13.3 AT660

13.3.1 General Information

The AT660 is a temperature module for temperature sensor type L, J and K.

13.3.2 Order Data

Model Number	Short Description	Image
3AT660.6	2005 analog input module, 8 inputs, temperature sensor type L/J/K, -200 to +1300 degrees C. Order TB170 terminal block separately.	
3TB170.9	2005 terminal block, 20-pin, screw clamps	
3TB170.91	2005 terminal block, 20-pin, cage clamps	
3TB170:90-02	2005 terminal block, 20-pin, 20 pcs., screw clamps	
3TB170:91-02	2005 terminal block, 20-pin, 20 pcs., cage clamps	
Terminal blocks not included in the delivery (see "Accessories").		

Table 289: AT660 order data

13.3.3 Technical Data

Product ID	AT660
C-UL-US Listed	Yes
B&R ID Code	$95
Number of Inputs Total in 2 Groups of	 8 4
Electrical Isolation Input - PLC Group - Group Input - Input	 Yes No No

Table 290: AT660 technical data

Product ID	AT660			
Each Group can be Set				
Sensor	FeCuNi	FeCuNi	NiCrNi	Raw Value
Sort	L	J	K	Measurement
Type	Acc. to DIN 43710	Acc. to DIN IEC 584	Acc. to DIN IEC 584	---
Standard	-8.15 to 53.14 mV[1)]	-7.89 to 54.95 mV[1)]	-5.891 to 52.398 mV[1)]	Standardized, 2 µV [2)]
Measurement Voltage Range	-200.0 to +900.0° C	-200.0 to +950.0° C	-200.0 to +1,300.0° C	-15 to +55 mV
Measurement Range in 0.1° C Steps	Yes	Yes	Yes	Depends on sensor
Linearization				in CPU
Each group can be set				
Terminal Temperature Compensation				
Internal	-20 to +80° C from internal compensation measurement			Can be read
External	-100 to +200° C adjustable			---
Reference Junction (internal)				
Temperature Measurement	Temperature profile measurement on the module using four temperature sensors Compensation temperature measured separately for each channel			
Measurement Precision (with natural convection)	Max. ±4° C in total ambient temperature range (0 to 60° C) Type +3° C / -1° C with an ambient temperature of 25° C			
Repeat Precision	≤0.1° C			
Digital Converter Resolution	Internal >14-bit (23841 internal ADC converter values in 20 ms)			
Thermo Voltage Raw Value [3)]	-7500 ($E2B4) at -15 mV 0 at 0 mV 27500 ($6B6C) at +55 mV			
Quantization (ADC value)	2.936 µV (internal)			
Measuring Procedure				
Conversion Principle	Integrated (voltage/frequence converter)			
Conversion Order of the Channels	1 and 5, 2 and 6, 3 and 7, 4 and 8 parallel			
Measurement Time per Conversion	20 ms / 16.67 ms / 10 ms / 8.33 ms (module related setting)			
Measurement Time for Internal Compensation Measurement	20 ms + 6 ms			
Maximum cycle time	**50 Hz**		**60 Hz**	
4 * (measurement time per conversion + module computing time)	4 * (20 + 6) ms		4 * (16.67 + 6) ms	
Internal Compensation Measurement (if activated)	20 ms + 6 ms		20 ms + 6 ms	
Cycle Time	130 ms		116.68 ms	
Inputs	Differential Inputs			
Input Resistance	>1 MΩ			
Input Filter	Bessel low pass 2nd order, cut-off frequency 8 Hz, with NOTCH characteristic measurement procedure (depending on the measurement time at 50 Hz / 60 Hz / 100 Hz / 120 Hz)			

Table 290: AT660 technical data (cont.)

