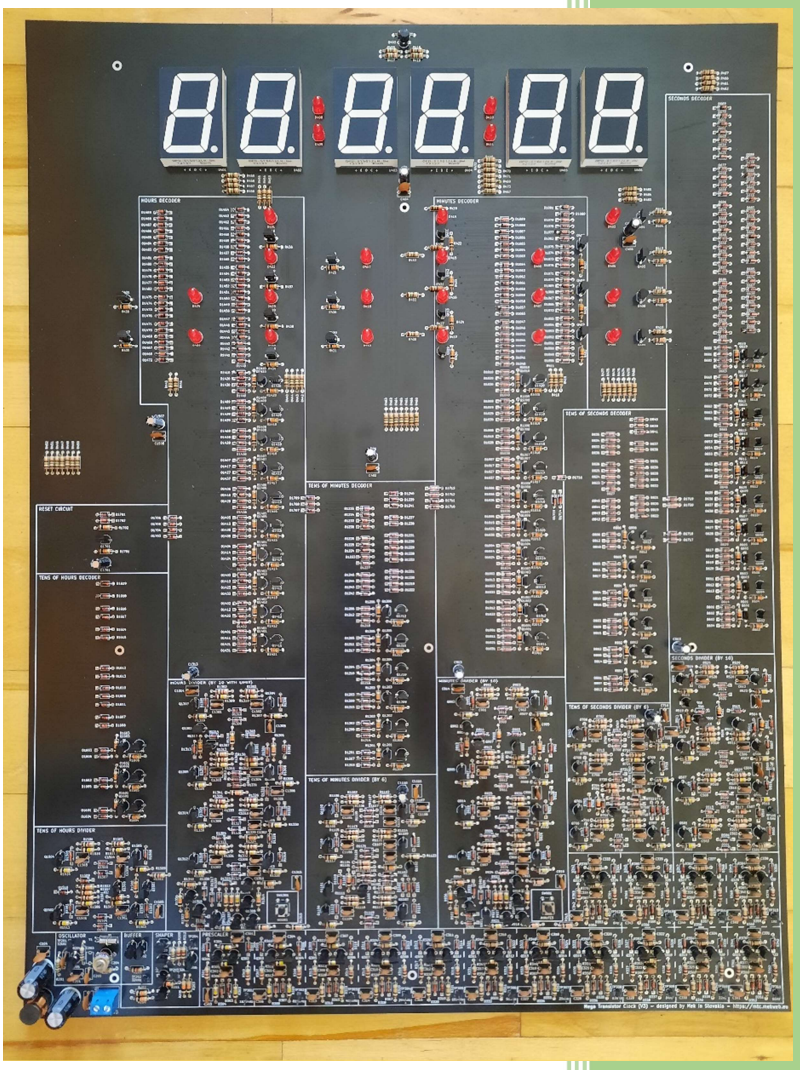
Mega Transistor Clock

Manual – V3



Designed by Mek in Slovakia

Contents

1. Introduction

Thank you for purchasing the material to build your own Mega Transistor Clock.

Just as people buy multi-thousand puzzles and they like to put them together, I think electronics enthusiasts will also enjoy building this transistor clock. All parts are general and easily obtainable. If you have some old parts obtained by disassembling old electronics, that are not good for anything other than switching purposes nowadays, they can be used here, too. Also, parts that have no part number on them, but you are sure it is some kind of a diode or transistor and it measured OK. Of course, if you ordered a set of parts together with the PCB, you get new parts.

This construction is intended for medium-advanced electronics enthusiasts who already know how to solder, and can identify parts, their parameters and polarity.

There are no integrated circuits in this construction. All functions are implemented solely using transistors and diodes – flip-flops, logic gates, which form dividers and decoders. Therefore, the number of parts is large and PCB dimensions are large as well. The PCB also contains a few mounting holes which can be used to mount the board on a panel and hang it somewhere, for example.

I believe that you will enjoy building this clock and when it is done, it will draw attention of your visitors. I wish you good luck with construction

Ing. Matej Kurpel (a.k.a. Mek)

2. Parameters

- Digital and binary time representation
- 24-hour time format, blinking double dots (colons)
- 2 push buttons for time setup (hours and minutes)
- Crystal resonator as time base
- Power supply: 5 V / 500 mA max.
- 596 diodes and 221 transistors
- PCB dimensions: 48.5 x 37 cm (height x width)

3. Part list (BOM)

Interactive part list is in file *BOM.html* and as a picture in *Top.png*

Capacitors

C301, C302, C303, C304, C305, C306, C307, C308, C309, C310, C311, C312, C313, C314, C315, C316, C317, C318, C319, C320, C321, C322, C323, C324, C325, C326, C327, C328, C329, C330, C331, C332, C333, C334, C335, C336, C337, C338, C339, C340, C341, C342, C343, C344, C345, C501, C502, C503, C504, C505, C506, C507, C508, C509, C510, C511, C512, C701, C702, C703, C704, C705, C706, C707, C708, C709, C901, C902, C903, C904, C905, C906, C907, C908, C909, C910, C911, C912, C1101, C1102, C1103, C1104, C1105, C1106, C1107, C1108, C1109, C1301, C1302, C1303, C1304, C1305, C1306, C1307, C1308, C1309, C1310, C1311, C1312, C1501, C1502, C1503, C1504, C1505, C1506 – 100p (105 pcs)

C102, C104, C201, C402, C404, C406, C514, C711, C914, C1111, C1314, C1508 – 100n (12 pcs)

C202, C203 – 22p

C204 – trimmer approx. 10p

C205 – 1n

C915, C1315 – 22n (2 pcs)

C401, C403, C405, C513, C710, C913, C1110, C1313, C1507, C1701 – 10M/16V (10 pcs)

C101, C103 – 1000M/16V

Resistors

R202, R203, R206, R210, R211, R401, R402, R403, R404, R405, R406, R407, R408, R420, R421, R422, R423, R424, R425, R426, R434, R435, R436, R437, R438, R439, R513, R514, R515, R519, R521, R601, R602, R603, R604, R605, R606, R607, R608, R609, R610, R611, R612, R613, R614, R615, R616, R617, R618, R619, R620, R701, R704, R708, R709, R716, R801, R802, R803, R804, R805, R806, R807, R808, R809, R810, R811, R812, R901, R906, R913, R914, R915, R917, R918, R922, R927, R929, R935, R936, R937, R940, R1001, R1002, R1003, R1004, R1005, R1006, R1007, R1008, R1009, R1010, R1011, R1012, R1013, R1014, R1015, R1016, R1017, R1018, R1019, R1020, R1101, R1104, R1108, R1109, R1116, R1201, R1202, R1203, R1204, R1205, R1206, R1207, R1208, R1209, R1210, R1211, R1212, R1301, R1306, R1313, R1314, R1315, R1317, R1318, R1322, R1327, R1329, R1335, R1336, R1337, R1340, R1341, R1401, R1402, R1403, R1404, R1405, R1406, R1407, R1408, R1409, R1410, R1411, R1412, R1413, R1414, R1415, R1416, R1417, R1418, R1419, R1420, R1508, R1512, R1514, R1601, R1602, R1603, R1604, R1605, R1606, R1701, R1702 – 10k (165 pcs)

