

USER'S MANUAL

for conventional dryers automatic control unit MC-412

- ◆ **Automatic / semiautomatic mode**
- ◆ **Temperature indication**
- ◆ **EMC indication**
- ◆ **MC indication**
- ◆ **Average MC indication**
- ◆ **6 inputs**
 - 4 for MC
 - 1 for temperature
 - 1 for EMC
- ◆ **4 outputs**
 - 1 for heating
 - 1 for alarm / drying end
 - 1 for cooling / conventional drying
 - 1 for spraying

Automatic control unit MC-412 is a device intended for drying process control in conventional (steam) dryers produced by "NIGOS-elektronik" but can also be used as main controller unit for dryers made by other manufacturers. Controller provides optimum conditions in the dryer through air temperature and humidity control.




MC-412 has one input for temperature and EMC measurement each, and 4 inputs for wood MC measurement. Only direct measurement of EMC is supported.

It can operate in automatic or semi-automatic mode, depending on settings made by user.

MC-412 TECHNICAL SPECIFICATION

Main characteristics		
Power supply		230 Vac; 50 / 60Hz; 4VA max
Number of inputs		6
Number of outputs		4
Displays		Two 2-digit and one 3-digit x 7 segment LED, red, 13 mm, plus one 1-digit x 7 segments LED, 13 mm, green
Operating conditions		T: 0 ÷ 50 °C; RH: 5 ÷ 90%
Storage		T: - 40 ÷ 85 °C; RH: 5 ÷ 90%
Dimensions (WxHxD)(mm)		96 x 96 x 145
Mounting hole (WxH) (mm)		91 x 91
Weight		600g

Inputs		
Temperature input	Number of inputs	1
	Range	-20 ÷ 110 °C; -200 ÷ 1100mV
EMC input	Number of inputs	1
	Range	3.4 ÷ 54% EMC; - 250 ÷ 3000 mV (EMC probes)
MC inputs	Number of inputs	4
	Range	5 ÷ 150 %

Outputs	
Relay outputs	 - for heating (2 - pin; 8A / 250 Vac)
	ALARM/END - alarm/drying end (2 - pin; 8A / 250 Vac)
	 - for conventional drying (3 - pin; 8A/ 250 Vac)
	 - for spraying (2 - pin; 8A / 250 Vac)



MC-412

1. INSTALLATION

Dimensions of the controller and mounting hole needed are given in the technical data table. Controller itself is fitted to the front panel of the control board with II profile.

1.1. POWER SUPPLY

Power supply is connected to contacts labeled 23 and 24 on the back side of the controller. Contacts 22 and 23 are internally short-circuited. Controller will start operating immediately after power supply connection.

