.5 and 6.0V. The phenomena is easily recognised as the program restarts and displays the version number on every attempt to start the engine. The starter will only turn for a fraction of a second before it stops again.

By allowing the system 15-30 seconds to recharge after turning on the main switch, maximum energy is achieved. The system will then be able to handle drops below critical level for a few hundred ms, enough time for the starter and engine to gain speed and reducing the battery load current below the level where the battery can maintain an acceptable voltage.

In cold climates, it can be a good idea to first let the glowing be active for the programmed 8 seconds and turn off automatically. By waiting additional 5 –7 seconds before engaging the starter, the voltage may be able to build up again after the drop caused by the 100A glow current. This may again give the system enough energy to survive starting drops of more than 1 second when the starter is engaged.

Control Unit - Electronics Module



LED No.	Colour	Description
1	Green	Main processor running
2	Red	Transmitting to Operator Panel Unit
3	Yellow	Receiving from Operator Panel Unit
4	Red	Retransmitting message to Operator Panel Unit
5	Yellow	Radio Communication Selected (no current sense)
6	Yellow	Communicating with IFU
7	Yellow	Receiving RPM data from RPM processor
8	Yellow	Spare
9	Yellow	Receiving RPM signal from Flail Engine (Perkins)
10	Yellow	Receiving RPM signal from Main Engine (Deutz)
11	Green	RPM processor running
R1	Green	Radio Modem power
R3	Yellow	Radio Modem receiving
R2	Red	Radio Modem transmitting

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Title	Minecat-Control Unit-Electronic Module	
Size: A3	Document Number: NOV-2004-002	Rev: 3
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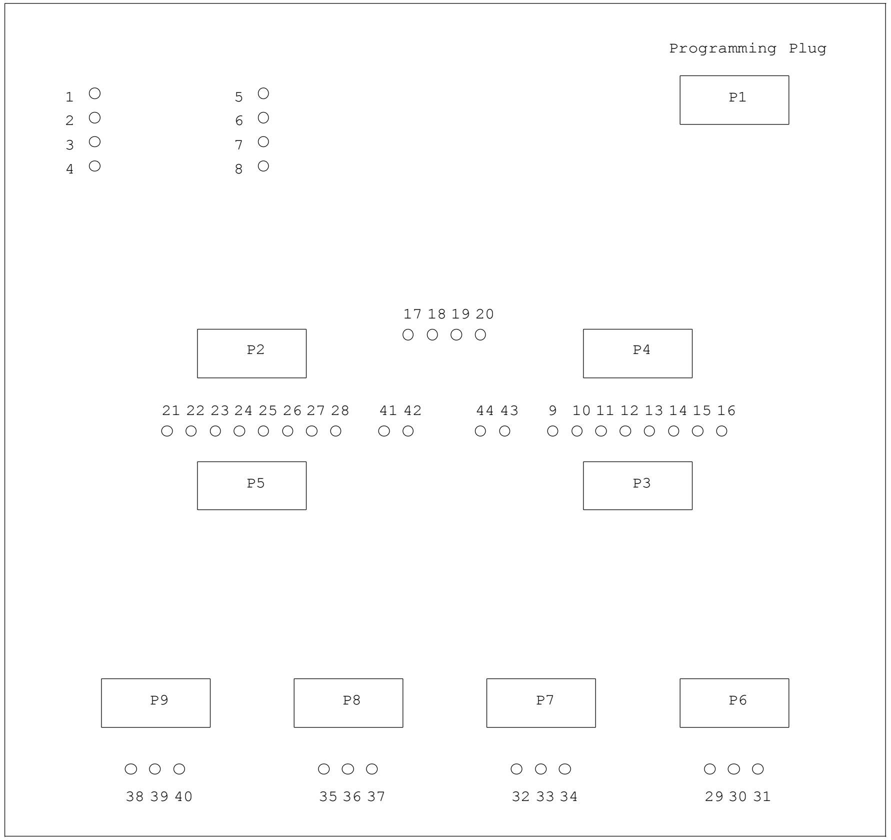
Interface Unit - Electronics Module



LED No.	Colour	Description
1	Green	Processor running
2	Yellow	Communicating with CTU
3	Yellow	Detecting valid sense on channel 1
4	Yellow	Detecting valid sense on channel 2
5	Red	Relay or fuse fail (PDU)
6	Red	Digital output fail (IFU)
7	Red	Actuator fail
8	Yellow	Spare
9	Yellow	Spare (DI7)
10	Yellow	Spare (DI6)
11	Yellow	Spare (DI5)
12	Yellow	Spare (DI4)
13	Yellow	Spare (DI3)
14	Yellow	Spare (DI2)
15	Yellow	Spare (DI1)
16	Yellow	Spare (DI0)
17	Yellow	Spare (DI12)
18	Yellow	Spare (DI11)
19	Yellow	Spare (DI10)
20	Yellow	Spare (DI19)
21	Yellow	Main Oil Temp switch
22	Yellow	Main Oil Level switch
23	Yellow	Main Oil Filter switch
24	Yellow	Spare (DIS4)
25	Yellow	Deutz Air Filter Switch
26	Yellow	Flail Oil Temp switch
27	Yellow	Flail Oil Level switch
28	Yellow	Spare (DIS0)
29	Green	Flail Cooling Fan
30	Green	Flail Float Bypass Valve
31	Green	Extra Hydraulic Valve
32	Green	Perkins Diesel Valve
33	Green	Perkins Starter Motor
34	Green	Perkins Quick Start
35	Green	Deutz Diesel Valve
36	Green	Deutz Starter Motor
37	Green	Deutz Glow Plugs
38	Green	Deutz Generator Field Supply
39	Green	Actuator, Sensor and Tacho Power
40	Green	Park Brake Hold
41	Green	Flail Pump PWM Output A (normal rotation)
42	Green	Flail Pump PWM Output B (reverse rotation)
43	Yellow	Spare (DI13)
44	Yellow	Spare (DI18)