Product ID	AT660			
Status Display	RUN LED (green), 6 status LEDs (yellow)			
Measurement Range Monitoring Open Inputs Wire break Range Exceeded (neg.) Range Exceeded (pos.)	 $7FFF $7FFF $8000 4) $7FFF			
Measurement Precision at 25° C 5) 6)	Type L ±0.5° C	Type J ±0.5° C	Type K ±0.8° C	---
Offset Drift 6)	±2.5 µV /° C			
Gain Drift 7)	±100 ppm /° C			
Common Mode Deviation	±9 V between the channels			
Common-Mode Rejection	75 dB (DC) / 65 dB (50 Hz)			
Maximum Modulation Compared to Ground Potential	±50 V			
Repeat Precision Measurement time 20 ms Measurement time 16.67 ms Measurement time 10 ms Measurement time 8.33 ms	 ≤2 LSB ≤3 LSB (scaled to 20 ms) 8) ≤4 LSB (scaled to 20 ms) 8) ≤6 LSB (scaled to 20 ms) 8)			
Power Consumption 5 V 24 V Total	 Max. 1.25 W Max. 4.75 W Max. 6 W			
Dimensions	B&R 2005 single-width			

Table 290: AT660 technical data (cont.)

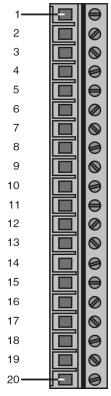
1) Standardized to 0° C compensation temperature.
2) Voltage standardized to 2 µV starting with rev. xx.01.
3) Specifications refer to 2 µV.
4) Not for raw value measurement.
5) Without consideration for the compensation measurement error.
6) Refers to the measurement range.
7) Refers to the current measurement value.
8) Depending on the measurement time, the internal resolution is reduced respectively, but the analog value is always scaled to 20 ms and output in this form. This prevents a value from being changed when the measurement time is changed.

13.3.4 Status LEDs

<table>
<tr><th>Image</th><th>LED</th><th>Description</th></tr>
<tr><td rowspan="4"> 
</td><td>RUN</td><td>The analog/digital converter is running.</td></tr>
<tr><td>60Hz</td><td>This LED indicates which measurement time is switched on. If this LED is lit, the measurement time is set to 16.67 ms, by which a 60 Hz mains power hum is filtered out. Otherwise a measurement time of 20 ms is selected. The measurement time is valid for all 8 channels.
Default Setting: 50 Hz; LED not lit</td></tr>
<tr><td>τ/2</td><td>This LED indicates if the half measurement time is set. If this LED is lit the measurement time is 10 ms or 8.33 ms (depending on whether the 60Hz LED is lit or not).
Default Setting: Full measuring time; LED not lit</td></tr>
<tr><td>ϑ1A/ϑ1B</td><td>These LEDs indicate the temperature sensor type setting for group 1 (channels 1 - 4).
Default Setting: Sensor type L; both LEDs not lit
<table><tr><th>ϑ1B</th><th>ϑ1A</th><th>Sensor Type</th></tr><tr><td>OFF</td><td>OFF</td><td>L (default setting) or wrong setting in mode register 2</td></tr><tr><td>OFF</td><td>ON</td><td>J</td></tr><tr><td>ON</td><td>OFF</td><td>K</td></tr><tr><td>ON</td><td>ON</td><td>Output of thermocouple voltage as standardized raw value 1) or compensation temperature</td></tr></table>1) Starting with Rev. xx.01.</td></tr>
<tr><td>ϑ2A/ϑ2B</td><td>These LEDs indicate the temperature sensor type setting for group 2 (channels 5 - 8).
Default Setting: Sensor type L; both LEDs not lit
<table><tr><th>ϑ2B</th><th>ϑ2A</th><th>Sensor Type</th></tr><tr><td>OFF</td><td>OFF</td><td>L (default setting) or wrong setting in mode register 2</td></tr><tr><td>OFF</td><td>ON</td><td>J</td></tr><tr><td>ON</td><td>OFF</td><td>K</td></tr><tr><td>ON</td><td>ON</td><td>Output of thermocouple voltage as standardized raw value 1) or compensation temperature</td></tr></table>1) Starting with Rev. xx.01.</td></tr>
</table>

Table 291: AT660 status LEDs

13.3.5 Pin Assignments



TB170

Connection	Assignment
1	+ Sensor 1
2	- Sensor 1
3	+ Sensor 2
4	- Sensor 2
5	+ Sensor 3
6	- Sensor 3
7	+ Sensor 4
8	- Sensor 4
9	Shield
10	Shield
11	Shield
12	Shield
13	+ Sensor 5
14	- Sensor 5
15	+ Sensor 6
16	- Sensor 6
17	+ Sensor 7
18	- Sensor 7
19	+ Sensor 8
20	- Sensor 8

Table 292: AT660 pin assignment

Signal Cable Connection

Shielded cables must be used for temperature sensor connection lines. The shield is grounded for two inputs using one of the terminal block shield connections provided. The minus leg of the sensor is grounded with some thermocouples, which does not affect the measurements negatively.