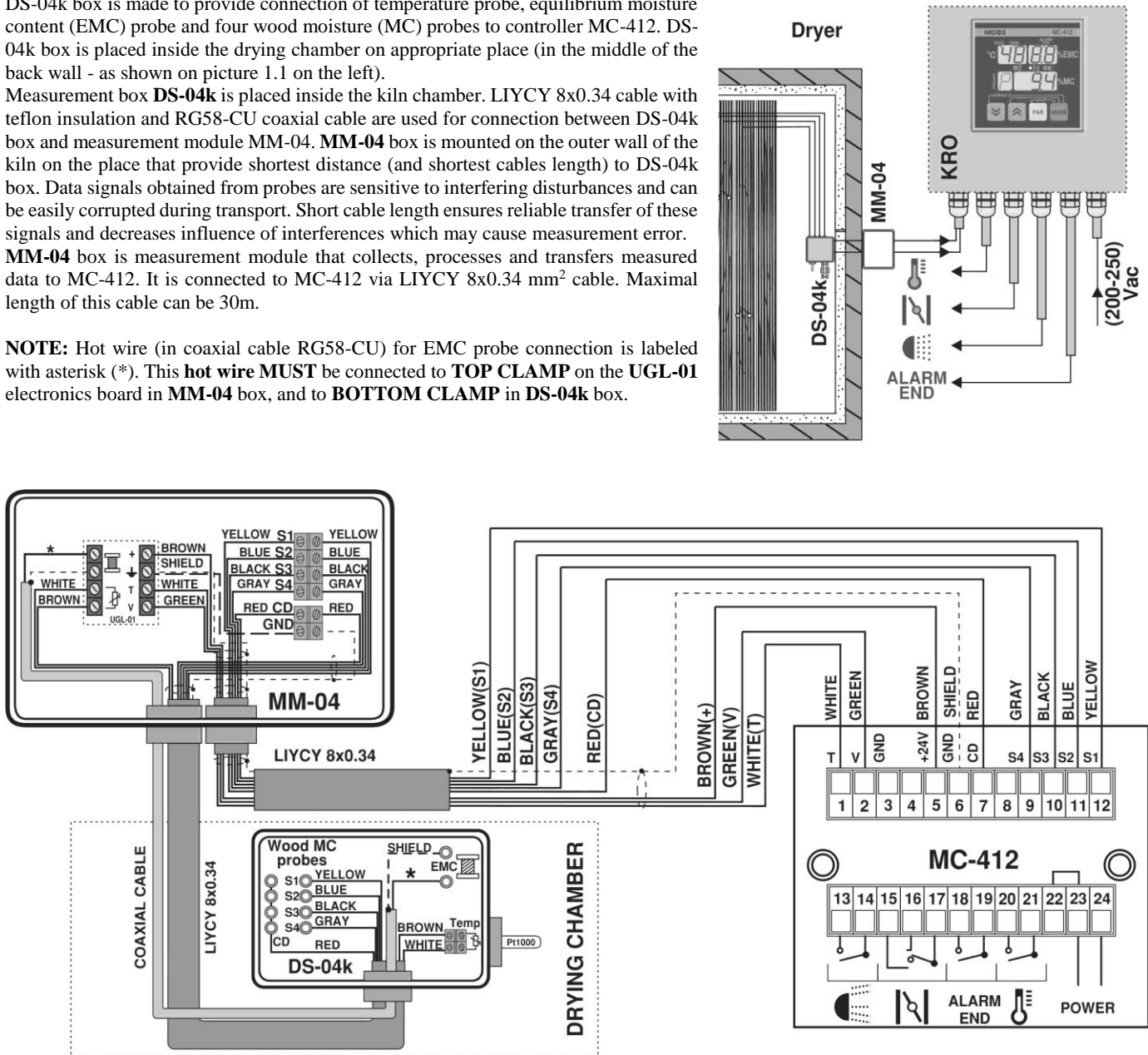
1.2. CONNECTION

Picture 1.1 shows connection scheme for automatic controller MC-412, measurement module MM-04 and connection box DS-04k connection. DS-04k box is made to provide connection of temperature probe, equilibrium moisture content (EMC) probe and four wood moisture (MC) probes to controller MC-412. DS-04k box is placed inside the drying chamber on appropriate place (in the middle of the back wall - as shown on picture 1.1 on the left).

Measurement box **DS-04k** is placed inside the kiln chamber. LIYCY 8x0.34 cable with teflon insulation and RG58-CU coaxial cable are used for connection between DS-04k box and measurement module MM-04. **MM-04** box is mounted on the outer wall of the kiln on the place that provide shortest distance (and shortest cables length) to DS-04k box. Data signals obtained from probes are sensitive to interfering disturbances and can be easily corrupted during transport. Short cable length ensures reliable transfer of these signals and decreases influence of interferences which may cause measurement error.

MM-04 box is measurement module that collects, processes and transfers measured data to MC-412. It is connected to MC-412 via LIYCY 8x0.34 mm² cable. Maximal length of this cable can be 30m.

NOTE: Hot wire (in coaxial cable RG58-CU) for EMC probe connection is labeled with asterisk (*). This **hot wire** **MUST** be connected to **TOP CLAMP** on the **UGL-01** electronics board in **MM-04** box, and to **BOTTOM CLAMP** in **DS-04k** box.

