A tube clock, some say "scope clock", what do we mean by that ? June-14-2021

An electronic assembly capable of displaying a clock on a variety of different electron beam tubes (crt's).
Alternatively, the microcontroller can be removed and a separate controller or single-board computer can take over the control of the tube. For this purpose, the inputs of the D/A converter and the brightness control are led to the outside and are operated with TTL levels.

Foreword

This document is intended to assist you in assembling the kit, putting it into operation, selecting the necessary components and assembling it into a complete clock with a cathode ray tube. A relatively high level of knowledge in the field of electronics is assumed. As voltages of up to 1600V are used, the following are some general notes on the dangers of working with high voltage. I do not guarantee the correctness and completeness of the following information. Everyone is responsible for their own safety! The reader should only be made aware of some of the dangers in dealing with high voltage.

Danger of electric shock

Danger does not only exist when touching a conductor, but at 1500V already a proximity is sufficient so that a spark can jump over and thus a current flows through the human body. In the high-voltage part of our assembly, this is limited to about 60mA due to the circuitry. This is not harmless, currents of more than 20mA can already be lethal !
Metal parts of the housing must be earthed. Never touch parts of a measuring or experimental setup when the HV source is switched on ! Capacitors can still contain a dangerous residual charge even after months and can also charge themselves statically over time ! High-voltage capacitors must be stored short-circuited for this reason. On our circuit board, all capacitors have discharge resistors so that touching them should be possible without danger at the latest one minute after switching off the supply voltage.

Danger due to implosion !

Safety glasses should always be worn when handling the tube. It is airless and in case of a hard impact or other damage it can implode and glass splinters fly around. There are interesting constructions with a naked tube, but it should still always be placed in a housing together with the electronics.

General information about the tube clock

Oscilloscope tubes, cathode ray tubes or whatever you like to call them are largely a thing of the past, as they are mostly replaced by LCD displays nowadays. However, there are still plenty of them lying dormant in numerous hobbyists' rooms. Bringing them to life and giving us a treat is the task of this module. It provides all signals and voltages necessary to control many 7-10cm tubes. If necessary, some adjustments have to be made to the voltage divider for the tube voltages (R54-R58). Tubes with larger diameters can also be operated, but this often requires an additional accelerating voltage. This can easily be obtained from a home-made high-voltage cascade, as the current requirement is in the µA range.

The module is designed as a 'radio clock' for receiving the DCF77 time signal. Alternatively, it is also possible to operate the clock synchronised with the mains. In this case, however, only the day of the date is counted up at midnight. Two buttons are used to set the time and date.
The refresh rate is mains-synchronised and is therefore 50 or 60 Hz, depending on the choice. This means that stray fields from neighbouring transformers do not cause flickering or flickering and that magnetic shielding of the tube can usually be dispensed with.

Operation

In the following, reference is made to the place designation (e.g. P51) of some trimmers, connectors, jumpers and other components. To find them, please use the enclosed drawing.

Manual setting via 2 push-buttons
Connecting the push-buttons to JP9: T2 between pin 13 and 14 and T1 between pin 15 and 16

- Press T1 once: activates the time setting by means of T2:

o within 60 seconds the minutes can now be set with T2
o Press T1 again: now the hours can be set with T2
o Press T1 again: now the days can be set with T2
o Press T1 again: now the months can be set with T2
o Press T1 again: now the year can be set with T2
o Press T1 again: exit the setting function

- Press T2 only: toggles between CET and UTC. Note: In the time after midnight, where switching to UTC would have to trigger a date jump to yesterday, the current date remains. This was not a convenience of the programmer, rather the memory in the µC was originally not sufficient for this realisation.

- Switch to CEST when operating without DCF77: Connect PIN 1 - 2 of the DCF input JP5 with a jumper.

Show less

Why would one want to do this ? Oscilloscope tubes are not wonders of brightness and the image becomes fainter the more the electron beam has to paint. In addition, the readability becomes worse with a full screen and greater distance, because the pointers hardly stand out from the background. which is also illuminated. With 2 jumpers at J6, the date, a part of the dial or both can be switched off. See wiring diagram. To do this, please disconnect the mains plug!

Adjusting the image position and size

This is certainly necessary during commissioning or when changing the tube. Also, if the location of the clock is changed, the position of the image on the screen will change due to the earth's magnetic field or nearby metal parts.

