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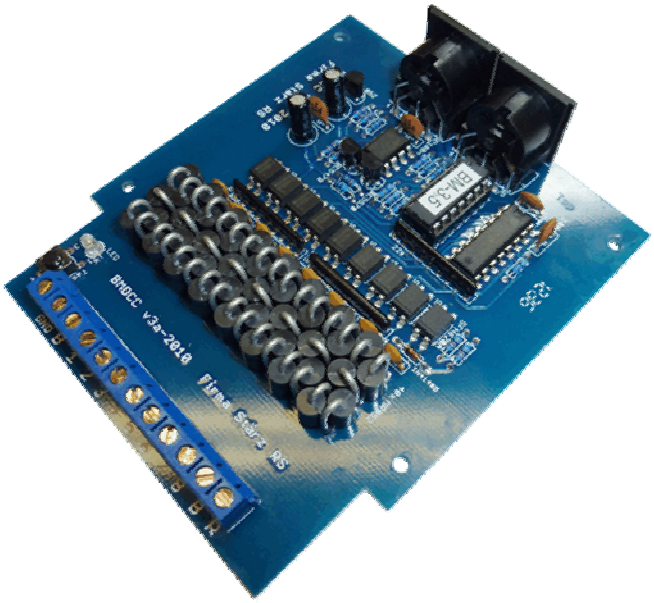
8-fold Track Occupancy Detector for digital systems with two-wire track (e.g. Selectrix®, DCC)

for monitoring to Selectrix®

BMDCC 3
v3a-2010



Degree of difficulty: **easy**
medium
difficult

Necessary skills:
- Simple assembly and soldering procedure of the board
- Assembly of power diodes

The Track Occupancy Detector BMDCC is a device for monitoring eight track blocks of a digitally controlled (e.g. Selectrix, DCC) model railway layout to monitor to the Selectrix bus system. Each block sustains a load of up to 3A (8A maximum overall load) and tracks are galvanically isolated from the bus. When used in combination with an accessory decoder, occupancy information can be presented through a switchboard type display.

Special features

- Independent of the track protocol
- Galvanic insulation of bus and track, thus ideal for multi protocol central units
- Does not require bus synchronous track signal, thus to be used at any SX bus
- High reliability by input comparators at SX-Bus
- Extra ground terminal for huge layouts
- Storage of occupancy state and further options

Table of content

Technical specifications

Size
107,7mm x 94,6mm x 20mm

Power Supply
The module is powered by the SX-Bus.
Power consumption: max. 10mA

Output current
Ca. 8A maximum overall load
Ca. 3A maximum load per block

Connectors
2x SX-Bus jacks
3x terminals for track current (1x brown/red (R) and 2x blue (B) clamp from central unit or boosters)
8x terminals for 8 track blocks (1 to 8)
1x terminal for SX-bus ground (GND)
Use cables with a sufficient cross section (0,75mm²) for wiring. Too thin cables will lead to malfunction or faulty detections.

Switch/Display
Push button and a status LED to switch to programming mode

Plugging to SX-Bus
The module is connected to the SX-data-bus via an (optional) SX-bus cable.
For large layouts with long cables an additional ground wiring of the SX-bus is suggested. Use terminal GND for that purpose.
Asynchronous rail and control bus may lead to flickering of the occupancy detection. Increase response delay and dropout delay to override this effect.
The module must never be connected to the Selectrix-Power-Bus (PX-bus)!
Bus cables may only be plugged or unplugged at power down of the model railway layout.

Assembly notes
The module is assembled following the instructions on the next page. For soldering the components on the PCB a soldering iron of 12 to 25 Watts or a soldering station with the temperate set to approx. 400℃ is needed together with 0.5 or 1.0 mm soldering wire with rosin flux. No special tools are required. Do not use soldering flux! Pay attention to solder speedy to avoid device damage by overheating.

Non-Use
When the module is not used it should be stored at a dry and clean place.

The Instruction
The full content of the instruction is important. Very important information is marked in **colours**; critical information is highlighted in red.