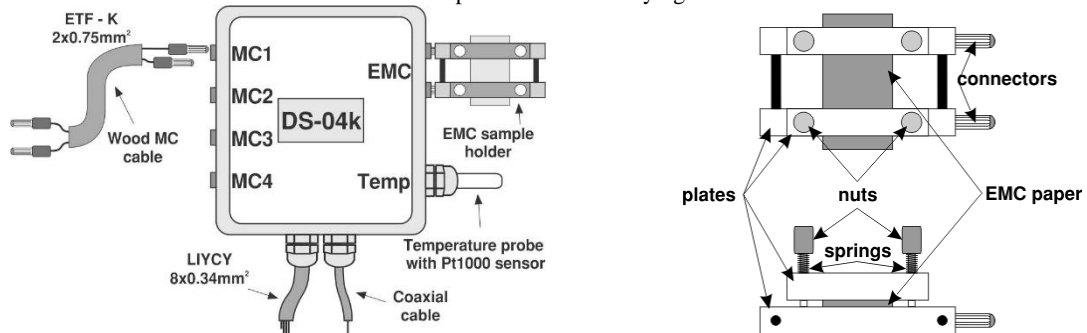


Picture 1.1. Schematic of DS-04k to MM-04 connection, and MM-04 to MC-412 connection

1.3. CONNECTION OF TEMPERATURE, EMC AND 4-POINTS MC MEASUREMENT SET

Standard set for temperature, EMC and 4-points MC measurement delivered with MC-502R contains: one MM-04 box, one DS-04k box, probes, sensors, and adequate cables.

- **DS-04k** box is made to provide connection of temperature probe, equilibrium moisture content (EMC) probe and four wood moisture (MC) probes to measurement module MM-04. DS-04k box is placed inside the drying chamber.



Picture 1.2. Connection of the measurement elements to DS-04k and EMC paper holder

- **Temperature measurement:** Temperature probe (sensor) Pt - 1000 is used for temperature measurement. This probe is mounted inside the DS-04k box by NIGOS - elektronik, and is connected to temperature connectors. On the other side of temperature connectors, appropriate wires of LIYCY 8x0.34 cable are connected (see picture 1.1).

- **Equilibrium Moisture Content (EMC) measurement:** Two hole-plugs, marked EMC, are placed on the top of the DS-04k box. They are used for connection of EMC paper holder and DS-04k box, as shown on picture 1.2. It is connected to MM-04 via coaxial cable RG58-CU. Connection on the DS-04k box is via connectors on the bottom side of the cover of DS-04k box. EMC paper is fitted according to picture 1.2.

EMC paper is made of special hygroscopic material. **ONE** EMC paper is used for only **ONE** drying cycle and should be replaced with new one before a new drying cycle starts. Certain amount of this paper (sufficient for exploitation in period of 1 to 2 years) is delivered to user. Additional amounts of the paper are provided when needed or during regular service. EMC paper should be stored on a dry and dark place.

- **EMC paper fitting sequence:** Unscrew nuts on the paper holder, so the springs remain free. Place new EMC paper between aluminum plates. Screw nuts back to achieve good coherence between EMC paper and aluminum plates.

IMPORTANT NOTE: EMC paper is used for ONLY ONE drying cycle. That means, after each drying cycle is finished, the old EMC paper should be discarded and replaced with new one according to given instructions.

- **Measurement of wood moisture content (MC) in 4 points:** 4-points MC measurement set consists of 4 connection cables and a set of wood moisture probes. These probes can be for "one-time-use" (galvanized screws) or "multiple-time-use" (INOX nails). NIGOS-elektronik recommend use of INOX probes. Each connection cable is 6 m long. They are made of 2 twisted wires with teflon insulation (labeled ETF-K 2 x 0.75 mm²). Cable has plug connectors, which provide connection with MC probe fitted in the wood. At the other end, cable has a pair of connectors for connection with DS-04k. Examples of connection of this cable are shown on picture 1.3.

Set of probes for MC measurement consists of an appropriate plastic box and certain amount of nails (MC probes).

Drying process is primarily based on average wood MC that is obtained from 4 different measuring spots. Therefore, proper fitting of the probes in the wood and their symmetrical disposition inside the chamber is most important.