Turn the precision trimmers carefully:

P41	X – position	P31	Y - position
P10	X – size	P14	Y - size

Adjusting the picture brightness and sharpness

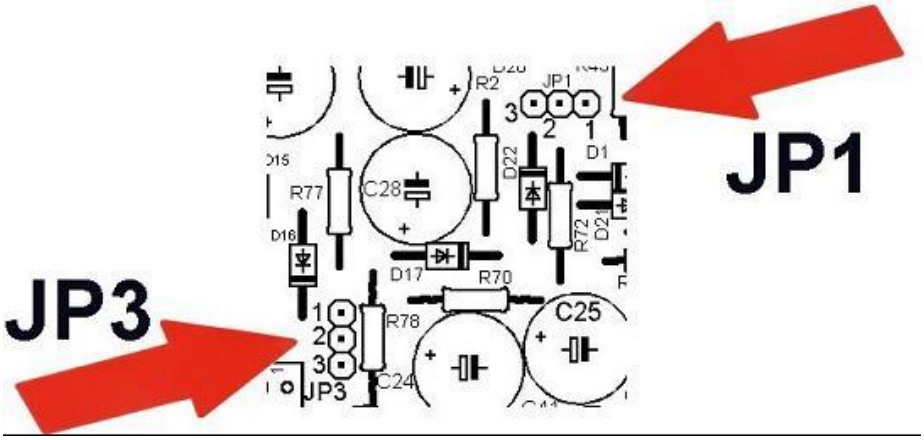
If the tube used matches the values of resistors R53 to R58, P52 can be used to adjust the brightness from completely dark to very (too) bright. If this range is shifted, it is usually sufficient to change R53. Often, it is not possible to set it dark enough, in which case R53 should be increased. Under no circumstances should the brightness be set so high that the beam runs, which are actually dark, are visible. By alternately adjusting P51 and P50, the beam sharpness can be optimally adjusted.

P52	Brightness	P51	Focus	P50	Astigmatism

Choice of anode voltage

In fact, for technical reasons, this is the negative cathode voltage. From the tube's point of view, however, this does not matter. With the jumpers JP1 and JP3 you can choose between -600V and -1500V in steps of 300V. See figure 1. Higher voltage results in brighter and sharper images, but also in increased wear of the tube. The image also becomes smaller as the electron beam

becomes 'harder' and more difficult to deflect. Therefore, correction is required after each anode voltage change with the appropriate adjusters**.**



JP1	JP3
1-2	1-2 600V
1-2	2-3 900V
2-3	1-2 1200V
2-3	2-3 1500V

Figure 1

Connection of the supply voltages

- **12...15 VAC, 120mA at X2,** Note: The power loss in the voltage regulators IC5 and IC6 increases with higher AC input voltage. If you stay in the range up to approx. 14VAC, cooling is not necessary. ATTENTION: The metal lug of IC6 is not connected to GND **!**

- **210...235 VAC, 50mA at X3**, Never connect the mains voltage directly ! The entire assembly would otherwise be at mains potential ! This is life-threatening !

- **6.3V** heating voltage at X1, 60mA...800mA, depending on the tube used. Attention: Some tubes need only **4V ! CAUTION !!! This voltage must be isolated from all others with a dielectric strength of at least 1600V ! Again ATTENTION: This voltage also has a potential of -1600V against GND !**

Do not tighten the screw terminals X1...X3 too much, they are only held by one solder pad each. It is best to fix them with a drop of super glue.

Notes on the supply voltages:

- Voltage specifications on transformers apply under nominal load. Since this is seldom reached with tube clock electronics, the voltages may be too high. It is better to measure all voltages under our load.
- Pre-resistors (1 watt is sufficient) can be used to reduce transformer voltages that are too high. Please note that due to the charging current of the electrolytic capacitors, the peaks of the AC voltage are cut. If you check the AC input voltage, a normal rms-value-calibrated multimeter will show values that are too high. It is better to measure the DC voltage. Cathode D7: 15...19V, cathode D15: 280...330V.
- The TRA800 toroidal transformer, specially made for this project, supplies all voltages and currents with a low stray field and a diameter of only 66mm. Of course, its heating winding has the necessary insulation of > 1600V against all other windings.

Connecting the tube

- The tube is connected to CON3. For some types we have collected suggestions for the correct connection. See the last page of this manual !

- For tubes whose cathode is connected to the filament, the resistors R61, R62 must be removed.
- The cables to the deflection plates must be laid with low capacitance, if possible not in a cable harness. The X/Y output stages are quite high-impedance, too high a capacitive load causes unsightly 'grinding' of edges. In addition, capacitive coupling between the lines can cause interference. Especially the line to the cathode (CON3 pin 7) could 'interfere', because the steep-flanked (0.25ns/V) blanking pulses with high voltage are on it. Keep it slightly away from the others to avoid unsightly distortions.