Installation site

The module should be located in a dry, ventilated and clean area being easily accessible and lying beside or next to the model railway layout.
The module must be kept free of coarse dirt or electro conductive parts falling down.
The module may be arranged without a housing needed. In that case the module shall be put on an insulating sub floor by means of the plastic spacer rings and screws delivered.
Keep all electro conductive tools, assembly kits and cables away from the module during operation.
A negligently and by external circumstances caused short-circuit (impinging on the module from above or from the bottom) may destroy the module. If that happens, all terms of warranty will become invalid.

Kit contents

Please first verify that the kit contains all the components listed below.

General parts:
1x circuit board
1x LED (red)
1x push button
1x voltage regulator 78L05
1x resistor network 22kOhm
1x resistor network 1k5Ohm
1x resistor network 47Ohm
9x optocoupler SFH628A
4x screws
4x spacer rings
1x SX-Bus cable (optional)
Connectors:
2x SX jacks
1x terminal clamps 12-pin (5mm pitch)
ICs:
1x LM393
1x 14-pin IC socket
1x PIC „BM“
1x 74HC257
Transistors:
1x BC557B
1x BC547B
Capacitors (Marking):
4x ceramic 100nF (104Z)
8x ceramic 33nF (333)
2x electrolytic 47µF
Diodes (Marking):
40x MR852 (or MR856)
1x 1N4148 (4148)
Resistors (Marking):
3x 100Ohm (brown, black, black, black, brown)
5x 4,7kOhm (yellow, lilac, black, brown, brown)
4x 22kOhm (rot, rot, black, rot, brown)
1x 2,2kOhm (rot, rot, black, brown, brown)
1x 680Ohm (blue, grey, black, black, brown)
2x 6,8kOhm (blue, grey, black, brown, brown)

Update

The heart of the module is a PIC that stores the software. A socket for the PIC provides easy access for the purpose of any software update.
Never use other PICs than those dedicated to this module. Disregarding may lead to destruction of the module and all term of warranty will become invalid.

Maintenance and care

Dust clumping together can, in combination with condensating liquids, become conductive and deteriorate the functionality of the module. It is therefore important to remove dust regularly by blowing it off or vacuuming the module.
CAUTION: A liquid cleaning of the part is prohibited!

Accessory and expendabilities

The following equipment is available:

Housing:

- **Housing for BMDCC: G 528 B** **Art. 212**

Please also visit our FAQ page at www.firma-staerz.de for any question first.

Assembly instruction

Assemble the kit in the order of these instructions. All components are placed on the top side of the PCB (marked “top”) as close to the PCB as possible and soldered on the bottom side of the PCB (marked “Bottom”). Use a bending tool (e.g. Conrad 425869 – 62) for bending. Cut the leads of components flush using a wire cutter after soldering.

Solder cleanly and precisely!

1. Resistors, diode D41

Bend the resistor leads for 7.5 mm pitch before insertion. To facilitate placing components on the PCB support the edges of the board with the help of two books, for instance, to leave enough space for the leads under the board. Insert the resistors on board aligning the coloured rings of all the resistors in the same way to make it easier to verify the value of the resistors later. Place a suitable plane piece of wood or similar on top of the resistors on board. Turn the board together with the wood upside down. The underside of the board is now conveniently accessible for soldering the components.

Solder one end of each resistor first and check that they are positioned properly before soldering the other end of each resistor.

R1-R3:	100Ohm	(brown, black, black, black, brown)
R4-R8:	4,7kOhm	(yellow, lilac, black, brown, brown)
R9-R12:	22kOhm	(rot, rot, black, rot, brown)
R13:	2,2kOhm	(rot, rot, black, brown, brown)
R14:	680Ohm	(blue, grey, black, black, brown)
R15, R16:	6,8kOhm	(blue, grey, black, brown, brown)
D41	1N4148	

2. Optocouplers

Observe the polarity: The orientation notch of the component must be aligned with the one printed on the circuit board. In case of optocouplers being marked otherwise, the designation must show to the track terminal blocks.