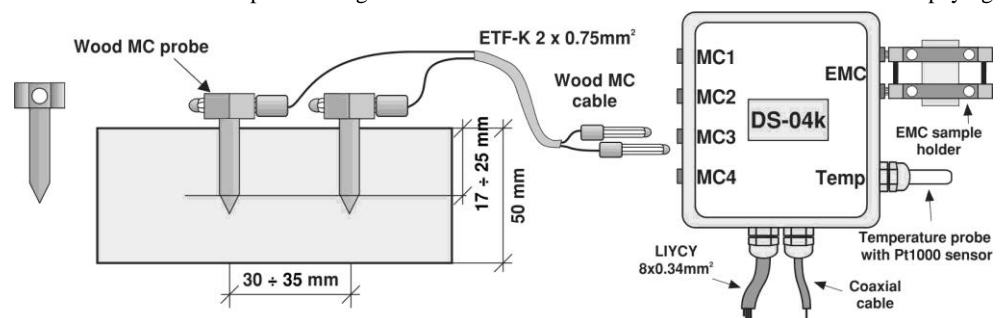
STAINLESS STEEL NAIL PROBES SET-UP (probes for multiple use):

These wood MC probes are made of stainless steel (INOX). They are for multiple use. After each drying cycle they must be carefully taken out of timber and saved for later use. They are replaced with new ones only in case of mechanical damage.

Each MC probe has one pair of stainless steel nails as shown on the picture. Recommended lengths of nails are:

- 30 mm - used for lumber up to 40 mm thick (thin lumber)
- 45 mm - used for lumber above 40 mm thickness (thick lumber)

One pair of probes is used for each MC measurement point. Probes are hammered in the lumber perpendicularly to board at distance of 30 to 35 mm (optimum distance is 32 mm) between them. A pair of holes Ø3.2 (3 ÷ 3.5) mm should be drilled in the lumber before hammering the probes. Depth of these holes should be 15 mm smaller than the probes' length. Probes should be then hammered into the holes whit paying attention that the depth of penetration must not be smaller than 1/3 of board depth (1/2 of board depth is best). In case when thin and soft lumber is used, user does not need to drill holes, but he can hammer the probes directly into the lumber. Picture 1.3 shows example of the wood probes fitting. Probe cable is connected on the other side to the patch board (DS-04k) placed on the wall, inside the drying chamber.



Picture 1.3. Proper fitting and connecting of the wood MC probe

2. OPERATION

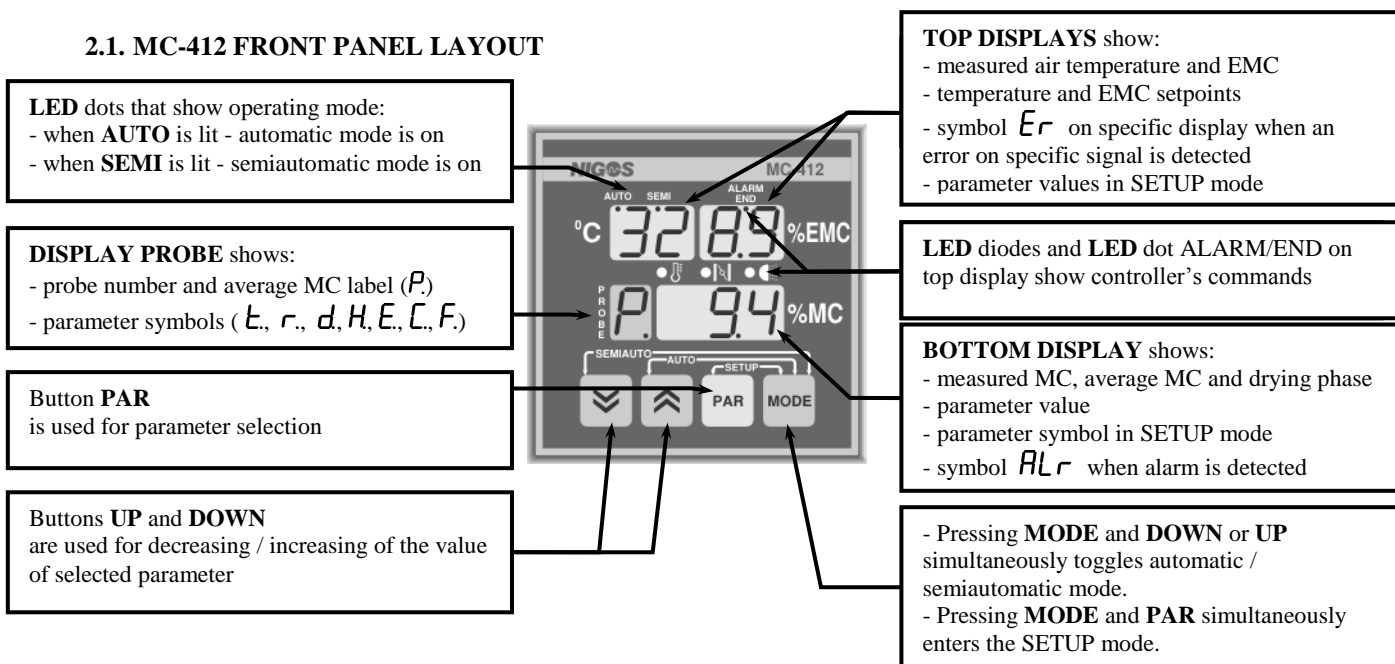
Automatic controller MC-412 has two operation modes: automatic and semiautomatic. It is possible to switch between automatic and semiautomatic mode at any time.