Hints and tips for the kit

Not all components that appear in the circuit diagram and in the assembly plan are actually assembled !
Some are prepared for future extensions. For components that are not to be assembled and in case of unclear component values or designations, please refer to the **parts list** !

Assembling the clock is easy if the builder takes time to assemble the PCB. First, mark the solder pads that are close to each other with a felt pen. It is usual to start with the wired components, whose connecting wires are then bent slightly to prevent them from falling out. In places where the solder pads are close together, these wire ends can easily touch each other and thus lead to serious short circuits that are very difficult to find. This is especially the case with the 4 deflection transistors T3-T6 and the surrounding components. The marking with the felt pen reminds you to pay special attention here. Finally, the IC sockets are assembled and soldered.
The transistor pairs T3 -T4 and T5 - T6 must be thermally coupled by screwing them together. You can use some electrically non-conductive thermal paste for this. The thicker line symbolises the metal surface, please do NOT mount with the metal surfaces facing each other ! All 4 face in the same direction.
The precision trimmers should rest on the PCB, otherwise they will wobble when turned and the little legs will break off sooner or later.
Soldering: Never cut into a solder joint with side cutters !!! Always shorten the connecting wires of the components before soldering!
Let's move on to IC1. It was unavoidable to use an SMD component here. However, a pin spacing of 1.27mm should not be an insurmountable hurdle. There are several videos on the internet (YouTube) that show how to solder this chip onto the PCB faster and cleaner than a wired component without any special equipment. And it works !

Commissioning and adjustment

- First you should check the voltages of the power supply without ICs and tube (each against GND, jumpers JP1 and JP3 to -600V.
- 5V to pin 40 of IC8
- +12 V at pin8 of IC3
- -12 V to pin4 of IC3
- +250V to positive pole of C26
- approx. -600V at one leg of R61

Adjustment:

- Switch off the mains voltage and wait > 1 min.
- Plug in all ICs
- P10 and P14 to the left stop
- Set voltage at CON3 Pin4 with P41 to approx. 140V.
- Check voltage at CON3 Pin3, should be 130V...150V.
- Check voltage at CON3 pin 2 and set to approx. 140V with P31.
- Check voltage at CON3 Pin1, should be 130V...150V.
- Voltage off, connect tube, voltage on. Now a luminous dot should appear on the screen (if necessary, adjust the brightness with P52).

- Correct the centre position with P31 and P41 if necessary.
- Use P50 to make the light spot as round as possible, then use P51 to focus (smallest diameter).
- Turn P10 and P14 to the right, now the illuminated dot should turn into a clock face.

Other

When selecting a tube, make sure that the entire screen diameter can be used. For some tubes, the angle of the max. Y-beam deflection is limited in favour of the Y-deflection sensitivity, see data sheet.

For tubes with a base where the pins are fused directly into the glass, please exercise extreme caution. The smallest forces exerted on the glass will cause it to break! In comparison, a raw egg is made of granite ! Use suitable tools to straighten bent pins so that not even the slightest bending moment reaches the glass. Only put on the socket when all pins are absolutely straight !

Every tube reacts to the earth's magnetic field. In commercial devices, this is usually so well shielded that this influence is very small. For aesthetic reasons, however, we often do without it in the tube clock and therefore have to deal with external fields. Some tubes react so sensitively that, depending on the direction of rotation, the beam does not reach large areas of the screen at all. With a small magnetised steel piece (even a tiny magnet is too strong) cleverly placed near the neck of the tube, the beam can be brought back.

Although the refresh rate of 50/60 Hz makes the display on the screen quite insensitive to magnetic fields of the same frequency, strong fields can be disturbing. So if the pointers no longer hit correctly or move away from their mounting, numbers are no longer where they should be, the only solution is to move the tube further away from the 'source of interference' or to rotate the transformer.

Optional connections

Connection of a DCF77 receiver

The DCF77 pulses must be 'positive', i.e. the short pulse HI and the longer pulse LOW. The pulse output is connected to JP5 pin 2, GND is on pin 3, a supply voltage of 3.3V for the receiver module can be taken from pin 1. For modules that require 5V operating voltage, D24 must be removed and R18 must be bridged. A flashing of the red LED1 every second indicates a sufficiently good reception of the time signal transmitter.