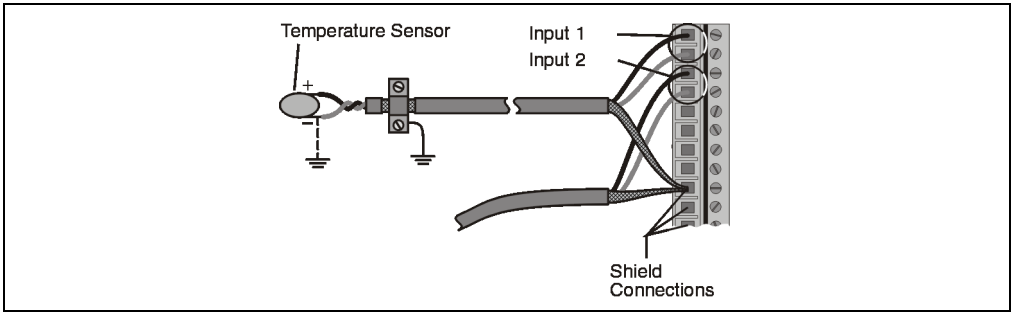


Table 293: AT660 signal cable connection

The four shielded connections are of equal value and each connected via RC elements with ground (⏚, i.e.: a spring contact and a mounting rail).

R: 22 kΩ, C: 10 nF / 60 V

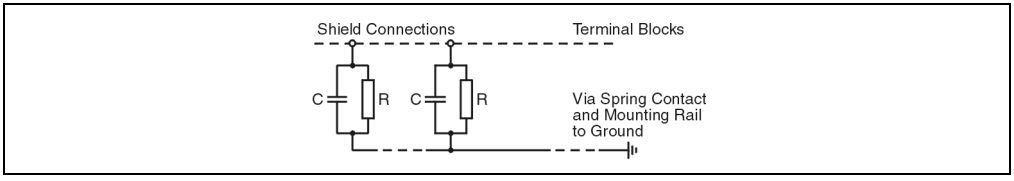


Figure 167: AT660 shielded connection

Influence of the Compensation Line Length

The measurement error caused by the line resistance can normally be disregarded. For a line resistance of Ω (this corresponds to a line length of approximately 40 m), the measurement errror is 9 µV.

13.3.6 Input Circuit Diagram

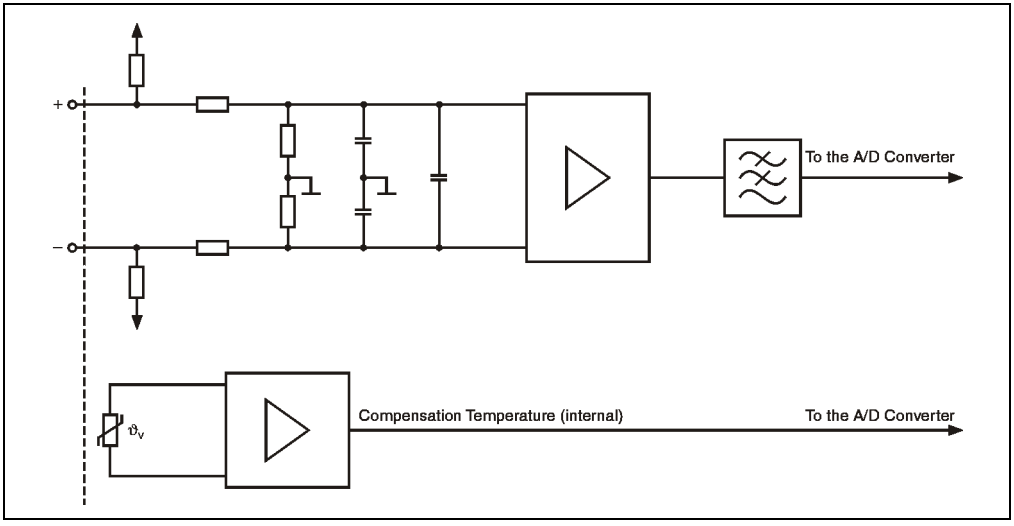


Figure 168: AT660 input circuit diagram

13.3.7 Measurement Range Monitoring

1) Causes for Exceeding the Measurement Range in the Positive Direction ($7FFF)

- No temperature sensor connected
- The input voltage from the temperature sensor is higher than the:
  a) Voltage range
  b) Measurement range of the temperature sensor

2) Causes for Exceeding the Measurement Range in the Negative Direction ($8000)

- The input voltage from the temperature sensor is lower than the:
  a) Voltage range
  b) Measurement range of the temperature sensor

3) Short Circuit Monitoring

Since a short circuit is generally a valid type of operation (0 mV), this cabling error status must be recognized with a plausibility check in the application program.