OK1-OK9:	SFH628A

3. Socket for PIC, ICs

Place and solder the PIC socket and ICs with the notches according to the component layout diagram on the PCB.

IC1:	Socket for PIC
IC2:	74HC257N
IC4:	LM393N

4. Push button S1

Place and solder the push button accordingly.

5. Resistor network

Place the resistor networks according to their marking: the marking has to face to the track terminals.

RN1:	22kOhm	(9x-1-223)
RN2:	1,5kOhm	(9x-1-152)
RN3	47Ohm	(9x-1-470)

6. LED

The cathode of the LED is to be placed to face the terminals. The shorter lead of the LED is the cathode and the collar is also flat on the cathode side.

7. Ceramic capacitors

C1-C4	100nF	(104)
C7-C14	33nF	(333)

8. Voltage regulator, transistors

The transistor and the voltage regulator can be placed simultaneously when proceeding similar to the resistors. Do not confuse the transistors with the voltage regulator 78L05!

T1:	BC547
T2:	BC557
IC3	78L05Z

9. Terminal blocks

X3:	12-pin terminal

10. Electrolytic capacitors, Watch polarity!

Capacitors are mounted the minus side to face the PCB edge.

C5-C6:	47µF

11. Diodes, Watch polarity!

Diodes are mounted in an upright position, their cathodes (stripe on the housing) facing upwards. To do so, bend the wire of the cathode as short as possible.

D1-D40:	MR852

12. SX-bus jacks

Solder the shielding (big pads) of the jacks generously.

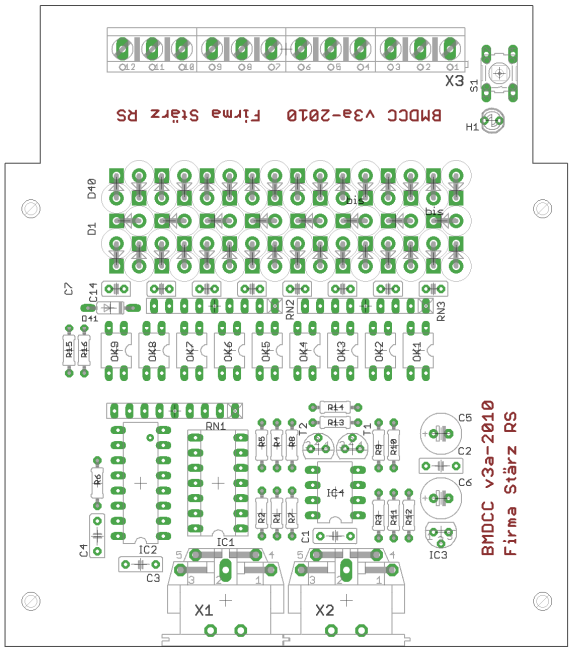
13. Verification and mounting the PIC

After soldering all components on the PCB verify once more that they are placed according component layout diagram and that they are oriented properly. Check that all solder points on the bottom side of the PCB look correct. Note especially if there are any undesired solder bridges between solder pads.

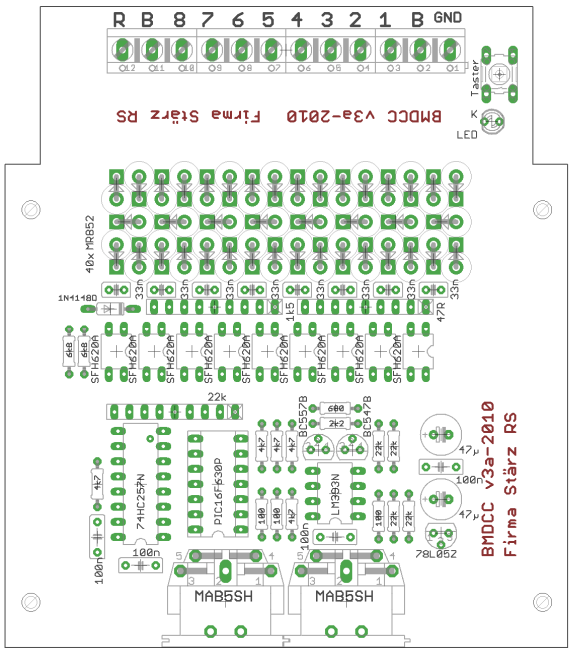
After the verification the PIC can be mounted:

IC1:	PIC „BM“

Component layout diagram on the PCB



Populated PCB



Description of operation

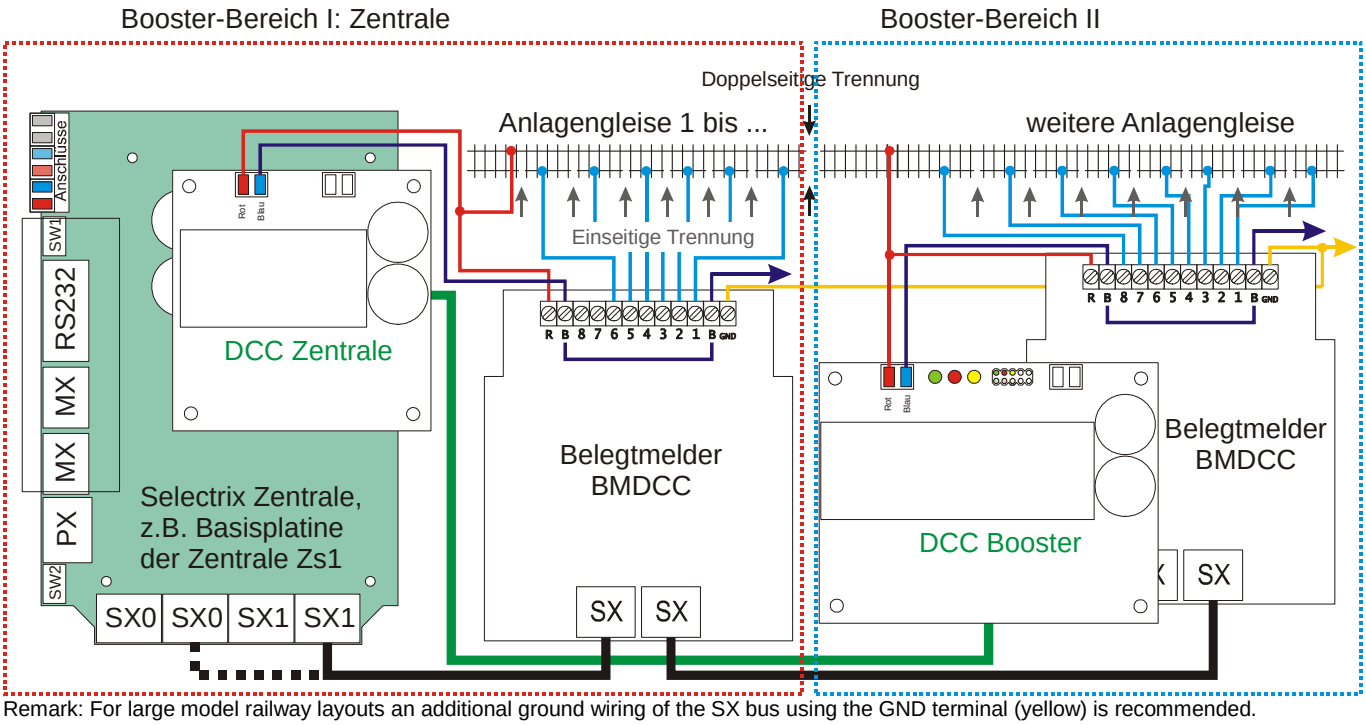
Operating principle of the occupancy detection module

When a locomotive or a rail car equipped with a locomotive decoder or an illuminated car is on track, its' decoder or the illumination draws electric current.
Track occupancy detector decoder monitors constantly the current consumption of eight track blocks. When a track block draws current, the corresponding address bit in the SX-bus is set and the information is available for the system central unit. Another system device configured for the same address (e.g. an accessory decoder) can read and display the status of the 8 track blocks automatically.