The status of the DCF reception is indicated by a symbol in the display:

Symbol	Beschreibung
	Clock runs synchronised with the mains. No DCF reception or no receiver connected.
	DCF pulses detected but faulty packet received or packet received or not yet synchronised (after switching on)
	Correct time signal received and clock synchronised

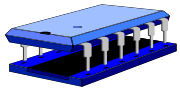
Connecting a motion detector

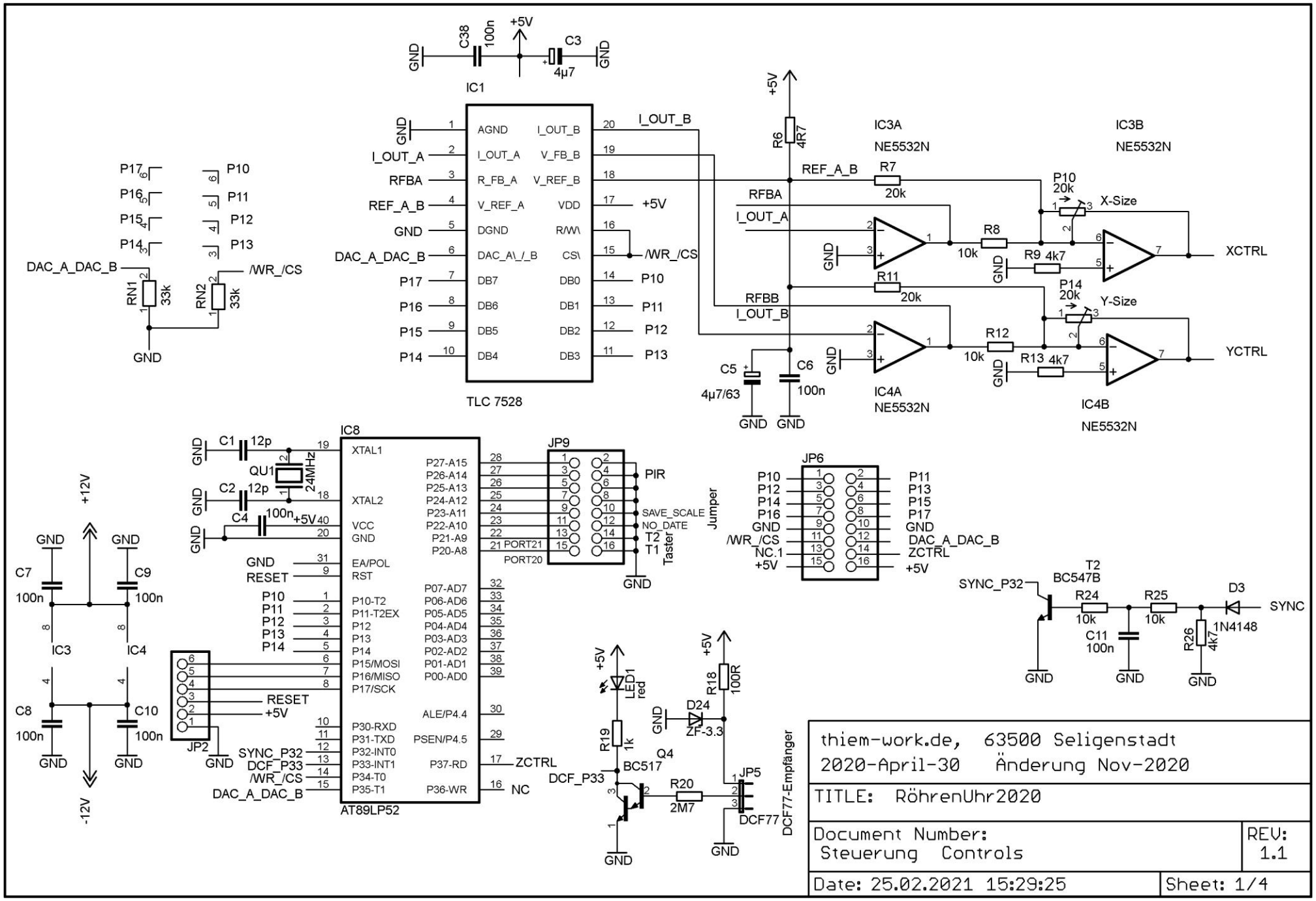
To protect the luminous layer of the tube, it can be switched to 'dark' by an external signal, e.g. that of a motion detector. To do this, pin 3 of JP9 must be switched to GND. This is done with an "open collector" npn-transistor, which must be able to handle about 5mA. Please do not apply any voltage

to this pin ! At JP4 pin 1 +12V operating voltage, max. 100mA, and at pin 2 0V (GND) can be taken. Some types, e.g. the sr501hc, can also be connected directly.