Drying process is divided into several phases. When drying process is started, automatic controller starts with **measurement phase**, no matter which operation mode is selected. In semiautomatic mode this phase lasts 20 sec which is required for measurement to stabilize. In automatic mode this phase lasts until average wood MC is calculated. After this controller advances to **heating phase** in case measured temperature is lower than first temperature in selected regime. During heating phase temperature is increased according to heating ramp rate until minimal temperature in regime is reached. At this point controller can enter **core heating phase** in case user has set the time for core heat phase to any value other than 0 hours. During this phase controller will maintain constant temperature (equal to minimal temperature from drying regime) for the time set by user (in hours). When this time elapses controller will advance into **drying phase**. In automatic mode controller will follow temperature and EMC curves from drying regime. In semiautomatic mode controller will disregard regime and only maintain values for temperature and EMC set by user. This is the most durable phase, and it lasts until desired average wood moisture content is reached, when drying process ends.




After drying phase, if it is enabled, system starts **conditioning phase** as the last phase of drying process, which provides equalization of wood moisture content inside the wood and on the wood surface. In case conditioning phase is disabled or when it is finished, cooling phase starts. During **cooling phase** only air exchange system (dampers i.e. flaps) is enabled. System decreases temperature in the kiln until the final temperature, set by user, is reached.

If power is lost while the drying process is running and then restored, in automatic mode, the unit performs measuring of wood moisture content and then determines temperature and EMC setpoints. After that, the unit determines proper point for resuming the process, and continues it. In semiautomatic mode, after restoring power, all parameters, including setpoints for temperature and EMC will be restored to their power-down values and process will be continued from where it was interrupted when power was lost.

2.1. MC-412 FRONT PANEL LAYOUT



2.2. LED functions

- LED  signals that controller has issued **heating** command. This signal is used to control opening/closing of heating valve.
- LED  signals that controller has issued **conventional drying** or **cooling** command on appropriate relay output. This output is used to control opening/closing of dampers (flaps). Conventional drying is activated when LED diode is lit constantly. When cooling command is issued, this LED will blink.
- When LED  is constantly lit, it signals that controller has issued **spraying command**. When this LED dot blinks, it signals spraying pause in progress or controller waits for spraying conditions.
- When LED dot on top display (labeled with %EMC) below the sign **ALARM/END** is constantly lit, it signals that **drying is finished** and user can turn off the power supply. When this LED dot blinks, it signals that controller has detected **alarm situation** and user intervention is required.

2.3. LED DISPLAYS

• **Temperature and EMC** are shown on top two displays labeled with $^{\circ}\text{C}$ - for temperature and $\% \text{EMC}$ - for EMC. Temperature display is without decimal point in range -9 to 99 . EMC display is in range 00 to 30 . Maximal value that can be shown on these displays is 99, so any value above this is shown as 99.

If an error occur on temperature or EMC inputs these displays will show blinking symbol Er .

If an error occur in temperature signal, drying is impossible and all relay outputs are off.

If an error occur in EMC signal and temperature is below minimum temperature for drying (i.e. heating phase is active) controller will continue to operate normally. If the temperature is higher then minimum temperature for drying (i.e. drying phase is active) controller will stop the drying and turn off all outputs. Immediately after this error is resolved controller will start with operation.