If 0° C is also in the operating range for the application, B&R recommend a plausibility check using additional logic.

Example: If the heater for Δt = n sec is switched on, the temperature must increase at least 2° C (reference value that can also be automatically, adaptively calculated).

13.3.8 Installation Notes

- Additional cooling lowers the absolute error of the internal compensation temperature calculation especially at higher environmental temperatures for the AT660 (to approximately ±2° C).
- For EMC reasons, it is recommended to short circuit open inputs.
- 5 minutes after switching on the controller, the AT660 has reached operating temperature for calculating the compensation temperature The measurement precision is now valid.

13.3.9 Internal Measurement Processing

A scaled raw value is created from the input voltage which has a linear relationship to the input voltage. Thermocouple temperature (for the given thermocouple type) is calculated from this raw value taking the compensation into consideration (compensation and linearization takes place internally).

The compensation temperature is calculated separately for each channel in the module. The required temperature measurement is made using four temperature sensors on the terminal block. The compensation temperature can be read by the user.

It is also possible to set the compensation temperature for each channel which will be used instead of the measured value for internal compensation ("external compensation"). Operation using external compensation is only possible for the entire module.

Special Types of Operation:

a) A thermocouple other than the defined types (J, K, L) is connected. Thermocouple temperature is calculated in an application program (main CPU) from the raw value and the compensation temperature measured on the module (for the respective channel).

b) It is necessary to install an external compensation reference junction (for long line lengths). Calculating thermocouple temperature should be done on an AT660 module in spite of this.

The thermocouple voltage is sent from the external compensation reference junction to the terminal of the AT660, the temperature measured on the external compensation reference junction (e.g. with PT100 - AT350) is placed in the IO area for the AT660 module. The AT660 module calculates thermocouple temperature internally from the measured voltage and the compensation temperature value (per channel).

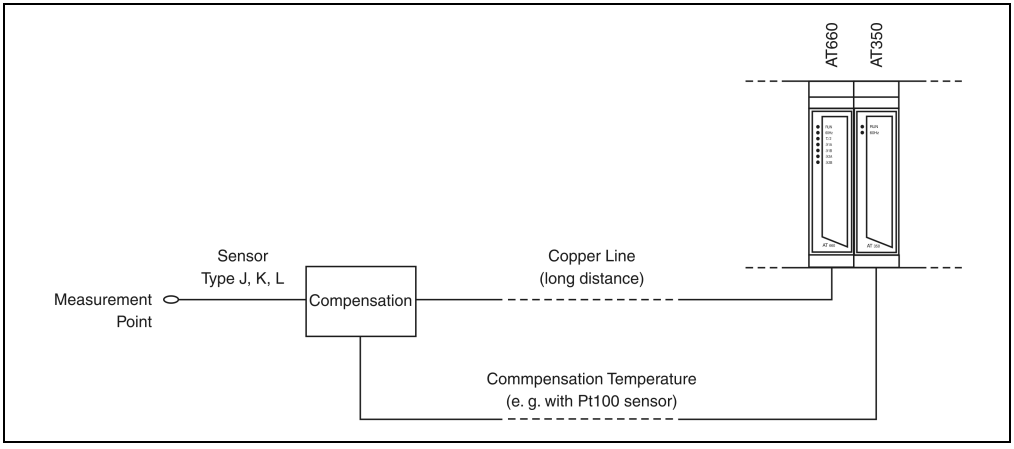


Figure 169: AT660 operation using an external compensation reference junction

13.3.10 Variable Declarations

The variable declaration is made in B&R Automation Studio™:

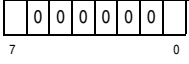
Function	Variable Declarations				
	Scope	Data Type	Length	Module Type	Chan.
Single Analog Input (Channel x)	tc_global	INT	1	Analog In	1 ... 8
Default External Reference Junction in 0.1° C Steps (channel x)	tc_global	INT	1	Analog Out	1 ... 8
Mode Register 1	tc_global	USINT	1	Status Out	0
Mode Register 2	tc_global	USINT	1	Status Out	1
Mode Register 3	tc_global	USINT	1	Status Out	2
Mode Register 4	tc_global	USINT	1	Status Out	3
Status Register 1	tc_global	USINT	1	Status In	0
Status Register 2	tc_global	USINT	1	Status In	1
Status Register 3	tc_global	USINT	1	Status In	2
Status Register 4	tc_global	USINT	1	Status In	3

Table 294: AT660 variable declaration

Mode Register 1

Bits 1 - 6 must be assigned with 0.

Mode Register 1	Bit	Description
	7	τ/2 - Half measurement time
	6	0
	5	0
	4	0
	3	0
	2	0
	1	0
	0	τ - Measurement time 16.67ms



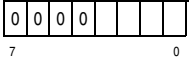
τ 0..... Measurement time per channel 20 ms (default setting) filtering of 50 Hz power hum
1..... Measurement time per channel 16.67 ms filtering of 60 Hz power hum

τ/2 0..... Depending on bit 0, the measurement time is 20 ms or 16.67 ms (default setting)
1..... Half measurement time: Depending on bit 0, the measurement time is 10 ms or 8.33 ms

Mode Register 2

Bits 4 - 7 must be assigned with 0. Please refer to the section "Relationship between Mode Registers 2 and 3".

Mode Register 2	Bit	Description
	7	0
	6	0
	5	0
	4	0
	3	ϑ2B - Sensor type for group 2 (channels 5 - 8)
	2	ϑ2A - Sensor type for group 2 (channels 5 - 8)
	1	ϑ1B - Sensor type for group 1 (channels 1 -4)
	0	ϑ1A - Sensor type for group 1 (channels 1 -4)



With standardized raw values, settings are **not** relevant and can be chosen in any way desired.

B&R Recommendation: $00

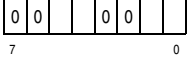
ϑ2		ϑ1		Sensor Type
B	A	B	A	
0	0	0	0	L (default setting)
0	1	0	1	J
1	0	1	0	K
1	1	1	1	Invalid Sensor Type Output of: -3276.8

Table 295: Definition of the Sensor Type

Mode Register 3

Bits 2 and 3 as well as 6 and 7 must be assigned with 0. Please refer to the section "Relationship between Mode Registers 2 and 3".

Mode Register 3	Bit	Description
		0
		0
		Raw value 2 - Group 2: Temperature as standardized raw value
		Raw value 1 - Group 1: Temperature as standardized raw value
		0
		0
		VSϑ2 - Group 2: Compensation temperature
		VSϑ1 - Group 1: Compensation temperature



VSϑ1 0..... Group 1: Sensor temperature output (default setting)
1..... Group 1: Compensation temperature output in 0.1° C steps [1)]

VSϑ2 0..... Group 2: Sensor temperature output (default setting)
1..... Group 2: Compensation temperature output in 0.1° C steps [1)]

Raw Value 1 0..... Group 1: Thermocouple voltage output as compensated temperature in 0.1° C steps (default setting)
1..... Group 1: Thermocouple voltage output as standardized raw value [2)]

Raw Value 2 0..... Group 2: Thermocouple voltage output as compensated temperature in 0.1° C steps (default setting)
1..... Group 2: Thermocouple voltage output as standardized raw value [2)]

1) The compensation temperature is either the terminal temperature (bit 5 in the mode register 4 = 0) or the temperature of an external compensation reference junction (bit 5 in the mode register 4 = 1).
2) It is not possible to output the compensation temperature as a standardized raw value. Standardization is made with 2 µV starting with rev. xx.01.

Relationship between Mode Registers 2 and 3

The output format is defined using both these registers.