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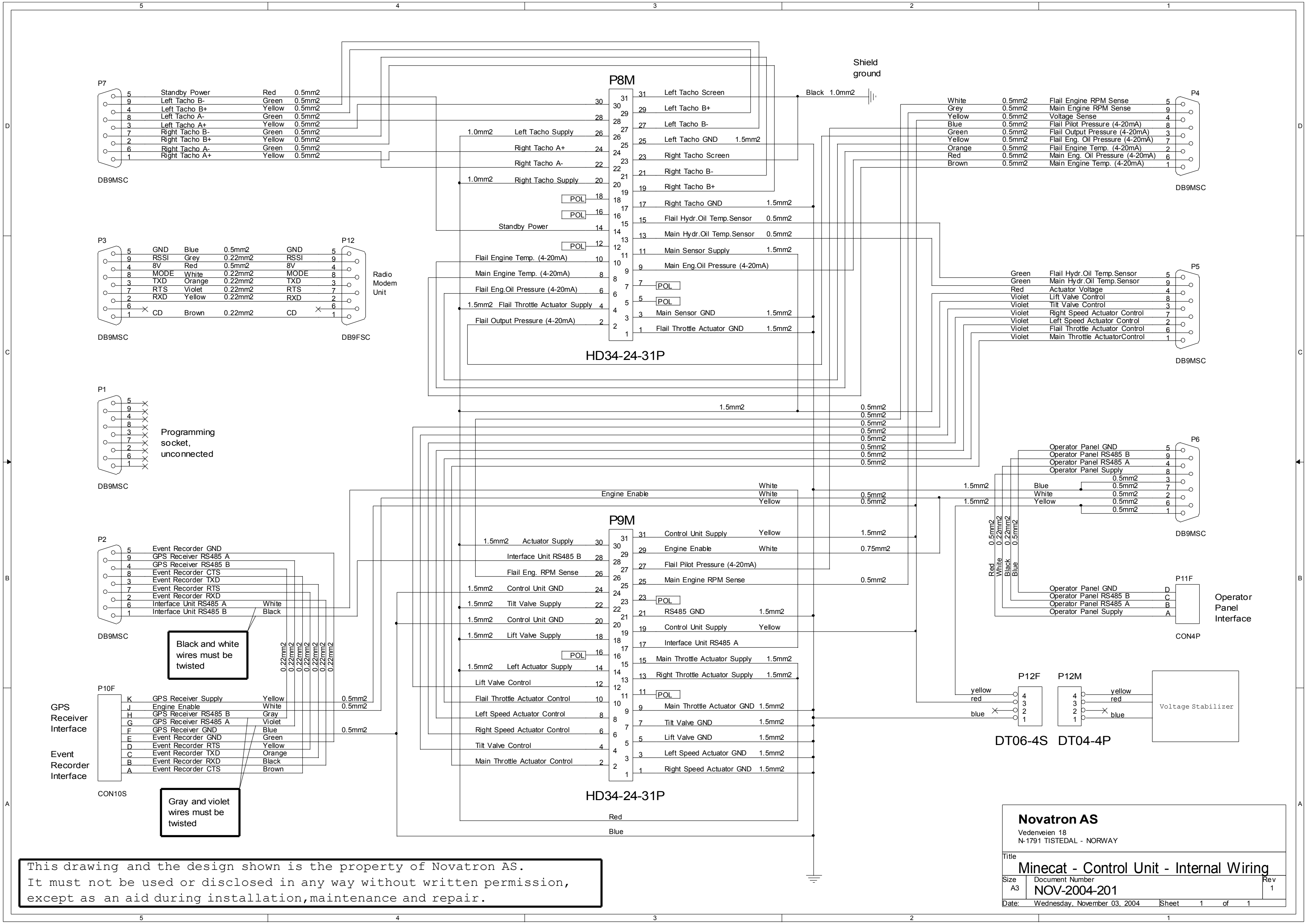
Title: Minecat-InterfaceUnit-ElectronicModule
Size: A3 | Document Number: NOV-2004-003 | Rev: 3
Date: Wednesday, August 04, 2004 | Sheet 1 of 1


P7
DB9MSC
Standby Power Red 0.5mm2
Left Tacho B- Green 0.5mm2
Left Tacho B+ Yellow 0.5mm2
Left Tacho A- Green 0.5mm2
Left Tacho A+ Yellow 0.5mm2
Right Tacho B- Green 0.5mm2
Right Tacho B+ Yellow 0.5mm2
Right Tacho A- Green 0.5mm2
Right Tacho A+ Yellow 0.5mm2
P8M
HD34-24-31P
Left Tacho Supply
Right Tacho A+
Right Tacho A-
Right Tacho Supply
Standby Power
POL
Flail Engine Temp. (4-20mA)
Main Engine Temp. (4-20mA)
Flail Eng.Oil Pressure (4-20mA)
Flail Throttle Actuator Supply
Flail Output Pressure (4-20mA)
Left Tacho Screen
Left Tacho B+
Left Tacho B-
Left Tacho GND
Right Tacho Screen
Right Tacho B-
Right Tacho B+
Right Tacho GND
Flail Hydr.Oil Temp.Sensor
Main Hydr.Oil Temp.Sensor
Main Sensor Supply
Main Eng.Oil Pressure (4-20mA)
Main Sensor GND
Flail Throttle Actuator GND
Shield ground
Black 1.0mm2
P4
DB9MSC
White 0.5mm2 Flail Engine RPM Sense
Grey 0.5mm2 Main Engine RPM Sense
Yellow 0.5mm2 Voltage Sense
Blue 0.5mm2 Flail Pilot Pressure (4-20mA)
Green 0.5mm2 Flail Output Pressure (4-20mA)
Yellow 0.5mm2 Flail Eng. Oil Pressure (4-20mA)
Orange 0.5mm2 Flail Engine Temp. (4-20mA)
Red 0.5mm2 Main Eng. Oil Pressure (4-20mA)
Brown 0.5mm2 Main Engine Temp. (4-20mA)
P3
DB9MSC
P12
DB9FSC
GND Blue 0.5mm2 GND
RSSI Grey 0.22mm2 RSSI
8V Red 0.5mm2 8V
MODE White 0.22mm2 MODE
TXD Orange 0.22mm2 TXD
RTS Violet 0.22mm2 RTS
RXD Yellow 0.22mm2 RXD
CD Brown 0.22mm2 CD
Radio Modem Unit
P5
DB9MSC
Green Flail Hydr.Oil Temp.Sensor
Green Main Hydr.Oil Temp.Sensor
Red Actuator Voltage
Violet Lift Valve Control
Violet Tilt Valve Control
Violet Right Speed Actuator Control
Violet Left Speed Actuator Control
Violet Flail Throttle Actuator Control
Violet Main Throttle ActuatorControl
P1
DB9MSC
Programming socket, unconnected
P6
DB9MSC
Operator Panel GND
Operator Panel RS485 B
Operator Panel RS485 A
Operator Panel Supply
Engine Enable
P9M
HD34-24-31P
Actuator Supply
Interface Unit RS485 B
Flail Eng. RPM Sense
Control Unit GND
Tilt Valve Supply
Lift Valve Supply
Left Actuator Supply
Lift Valve Control
Flail Throttle Actuator Control
Left Speed Actuator Control
Right Speed Actuator Control
Tilt Valve Control
Main Throttle Actuator Control
Control Unit Supply
Engine Enable
Flail Pilot Pressure (4-20mA)
Main Engine RPM Sense
RS485 GND
Interface Unit RS485 A
Main Throttle Actuator Supply
Right Throttle Actuator Supply
Main Throttle Actuator GND
Tilt Valve GND
Lift Valve GND
Left Speed Actuator GND
Right Speed Actuator GND
Red
Blue
P2
DB9MSC
Event Recorder GND
GPS Receiver RS485 A
GPS Receiver RS485 B
Event Recorder CTS
Event Recorder TXD
Event Recorder RTS
Event Recorder RXD
Interface Unit RS485 A White
Interface Unit RS485 B Black
Black and white wires must be twisted
P10F
CON10S
GPS Receiver Interface
Event Recorder Interface
GPS Receiver Supply Yellow
Engine Enable White
GPS Receiver RS485 B Gray
GPS Receiver RS485 A Violet
GPS Receiver GND Blue
Event Recorder GND Green
Event Recorder RTS Yellow
Event Recorder TXD Orange
Event Recorder RXD Black
Event Recorder CTS Brown
Gray and violet wires must be twisted
P11F
CON4P
Operator Panel Interface
P12F
P12M
DT06-4S
DT04-4P
yellow
red
blue
Voltage Stabilizer
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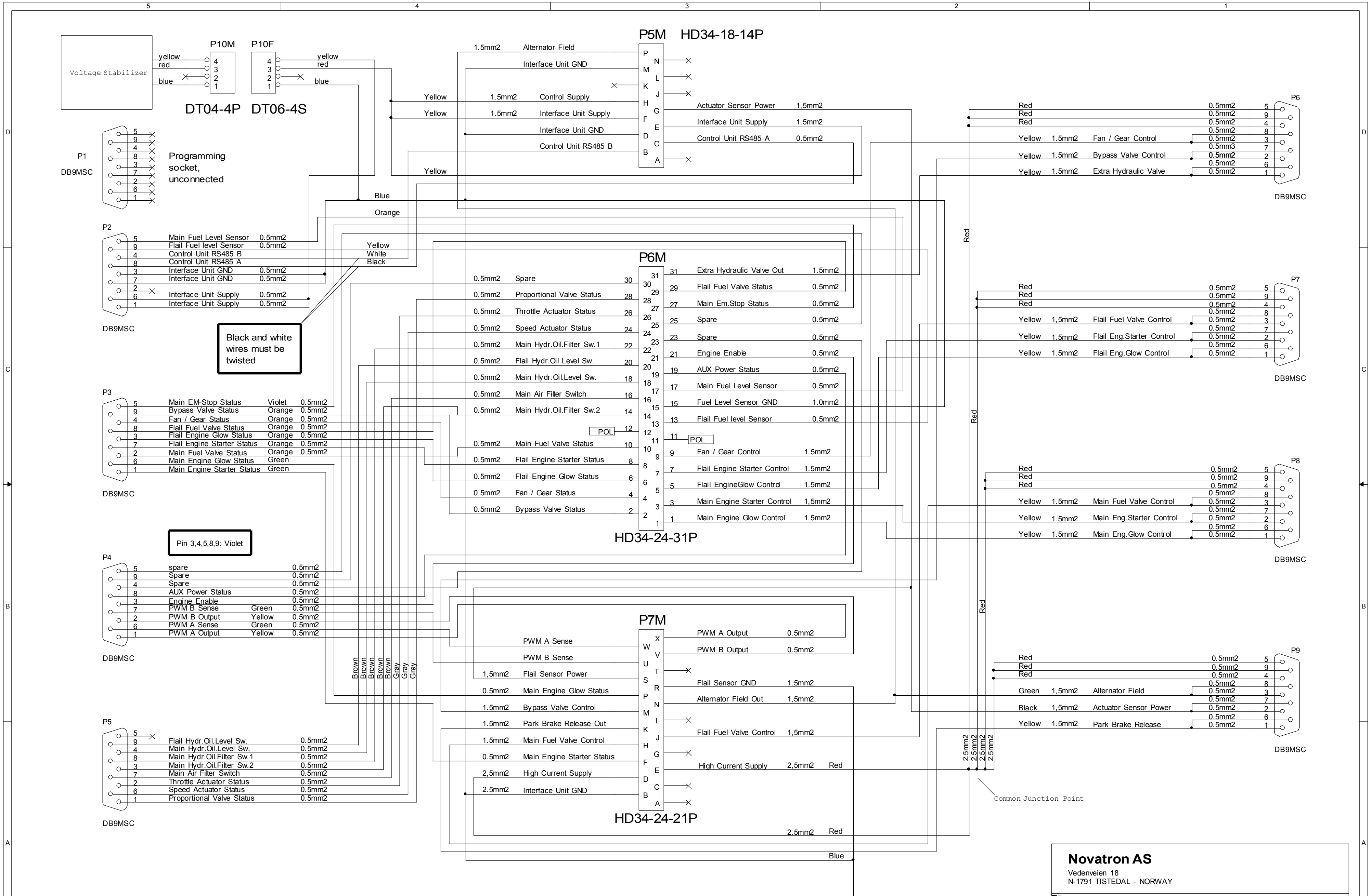
Novatron AS
Vedenveien 18
N-1791 TISTEDAL - NORWAY
Title
Minecat - Control Unit - Internal Wiring
Size A3
Document Number NOV-2004-201
Rev 1
Date: Wednesday, November 03, 2004
Sheet 1 of 1



