Telecom Saint-Étienne

CNC TECHNICAL MANUAL

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1. IMPORTANT INFORMATION

The CNC machine described in this manual has been significantly modified from its original manufactured state. The modifications include changes to the machine's circuit, motherboard, drivers, and firmware. These alterations were performed by students and are not endorsed or certified by the original manufacturer.

1.1. Disclaimer, Safety Notice and Acknowledgment

Because of the variety of uses for the described machine in this manual, those responsible for the application and use of this control equipment must satisfy themselves that all necessary steps have been taken to assure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes and standards.

The purpose of this manual is to provide a technical description of the equipment and its functions. It is intended to be used by persons responsible for the installation, programming, and operation of the equipment.

Throughout this manual we make notes to alert you to possible injury to people or damage to equipment under specific circumstances

1.1.a) Hazards and Risks

The machine described in this manual is a powerful tool that can cause serious injury. The use and operation of this modified CNC machine involve inherent risks. It is imperative that all operators and individuals in proximity to the machine strictly adhere to the safety guidelines described throughout this manual.

Regularly inspect the machine for any signs of wear, damage, or malfunction. Perform routine maintenance as outlined in this manual to ensure the machine remains in safe working condition.

Any further modifications or repairs should only be carried out by qualified personnel. Unauthorized changes can compromise the safety and functionality of the machine.

1.1.b) Limitation of Liability

The authors of this manual who modified the CNC machine are not liable for any damages, injuries, or losses resulting from the use or operation of the machine. The user assumes all risks associated with the operation of the machine.

By using this CNC machine, you agree to indemnify and hold harmless The authors of this manual from any claims, liabilities, damages, and expenses (including legal fees) arising from the use or misuse of the machine.

1.1.c) Acknowledgment

By operating this CNC machine, you acknowledge that you have read and understood this notice, and you agree to abide by all safety protocols and assume full responsibility for any risks involved.

2. Electrical and Electronics Documentation

2.1. Machine components

2.1.a) CNC Machine

The CNC machine is composed of 3 axes (X, Y, Z) and a spindle. Each axis is controlled by a `NEMA 23` 1.8° stepper motor powered with 24VDC/2A. These stepper motors are connected to separate `DRV8825` stepper drivers which have been prone to overheating during machine testing.

The spindle is a separate and removable component of the machine which is not directly controlled by the CNC motherboard. It is powered by 230VAC and controlled through a control box which only provides on/off functionality. The control box will only supply power to the spindle when the machine is powered on and the protective cover is closed.

On each of the 3 axes, there are NC limit switches which are all identical and used to set the machine's home position as well as prevent the machine from moving beyond its physical limits. The X-Axis limit switch is located on the left side of the machine under the X-Axis rail. The Y-Axis limit switch is located inside the Y-Axis motor case and is triggered by a metal rod attached to the moving machine base. The Z-Axis limit switch is located inside the metal support slab behind the spindle.

> **WARNING:** The limit switches are connected to the shield via a custom 3 pin connector. This connector is a replacement of the previous one and has been loosely soldered to the shield. The connections for the X-Axis and Z-AXis are **not completely reliable** and are **sensitive to pressure** on the pins. These connections should be checked and tested after any handling of the shield.

A Z-Axis touch probe is provided to set the Z-Axis limit of the working area. The touch probe is located on the top left corner of the support plate and involves a cylindrical metal button that is pressed down to trigger a NC switch. The wires of this switch run down beneath the support plate.

On the front panel of the machine is a capped trigger switch which is used to power on/off the machine. The switch is connected in series with the emergency stop button located on the left. Both of these components are connected to the 230VAC plug and should be handled while the machine is **unplugged**. The OFF button below the power switch is a remnant of the original machine and is not connected to anything, thereby non-functional.

Inside the machine is a 230VAC power relay (`Finder 55.32.8.230.0040`) which is used to control the AC Live wire connectivity to the power supply. The relay is triggered by the front panel components. If the circuit is opened by these components, power is then cut to the power supply.

The power supply is also inside the machine and converts the 230VAC on the 2 separate 24VDC outputs. One of these is used to power the motherboard and the other is used to power the control box for the spindle.