• **Wood MC** is shown on bottom display labeled with $\% \text{MC}$, with one decimal point in range 0.1 to 99.9 . Higher values (above 99.9%) are shown without decimal point.

• Display labeled with **PROBE** shows **MC probe number** in range 1 to 4 , and label P , which represent average MC value. If the probe number is shown with decimal point it means that the probe is **active** (in **ON** mode). If the number is shown without the decimal point then that probe is **passive** (in **OFF** mode) and its value is not calculated in average calculus.

This display also shows current drying phase when label F is displayed. At same time display $\% \text{MC}$ will show label of current phase according to following list: End - drying is stopped, St - drying started / measurement phase, ht - heating phase, Ht - core heating phase, dr - drying phase, cn - conditioning phase, cl - cooling phase.

2.4. OPERATING MODES

2.4.1. Automatic mode

For automatic operation mode, user must choose automatic mode and set all user's parameter to desired values before the drying process starts. This means that the user must choose adequate wood type, regime (schedule) and wood thickness. All this parameters are absolutely vital for good drying because controller controls the drying process and calculates setpoints according to these parameters. Parameters can be changed after the drying has started. After drying has started, user activity is only to occasionally monitor the system. The controller will follow chosen drying regime. It is recommended that user take note of every alarm situation which occur, and if necessary, act according to procedures given in chapter 4.





2.4.2. Semi-automatic mode

For semi-automatic mode, user must choose semi-automatic mode and adjust the value for wood type.

The difference between automatic and semi-automatic mode is that in automatic mode the controller calculates necessary values for temperature and EMC automatically, while in semi-automatic mode user must set these values himself, and the controller will only maintain these values. Setting of the values for temperature and EMC is done according to procedures described in chapter 2.5.


2.4.3. Changing of operating mode (auto to semi-auto and vice versa)



There is a possibility of change from automatic to semi-automatic mode at any point of operation. After the change, drying process starts from beginning. In semi-automatic mode, currently measured values become setpoints, while in automatic mode they are calculated according to the program.


To switch from automatic to semi-automatic mode, user must press the buttons  and  simultaneously. To return to automatic mode, user must press simultaneously buttons  and .


After each mode **alternation from semi-automatic to automatic mode**, all relay outputs are turned off for about 20 seconds (shorten measurement phase), after which the controller calculates setpoints.

2.5. PARAMETER SETTINGS


Button  is used for parameter viewing and setting. When this button is pressed, parameters shown on adequate displays are changed.

Buttons  and  are used for increasing and decreasing of the currently selected parameter.

1. When button  is first time pressed, **temperature setpoint** starts to blink on the *temperature display* (values and range are given in the table 2.3).

2. When button  is pressed again, **EMC setpoint** starts to blink on *EMC display* (values and range are given in the table 2.3)

NOTE: In automatic mode these parameters (temperature and EMC setpoints) can only be viewed. In semi-automatic mode, user can change these parameters and set it to desired value up to 30% for EMC and up to temperature defined by parameter Utsu (*Maximum drying temperature*).

3. With next pressing of the button , **probe number** blinks on *PROBE display* and **probe state** blinks on *MC display*. These states can be: **ON** for **active** state or **OFF** for **passive** state, and can be changed. This process should be repeated for all 4 probes with notice that it

is not possible to put all 4 probes in passive state. Active state means that value obtained from that probe is calculated in the average MC calculus, while values from passive probes are disregarded.

4. After the state of probes is adjusted, with next pressing of the button **PAR**, parameter **L** is shown on the *PROBE display*. Now, user can make selection of the wood type. Possible values are in range **1** to **4**, depending of the actual used wood type. It is necessary to define the type of the wood that is dried in order to achieve proper wood moisture content (MC) measurement. All wood species are divided into 4 groups, which are given in the next table (2.1).