Bringing into service

The address of the occupancy detector BMDCC, response delay and dropout delay as well as additional parameters (options) are programmed through the SX bus. In order to do so, a controller, e.g. a central unit ZS1, a controller unit SPF-PIC or a (bus)-interface with corresponding computer programme are required.
After plugging occupancy detector BMDCC to the SX bus these parameters can be set.
During programming of the occupancy detector BMDCC the bus addresses 0 to 3 will be used temporarily. That means during programming the contents of these addresses will be changed.

Connection scheme



Remark: For large model railway layouts an additional ground wiring of the SX bus using the GND terminal (yellow) is recommended.

Parameters and Programming

Programming

By programming the address of this module and all further parameters are set. Here all parameters are explained. Refer to the last page of these instructions for an example for the programming procedure.

Convention Bit and Key

In information technology "Bit 0" to "Bit 7" is common.
For model railroaders a numbering of "bit 1" to "bit 8" is much more convenient, as "Bit 1" becomes equal to "Key 1" or "position 1". This convention is used in these instructions.

Overview of parameters

Address 0: Address of this module — **1 to 103 / 111 (90)**
see table of addresses

Address 1: Response delay — **1 to 254 (8)**
In steps of 10, 20, 40 or 80 milliseconds

Address 2: Dropout delay — **1 to 254 (50)**
In steps of 10, 20, 40 or 80 milliseconds

Address 3: Extended options
Occupancy detection at ZE Stop
Occupancy detection at track power off/short circuit
Occupancy or Free detection
Cycle length of response and dropout delay
Storage of occupancy status

Address of this module

The address of this module can be set to any value in the range from 1 to 111. Note that at certain central units addresses 104 to 111 are reserved for internal purposes during operation and should thus not be used.
Also, addresses 0 to 3 are often used for programming parameters of modules. Therefore these addresses should also not be used.

Response and dropout delay

Response delay is defined as the time between the actual detection of an occupied rail and its reporting to the Selectrix bus.
Similarly the dropout delay is defined as the time between detecting a free rail and reporting to the Selectrix bus.
Both delays can be set to values between 0,01 and 20 seconds in steps of 10, 20, 40 or 80 milliseconds, (🕮 Cycle length for response and dropout delay).
Depending on the sensitivity of the model railway layout (rail contacts of rolling material, wiring) different values can avoid flickering or faulty ghost detection reports.
The response/dropout delay is calculated from the sum of the values of each position (bit) (1 up to 255), multiplied by the 🕮 Cycle length for response and dropout delay (10 milliseconds per default):

Key	1	2	3	4	5	6	7	8
Value	1	2	4	8	16	32	64	128
Time [s]	0,01	0,02	0,04	0,08	0,16	0,32	0,64	1,28

In the following some examples (Seconds {cycle length}):

Key	1	2	3	4	5	6	7	8
Value	1	2	4	8	16	32	64	128
0,4 {10}	-	-	-	/	-	/	-	-
0,8 {20}	-	-	-	/	-	/	-	-
4,0 {40}	-	-	/	-	-	/	/	-
16 {80}	-	-	-	/	-	-	/	/

Extended options

Option occupancy detection at ZE Stop

Most occupancy detectors monitor the block status also when the central unit is set in Stop mode to disable digital track voltage. In Stop mode this occupancy detector will indicate monitored track blocks being free by default.

When automatic control functions are used or when connecting a trackside signal to the occupancy detector of the following track block, some undesirable side effects may occur. An example is a signal showing 'proceed' aspect while the track block ahead is still occupied.

For this option terminal R must be connected to the central unit/booster.

The option occupancy detection at ZE Stop can be configured with four values corresponding four different decoder behaviours in Stop mode:

Key 1	Key 2	Behaviour in Stop mode:
Off	Off	Default behaviour
Off	On	No change
On	Off	Block free
On	On	Block occupied

Default behaviour: In Stop mode normally a block is detected as free if the decoder is connected to the first or the only SX bus of the central unit as no track voltage is turned on even if it's actually occupied. This is not the case when the decoder is connected to a SX bus of a second central unit which is set to stop mode since the SX bus of the first central unit feeding the track is on and not stopped.