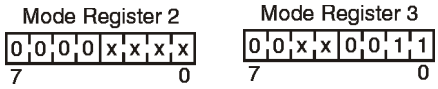
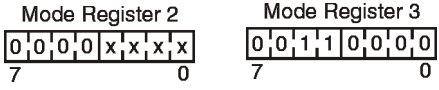
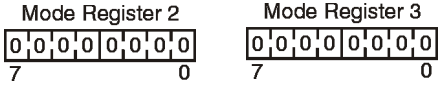
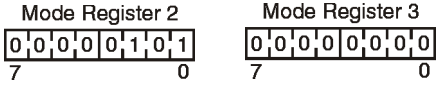
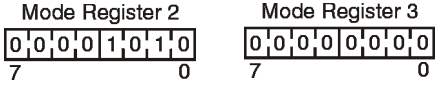
1) Compensation Temperature Output	
2) Thermocouple Voltage Output as Standardized Raw Value	
3) L (default setting)	
4) Sensor Type J	
5) Sensor Type K	

Table 296: AT660 relationship between mode register 2 and 3

Mode Register 4

Selectively switching off (locking) the channels or the compensation temperature reduces the cycle time.

Bits 6 and 7 must be assigned with 0.

Mode Register 4	Bit	Description
	7	0
	6	0
	5	$COMP_{External}$ - External Compensation Temperature
	4	T_{Comp} - Updating the internal compensation temperature locking
	3	C4/8 - Locking channels 4 and 8
	2	C3/7 - Locking channels 3 and 7
	1	C2/6 - Locking channels 2 and 6
	0	C1/5 - Locking channels 1 and 5

C1/5
0 .....Measuring Channels 1 and 5 (default setting)
1 .....Locking channels 1 and 5. The value last measured is retained.

C2/6
0 .....Measuring Channels 2 and 6 (default setting)
1 .....Locking channels 2 and 6. The value last measured is retained.

C3/7
0 .....Measuring Channels 3 and 7 (default setting)
1 .....Locking channels 3 and 7. The value last measured is retained.

C4/8
0 .....Measuring Channels 4 and 8 (default setting)
1 .....Locking channels 4 and 8. The value last measured is retained.

T_{Comp}
0 .....The internal compensation temperature (terminal temperature) is constantly updated (default setting)
1 .....The internal compensation temperature is no longer being updated. The values last measured are retained and are used for terminal compensation temperature.

$COMP_{External}$
0 .....Internal compensation reference junction is active (terminal compensation temperature is used - default setting)
1 .....External reference junction is active (applies to all 8 channels). If the operating mode is selected, Firmware does not use the sensor measurement values on the module for compensation temperature. Instead, a value is set by the user is used. These values are written in the I/O area in steps of 0.1° C using "Analog Out" channels 1 - 8.

Status Register 1

Status Register 1	Bit	Description
	7	x
	6	x
	5	x
	4	x
	3	x
	2	x
	1	x
	0	IERR - Module error

x	x	x	x	x	x	x	

7 0

IERR 0 ..... Data values in the DPR correspond to definitions

1 ..... An internal error exists. That means that the data values in the DPR do not correspond to the definitions. Please contact B&R if this occurs.

Status Register 2, 3 and 4

Mode register settings 2, 3 and 4 are given again status registers 2, 3 and 4. Settings are only valid if the status register is the same as the mode register.

The respective status register returns a message (mode register) to the application program (task) when the settings have been transferred completely.

Status Register 2

Status Register 2	Bit	Description
	7	x
	6	x
	5	x
	4	x
	3	ϑ2B - Sensor type for group 2 (channels 5 - 8)
	2	ϑ2A - Sensor type for group 2 (channels 5 - 8)
	1	ϑ1B - Sensor type for group 1 (channels 1 -4)
	0	ϑ1A - Sensor type for group 1 (channels 1 -4)

x	x	x	x				

7 0

Status Register 3

Status Register 3	Bit	Description
		x
		x
		Raw value 2 - Group 2: Temperature as standardized raw value
		Raw value 1 - Group 1: Temperature as standardized raw value
		x
		x
		VSϑ2 - Group 2: Compensation temperature
		VSϑ1 - Group 1: Compensation temperature

x	x			x	x		
7							0

Status Register 4

Status Register 4	Bit	Description
	7	x
	6	x
	5	$COMP_{External}$ - External Compensation Temperature
	4	T_{Comp} - Updating the internal compensation temperature locking
	3	C4/8 - Locking channels 4 and 8
	2	C3/7 - Locking channels 3 and 7
	1	C2/6 - Locking channels 2 and 6
	0	C1/5 - Locking channels 1 and 5

x	x						
7							0