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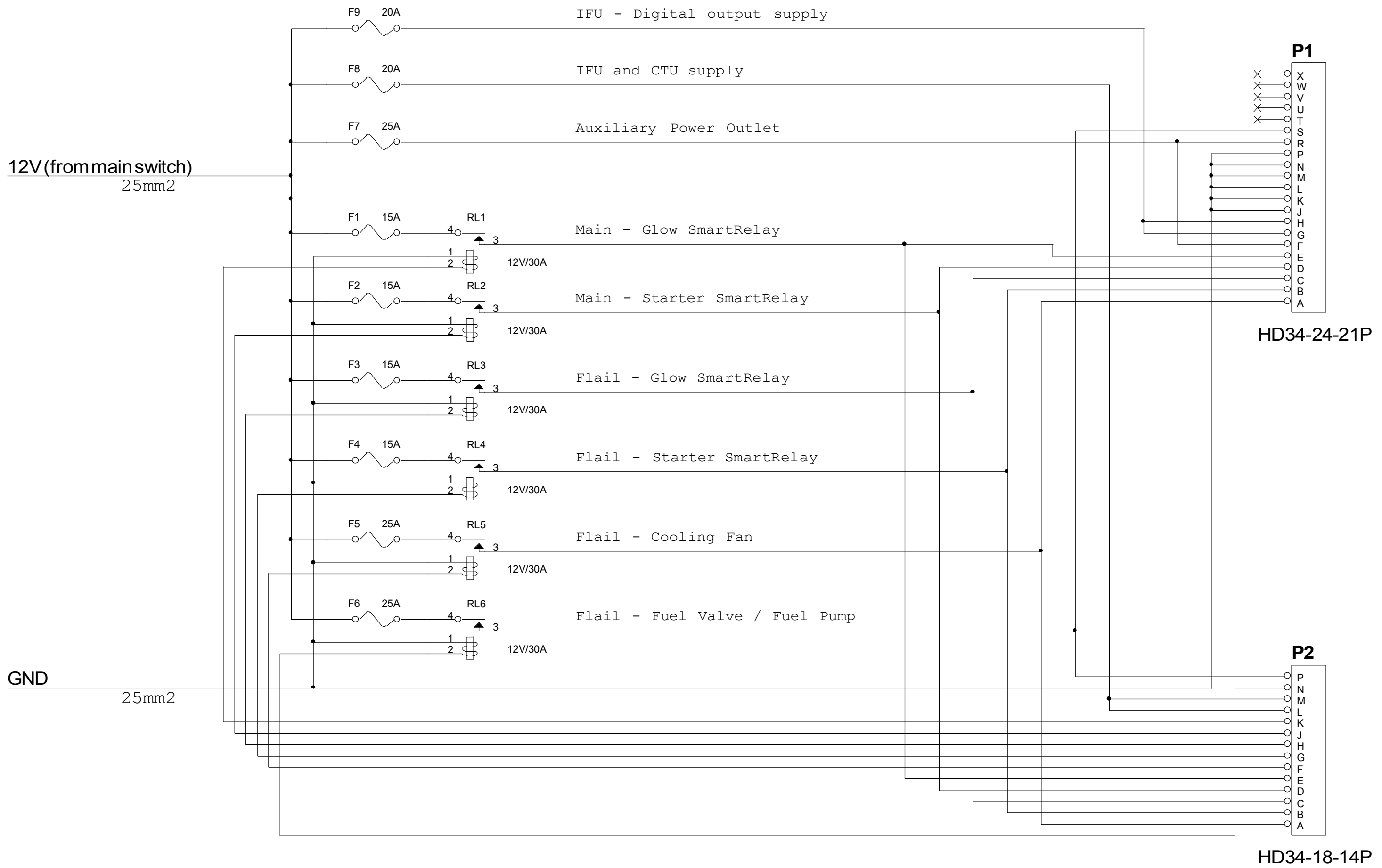
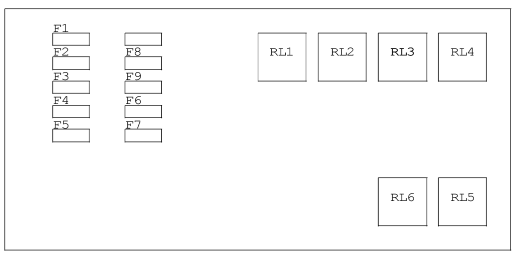
Novatron AS
Vedenveien 18
N-1791 TISTEDAL - NORWAY