In **No change** mode the track status is not updated at ZE stop, the last known status (occupied or free) remains active at the SX bus. If the central unit is on, each occupancy or free detection is stored in occupancy detector BMDCC (occupancy detector's LED blinks in this case). That allows the SX bus, when powered down, to recover the last state of the tracks (see storage of occupancy detection).

In **Block Free** mode all blocks monitored by the occupancy detector are reported being free when the central unit is in stop mode.

In **Block occupied** mode all blocks monitored by the occupancy detector are reported being occupied when the central unit is in stop mode.

Option occupancy detection at track power off

Most occupancy detectors will try to monitor the block status also when there is no power or digital signal on the track due to a disconnected wire or short circuit. In such a case the track blocks will be indicated being free by default. Some decoders will under these circumstances set the block status occupied.

When automatic control functions are used or when connecting a trackside signal to the occupancy detector of the following track block, some undesirable side effects may occur. An example is a signal showing 'proceed' aspect while the track block ahead is still occupied. Another possibility is a free block indicated being occupied before an entering train has reached the block.

For this option terminal R must be connected to the central unit/booster.

Occupancy detection with power off option can be configured with four values corresponding four different decoder behaviours in power off situation:

Key 3	Key 4	When track power off:
Off	Off	Default behaviour
Off	On	No change
On	Off	Block free
On	On	Block occupied

Default behaviour: When track power is off normally a track is detected to be free if the decoder is connected to the first or the only SX bus of the central unit. During short circuit on the rails ghost detections may occur and thus occupancy or free detection is not reliable.

In **No change** mode there is no detection when the track power is off and the last detection reported to the SX bus remains unchanged.

In **Block Free** mode all blocks monitored by the occupancy detector are reported being free when there is no track power.

In **Block occupied** mode all blocks monitored by the occupancy detector are reported being occupied when there is no track power.

Option occupancy or free detection

Most occupancy detectors signal an occupied track block status by the bit value **On** and a block free status by **Off**.

The occupancy detector BMDCC allows to invert occupancy detection into a free detection.

The option occupancy or free detection defines the convention of how occupancy or free information is coded:

Key 5	Occupancy or free detection
Off	Occupied = On, Free = Off
On	Occupied = Off, Free = On

For instance when using accessory decoders set to the same address as the occupancy detector with free detection track signals will have to be connected in the way signalling halt when the corresponding accessory decoder output is off.

Option cycle length for response and dropout delay

Normally the cycle length for response and dropout delay is set to 10 milliseconds. The maximum delay to be set with this cycle length is thus 2,54 seconds.

For some automatic control functions it might be useful to increase the dropout delay (the time a track is still signalised to be occupied although the train already left the track).

Key 6	Key 7	Cycle length
Off	Off	10 ms
Off	On	20 ms
On	Off	40 ms
On	On	80 ms

Doing so allows increasing response and dropout delay up to 20 seconds.

The cycle length is used in common for response and dropout delay.

Option Storage of occupancy status

If option **Occupancy detection at ZE Stop** is configured to **No Change** by Key 1 Off and Key 2 On, then every time a block status changes, the new status information is stored in the decoder. When restarting the system after a shut down the block status information is retrieved from decoder's memory to the SX bus rather from the block detection as the track might still be powered down by the central unit.

Key 8	Storage of occupancy status
Off	Always
On	Only if central unit is in Stop mode

The memory of the occupancy decoder BMDCC can store the block status for about 1 million times which corresponds to thousands of system operation hours. Normally it is sufficient that the block status is stored just before turning the system off. If the decoder is set to store the status only when the central unit is in Stop mode, the block status is not stored in the memory permanently but **only when the central unit is set to Stop mode** before turning it off.