R303, R304, R305, R306, R309, R310, R311, R312, R319, R320, R321, R322, R323, R324, R325, R326, R327, R328, R329, R330, R341, R342, R343, R344, R345, R346, R347, R348, R349, R350, R351, R352, R353, R354, R355, R356, R357, R358, R359, R360, R371, R372, R373, R374, R375, R376, R377, R378, R379, R380, R381, R382, R383, R384, R385, R386, R387, R388, R389, R390, R501, R502, R504, R505, R507, R508, R510, R511, R516, R517, R520, R522, R523, R525, R526, R528, R705, R706, R707, R710, R715, R717, R718, R719, R720, R721, R722, R723, R907, R908, R909, R910, R911, R912, R916, R919, R920, R921, R928, R930, R931, R932, R933, R934, R938, R939, R1105, R1106, R1107, R1110, R1115, R1117, R1118, R1119, R1120, R1121, R1122, R1123, R1307, R1308, R1309, R1310, R1311, R1312, R1316, R1319, R1320, R1321, R1328, R1330, R1331, R1332, R1333, R1334, R1338, R1339, R1503, R1506, R1507, R1509, R1510, R1511, R1513, R1516 – 100k (144 pcs)

R205, R209, R212, R301, R302, R307, R308, R313, R314, R315, R316, R317, R318, R331, R332, R333, R334, R335, R336, R337, R338, R339, R340, R361, R362, R363, R364, R365, R366, R367, R368, R369, R370, R503, R506, R509, R512, R518, R524, R527, R529, R702, R703, R711, R712, R713, R714, R902, R903, R904, R905, R923, R924, R925, R926, R1102, R1103, R1111, R1112, R1113, R1114, R1302, R1303, R1304, R1305, R1323, R1324, R1325, R1326, R1501, R1502, R1504, R1505, R1515 – 1k (74 pcs)

R409, R410, R411, R412, R413, R414, R415, R416, R417, R418, R419, R427, R428, R429, R430, R431, R432, R433, R440, R441, R442, R443, R444, R445, R446, R447, R448, R449, R450, R451, R452, R453, R454, R455, R456, R457, R458, R459, R460, R461, R462, R463, R464, R465, R466, R467, R468, R469,

R470, R471, R472, R473, R474, R475, R476, R477, R478, R479, R480, R481, R482, R483, R484, R485, R486, R487 – 150 R (66 pcs)

R201, R208 – 1M

R204 – 10M

R207 – 470k

Diodes

D301, D302, D303, D304, D305, D306, D307, D308, D309, D310, D311, D312, D313, D314, D315, D316, D317, D318, D319, D320, D321, D322, D323, D324, D325, D326, D327, D328, D329, D330, D331, D332, D333, D334, D335, D336, D337, D338, D339, D340, D341, D342, D343, D344, D345, D346, D347, D348, D349, D350, D351, D352, D353, D354, D355, D356, D357, D358, D359, D360, D501, D502, D503, D504, D505, D506, D507, D508, D509, D510, D511, D512, D513, D514, D515, D516, D517, D518, D519, D520, D521, D522, D523, D524, D601, D602, D603, D604, D605, D606, D607, D608, D609, D610, D611, D612, D613, D614, D615, D616, D617, D618, D619, D620, D621, D622, D623, D624, D625, D626, D627, D628, D629, D630, D631, D632, D633, D634, D635, D636, D637, D638, D639, D640, D641, D642, D643, D644, D645, D646, D647, D648, D649, D650, D651, D652, D653, D654, D655, D656, D657, D658, D659, D660, D661, D662, D663, D664, D665, D666, D667, D668, D669, D670, D671, D672, D673, D674, D675, D676, D677, D678, D679, D680, D681, D682, D683, D684, D685, D686, D687, D688, D689, D701, D702, D703, D704, D705, D706, D707, D708, D709, D710, D711, D712, D713, D714, D715, D716, D717, D718, D719, D720, D721, D722, D801, D802, D803, D804, D805, D806, D807, D808, D809, D810, D811, D812, D813, D814, D815, D816, D817, D818, D819, D820, D821, D822, D823, D824, D825, D826, D827, D828, D829, D830, D831, D832, D833, D834, D835, D836, D837, D838, D839, D840, D841, D842, D843, D844, D845, D901, D902, D903, D904, D905, D906, D907, D908, D909, D910, D911, D912, D913, D914, D915, D916, D917, D918, D919, D920, D921, D922, D923, D924, D925, D926, D927, D928, D929, D930, D1001, D1002, D1003, D1004, D1005, D1006, D1007, D1008, D1009, D1010, D1011, D1012, D1013, D1014, D1015, D1016, D1017, D1018, D1019, D1020, D1021, D1022, D1023, D1024, D1025, D1026, D1027, D1028, D1029, D1030, D1031, D1032, D1033, D1034, D1035, D1036, D1037, D1038, D1039, D1040, D1041, D1042, D1043, D1044, D1045, D1046, D1047, D1048, D1049, D1050, D1051, D1052, D1053, D1054, D1055, D1056, D1057, D1058, D1059, D1060, D1061, D1062, D1063, D1064, D1065, D1066, D1067, D1068, D1069, D1070, D1071, D1072, D1073, D1074, D1075, D1076, D1077, D1078, D1079, D1080, D1081, D1082, D1083, D1084, D1085, D1086, D1087, D1088, D1089, D1101, D1102, D1103, D1104, D1105, D1106, D1107, D1108, D1109, D1110, D1111, D1112, D1113, D1114, D1115, D1116, D1117, D1118, D1119, D1120, D1121, D1122, D1201, D1202, D1203, D1204, D1205, D1206, D1207, D1208, D1209, D1210, D1211, D1212, D1213, D1214, D1215, D1216, D1217, D1218, D1219, D1220, D1221, D1222, D1223, D1224, D1225, D1226, D1227, D1228, D1229, D1230, D1231, D1232, D1233, D1234, D1235, D1236, D1237, D1238, D1239, D1240, D1241, D1242, D1243, D1244, D1245, D1301, D1302, D1303, D1304, D1305, D1306, D1307, D1308, D1309, D1310, D1311, D1312, D1313, D1314, D1315, D1316, D1317, D1318, D1319, D1320, D1321, D1322, D1323, D1324, D1325, D1326, D1327, D1328, D1329, D1330, D1331, D1332, D1401, D1402, D1403, D1404, D1405, D1406, D1407, D1408, D1409, D1410, D1411, D1412, D1413, D1414, D1415, D1416, D1417, D1418, D1419, D1420, D1421, D1422, D1423, D1424, D1425, D1426, D1427, D1428, D1429, D1430, D1431, D1432, D1433, D1434, D1435, D1436, D1437, D1438, D1439, D1440, D1441, D1442, D1443, D1444, D1445, D1446, D1447, D1448, D1449, D1450, D1451, D1452, D1453, D1454, D1455, D1456, D1457, D1458, D1459, D1460,