Title	Minecat - Interface Unit - Internal Wiring
Size	A3
Document Number	NOV-2004-211
Rev	1
Date:	Wednesday, November 03, 2004
Sheet	1 of 1



Fuse and Relay Panel Layout (Serial No.: 2001)



F1	15A	Main - Glow SmartRelay			
F2	15A	Main - Starter Smart Relay	F8	20A	IFU and CTU controller supply
F3	15A	Flail - Glow SmartRelay	F9	20A	IFU digital output supply
F4	15A	Flail - Starter SmartRelay	F6	25A	Flail - Fuel Valve
F5	25A	Flail - Cooling Fan	F7	25A	Auxiliary Power Outlet

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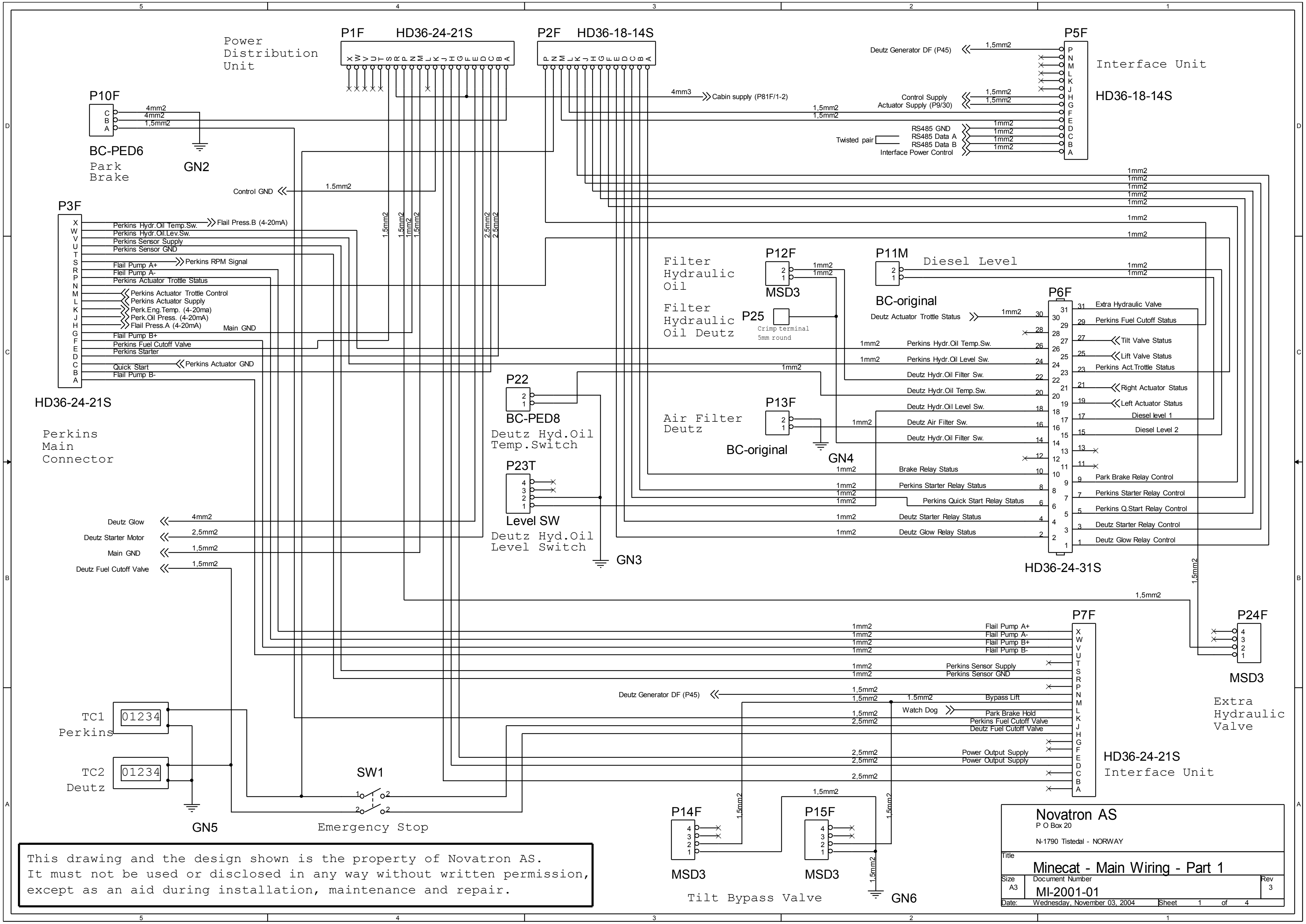
N-1791 Tistedal - NORWAY