Factory default settings

Address of this module:	90
Response delay:	8 (= 0,08 sec.)
Dropout delay:	50 (= 0,5 sec.)
Occupancy detection at ZE Stop:	Off, Off
Occupancy detection at track power off:	Off, Off
Occupancy or free detection:	Off (= Occupied)
Cycle length:	Off, Off (= 10 ms)
Storage of occupancy status:	Off (= always)

If the address of this module is set to a value greater than 111, it will be reset to the factory default setting (90).

Setting the address of this module to the value of 255 will reset all parameters to their factory default settings.

Revert back to previous settings

Entering 0 as address, response or dropout delay reverts the corresponding value to its previously programmed one.

Programming parameters e.g. with the Control Panel SPF-PIC

Preparations for Programming:
To be able to programme the parameters, the occupancy detector BMDCC is required to be connected to a central unit via the SX-bus cable.

Enter programming mode:
Set the central unit to STOP mode by pressing the "ZE"-key (ZE aus).
Press the programme button S1 of the occupancy detector. The module's LED activates to indicate programming mode.
Remark: Activate decimal decoding in the Control Panel to facilitate decimal conversion.

Enter the address of the occupancy detector:
Select address 00 in Control Panel.
Enter switching mode by key "Adr" and enter 0, 0. The current address of the occupancy decoder is displayed, e.g. address 90:

```
Adr -/-//-/-=090
000 12345678 aus
```

Enter new address of this module
e.g. address 34 with keys 2 and 6:

```
Adr -/---/--=034
000 12345678 aus
```

Enter response delay:
Select address 01 in Control Panel.
Enter switching mode by key "Adr" and enter 0, 1. The current response delay is displayed, e.g. 0,44 seconds (with a cycle length setting of 10 milliseconds):

```
Adr --//-/--=044
001 12345678 aus
```

Enter new response delay
e.g. 0,08 seconds (with a cycle length of 40 milliseconds to be set later on) with key 2:

```
Adr -/------=002
001 12345678 aus
```

Enter dropout delay:
Select address 02 in Control Panel.
Enter switching mode by key "Adr" and enter 0, 2. The current dropout delay is displayed, e.g. 0,05 seconds (with a cycle length setting of 10 milliseconds):

```
Adr /-/-----=005
002 12345678 aus
```

Enter new dropout delay
e.g. 3,2 seconds (with a cycle length of 40 milliseconds to be set later) with key 5 and 7:

```
Adr ----/-/-=080
002 12345678 aus
```

Enter the options:
Enter address 03 in Control Panel.
Select switching mode by key "Adr" and enter 0, 3. The current options are displayed, e.g.:

```
Adr /-//----=013
003 12345678 aus
```

Position 1 and 2 = occupancy detection at ZE Stop: Block free
Position 3 and 4 = occupancy at short circuit: Block occupied
Position 5 = occupied = On, free = Off
Position 6 and 7 = cycle length for delays: 10ms
Position 8 = storage of occupancy status: always

Enter new options
e.g. keys 2, 4, 5 and 6:

```
Adr -/-///--=058
003 12345678 aus
```

Position 1 and 2 = occupancy detection at ZE Stop: No Change
Position 3 and 4 = occupancy at short circuit: No Change
Position 5 = occupied = Off, free = On
Position 6 and 7 = cycle length for delays: 40ms
Position 8 = storage of occupancy status: always

Exit programming mode:
Press the programme button of the occupancy detector or enable track current by pressing "ZE" at the central unit or Control Panel. The LED of the occupancy detector will blink twice for confirmation.
All parameters programmed via the addresses 0 to 3 have been stored in the registers of the occupancy detector BMDCC.