D1461, D1462, D1463, D1464, D1465, D1466, D1467, D1468, D1469, D1470, D1471, D1472, D1473, D1474, D1475, D1476, D1477, D1478, D1479, D1480, D1481, D1482, D1483, D1484, D1485, D1486, D1487, D1488, D1489, D1501, D1502, D1503, D1504, D1505, D1506, D1507, D1508, D1509, D1510, D1601, D1602, D1603, D1604, D1605, D1606, D1607, D1608, D1609, D1610, D1611, D1612, D1613, D1614, D1615, D1616, D1617, D1618, D1619, D1701, D1702, D1703, D1704, D1705, D1706, D1707, D1708, D1709, D1710, D1711, D1712, D1713, D1714, D1715, D1716, D1717, D1718, D1719, D1720 – 1N4148 (596 pcs)

D401, D402, D403, D404, D405, D406, D407, D408, D409, D410, D411, D412, D413, D414, D415, D416, D417, D418, D419, D420, D421, D422, D423, D424 – LED 5 mm (24 pcs)

U401, U402, U403, U404, U405, U406 – LED displays, digit height 38,1 mm, e.g. LSD150BUE-101B

Transistors

Q201, Q202, Q205, Q206, Q207, Q208, Q301, Q302, Q303, Q304, Q305, Q306, Q307, Q308, Q309, Q310, Q311, Q312, Q313, Q314, Q315, Q316, Q317, Q318, Q319, Q320, Q321, Q322, Q323, Q324, Q325, Q326, Q327, Q328, Q329, Q330, Q401, Q402, Q403, Q404, Q405, Q406, Q407, Q408, Q409, Q410, Q411, Q412, Q413, Q414, Q415, Q416, Q417, Q418, Q419, Q420, Q421, Q501, Q502, Q503, Q504, Q505, Q506, Q507, Q509, Q510, Q511, Q601, Q602, Q603, Q604, Q605, Q606, Q607, Q608, Q609, Q610, Q611, Q612, Q613, Q614, Q615, Q616, Q617, Q618, Q619, Q620, Q701, Q703, Q704, Q705, Q706, Q707, Q708, Q709, Q801, Q802, Q803, Q804, Q805, Q806, Q807, Q808, Q809, Q810, Q811, Q812, Q901, Q903, Q904, Q905, Q906, Q907, Q910, Q911, Q912, Q913, Q914, Q915, Q917, Q918, Q1001, Q1002, Q1003, Q1004, Q1005, Q1006, Q1007, Q1008, Q1009, Q1010, Q1011, Q1012, Q1013, Q1014, Q1015, Q1016, Q1017, Q1018, Q1019, Q1020, Q1101, Q1103, Q1104, Q1105, Q1106, Q1107, Q1108, Q1109, Q1201, Q1202, Q1203, Q1204, Q1205, Q1206, Q1207, Q1208, Q1209, Q1210, Q1211, Q1212, Q1301, Q1303, Q1304, Q1305, Q1306, Q1307, Q1310, Q1311, Q1312, Q1313, Q1314, Q1315, Q1317, Q1318, Q1401, Q1402, Q1403, Q1404, Q1405, Q1406, Q1407, Q1408, Q1409, Q1410, Q1411, Q1412, Q1413, Q1414, Q1415, Q1416, Q1417, Q1418, Q1419, Q1420, Q1501, Q1502, Q1503, Q1504, Q1505, Q1506, Q1601, Q1602, Q1603, Q1604, Q1605, Q1606, Q1701 – universal NPN, e.g. BC546-549, BC171-174, KC/BC237-239… (208 pcs)

Q203, Q204, Q508, Q702, Q902, Q908, Q909, Q916, Q1102, Q1302, Q1308, Q1309, Q1316 – universal PNP, e.g. BC556-559 (13 pcs)

Other

L101 – radial choke 220 µH / 1 A

Y1 – crystal resonator 32.768 kHz

SW901, SW1301 – 6 mm push button switch

TPxxx – test points, pin header 01x01 2,54 mm (20 pcs)

J101 – PCB screw terminal block, 5 mm lead spacing

4. Notes for parts

4.1 Choke L101

This choke takes part in C-L-C filter of supply voltage. Its inductance is not critical, a different one may be supplied than the one in part list, depending on market availability. Physical dimensions and maximum current are more important. If you don't have such a choke, you can bridge it over with a piece of wire.

4.2 Capacitors C202, C203, trimmer capacitor C204

After finishing parts Oscillator, Buffer, Shaper, it's good to check the accuracy of frequency 32.768 kHz using a counter or oscilloscope (in test point TP204), since the accuracy of the whole clock will depend on accuracy of this frequency. Minor deviations can be fixed using C204, but if that's not enough, capacitors with greater or smaller capacity in place of C202 and C203 should fix it, you need to experiment. It might happen that the oscillator will not start with certain values of these capacitors. Or a better situation, that the oscillator frequency is exact, but it will take a few moments to start after connecting supply voltage.

Trimmer capacitor C204 may not be supplied with ordered parts because of difficult availability. A used one pulled from old electronic devices can be used, or, by experimenting, a fixed capacitor may be mounted. Since C204 is parallel to C203, their capacity will sum up.

It is best to not place C203 (22 pF) initially. Place it only if the oscillator is too fast.

4.3 Resonator Y1

A common watch crystal resonator used in consumer electronics, PC, watches. It is advised to wrap it with a piece of plain wire and solder both ends of the wire to the board – there are holes for that. The resonator is a fragile device sensitive to mechanical and heat stress. It is important to solder it very carefully and not heat it up too much.

4.4 Transistors

Suitable transistors are any universal low-signal transistors of appropriate polarity (NPN/PNP) in TO-92 (or similar) package and with leads in CBE (front side) or EBC order. Collector current should be at least 100 mA. There may be various transistor types in the supplied parts, depending on market availability.

4.5 Displays

The PCB is adapted for displays of digit height 38,1 mm (1,5 in), and pin layout is common for this type of displays.