Sources of supply: First address for tubes and accessories is the company "Frag Jan zuerst", Dipl.-Ing. Jan Philipp Wüsten, Preiler Ring 10, D-25774 Lehe, Phone: (+49) 04882-6054551 http://www.scopeclock.de/

My heartfelt thanks to Deepl, who helped me a lot with the translation.

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RFBA
REF_A_B
DGND
DAC_A_DAC_B
DB7
DB6
DB5
DB4
I_OUT_B
V_FB_B
V_REF_B
VDD
R/W\
CS\
DB0
DB1
DB2
DB3
+5V
/WR_/CS
P10
P11
P12
P13
P14
P15
P16
P17
RN1 33k
RN2 33k
C38 100n
C3 4µ7
C5 4µ7/63
C6 100n
R6 4R7
R7 20k
R8 10k
R9 4k7
R11 20k
R12 10k
R13 4k7
P10 20k
X-Size
P14 20k
Y-Size
IC3A
NE5532N
IC4A
NE5532N
IC3B
NE5532N
IC4B
NE5532N
XCTRL
YCTRL
REF_A_B
RFBA
I_OUT_A
RFBB
I_OUT_B
GND
IC8
AT89LP52
XTAL1
XTAL2
VCC
EA/POL
RST
P10-T2
P11-T2EX
P12
P13
P14
P15/MOSI
P16/MISO
P17/SCK
P30-RXD
P31-TXD
P32-INT0
P33-INT1
P34-T0
P35-T1
P27-A15
P26-A14
P25-A13
P24-A12
P23-A11
P22-A10
P21-A9
P20-A8
P07-AD7
P06-AD6
P05-AD5
P04-AD4
P03-AD3
P02-AD2
P01-AD1
P00-AD0
ALE/P4.4
PSEN/P4.5
P37-RD
P36-WR
ZCTRL
NC
C1 12p
C2 12p
QU1 24MHz
C4 100n
RESET
SYNC_P32
DCF_P33
/WR_/CS
DAC_A_DAC_B
JP2
JP9
PIR
SAVE_SCALE
NO_DATE
T2
T1
Taster
PORT21
PORT20
JP6
Jumper
P10
P12
P14
P16
GND
/WR_/CS
NC.1
+5V
P11
P13
P15
P17
GND
DAC_A_DAC_B
ZCTRL
+5V
IC3
IC4
C7 100n
C8 100n
C9 100n
C10 100n
+12V
-12V
LED1 red
R19 1k
Q4
BC517
R20 2M7
R18 100R
D24 ZF-3.3
JP5
DCF77
DCF77-Empfänger