Title: Minecat - Power Distribution Unit

Size: A3 | Document Number: MI-00-11 | Rev: 7

Date: Thursday, October 14, 2004 | Sheet 1 of 1



Power Distribution Unit
P1F HD36-24-21S
P2F HD36-18-14S
P5F
Interface Unit
HD36-18-14S
Deutz Generator DF (P45)
Cabin supply (P81F/1-2)
Control Supply
Actuator Supply (P9/30)
RS485 GND
RS485 Data A
RS485 Data B
Interface Power Control
Twisted pair
P10F
BC-PED6
Park Brake
GN2
Control GND
P3F
Perkins Hydr.Oil Temp.Sw.
Flail Press.B (4-20mA)
Perkins Hydr.Oil.Lev.Sw.
Perkins Sensor Supply
Perkins Sensor GND
Perkins RPM Signal
Flail Pump A+
Fleil Pump A-
Perkins Actuator Trottle Status
Perkins Actuator Trottle Control
Perkins Actuator Supply
Perk.Eng.Temp. (4-20ma)
Perk.Oil Press. (4-20mA)
Flail Press.A (4-20mA)
Main GND
Flail Pump B+
Perkins Fuel Cutoff Valve
Perkins Starter
Quick Start
Perkins Actuator GND
Flail Pump B-
HD36-24-21S
Perkins Main Connector
Filter Hydraulic Oil
P12F
MSD3
Filter Hydraulic Oil Deutz
P25
Crimp terminal 5mm round
P11M
Diesel Level
BC-original
P6F
Deutz Actuator Trottle Status
Perkins Hydr.Oil Temp.Sw.
Perkins Hydr.Oil Level Sw.
Deutz Hydr.Oil Filter Sw.
Deutz Hydr.Oil Temp.Sw.
Deutz Hydr.Oil Level Sw.
Deutz Air Filter Sw.
Deutz Hydr.Oil Filter Sw.
Brake Relay Status
Perkins Starter Relay Status
Perkins Quick Start Relay Status
Deutz Starter Relay Status
Deutz Glow Relay Status
Extra Hydraulic Valve
Perkins Fuel Cutoff Status
Tilt Valve Status
Lift Valve Status
Perkins Act.Trottle Status
Right Actuator Status
Left Actuator Status
Diesel level 1
Diesel Level 2
Park Brake Relay Control
Perkins Starter Relay Control
Perkins Q.Start Relay Control
Deutz Starter Relay Control
Deutz Glow Relay Control
HD36-24-31S
P22
BC-PED8
Deutz Hyd.Oil Temp.Switch
P23T
Level SW
Deutz Hyd.Oil Level Switch
GN3
Air Filter Deutz
P13F
BC-original
GN4
Deutz Glow
Deutz Starter Motor
Main GND
Deutz Fuel Cutoff Valve
P7F
Flail Pump A+
Flail Pump A-
Flail Pump B+
Flail Pump B-
Perkins Sensor Supply
Perkins Sensor GND
Deutz Generator DF (P45)
Bypass Lift
Watch Dog
Park Brake Hold
Perkins Fuel Cutoff Valve
Deutz Fuel Cutoff Valve
Power Output Supply
Power Output Supply
HD36-24-21S
Interface Unit
P24F
MSD3
Extra Hydraulic Valve
TC1 Perkins
TC2 Deutz
01234
GN5
SW1
Emergency Stop
P14F
MSD3
P15F
MSD3
Tilt Bypass Valve
GN6
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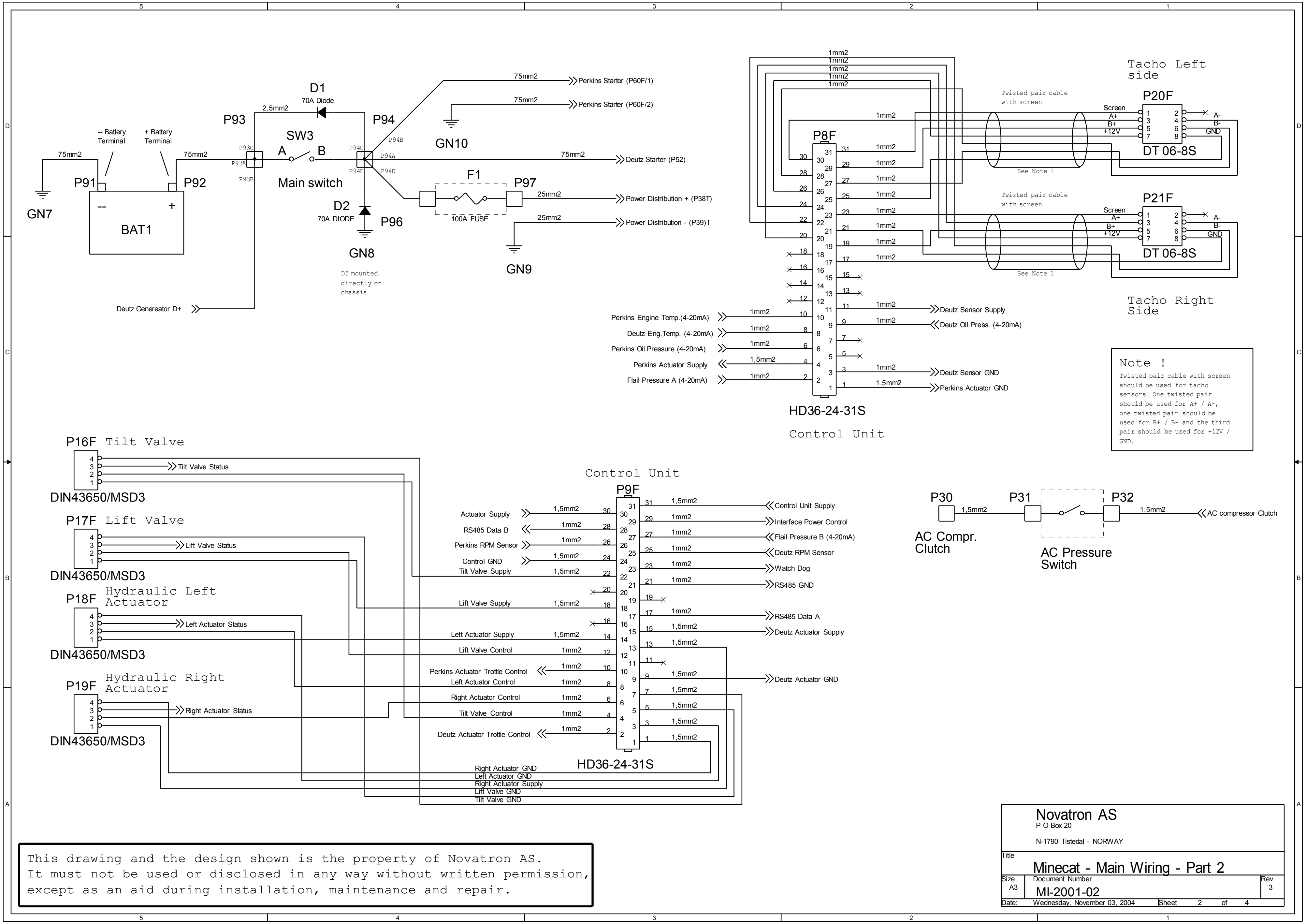
P O Box 20
N-1790 Tistedal - NORWAY
Title
Minecat - Main Wiring - Part 1
Size A3
Document Number MI-2001-01
Rev 3
Date: Wednesday, November 03, 2004
Sheet 1 of 4