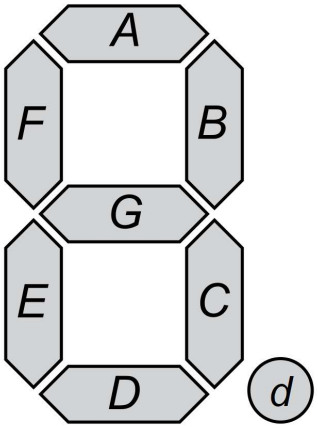


Fig. 1: 7-segment display

5. Construction procedure and required equipment

To build this construction, only a multimeter is needed, but an oscilloscope or counter is also recommended. It is best to place the parts by sections and after each section it should be checked if it is working correctly, in following order (sections are also highlighted on the PCB):

1. Oscillator (do not place C203 initially)
2. Buffer
3. Shaper
4. Prescaler
5. LED diodes for colons (and their driver)
6. Reset circuit
7. Seconds divider (by 10)
8. LED diodes for binary representation of seconds (and their driver)
9. Seconds decoder
10. Display for seconds
11. Tens of seconds divider (by 6)
12. LED diodes for binary representation of tens of seconds (and their driver)
13. Tens of seconds decoder
14. Display for tens of seconds
15. Minutes divider (by 10)
16. LED diodes for binary representation of minutes (and their driver)
17. Minutes decoder
18. Display for minutes
19. Tens of minutes divider (by 6)
20. LED diodes for binary representation of tens of minutes (and their driver)
21. Tens of minutes decoder
22. Display for tens of minutes
23. Hours divider (by 10 with limit)
24. LED diodes for binary representation of hours (and their driver)
25. Hours decoder

26. Display for hours
27. Tens of hours divider
28. LED diodes for binary representation of tens of hours (and their driver)
29. Tens of hours decoder
30. Display for tens of hours

In the places where an oscilloscope can be connected if there are problems, there are test points marked TPxxx, a single pin header should be soldered there to make the connection of an oscilloscope probe easier.

Part placement plan can be found in file *Top.png* and its interactive version in *BOM.html*

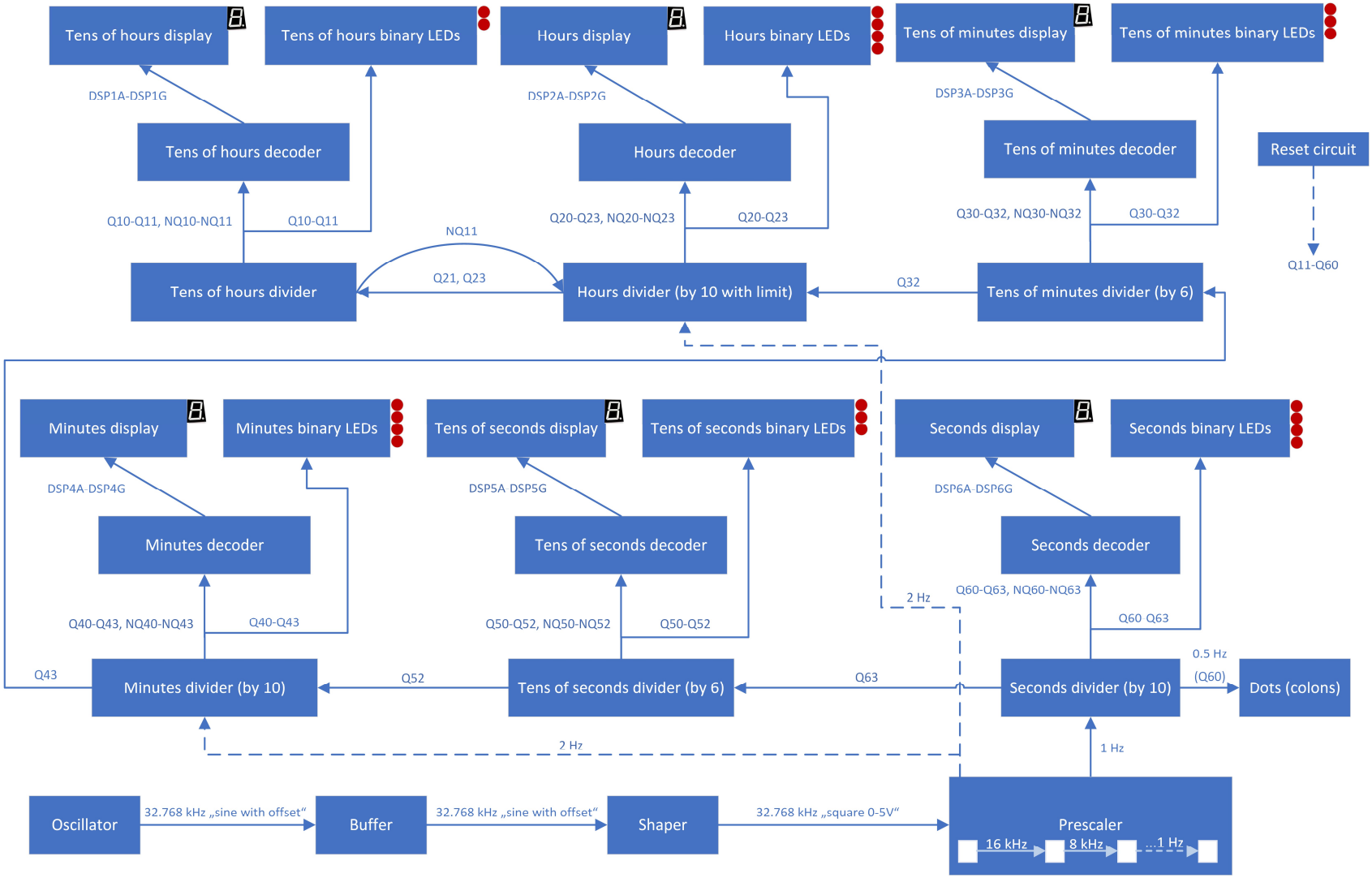


Fig. 2: Block schematic

6. Circuit description

Complete schematic is in file *Schema.pdf* and a block schematic is in fig. 2.

6.1 Design conventions

Part numbering follows the system where each section is numbered in the place of hundreds, and then the parts in that sections are numbered from 1 to 99. For example, parts in section Prescaler are numbered from 300 to 399.

Flip-flop outputs in dividers that are used to display time, are marked Qxy, where x je is digit number from 1 to 6 (1 – tens of hours, ... 5 – tens of seconds, 6 – seconds) and y is bit number (0 is LSB). Negated outputs of flip-flops are marked NQxy, where xy is the same as above.

Decoder outputs for displays are marked DSPxy, where x is digit number (as for the flip-flops) and y is segment letter from A to G.

6.2 Circuit description

5 V supply voltage is connected to PCB terminal block J101 followed by a C-L-C filter.

The oscillator is controlled by a common watch crystal with frequency 32.768 kHz. The circuit of oscillator section is a standard one, often used in many circuits. Frequency of the oscillator can be slightly adjusted by changing the capacitance of C202, C203, and C204. However, the output cannot be processed further, that's why there is also a buffer consisting of two transistors forming a Darlington pair. Buffer output is the same as oscillator output, but it can drive following circuits. Outputs of both buffer and oscillator is a signal with frequency 32.768 kHz, roughly resembling a sine wave, however, oscillating around 2.5 V with amplitude 2 V, see the oscillogram on fig. 3. This signal needs to be converted to logic levels - a square/rectangular wave of 0 to 5 V.

The job of Shaper section is to make a logic level wave from 0 to 5 V. Duty cycle of its output waveform is not 50%, but that is not a problem, as the flip-flops are triggered on falling edge and the distance of falling edges is constant. The shaper is in fact a comparer that compares its input signal with a reference level given by resistor divider R203 and R209. If input signal is lower than the reference level, output signal is log. 0, otherwise log. 1. Output of the shaper is in fig. 4.