T2 BC547B
R24 10k
R25 10k
C11 100n
R26 4k7
D3 1N4148
SYNC
SYNC_P32
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2020-April-30 Änderung Nov-2020
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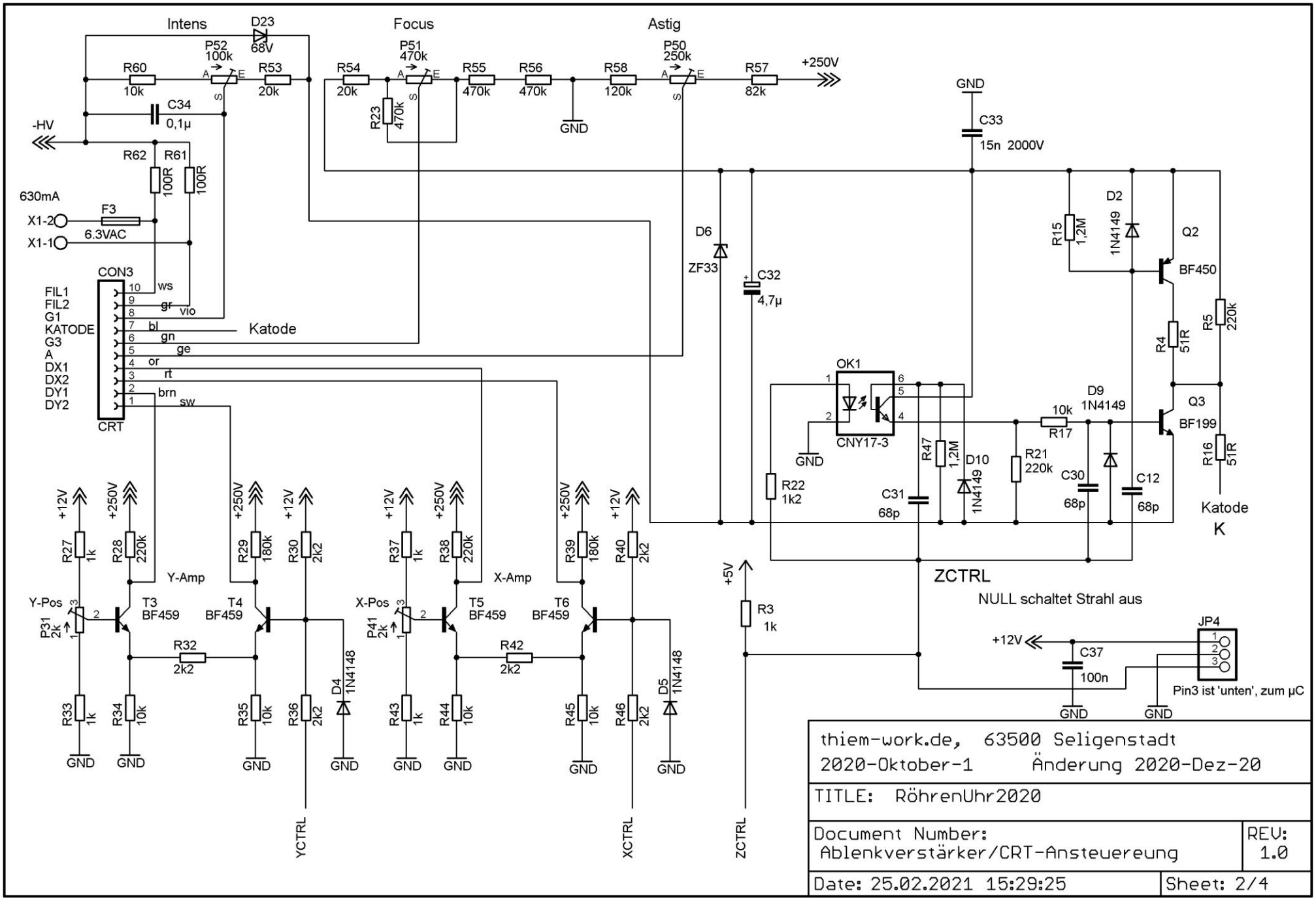
Intens
Focus
Astig
D23
68V
P52
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P51
470k
P50
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R60
10k
R53
20k
R54
20k
R23
470k
R55
470k
R56
470k
R58
120k
R57
82k
+250V
GND
C34
0,1µ
-HV
R62
100R
R61
100R
630mA
F3
6.3VAC
X1-2
X1-1
CON3
FIL1
FIL2
G1
KATODE
G3
A
DX1
DX2
DY1
DY2
CRT
ws
gr
vio
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gn
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or
rt
brn
sw
Katode
C33
15n 2000V
D6
ZF33
C32
4,7µ
R15
1,2M
D2
1N4149
Q2
BF450
R5
220k
R4
51R
OK1
CNY17-3
D9
1N4149
Q3
BF199
10k
R17
R16
51R
R47
1,2M
D10
1N4149
R21
220k
C30
68p
C12
68p
C31
68p
R22
1k2
Katode
K
ZCTRL
NULL schaltet Strahl aus
+5V
R3
1k
JP4
+12V
C37
100n
Pin3 ist 'unten', zum µC
Y-Amp
Y-Pos
P31
2k
T3
BF459
T4
BF459
R27
1k
R28
220k
R29
180k
R30
2k2
R32
2k2
R33
1k
R34
10k
R35
10k
R36
2k2
D4
1N4148
YCTRL
X-Amp
X-Pos
P41
2k
T5
BF459
T6
BF459
R37
1k
R38
220k
R39
180k
R40
2k2
R42
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R43
1k
R44
10k
R45
10k
R46
2k2
D5
1N4148
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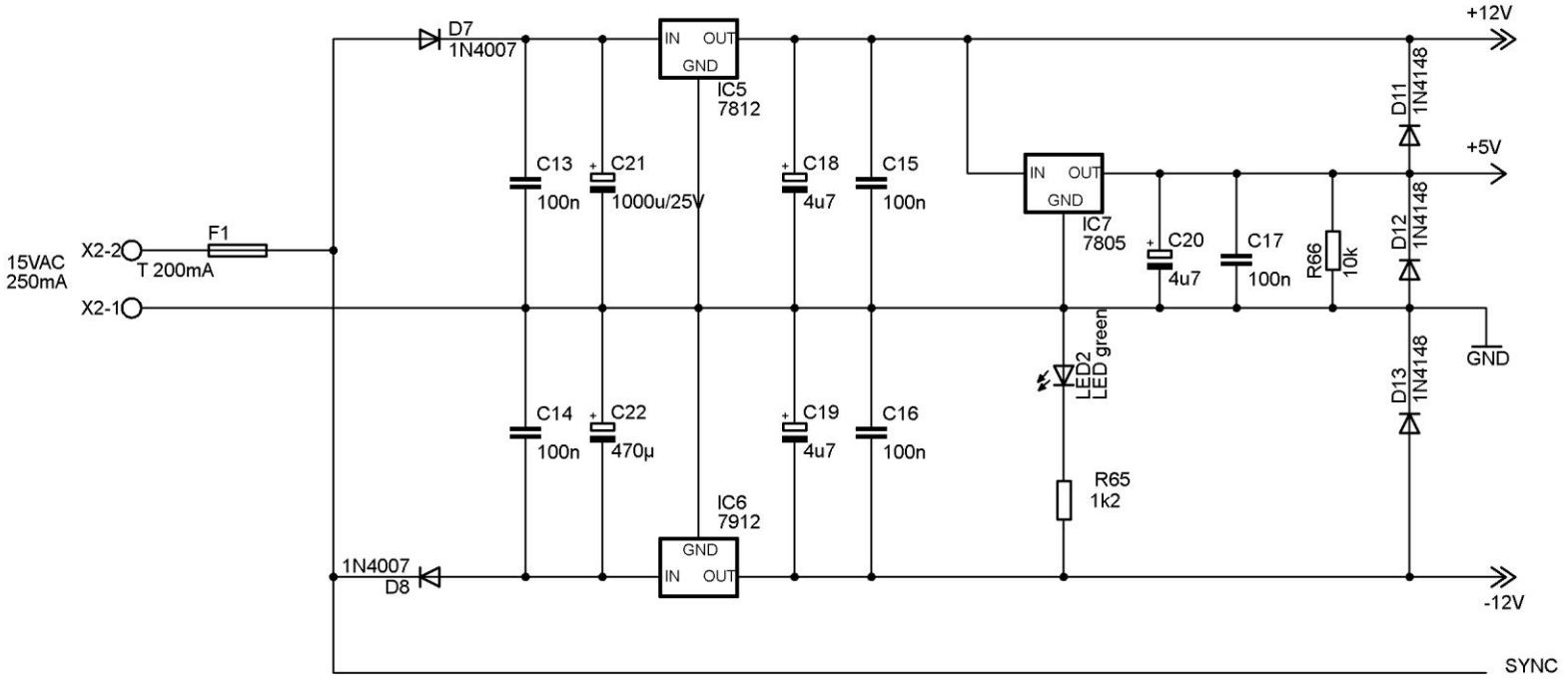

