Wire it up with CANopen

To reduce cabling effort, Moba developed a controller that contains an integrated terminal strip on top. OEMs are now able to wire their machines directly to the top of the controller.

The MCP allows a variety of combinations of components, such as keypad, joystick and display modules. Furthermore, two gateway controllers are integrated to get a redundancy of the I/O’s if needed. In the case of two controllers, the left controller is key element and operates as a gateway of the internal Moba bus to the external machine bus. Also, the left controller administers all Moba components through CANopen, CiA 301 Version 4.02. Both controllers are integrated into the machine bus and communicate via the CANopen protocol. This facilitates an easy integration of the control panel into the machine of any manufacturer. Figure 3 demonstrates the CAN communication of Ruthmann’s ‘Cockpit’, an exemplary MCP with two controllers, two joystick modules, one keypad module, and one display module.

CANopen devices of the same bus must clearly be identifiable with their node number. Since there are MCP variants with two controllers, the controllers must somehow be addressable from the outside. For this reason, two analog pins were added to the hardware of the controller, to be able to influence the node number. The analog pins can have three states (open, high, and low), which enables $3^2 = 9$ different node numbers. All addressings of the controller are displayed in Table 1.

Furthermore, the Moba components obtain electricity through the connection board of the gateway controller. This connection can be operated via the software. By this means, an individual reset of the panel is possible without...
having to reset the whole machine. This is beneficial for e.g. an exchange of the joysticks. They can be exchanged without disassembling the whole panel. For a subsequent new initialization of the joysticks, a voltage reset is necessary, easily carried out by a controller reset. This works either with a key combination or via the CANopen object directory. Another special feature is the joystick configuration. It is a well-known problem that each machine has another control, depending on the manufacturer. For operators it thus is a challenge to adapt to the control every time a new machine needs to be operated, especially when renting an aerial working platform. For this reason, the micro-controller has a setting that allows to change the logic of the joystick signals. These signals are correspondingly forwarded to the machine control.

Table 1: All addressings of the controller in dependence of the analog pin (Photo: Moba)

<table>
<thead>
<tr>
<th>Controller</th>
<th>Analog Pin 1</th>
<th>Analog Pin 2</th>
<th>Node number</th>
<th>Bitrate in kbit/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left controller</td>
<td>Open</td>
<td>Open</td>
<td>0x32</td>
<td>125</td>
</tr>
<tr>
<td>Right controller</td>
<td>Low</td>
<td>Open</td>
<td>0x3C</td>
<td>125</td>
</tr>
<tr>
<td>Left controller</td>
<td>Open</td>
<td>Low</td>
<td>0x33</td>
<td>125</td>
</tr>
<tr>
<td>Right controller</td>
<td>Low</td>
<td>Low</td>
<td>0x3D</td>
<td>125</td>
</tr>
<tr>
<td>Left controller</td>
<td>High</td>
<td>Open</td>
<td>0x32</td>
<td>250</td>
</tr>
<tr>
<td>Right controller</td>
<td>High</td>
<td>Low</td>
<td>0x3C</td>
<td>250</td>
</tr>
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<td>250</td>
</tr>
</tbody>
</table>

This adjustment option is called ‘joystick permutation’. It can be carried out with a key combination or via the CANopen object directory. In total, there are 384 different joystick permutations based on two joysticks. So far, there have been implemented 192 into the controller. The other 192, however, can be implemented anytime if necessary.

Controller features

Beside its function as the administrator of several Moba components, the controller can be used as a plain I/O device. It has 16 digital and 8 analog inputs. The switching level of the digital inputs is dependent on the present operating voltage and switches at 0.65 $U_b$ to 0.75 $U_b$, while $U_b$ is the operating voltage. The digital inputs can be configured as NPN or PNP input through transistors, which are connected to the micro-controller. For the user, it thus is possible to individually configure each digital input with the CANopen object directory. The evaluated digital inputs are subsequently sent via defined PDOs. Three of the digital inputs can optionally be used as a frequency input.

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user thus has the possibility to measure a frequency range of 0 kHz to 30 kHz with an accuracy of ±0.2 %. The analog inputs contain the operating modes 0 V to 5 V voltage input, 0 V to 10 V voltage input, 0 mA to 20 mA current input, or 4 mA to 20 mA current input.

Similar to the configuration of the digital inputs, each analog input can individually be configured via the CANopen object directory (index 2015). During the conversion from analog to digital, the micro-controller has a resolution of 12 bit. For the accuracy to be at least ±1 % FS (Full-scale), each analog input is calibrated by the in-house test system. The calibrated values are subsequently saved into the EEPROM, which is situated at the controller. The controller has four digital outputs, which are checked through a feedback to the controller, and additional six PWM outputs. For safety reasons, all outputs are connected via an AND gate. The AND gate does only connect through if the voltage supply of the controller is stable and the controller is in faultless operation. If a fault is detected by the software, the micro-controller switches off the AND gate through a control line. Each PWM output contains a control circuit (Figure 4), which enables the current control of the PWM outputs. Via the CANopen object directory it is also possible to deactivate the current control in order to directly adjust the pulse-pause ratio. Also, it is possible to individually adjust the PWM frequency (200 Hz to 1000 Hz).

The controller sends the following PDOs: the evaluated analog inputs with 12-bit resolution, digital input level or frequency, the keys of the HMI keypad and the current position of the joysticks, and a PDO that forwards data from the display. It receives the following PDOs: the current set point for every PWM output, the condition of the digital outputs, the LED actuation of the HMI keypad and the joysticks, and a PDO to forward data to the display.

With the CANopen object directory, the following configurations are possible:
- Individually configuring digital inputs as NPN or PNP inputs,
- Individually configuring analog inputs for four operating modes,
- Saving the complete object directory in EEPROM - this special feature has retrospectively been implemented to avoid an adjustment of the complete object directory when restarting,
- Flexibly adjusting the PWM frequency,
- PWM outputs with current control or via the direct adjustment of the pulse-pause ratio,
- Button-pressed-time to get into special operator interaction,
- Reading the software version of the Moba components.

![Figure 2: Wiring of the two controllers of Ruthmann’s Cockpit (Photo: Moba)](Image)

![Figure 3: Overview of CAN messages of an exemplary MCP with two controllers, two joysticks, one keypad, and one display (Photo: Moba)](Image)
Conclusion

All things considered, the described controller is the right choice for a space-optimized cabinet, which does not allow too much cable work and thus requires special terminal strips. Furthermore, by saving considerable amounts of clamps and cables, the associated wiring work is omitted, thereby reducing wiring faults to a minimum. The possibility of a time-efficient exchange is an extra advantage for the machine manufacturer’s service team, saving considerable resources.
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