Frequency 32.768 kHz is too high for the needs of a clock, so it must be divided many times to get a 1 Hz signal. That is the job of the Prescaler section, consisting of flip-flops connected in series. Each of these flip-flops divides by 2 and they are joined with ceramic 100p capacitors, which create a short pulse on falling edge. This pulse causes the next flip-flop to trigger. Such principle is also utilized in other flip-flops that form the dividers. Output of each flip-flop leads to pin header TPxxx that can be used to connect an oscilloscope probe or counter.

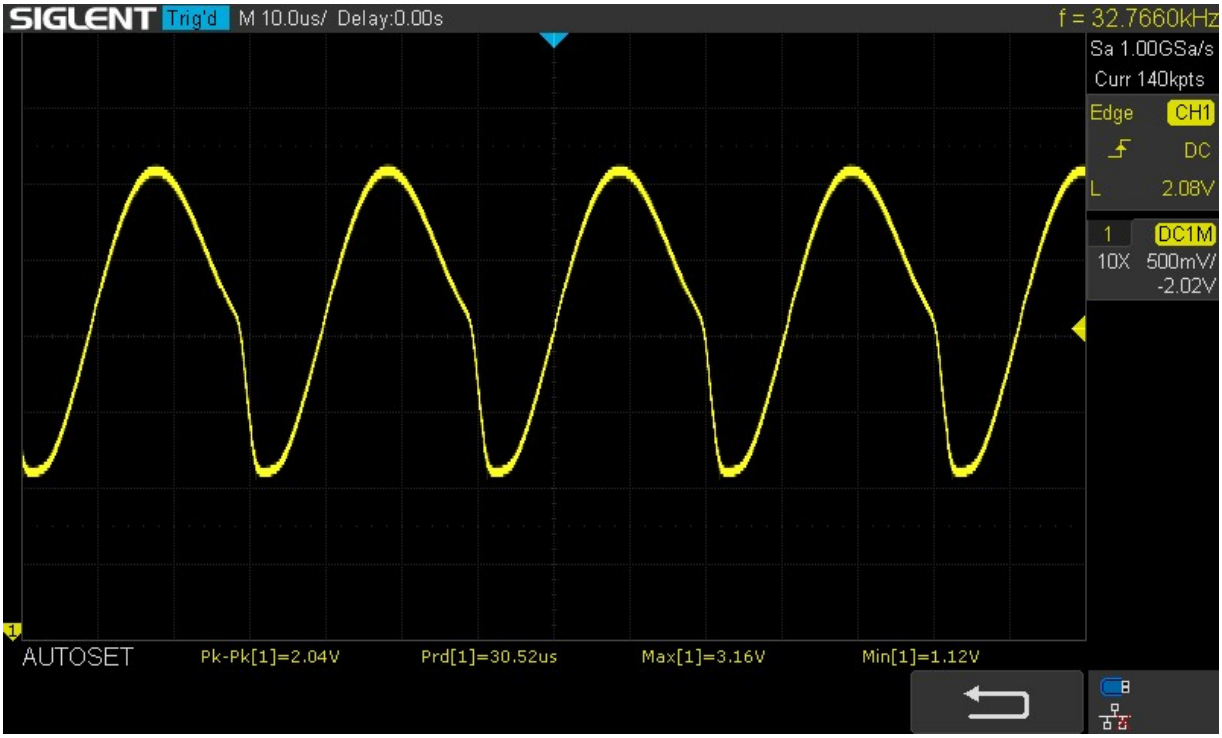


Fig. 3: Buffer output

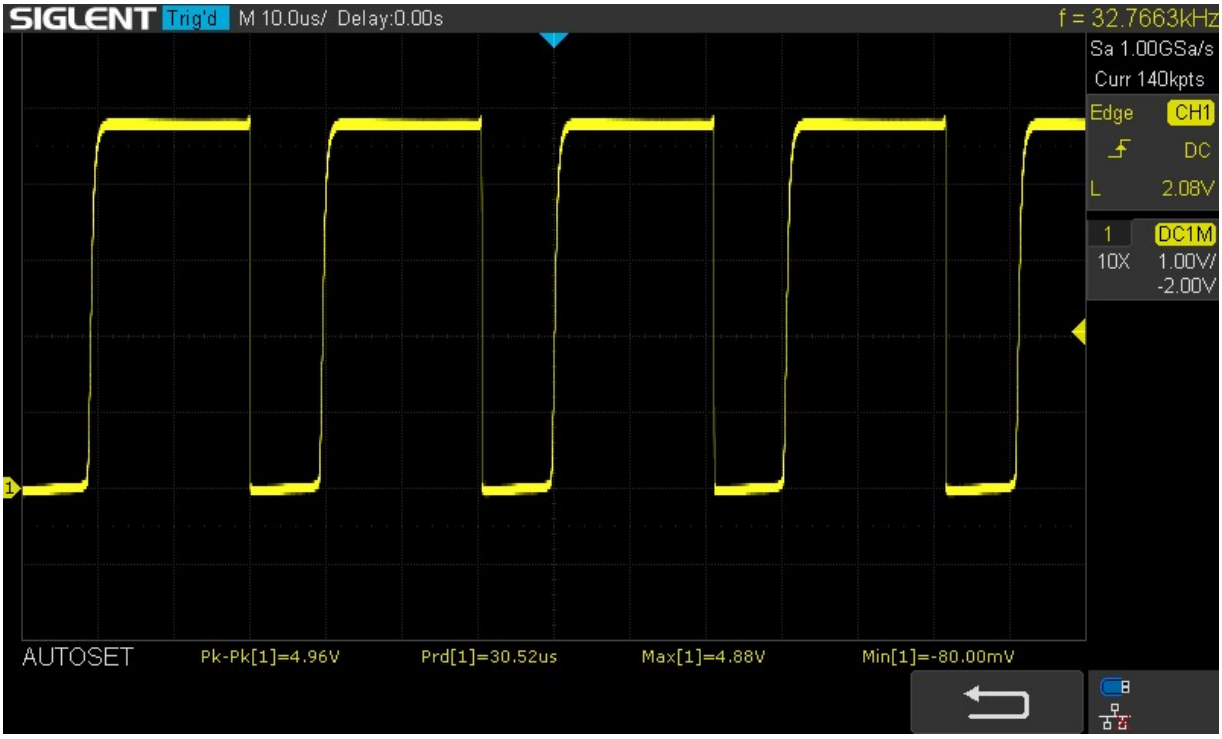


Fig. 4: Shaper output

The 1 Hz signal is used as an input to count seconds – first section dividing by 10 (Seconds divider). This section comprises of 4 flip-flops and a few logic gates interconnected so that after 9, all flip-flops return to 0. It's basically a sequential logic circuit made from transistors. Signal of frequency 0.5 Hz (that is the output of the first flip-flop) is also used to drive the colons between the displays. The output of each flip-flop is also connected to a LED for binary time representation, so these LEDs can be used to observe the current state of the flip-flops.