2.1.b) External module

The external module is a 3D printed casing which will contain the CNC motherboard and assure that wires are correctly connected. The shield is placed on the right side near the cooling fans for the stepper drivers. The overheating is mitigated by the addition of a 12VDC/0.17A cooling fan (`B01138812M-3M`) inside the external command module and is powered by 24VDC from one

of the 24VDC/12VDC motherboard outputs. However long machine operations have not been tested and may lead to overheating of the stepper drivers. Additionally the fan was not designed to be powered by 24VDC and must frequently be checked for any malfunction, in which case a suitable 24VDC fan replacement should be found.

To power the spindle lights, and status LED, the 3.3V output of the I2C connector is used and connects back to the I2C GND pin. This is not a long term solution and should be reviewed for a more suitable connection.

To avoid any connectivity problems the limit switches are connected to a domino connector from which the cabling to the machine is made.

The external module also comes equipped with a TS35 touch screen that can control the machine and display the current machine status. This is connected to the shield through the `EXP1` and `EXP2` cable connectors. Sometimes during homing operations a false positive `error: homing fail` can be displayed, this is to be ignored.

The CNC motherboard used in this machine is a Makerbase DLC32 V2.0 which comes with an SD-Card slot (which is not used) and a wifi antenna (also not used).

2.2. Electrical Circuit and Wiring

The electrical circuitry of this machine can be separated into 2 sections: the power circuit and the control circuit. The power circuit is responsible for converting the 230VAC to 24VDC and controlling the spindle whereas the control circuit will control the stepper motors and other components based on different machine states.

2.2.a) Power circuit

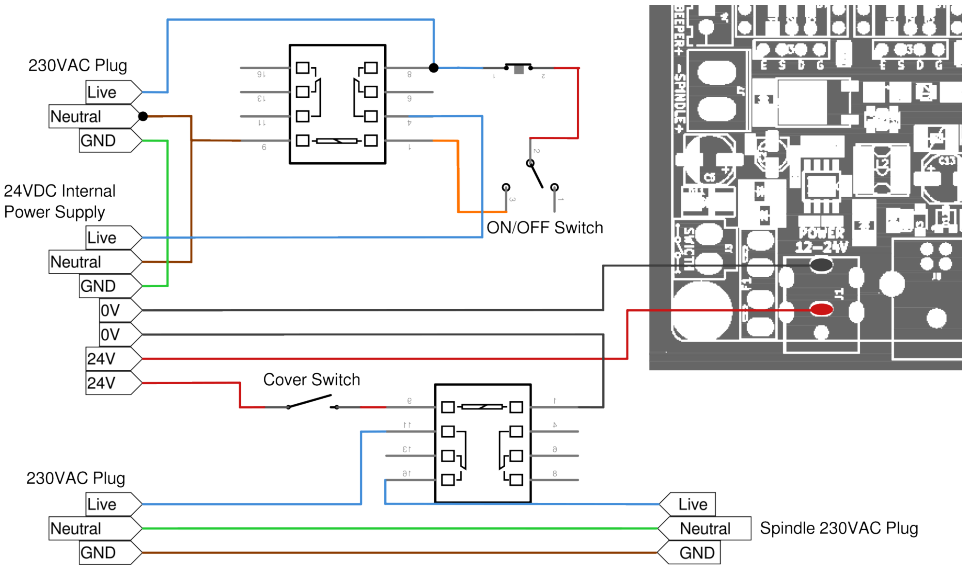

Figure 2.1. Power circuit inside the machine

In the circuit above, the 230VAC is connected to connected to a a 230VAC relay which is controlled by the emergency stop button and the front panel switch. If the latter are closed the relay will be triggered and power will be supplied to the power supply which in turn powers the motherboard.

The cable going from the power supply to the motherboard is custom-made and has been extended in order to reach the external module. The red wire is the 24VDC output and the yellow wire is the GND.

The cover switch is a magnetic contact sensor attached to the left side of the machine case and connected at the back of the machine on the `Capot` port. The switch is normally open and will close when the cover is lowered.

Internally the connector has been soldered in series with the `10A relay` port which powers the spindle control box. This way the spindle will only be powered when the cover is closed. The cable going to the spindle control box is a custom RCA to stereo jack adaptor which has been extended to reach the control box.