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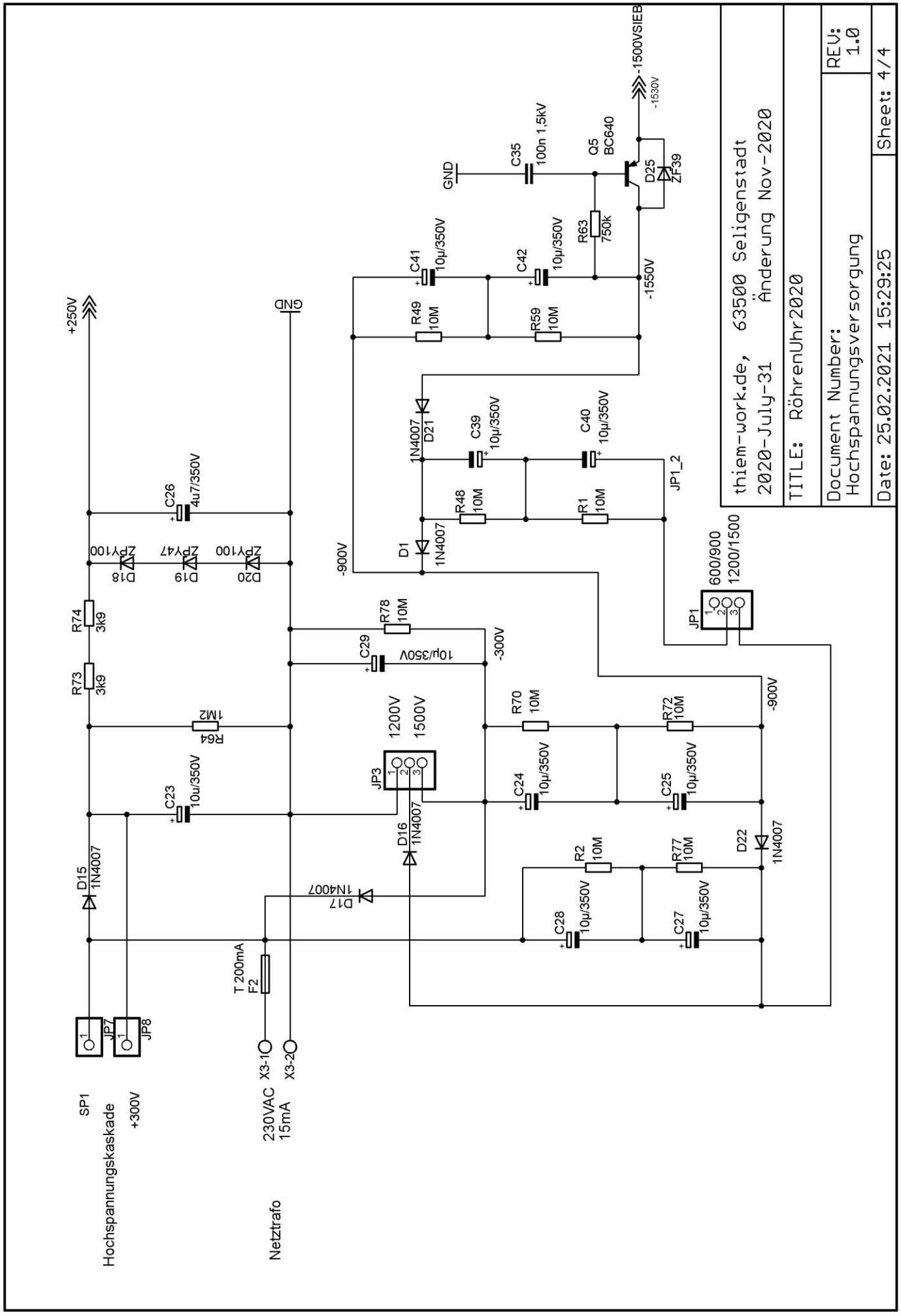
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230VAC
15mA
X3-1
X3-2
T 200mA
F2
JP7
JP8
JP1
600/900
1200/1500
JP3
1200V
1500V
JP1_2
+250V
GND
-300V
-900V
-1500VSIEB
-1530V
-1550V
C35 100n 1,5kV
Q5 BC640
D25 ZF39
R63 750k
C41 10µ/350V
C42 10µ/350V
R49 10M
R59 10M
D21 1N4007
C39 10µ/350V
C40 10µ/350V
R48 10M
R1 10M
D1 1N4007
C26 4u7/350V
D18 ZPY100
D19 ZPY47
D20 ZPY100
R74 3k9
R73 3k9
R64 1M2
R78 10M
C29 10µ/350V
R70 10M
R72 10M
C24 10µ/350V
C25 10µ/350V
C23 10u/350V
D16 1N4007
D17 1N4007
D15 1N4007
R2 10M
R77 10M
D22 1N4007
C28 10µ/350V
C27 10µ/350V