Signals Q60-Q63 and NQ60-NQ63 lead to seconds decoder. The decoder determines which segments of the display will be lit in which state of the flip-flops. It is self-explanatory how this works from looking in the schematic. For example, when NQ63 = 1 (and so Q63 = 0), Q62-Q60 = 1, it represents digit "7", thus, display segments A, B, C. There are many diodes so that the decoders do not influence each other.

Signal Q63 is used as an input for divider by 6, which is again a sequential logic circuit, but this time comprised of 3 flip-flops that return to 0 after number 5.

Dividers for minutes and tens of minutes work the same way as for seconds. There is only a difference in the push button switch for set-up of minutes. When the button is pressed, minutes are driven by a 2 Hz signal, not by Q63.

Dividers for hours and tens of hours are connected to each other in such way that they count from 0 to 23. That's why the hours divider has (with limit) in its name – it means that if NQ11 = 1 (meaning that tens of hours are in state „2"), it must count only to 3.

Connection diagrams of the dividers on logic gate level are depicted later in this document.

A reset circuit is also part of the construction. It is there to make sure that after connecting supply voltage, all flip-flops of the dividers start in state 0. If this reset circuit was not present, the clock wouldn't start on 00:00:00, but in some random, often unrepresentable, state. After connecting supply voltage, a short pulse is formed with time constant given by RC circuit R1701, C1701 which is connected via a transistor and diodes to each flip-flop. Diodes are present so that the flip-flops are not influenced by each other during normal operation.

6.3 Flip-flop

Fig. 7 shows a bi-stable flip-flop used in this construction (the picture is from the Prescaler section). Input is from the 100p capacitor, outputs are on the collectors of the transistors. By definition, both outputs are inverse of each other. The circuit can be triggered to enter desired state by supplying a short pulse onto one of the outputs – that is how the reset circuit works (see above).

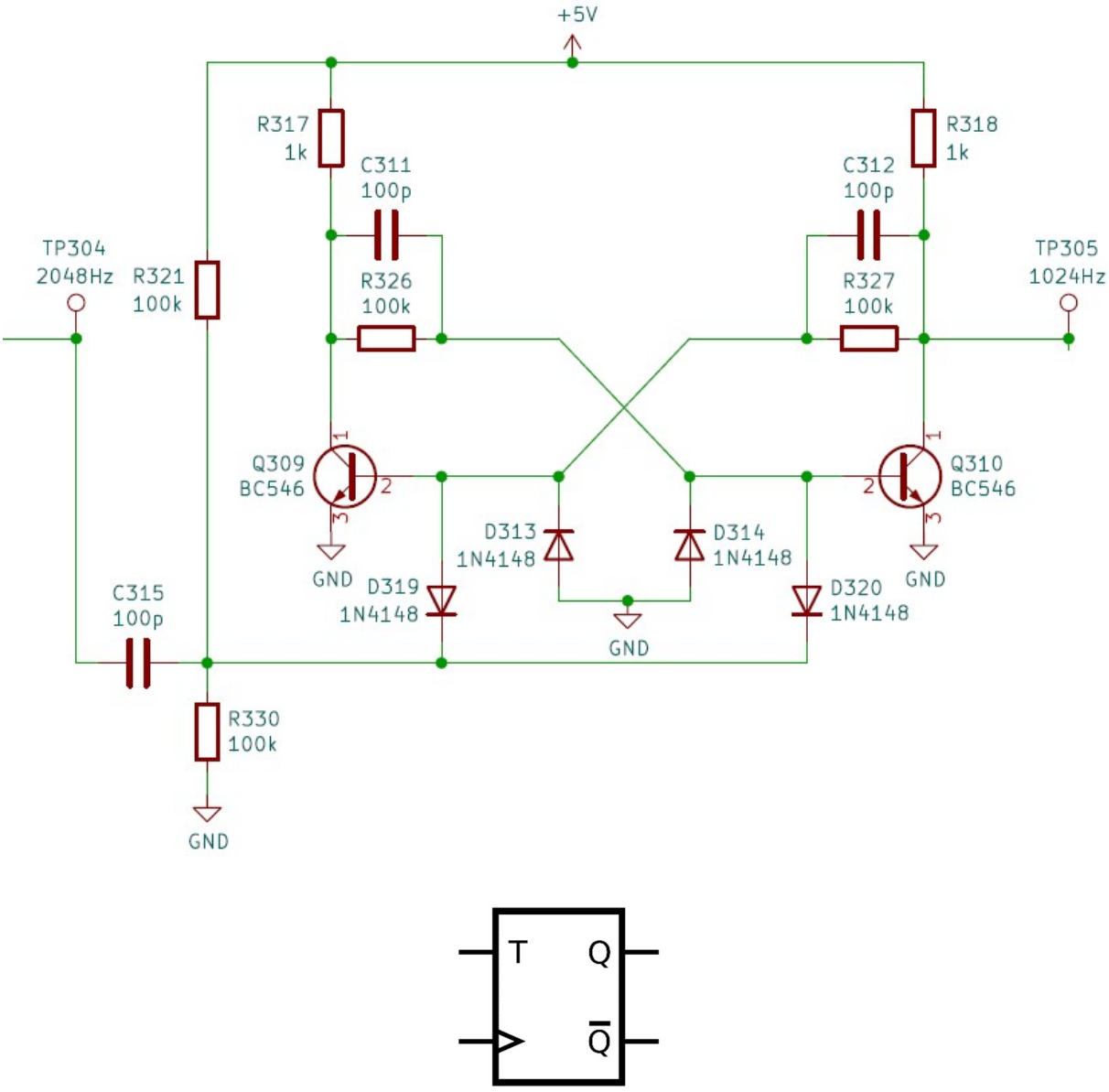


Fig. 5: Flip-flop

6.4 AND gate

Fig. 6 shows an AND gate made from diodes. The number of inputs is given by the count of diodes (there are two inputs in the picture). The output is on the right side of the schematic.

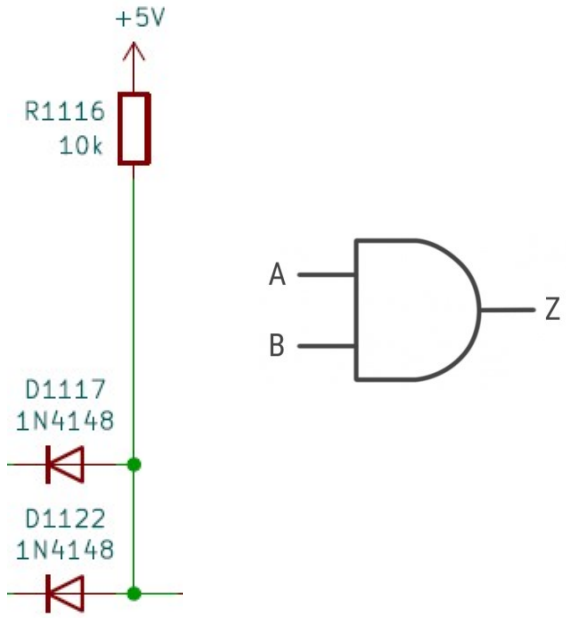


Fig. 6: AND gate

6.5 OR gate

Fig. 7 shows an OR gate. Both types are used in this construction. The inputs are on the left side, outputs are on the right side of the schematic.