Address table

Bit:	1	2	3	4	5	6	7	8
Value:	1	2	4	8	16	32	64	128
Address								
0	-	-	-	-	-	-	-	-
1	/	-	-	-	-	-	-	-
2	-	/	-	-	-	-	-	-
3	/	/	-	-	-	-	-	-
4	-	-	/	-	-	-	-	-
5	/	-	/	-	-	-	-	-
6	-	/	/	-	-	-	-	-
7	/	/	/	-	-	-	-	-
8	-	-	-	/	-	-	-	-
9	/	-	-	/	-	-	-	-
10	-	/	-	/	-	-	-	-
11	/	/	-	/	-	-	-	-
12	-	-	/	/	-	-	-	-
13	/	-	/	/	-	-	-	-
14	-	/	/	/	-	-	-	-
15	/	/	/	/	-	-	-	-
16	-	-	-	-	/	-	-	-
17	/	-	-	-	/	-	-	-
18	-	/	-	-	/	-	-	-
19	/	/	-	-	/	-	-	-
20	-	-	/	-	/	-	-	-
21	/	-	/	-	/	-	-	-
22	-	/	/	-	/	-	-	-
23	/	/	/	-	/	-	-	-
24	-	-	-	/	/	-	-	-
25	/	-	-	/	/	-	-	-
26	-	/	-	/	/	-	-	-
27	/	/	-	/	/	-	-	-
28	-	-	/	/	/	-	-	-
29	/	-	/	/	/	-	-	-
30	-	/	/	/	/	-	-	-
31	/	/	/	/	/	-	-	-
32	-	-	-	-	-	/	-	-
33	/	-	-	-	-	/	-	-
34	-	/	-	-	-	/	-	-
35	/	/	-	-	-	/	-	-
36	-	-	/	-	-	/	-	-
37	/	-	/	-	-	/	-	-
38	-	/	/	-	-	/	-	-
39	/	/	/	-	-	/	-	-

Bit:	1	2	3	4	5	6	7	8
Value:	1	2	4	8	16	32	64	128
Address								
40	-	-	-	/	-	/	-	-
41	/	-	-	/	-	/	-	-
42	-	/	-	/	-	/	-	-
43	/	/	-	/	-	/	-	-
44	-	-	/	/	-	/	-	-
45	/	-	/	/	-	/	-	-
46	-	/	/	/	-	/	-	-
47	/	/	/	/	-	/	-	-
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70	-	/	/	-	-	-	/	-
71	/	/	/	-	-	-	/	-
72	-	-	-	/	-	-	/	-
73	/	-	-	/	-	-	/	-
74	-	/	-	/	-	-	/	-
75	/	/	-	/	-	-	/	-
76	-	-	/	/	-	-	/	-
77	/	-	/	/	-	-	/	-
78	-	/	/	/	-	-	/	-
79	/	/	/	/	-	-	/	-

Bit:	1	2	3	4	5	6	7	8
Value:	1	2	4	8	16	32	64	128
Address								
80	-	-	-	-	/	-	/	-
81	/	-	-	-	/	-	/	-
82	-	/	-	-	/	-	/	-
83	/	/	-	-	/	-	/	-
84	-	-	/	-	/	-	/	-
85	/	-	/	-	/	-	/	-
86	-	/	/	-	/	-	/	-
87	/	/	/	-	/	-	/	-
88	-	-	-	/	/	-	/	-
89	/	-	-	/	/	-	/	-
(**) 90	-	/	-	/	/	-	/	-
91	/	/	-	/	/	-	/	-
92	-	-	/	/	/	-	/	-
93	/	-	/	/	/	-	/	-
94	-	/	/	/	/	-	/	-
95	/	/	/	/	/	-	/	-
96	-	-	-	-	-	/	/	-
97	/	-	-	-	-	/	/	-
98	-	/	-	-	-	/	/	-
99	/	/	-	-	-	/	/	-
100	-	-	/	-	-	/	/	-
101	/	-	/	-	-	/	/	-
102	-	/	/	-	-	/	/	-
103	/	/	/	-	-	/	/	-
(*) 104	-	-	-	/	-	/	/	-
(*) 105	/	-	-	/	-	/	/	-
(*) 106	-	/	-	/	-	/	/	-
(*) 107	/	/	-	/	-	/	/	-
(*) 108	-	-	/	/	-	/	/	-
(*) 109	/	-	/	/	-	/	/	-
(*) 110	-	/	/	/	-	/	/	-
(*) 111	/	/	/	/	-	/	/	-

(**) Factory default setting

(*) Those addresses are available with restrictions. Consult the remarks in the instructions of the central unit or SX bus extension uses.

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