Connection of some tubes to our tube clock electronic **ACHTUNG Attention** The resistance values are for orientation only. Blank fields: no change

Signal	CON3	B7 S2	D7-16	5ADP-1, DG13-14, DN10-14	B7 S4-01	D13-27	D7-210	D3-11, D3-111	8LO29I	DG7-74A	DG7-32 DG7-31	DG7-363WP12	D13-480	3JP12	DG7-6
FIL1	10 ws	14	1	1	1	1	1	1	1	1	1	1	1	14	9
FIL2	9 gr	1	2	14	14	14	2	2	14	12	12	12	14	1	1
G1	8 vio	3	3	3	3	3	3	3	3	2	2	2	3	3	8
K	7 bl	2	4	2	2	2	4	4	2	3	3	3	7	2	
G3	6 gn	4	5	5	4	4	5	5	5	4	4	4	8	5	7
DX2	3 rot	7	6	8	6	10	7	11	11	7	6	6	4	8	2
DX1	4 or	8	7	7	7	9	8	9	10	6	7	7	6	7	3
a,G2,G4	5 ge	9, 12, a	8	9	5, 8, 12, a	5, 8, 11, 12	10	8	9	8, a2 (lateral)	8	8	9	9	4
DY1	2 brn	10	9	10	10	6	11	6	8	9	9	9	10	10	5
DY2	1 sw	11	10	11	9	7	13	7	7	10	10	10	12	11	6
R53		39k					8k2	10k			100k				
R54				120k			100k	120k				100k		220k	
R56															0
R58														180k	0
															remove R61+R62

No guarantee for the correctness ! Please optimize by own tests, e.g. by swapping the X/Y deflection connections 2021-März-1