Inside the spindle control box is a 24VDC relay which when triggered will close the circuit of the live wire to the spindle power socket.

2.2.b) Control circuit

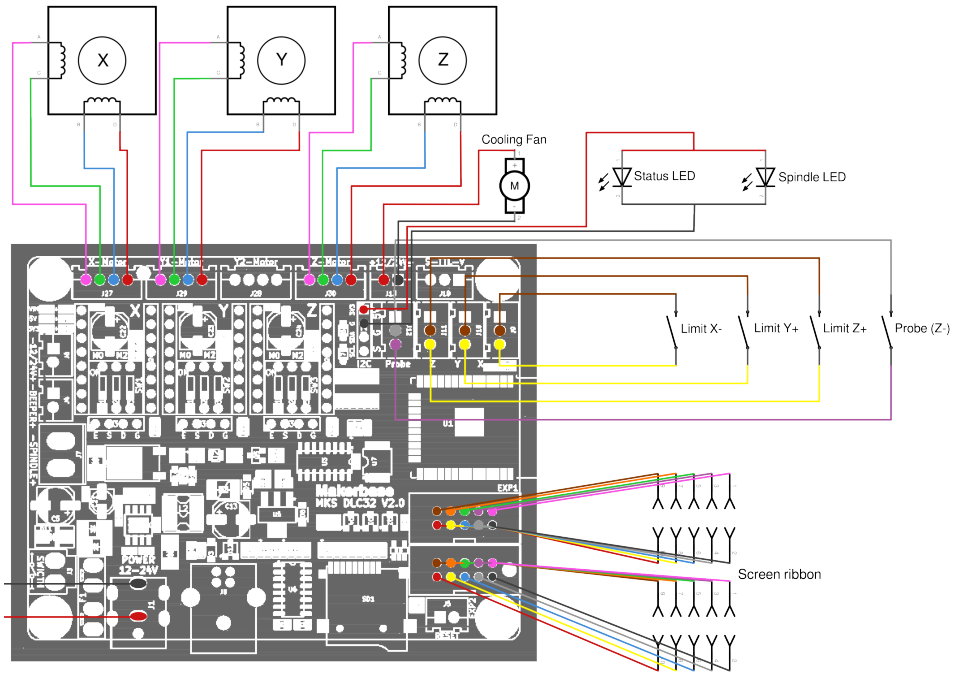

Figure 2.2. control circuit inside the external module

The 3 axes are controlled by stepper motors inside the machine that are connected to the CNC motherboard via custom-made cables these connect to the `X`, `Y1`, `Z` outputs of the shield. For each axis a `DRV8825` stepper driver is used to control the stepper motors, the Z-Axis drive being the only one missing a heat-sync.

The axis cables contain 6 inner wires: 4 for the stepper motor (2 for each coil) and 2 for the limit switch. These limit switches are connected through a domino connector to the motherboard since the connectors themselves have unreliable connectivity issues. The Z-Axis cable contains an additional 2 wires for the spindle LEDs.

The wires of the spindle LED are interconnected with the status LED wires coming from the RJ45 cable in order to be in a parallel circuit. These cables are then connected to the motherboard on the 3.3V output and the GND pin of the I2C connector.

Note: Because the wires of the status LED and spindle LED are interconnected and

soldered, the Z-Axis cable and RJ45 cable are bound to each other.

The Z touch probe is connected to the motherboard through the RJ45 cable on the `Z-Probe` pins of the shield. The connectors are not custom-made, the connectivity is made with single strand female connectors.

Caution: Since this connection is made with single strand connectors, the connection is not reliable and can be easily disconnected. This connection should be checked after any handling of the shield.

To cool the stepper drivers a 12VDC/0.17A fan is placed inside the external module and is powered by the 24VDC output of the motherboard.

The external module also contains a TS35 touch screen which is connected to the CNC motherboard through the `EXP1` and `EXP2` connectors. The touch screen is powered by the motherboard and displays the current machine status.

2.2.c) Complete Circuit

The complete circuit of the machine is shown below.