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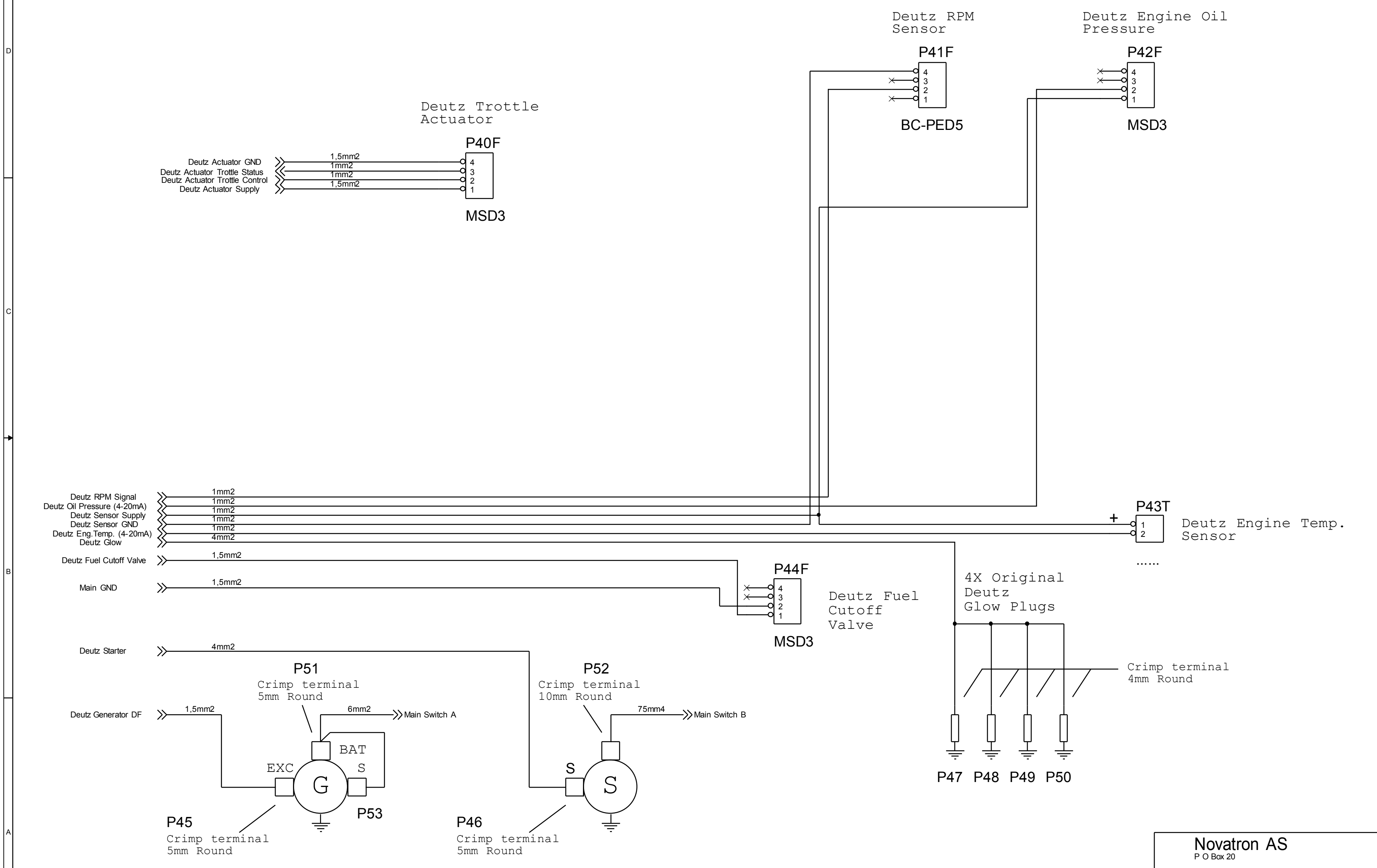

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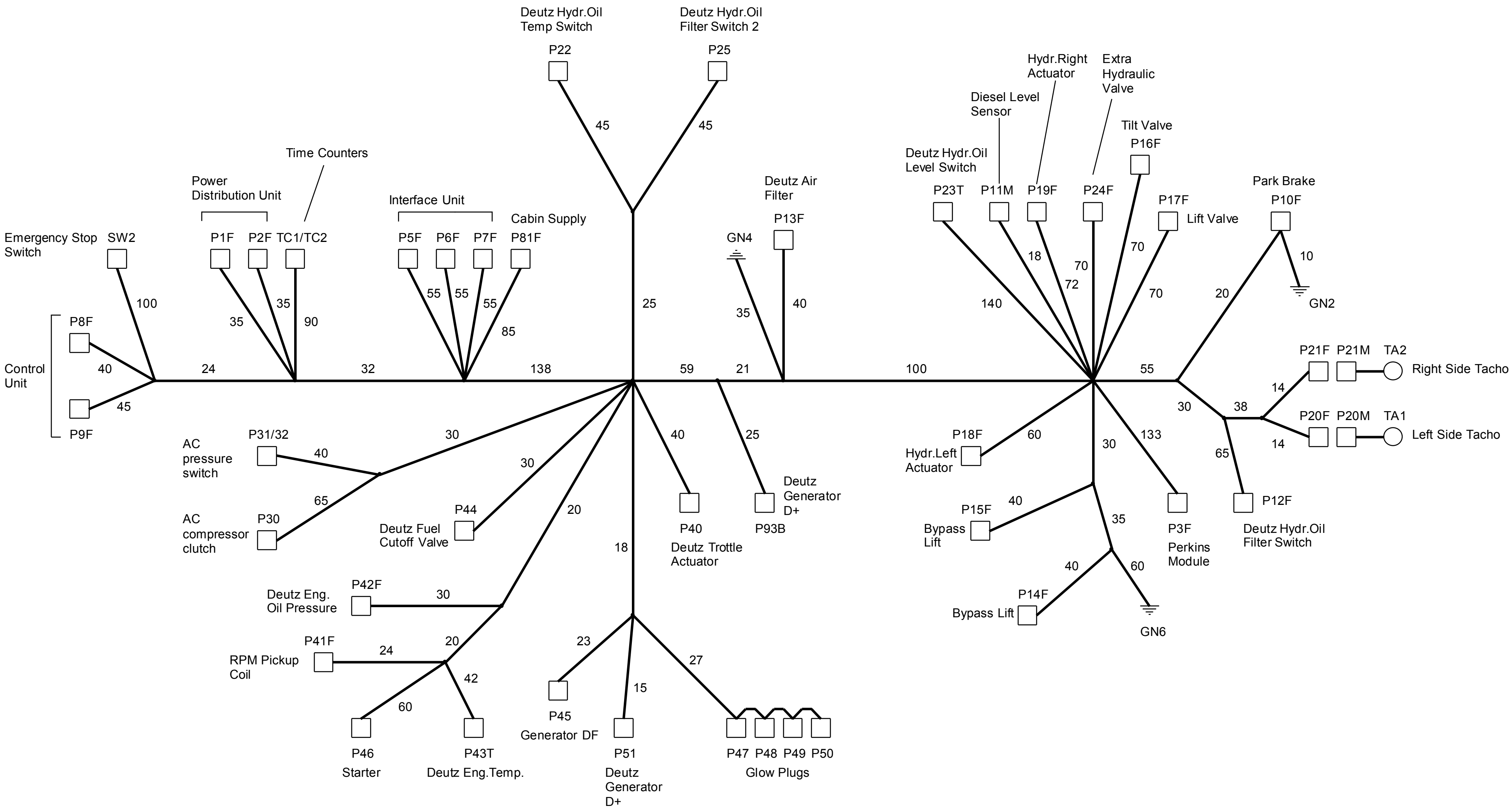
P O Box 20
N-1790 Tistedal - NORWAY

Title: Minecat - Main Wiring - Part 3

Size	Document Number	Rev
A3	MI-2001-03	3

Date: Wednesday, November 03, 2004 Sheet 3 of 4

All numbers indicate length between junctions measured in [cm].



