VPC1 Keyboard Scanning

Prepared by Jack O'Flaherty January 31, 2014

Contents:

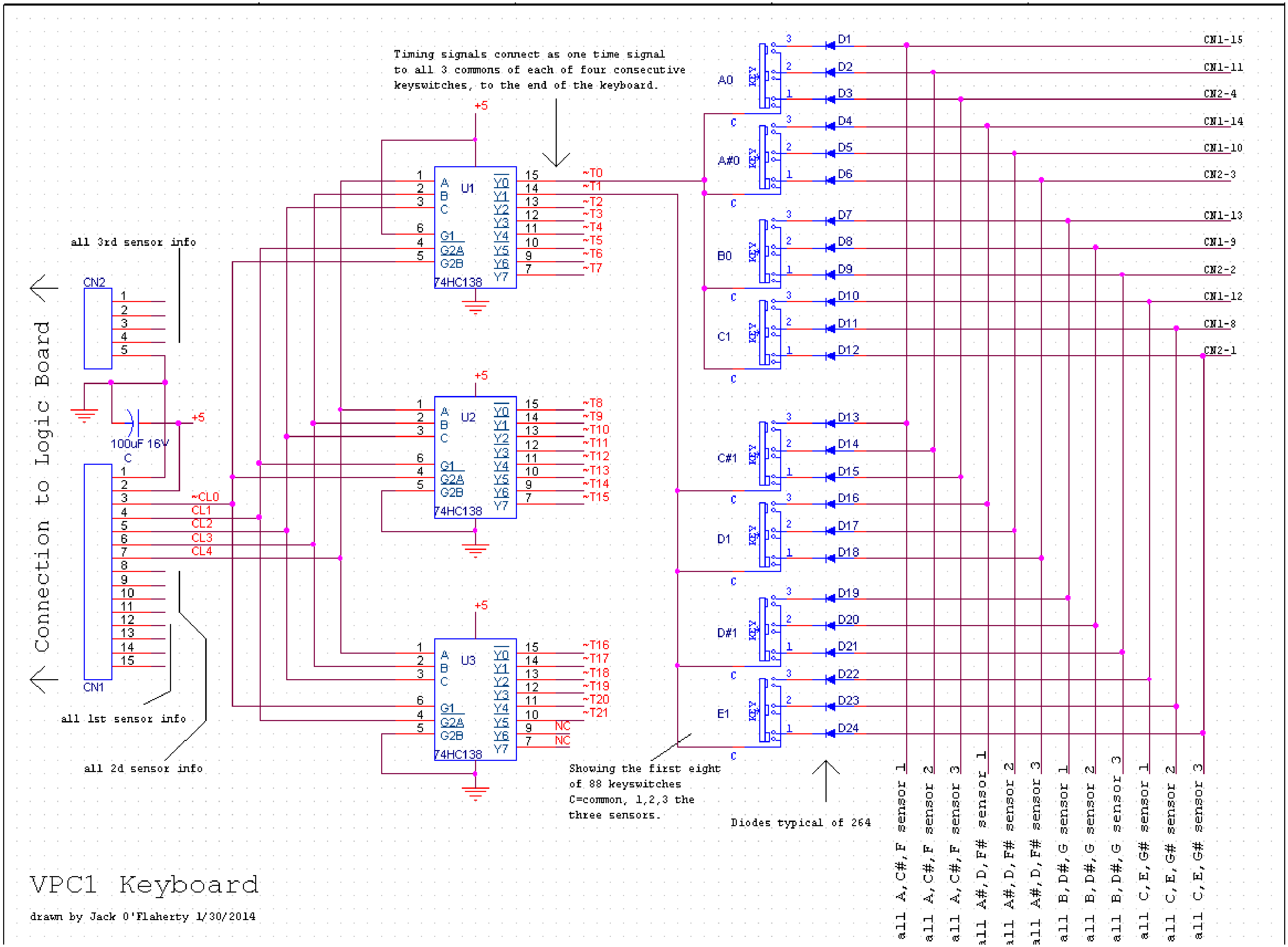
The VPC1 uses scanning and time multiplexing to detect keypresses.

The timing signals are generated as a binary count by the main board, and connected through 5 wires (CN1-3 through CN1-7) to three 74HC138 1-of-8 decoder chips (U1-U3) on the keyboard circuit board to make the negative-going signals T0-T23.

There are 88 keys. Each key has three contacts (sensors): the first, second and third made after the key is struck. There are 24 timing signals available (3 decoder chips * 8 outputs each), of which the first 22 are used. These are applied to the switch commons, the same time signal to all three commons of each keyswitch for each note in a group of four keys. So, beginning at the left end of the keyboard, all three contacts of keys A_0, $A^{\#}_0$, B_0 and C_1 are tied to T_0, the first of the 22 time signals. The next four keys, $C^{\#}_1$, D_1, $D^{\#}_1$, E_1 are tied to T_1, the second of the 22 time signals. The pattern proceeds that way through all 88 keys of the keyboard, ending with T_{21}, the 22d time signal, on the last four keys of the board.