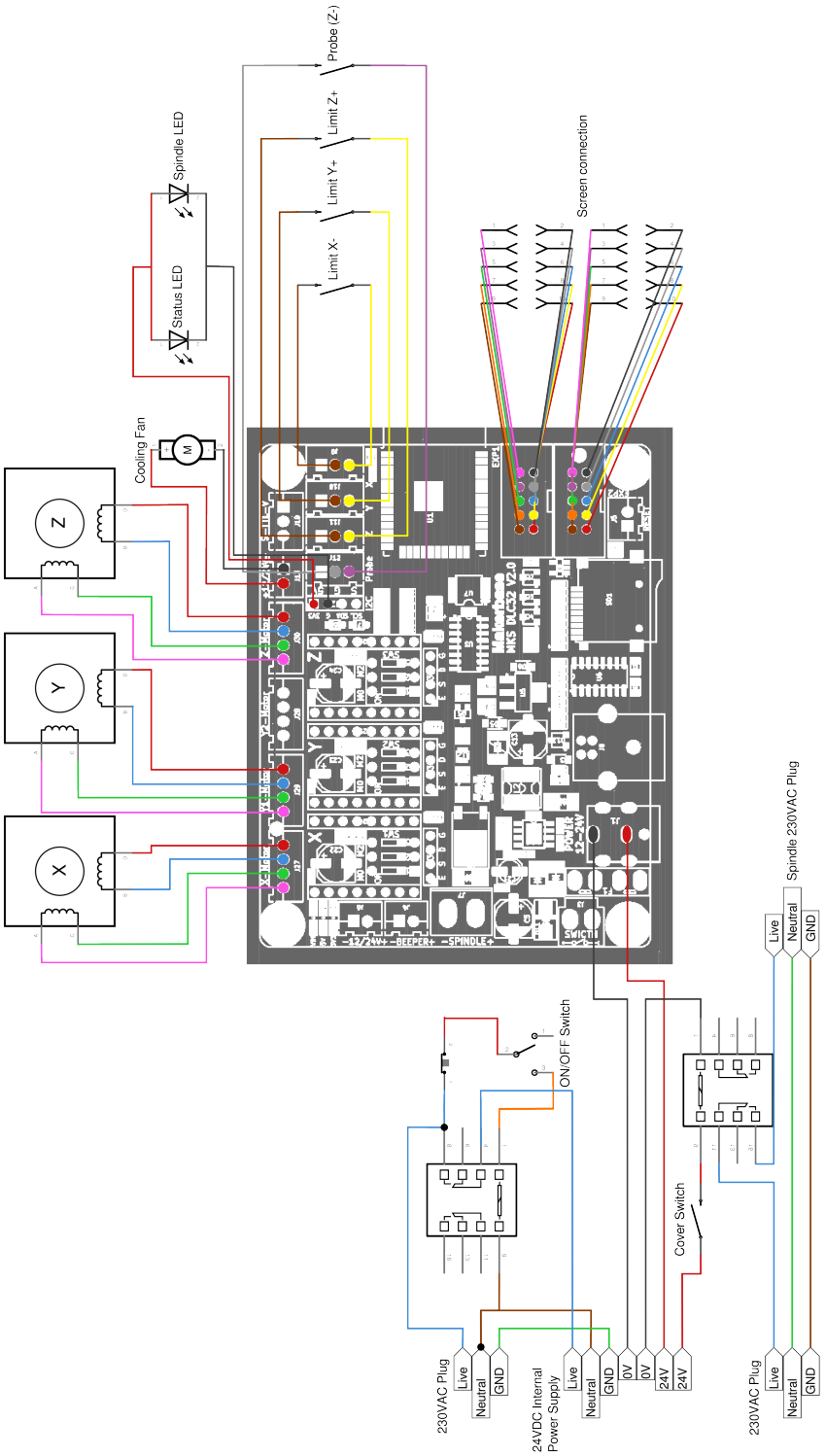

Figure 2.3. Complete circuit of the machine

3. Basic Control Operation

3.1. Startup Procedure

WARNING: After prolonged use of the machine or after reconfiguration of any machine component including the external module and the shield these guidelines must be followed.

ANY DEVIATION FROM THE EXPECTED BEHAVIOR MUST REQUIRE A FULL REVIEW OF THE MACHINE AND ITS COMPONENTS.