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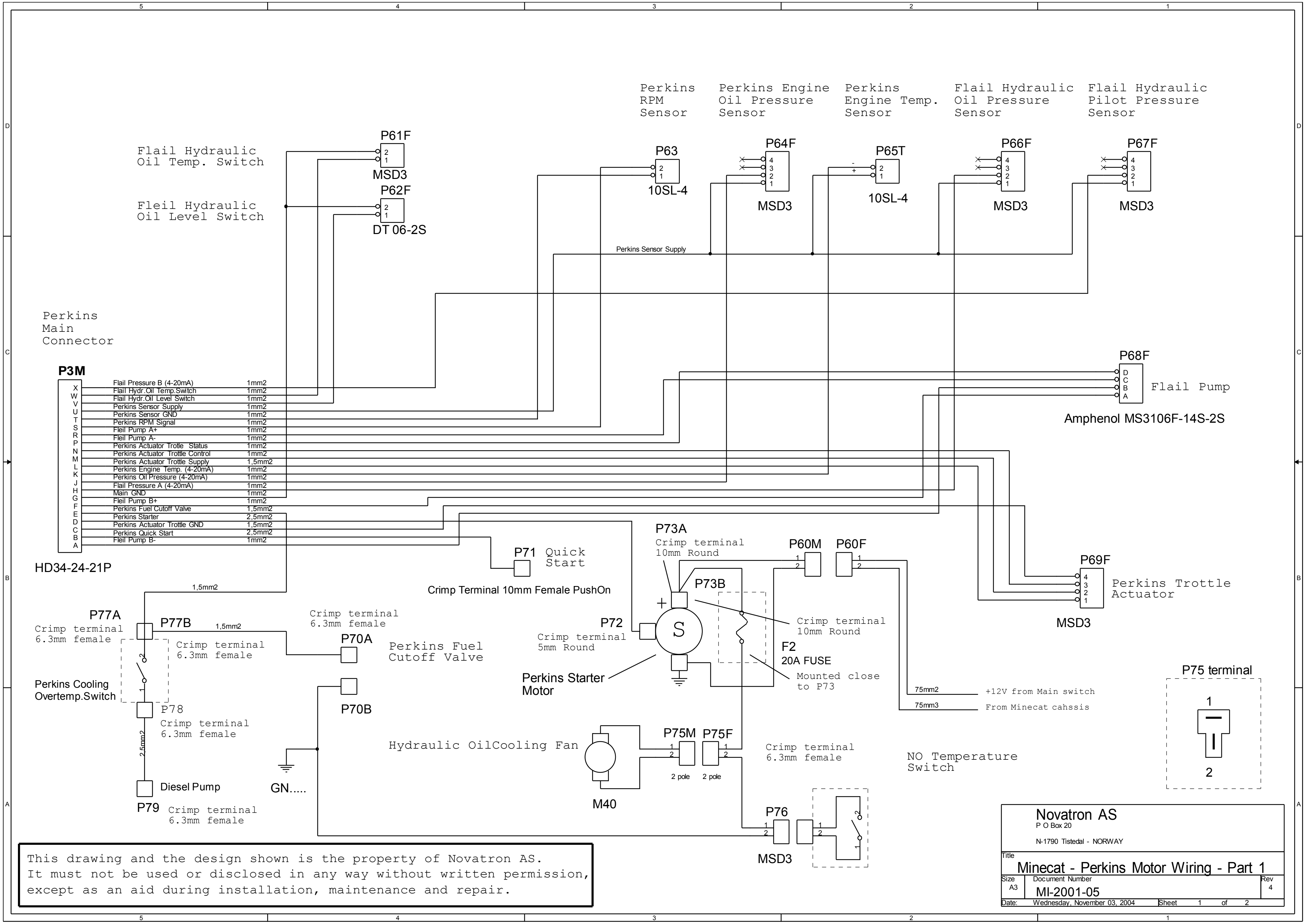
P O Box 20
N-1790 Tistedal - NORWAY

Title	Minecat - Main Wiring - Part 4		
Size A3	Document Number MI-2001-04		Rev 2
Date:	Wednesday, November 03, 2004	Sheet 4 of 4	


Perkins RPM Sensor
Perkins Engine Oil Pressure Sensor
Perkins Engine Temp. Sensor
Flail Hydraulic Oil Pressure Sensor
Flail Hydraulic Pilot Pressure Sensor
P61F
Flail Hydraulic Oil Temp. Switch
MSD3
P62F
Fleil Hydraulic Oil Level Switch
DT 06-2S
P63
10SL-4
P64F
MSD3
P65T
10SL-4
P66F
MSD3
P67F
MSD3
Perkins Sensor Supply
Perkins Main Connector
P3M
X Flail Pressure B (4-20mA) 1mm2
W Flail Hydr.Oil Temp.Switch 1mm2
V Flail Hydr.Oil Level Switch 1mm2
U Perkins Sensor Supply 1mm2
T Perkins Sensor GND 1mm2
S Perkins RPM Signal 1mm2
R Fleil Pump A+ 1mm2
P Fleil Pump A- 1mm2
N Perkins Actuator Trotle Status 1mm2
M Perkins Actuator Trottle Control 1mm2
L Perkins Actuator Trottle Supply 1,5mm2
K Perkins Engine Temp. (4-20mA) 1mm2
J Perkins Oil Pressure (4-20mA) 1mm2
H Flail Pressure A (4-20mA) 1mm2
G Main GND 1mm2
F Fleil Pump B+ 1mm2
E Perkins Fuel Cutoff Valve 1,5mm2
D Perkins Starter 2,5mm2
C Perkins Actuator Trottle GND 1,5mm2
B Perkins Quick Start 2,5mm2
A Fleil Pump B- 1mm2
HD34-24-21P
P68F
Flail Pump
Amphenol MS3106F-14S-2S
P71 Quick Start
Crimp Terminal 10mm Female PushOn
P73A
Crimp terminal 10mm Round
P60M
P60F
P69F
Perkins Trottle Actuator
MSD3
1,5mm2
P77A
Crimp terminal 6.3mm female
P77B
1,5mm2
Crimp terminal 6.3mm female
Perkins Cooling Overtemp.Switch
Crimp terminal 6.3mm female
P70A
Perkins Fuel Cutoff Valve
P70B
P72
Crimp terminal 5mm Round
P73B
Crimp terminal 10mm Round
F2
20A FUSE
Mounted close to P73
Perkins Starter Motor
75mm2
+12V from Main switch
75mm3
From Minecat cahssis
P75 terminal
P78
Crimp terminal 6.3mm female
2,5mm2
Diesel Pump
P79
Crimp terminal 6.3mm female
GN.....
Hydraulic OilCooling Fan
P75M
P75F
2 pole
2 pole
M40
Crimp terminal 6.3mm female
NO Temperature Switch
P76
MSD3
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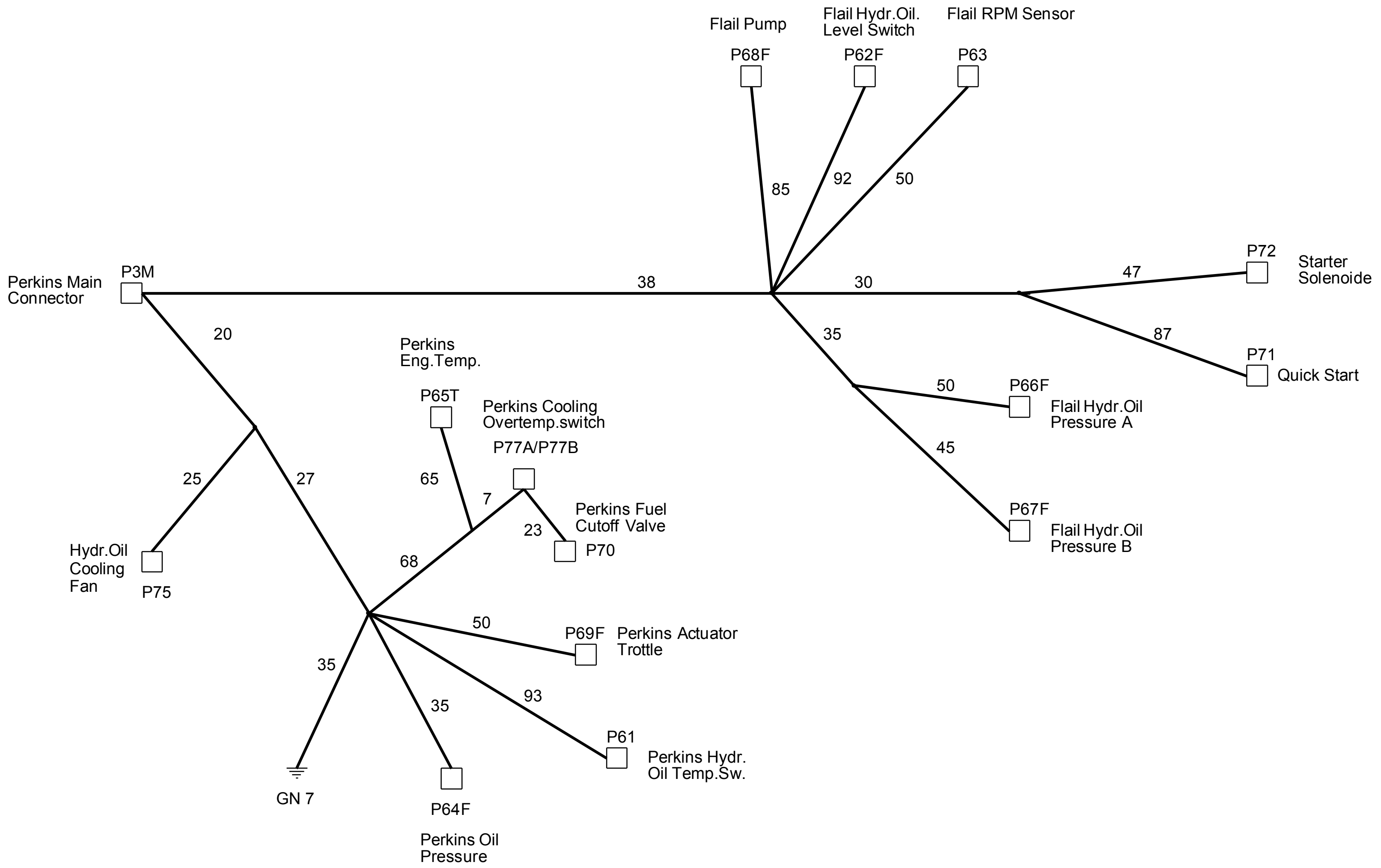
Novatron AS
P O Box 20
N-1790 Tistedal - NORWAY
Title
Minecat - Perkins Motor Wiring - Part 1
Size A3
Document Number MI-2001-05
Rev 4
Date: Wednesday, November 03, 2004
Sheet 1 of 2