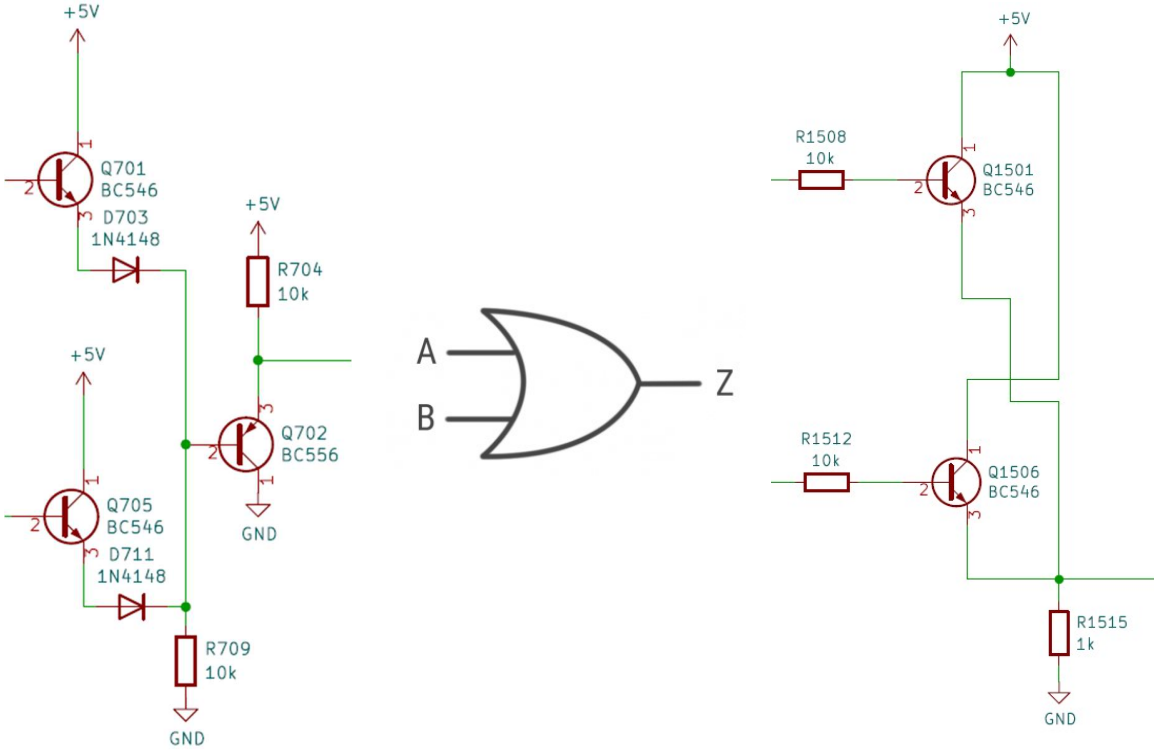


Fig. 7: OR gate

6.6 Dividers

Figs 8, 9, and 10 show the dividers used in this Mega Transistor Clock. They form sequential logic circuits made from flip-flops and logic gates. The pictures are from Logisim – a simulator of logic circuits. There are small circles in the bottom of each picture – those are LED diodes representing current state of the flip-flops.

Divider by 24 handles both the tens of hours and hours at the same time – hours count only to 3 if tens of hours are in state „2“.