Each non-common switch contact is connected to the cathode of a diode, wire-oring it with 22 other contacts going up the keyboard. The wire-ors are connected through the output connectors CN1 and CN2 back to the main board. There are three groups of outputs of four wires each. The three groups are for first contact, second contact, and third contact. Each of the four wires in each group carries signals for three notes in all octaves, based on how the diodes are connected together. For example, the wire on CN1-15 carries signals from the first contact for A, C#, and F in all octaves. Since each of the signals occurs at a different time because of the timing signals connected to the switch commons, all of the keypresses can be detected independently by the main board. For example, if the chip on the main board sees a negative pulse on CN1-15, and it occurs at T_5 , it must be the first contact of the key F_2 (see attached table for the details for all keys).

Thus, all 3 contacts for each of 88 keys (264 switches) are connected through 12 wires and are detected independently.



Connection to Logic Board
CN1
CN2
all 3rd sensor info
all 1st sensor info
all 2d sensor info
100uF 16V
+5
~CL0
CL1
CL2
CL3
CL4
Timing signals connect as one time signal
to all 3 commons of each of four consecutive
keyswitches, to the end of the keyboard.
U1
U2
U3
74HC138
~T0 ~T1 ~T2 ~T3 ~T4 ~T5 ~T6 ~T7
~T8 ~T9 ~T10 ~T11 ~T12 ~T13 ~T14 ~T15
~T16 ~T17 ~T18 ~T19 ~T20 ~T21
NC
A0
A#0
B0
C1
C#1
D1
D#1
E1
KEY
D1 D2 D3 D4 D5 D6 D7 D8 D9 D10 D11 D12
D13 D14 D15 D16 D17 D18 D19 D20 D21 D22 D23 D24
CN1-15
CN1-11
CN2-4
CN1-14
CN1-10
CN2-3
CN1-13
CN1-9
CN2-2
CN1-12
CN1-8
CN2-1
Showing the first eight
of 88 keyswitches
C=common, 1,2,3 the
three sensors.
Diodes typical of 264
all A,C#,F sensor 1
all A,C#,F sensor 2
all A,C#,F sensor 3
all A#,D,F# sensor 1
all A#,D,F# sensor 2
all A#,D,F# sensor 3
all B,D#,G sensor 1
all B,D#,G sensor 2
all B,D#,G sensor 3
all C,E,G# sensor 1
all C,E,G# sensor 2
all C,E,G# sensor 3
VPC1 Keyboard
drawn by Jack O'Flaherty 1/30/2014