Table 2.1. Table of wood types and related groups of wood species according to which the MC measurement is made

WOOD TYPE	WOOD SPECIES
1	Zebrano, Cork, Rubber Tree
2	Beech, Poplar, Lime, Niangon, Ebony, Olive, Iroko
3	White Beech, Pine, Ash, Birch, Larch, Locust, Acacia, Mahogany, Oak, Sappeli, Walnut, Maple, Chestnut, various fruit trees...
4	Dibetou, Kapur, Sipo, Utile

5. When button **PAR** is pressed again, parameter **r** is shown on the *PROBE display*. This parameter defines drying regime (schedule) according to which will MC-412 control the drying process in automatic mode. Each regime defines temperature and EMC curves (relations between chosen parameter - T or EMC, and time), temperature gradient for heating, minimal drying temperature, temperature and humidity setpoints for conditioning phase and duration of the conditioning phase. **All regimes are made for lumber thickness of 50 mm.** User can select any regime between 60 possible. Adequate regime is chosen according to the *recommended drying regime table* (table 2.2) and user experience. These are factory-defined regimes and cannot be changed.

Table 2.2. Table of drying regimes pre-defined by "NIGOS - elektronik"

Wood species	Group (measurement)	Schedule recommendation				
		Verv slow	Slow	Medium	Fast	Verv fast
Fir, Spruce	3	17	22	27	28	30
Pine	3	16	21	22	28	30
Larch	3	16	21	22	28	30
Beech, steamed	2	16	17	18	19	24
Beech, un-steamed	2	11	12	13	14	15
Beech, white	2	-	3	4	5	10
Oak, slavonian	3	6	11	12	13	19
Oak, sessile	3	2	3	4	9	14
Ash	3	7	11	12	14	20
Poplar	2	11	17	21	22	28
Linden	2	11	16	17	18	23
Birch	3	11	16	17	18	23
Cherry	3	11	12	17	18	20
Acacia	3	11	12	17	18	19
Nut	3	11	12	17	18	19
Mahogany	3	11	12	17	22	23
Samba	2	21	22	27	28	34

IMPORTANT WARNING FOR USING PRE-DEFINED SCHEDULES!!

Drying regimes which are inserted in controller's memory are based on both significant practice knowledge of drying wood and laboratory testing made in well-known wooden industries. Since there are many factors that can influence drying process such as wood origin, quality of wood, wood surface conditions, stock height, stock assemblage, etc... - drying characteristics for certain lumber can differ from the one used for creating schedule. That is why we recommend strict monitoring of drying process to achieve both maximum efficiency in drying progress and proper parameter settings for **your** type of wood.

NIGOS-elektronik do not accept responsibility for any faults on the timber (bent, crack, twist, etc...) or any accidental situation during drying process caused by either operator's negligence or disregarding process, even when the manufacturer's pre-defined drying regime is used.

NOTE: * - drying regimes number 38 and 39 are especially developed for time-based drying control. In this mode, automatic controller do not pay attention to measured MC. Instead, it just try to maintain setpoints for temperature and humidity for given time (segments in hours). As soon as one segment pass, controller advance to next segment. These regimes are fully supported by automatic controllers MC-600 and MC-2000. MC-412 do not provide full support for these regimes. **It is NOT recommended to use these regimes on MC-412!**

6. When button **PAR** is pressed again, parameter **d** is shown on the *PROBE display*, and current value of this parameter is shown on the *wood MC display (%MC)*. This parameter defines average thickness of the lumber, which is very important for normal drying process. Regimes and curves are pre-defined for lumber 50 mm thick. Thinner lumber require faster schedule and vice versa, for thicker lumber drying schedule should be slowed down. Adjusting the parameter value to actual lumber thickness (if possible) provides that the controller performs all other relevant schedule settings automatically.

Speeding of the regime for thickness lower then 50 mm is done by following:

- values for moisture curve are decreased
- temperature ramp ratios are increased.

Slowing of the regime for thickness higher then 50 mm is done by following:

- values for moisture curve are increased,
- temperature ramp ratios are decreased.

Calculations are made in percentage relative to the thickness in millimeters.

7. When button **PAR** is pressed again, parameter **H** is shown on the *PROBE display*, and current value of this parameter is shown on the *wood MC display (%MC)*. This parameter defines duration of the core heating phase. Its value is set in hours (h) and if the value is set to zero, this phase will be neglected and drying phase will start. This phase is used to evenly heat up wood and avoid difference between wood surface and wood core. This phase is generally suggested whenever hardwood is dried because the timber will soak up and drying of the wood in later process will be faster with better quality of dried material. Controller will store user setting for this parameter and use it for each new drying cycle (until it is changed).