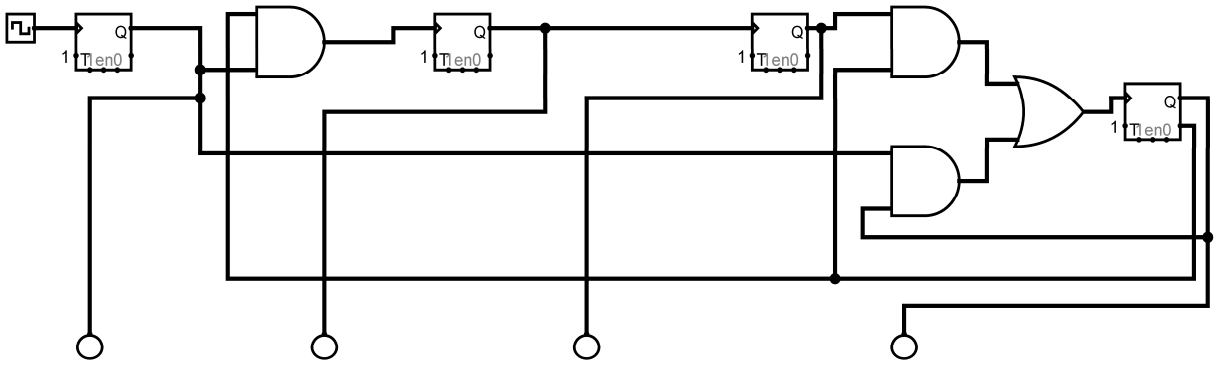


Fig. 8: Divider by 10

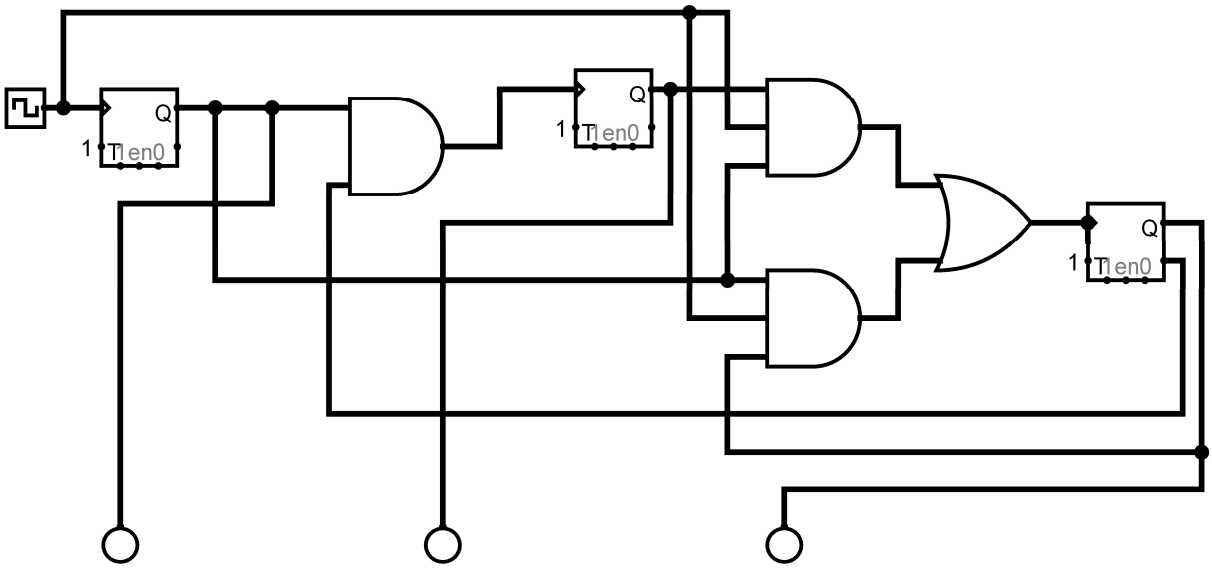


Fig. 9: Divider by 6

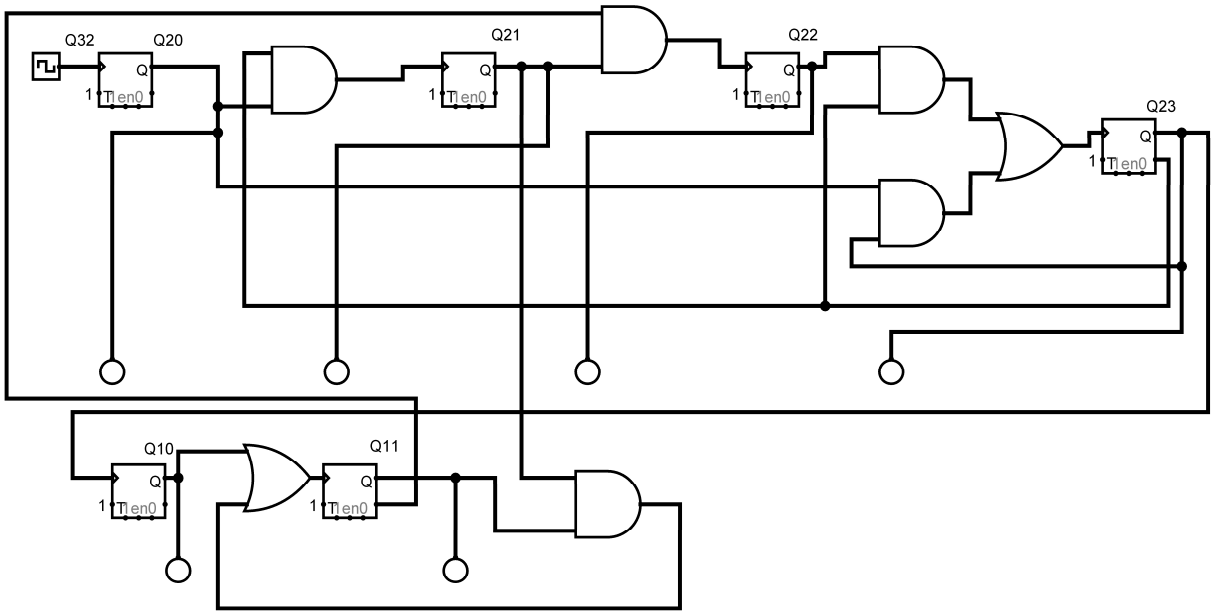


Fig. 10: Divider by 24

7. Troubleshooting and advice

During construction, it is good to connect a power supply with current limit so that in the event of a short-circuit, components or PCB traces are not damaged. Current limit can be set to 500 mA.

It is also recommended that during part placement (in the order of section 5 of this document), supply voltage with current limit is connected after finishing each section to make sure everything works as expected and current consumption of the PCB is non-zero, but not too high. If something goes wrong, it is simpler to search for a mistake in the recently placed section, instead of the whole PCB.

7.1 Nothing happens after connecting supply voltage

If current consumption is zero, there is a damaged PCB trace somewhere in the supply rail, or some part is damaged.

If current consumption is over the limit (power supply indicates a short-circuit), there might be an unintentional solder bridge between pins next to each other, or some part is placed with incorrect polarity or damaged.

If current consumption is normal (depending on the number of already placed parts), the clock may be counting, but nothing is displayed. Check if the oscillator is running, and the operation of dividers and decoders. However, this problem is highly improbable.

7.2 The displays always show 00:00:00

Is the oscillator running? Wait a few seconds, maybe it will eventually start – this may happen when experimenting with capacitors C202, C203, C204.

Check the signal in test points and find out where it is lost. If the oscillator is running up until 1 Hz, maybe it is not passing further. Check also the outputs of divider flip-flops.

7.3 Some digits do not display, but the clock otherwise counts fine

For example, 0 – 1 – 2 – (blank) – 4 – 5 - ... . This behavior indicates a problem in the specific decoder of specific digit – using the schematic, check that the placement of parts in the decoder is OK, parts are of correct type and in correct polarity.

7.4 Some digits have missing or superfluous segments

Check the placement of diodes in the specific decoder of the specific digit (see the schematic for details).

7.5 Clock counts incorrectly

Whether some numbers are skipped, or a digit returns to zero sooner than it should – the problem will most likely be in the divider corresponding to that display.

7.6 Clock does not start on 00:00:00

There is a problem in the reset circuit. If some displays always start at 0 and some do not, it is sufficient to only check the diodes connected to Q outputs of the divider belonging to the problematic display.

7.7 Binary LEDs do not light up or show incorrect data

LEDs are driven by transistors and resistors. In the schematic, in section Display, find out which parts belong to the problematic LEDs, check their connection, types and values of parts, polarity of transistors and LED diodes, unintentional solder bridges between pins of placed parts, and if there is no broken trace on the PCB. If everything is OK, maybe there is no signal for the driver transistor from the Q output of corresponding flip-flop.

7.8 LED diodes – colons between displays – do not work correctly

Check R403, R409, R417, R418, R419, Q403, polarity of LEDs, continuity of PCB trace from the flip-flop – signal Q60, if the clock otherwise runs normally. See also section 7.7.

7.9 Clock goes too slowly

This problem is visible by time differences against real time after a few days. Clock accuracy depends on oscillator frequency.

In this case, the oscillator is a few Hz slower than 32.768 kHz. Connect a counter or oscilloscope to TP204 and measure oscillator frequency. To make it go faster, tune C204. If even at the lowest capacity of C204 the oscillator is too slow, omit C203. If the oscillator is too fast after omitting it, connect C203 of a lower capacity than it was originally and tune the difference using C204. In case when C204 is not placed at all, experiment with various values of C203. Another possibility is to use a different crystal, it may be more accurate.

When measuring oscillator frequency, use a precise counter or an oscilloscope. Some multimeters can measure frequency, but not really accurately, as it is only a supplemental functionality. In this case, rough frequency setting can only be verified experimentally over time.

7.10 A flip-flop does not want to flip

For example, a number that is supposed to count from 0 to 9, counts only to 7.

Check transistors and diodes in that flip-flop, consider replacing them. Measure PCB traces for continuity as they may have accidentally broken while soldering. If nothing helps, try replacing the capacitor at the input of the flip-flop (100 pF) to 150 pF.