IF ANY OF THE AXIS START MOVING DURING THIS PROCEDURE IMMEDIATELY HIT THE EMERGENCY STOP BUTTON.

Before starting, check that the front panel switch is in the OFF position and the switch cap is closed.

To start the machine plug the 230VAC plug into the wall socket. Assure that the emergency stop button is disengaged, twist the button clockwise to release it. The machine in now ready to be powered on.

To power on the machine flick the front panel switch cap to an open position. Then set the switch to the ON position.

A single clicking sound should be heard from the relays inside the machine. The machine should power on with a whizzing sound from the axis motors for a few seconds, but **no movement should occur**.

3.2. Manual Controls

When using manual controls the machine can be entirely controlled in an unrestricted manner. This means that the machine will ignore any physical limits and will move in the direction specified by the user.

Caution: While in manual controls, the axis hard limits will only stop **a single instruction** from moving past physical limits. However if the user insists on moving the machine past these limits, the machine will do so **ignoring the hard limits.**

The user is responsible for the machine's movement and must be aware of the machine's position at all times.

3.2.a) Touch screen

The touch screen is an interface that allows the user to control the machine. The screen contains 3 main pages: `Control`, `File`, `Settings`.

The `Control` page is the main page and allows the user to control the machine.

NEEDS TO BE COMPLETED

3.2.b) USB Connection

Numerical control by a computer is done through a USB cable connected to the motherboard. The CNC is recognized as a serial port and can be controlled by CNC milling software, such as **CNCjs**.

Once connected to the machine using the software of choice, the machine does not yet know its current position. Any values displayed on the software interface or TS35 touch screen should not be considered accurate.

If the machine can not yet be controlled by the software. This means it is in a `lock state`. To remove this state, `$X` must be typed in the machine console. This will unlock the machine and allow it to be manually controlled.

> **WARNING: DO NOT, UNDER ANY CIRCUMSTANCES, SOFT-RESET THE MACHINE TO UNLOCK.**
> **Soft-resetting the machine will cause the machine to run a startup command that will move the machine to its home position which has not yet been set.**

3.3. Automatic controls

To start an automatic control operation or a job the machine must first know its current position. This is done by homing the machine. Homing the machine can be done through the software interface (or in the console using `$H`), or through the TS35 touch screen in the control page.

The machine should first rise and trigger the Z-Axis limit switch. Then move to the back left corner and trigger the X and Y-Axis limit switches.

> **WARNING: BEFORE ANY OPERATION IS MADE THE MACHINE MUST BE HOMED.**
>
> **Due to the machine not knowing where it is, any movement can lead the machine to pushing past physical limits and may cause severe damage to its components.**

Once the machine is homed the machine coordinates should update to (3,-3,-3), both on the software interface and the TS35 touch screen. This however is insufficient since no information about the length of the spindle is known.

In order to calibrate the machine to the spindle height, a custom macro must be run by the software. The macro will use machine coordinates to place itself on top of the Z touch probe then lower itself slowly until the probe is triggered. The machine will then update its Z coordinate to the height of the spindle with a 1.5mm offset since the probe is triggered 1.5mm below the support plate.

Once this is done the machine will automatically go to the home position of the machine and place the working coordinates of the machine to the center of the support plate. The machine is now ready to be used to start a job.

> **WARNING: NEVER RUN THE Z PROBE MACRO WITHOUT HOMING THE MACHINE.**
>
> **The macro relies on machine coordinated to function correctly. If the machine coordinates have not been correctly updated, the machine will not be aligned with the touch probe and may cause damage to the machine.**

The macro code is given below:

```
; Remove soft limits
$20=0

; Place above probe
G21
G53 G0 Z-3
G53 G0 X21.5 Y-16

; Z-Probe
G91
G38.4 Z-35 F200
G90

;Set  Z-axis center
G10L20 Z-1.3
G10L20 X-75.5 Y137

; Retract from the touch plate and go to work center
G53 G0 Z-3
G53 G0 X3 Y-3
G4 P1
; Soft limit
$20=1
%Z0=posz+3
$132=[Z0]
```

Figure 3.1. Z-Probe Macro