8. Pressing the button **PAR** again, selects parameter **E** which defines final wood MC. Current value is shown on the *wood MC display (%MC)*. When AVERAGE wood MC calculated from all active MC probes is equal to this value, controller will stop the drying and either advance to conditioning phase, or turn on END relay output to notify user that drying is finished.

9. When button **PAR** is pressed again, parameter **C** is shown. It will enable / disable conditioning phase after drying phase is finished. Conditioning is performed at the end of drying process with main intention to equalize moisture content at the surface and inside the boards. During this process, temperature is gradually (following given gradient) lowered from current temperature to *conditioning temperature*, while EMC is increased from current until *conditioning EMC* is reached (also following given gradient).

10. When button **PAR** is pressed again, parameter **F** is shown. This parameter is used to start or stop drying process.

Next pressing of the button **PAR** will reset display to home display mode. Pressing of the button **MODE** at any moment will interrupt parameter setting sequence immediately. If no button is pressed within 10 sec, the controller returns to home display mode automatically.

Table 2.3. User's parameters table

PARAMETER LABEL	DESCRIPTION	RANGE OF PARAMETER VALUES	DEFAULT VALUE
	Temperature setpoint	00 ÷ 0t50	35
	EMC setpoint	01 ÷ 30	5
1	State of wood MC probe 1	on, off	on
2	State of wood MC probe 2	on, off	on
3	State of wood MC probe 3	on, off	on
4	State of wood MC probe 4	on, off	on
t.	Type of the wood	1, 2, 3, 4	3
r.	Regime (schedule)	1 ÷ 20	9
d	Lumber thickness	20 ÷ 80 mm	50 mm
H	Core heating phase duration	0 ÷ 100 h	0 h
E	Final wood MC	00 ÷ 250 %	120 %
C	Conditioning phase selection	on, off	off
F	Drying START / STOP	End, Str	End

3. STARTING AND STOPPING OF THE DRYING PROCESS

As soon as the power is connected to controller MC-412 (main switch on power electric board is switched on), it will start to operate but drying will not start immediately.

User must set up drying parameters and set parameter F . to Str in order to start drying process. Controller will automatically go through all phases of drying process. When average moisture content in wood reaches final wood MC defined by parameter E ., controller will stop the drying and advance to conditioning phase (if enabled) and then cooling phase. Depending on the selected operating mode LED diode AUTO or SEMI will blink when drying process is in progress. When drying is ended (including conditioning and cooling phase) LED diode END AUTO or SEMI will be lit constantly. If required, drying process can be stopped manually by selecting value End for parameter F .. The controller will stop drying, turn off all outputs and behave in the same way as if regular end of drying process has occurred.

NOTE: When drying is finished, controller will turn on ALARM/END output for 2 minutes constantly. After that, all outputs will be turned off. Pay attention that fans will still operate because MC-412 controller does not control them. In order to shut down all equipment in the chamber, custom electronics must be installed in power electric switch board. This equipment must detect constant activity of ALARM/END output, and use that signal to cut off power to all equipment in the chamber.

4. IRREGULAR SITUATIONS

During operation certain irregular situation can occur. These situations signal that there is some kind of error in measured data and are not necessarily signal for hardware malfunction on measurement equipment or controller. There are 2 types of irregular situations. First one is not critical and is considered as “warning”. These situations can be recognized when LED dot ALARM on the top display of MC-412 is blinking, but controller can continue drying and try to solve the problem automatically. Second type of irregular situation is considered as “alarm” situations. This indicate occurrence of critical error and controller will stop drying in most cases until error is solved. When alarm situation occur, MC-412 controller will blink LED diode ALARM and display message ALr on wood MC display.

Most common possible causes and controller reaction for irregular situations are:

- If MC-412 operate in automatic mode and all MC probes are passive, or probe for temperature or EMC does not measure values regularly (in any operating mode), MC-412 controller will shut off all relay outputs.
- If temperature inside the kiln has exceeded maximal drying temperature + 5 °C, all relay outputs are turned off except output for cooling. This state is automatically ended when temperature falls below maximal drying temperature +3 °C.

When irregular situation is over, controller will continue starting from measurement phase. If the alarm situation persist, please call NIGOS authorized service personnel.