Order no.: JSH-9001



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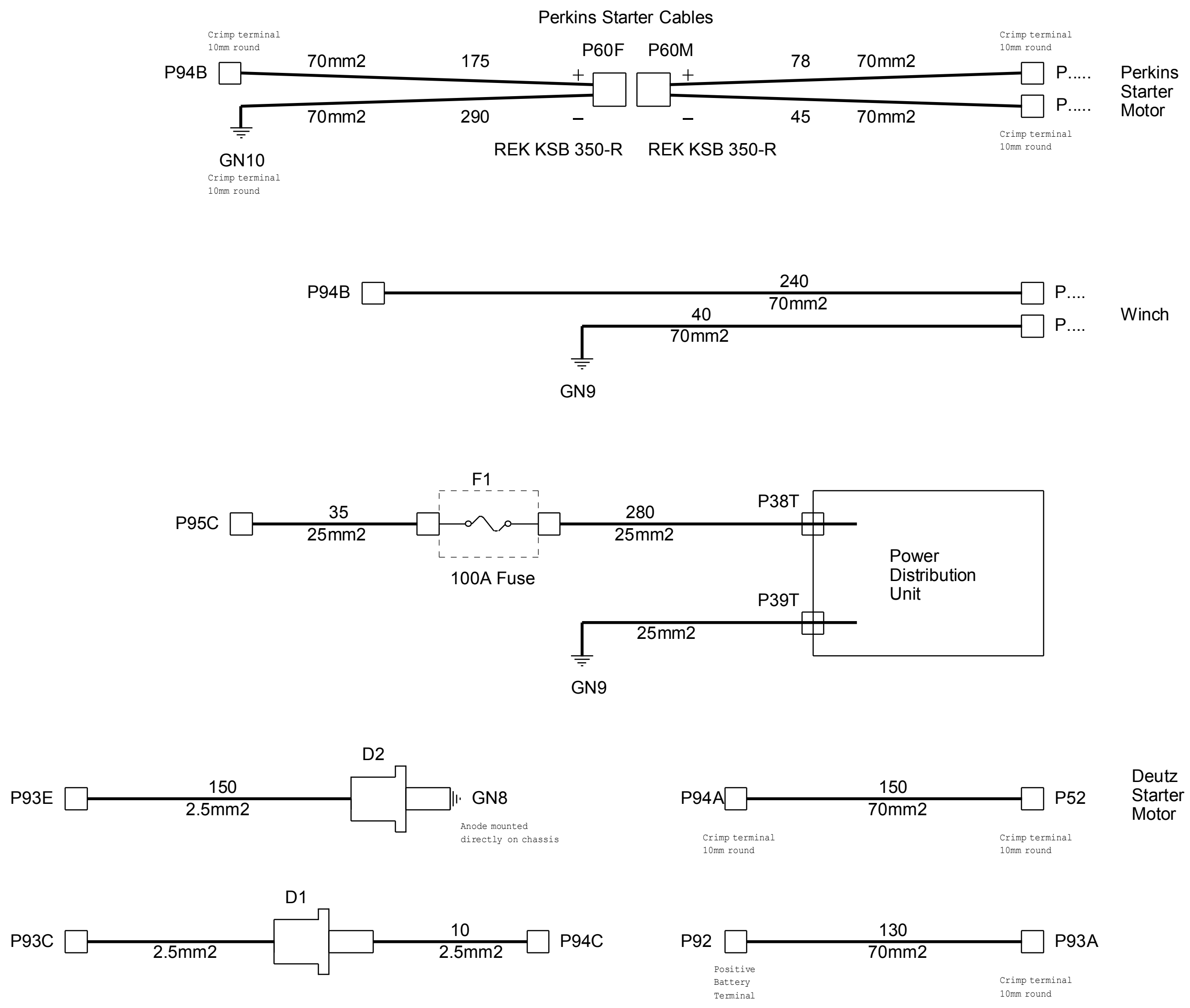
N-1791 Tistedal - NORWAY

Title	Minecat - Perkins Motor Wiring - Part 2	
Size A3	Document Number MI-2001-06	Rev 4
Date: Tuesday, January 21, 2003	Sheet 2 of 2	



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P O Box 20
N-1790 Tistedal - NORWAY

Title		
Minecat - High Current Cables		
Size: A3	Document Number: MI-2001-08	Rev: 3
Date: Wednesday, November 03, 2004	Sheet 1 of 1	