VPC1 keyboard			Tabular listing of keyswitch connections.					
			1st contact		**2nd contact**		**3rd contact**	
KEY	**Timing signal**	**Chip-pin**	**Diode**	**Output connection**	**Diode**	**Output connection**	**Diode**	**Output connection**
A_0	T_0	U1-15	D1	CN1-15	D2	CN1-11	D3	CN2-4
$A^\#_0$	T_0	U1-15	D4	CN1-14	D5	CN1-10	D6	CN2-3
B_0	T_0	U1-15	D7	CN1-13	D8	CN1-9	D9	CN2-2
C_1	T_0	U1-15	D10	CN1-12	D11	CN1-8	D12	CN2-1
$C^\#_1$	T_1	U1-14	D13	CN1-15	D14	CN1-11	D15	CN2-4
D_1	T_1	U1-14	D16	CN1-14	D17	CN1-10	D18	CN2-3
$D^\#_1$	T_1	U1-14	D19	CN1-13	D20	CN1-9	D21	CN2-2
E_1	T_1	U1-14	D22	CN1-12	D23	CN1-8	D24	CN2-1
F_1	T_2	U1-13	D25	CN1-15	D26	CN1-11	D27	CN2-4
$F^\#_1$	T_2	U1-13	D28	CN1-14	D29	CN1-10	D30	CN2-3
G_1	T_2	U1-13	D31	CN1-13	D32	CN1-9	D33	CN2-2
$G^\#_1$	T_2	U1-13	D34	CN1-12	D35	CN1-8	D36	CN2-1
A_1	T_3	U1-12	D37	CN1-15	D38	CN1-11	D39	CN2-4
$A^\#_1$	T_3	U1-12	D40	CN1-14	D41	CN1-10	D42	CN2-3
B_1	T_3	U1-12	D43	CN1-13	D44	CN1-9	D45	CN2-2
C_2	T_3	U1-12	D46	CN1-12	D47	CN1-8	D48	CN2-1
$C^\#_2$	T_4	U1-11	D49	CN1-15	D50	CN1-11	D51	CN2-4
D_2	T_4	U1-11	D52	CN1-14	D53	CN1-10	D54	CN2-3
$D^\#_2$	T_4	U1-11	D55	CN1-13	D56	CN1-9	D57	CN2-2
E_2	T_4	U1-11	D58	CN1-12	D59	CN1-8	D60	CN2-1
F_2	T_5	U1-10	D61	CN1-15	D62	CN1-11	D63	CN2-4
$F^\#_2$	T_5	U1-10	D64	CN1-14	D65	CN1-10	D66	CN2-3
G_2	T_5	U1-10	D67	CN1-13	D68	CN1-9	D69	CN2-2
$G^\#_2$	T_5	U1-10	D70	CN1-12	D71	CN1-8	D72	CN2-1
A_2	T_6	U1-9	D73	CN1-15	D74	CN1-11	D75	CN2-4
$A^\#_2$	T_6	U1-9	D76	CN1-14	D77	CN1-10	D78	CN2-3
B_2	T_6	U1-9	D79	CN1-13	D80	CN1-9	D81	CN2-2
C_3	T_6	U1-9	D82	CN1-12	D83	CN1-8	D84	CN2-1
$C^\#_3$	T_7	U1-7	D85	CN1-15	D86	CN1-11	D87	CN2-4
D_3	T_7	U1-7	D88	CN1-14	D89	CN1-10	D90	CN2-3
$D^\#_3$	T_7	U1-7	D91	CN1-13	D92	CN1-9	D93	CN2-2
E_3	T_7	U1-7	D94	CN1-12	D95	CN1-8	D96	CN2-1
F_3	T_8	U2-15	D97	CN1-15	D98	CN1-11	D99	CN2-4
$F^\#_3$	T_8	U2-15	D100	CN1-14	D101	CN1-10	D102	CN2-3
G_3	T_8	U2-15	D103	CN1-13	D104	CN1-9	D105	CN2-2
$G^\#_3$	T_8	U2-15	D106	CN1-12	D107	CN1-8	D108	CN2-1
A_3	T_9	U2-14	D109	CN1-15	D110	CN1-11	D111	CN2-4
$A^\#_3$	T_9	U2-14	D112	CN1-14	D113	CN1-10	D114	CN2-3
B_3	T_9	U2-14	D115	CN1-13	D116	CN1-9	D117	CN2-2
C_4	T_9	U2-14	D118	CN1-12	D119	CN1-8	D120	CN2-1
$C^\#_4$	T_{10}	U2-13	D121	CN1-15	D122	CN1-11	D123	CN2-4
D_4	T_{10}	U2-13	D124	CN1-14	D125	CN1-10	D126	CN2-3
$D^\#_4$	T_{10}	U2-13	D127	CN1-13	D128	CN1-9	D129	CN2-2
E_4	T_{10}	U2-13	D130	CN1-12	D131	CN1-8	D132	CN2-1
F_4	T_{11}	U2-12	D133	CN1-15	D134	CN1-11	D135	CN2-4
$F^\#_4$	T_{11}	U2-12	D136	CN1-14	D137	CN1-10	D138	CN2-3
G_4	T_{11}	U2-12	D139	CN1-13	D140	CN1-9	D141	CN2-2

$G^{\#}_{4}$	T_{11}	U2-12	D142	CN1-12	D143	CN1-8	D144	CN2-1
A_4	T_{12}	U2-11	D145	CN1-15	D146	CN1-11	D147	CN2-4
$A^{\#}_{4}$	T_{12}	U2-11	D148	CN1-14	D149	CN1-10	D150	CN2-3
B_4	T_{12}	U2-11	D151	CN1-13	D152	CN1-9	D153	CN2-2
C_5	T_{12}	U2-11	D154	CN1-12	D155	CN1-8	D156	CN2-1
$C^{\#}_{5}$	T_{13}	U2-10	D157	CN1-15	D158	CN1-11	D159	CN2-4
D_5	T_{13}	U2-10	D160	CN1-14	D161	CN1-10	D162	CN2-3
$D^{\#}_{5}$	T_{13}	U2-10	D163	CN1-13	D164	CN1-9	D165	CN2-2
E_5	T_{13}	U2-10	D166	CN1-12	D167	CN1-8	D168	CN2-1
F_5	T_{14}	U2-9	D169	CN1-15	D170	CN1-11	D171	CN2-4
$F^{\#}_{5}$	T_{14}	U2-9	D172	CN1-14	D173	CN1-10	D174	CN2-3
G_5	T_{14}	U2-9	D175	CN1-13	D176	CN1-9	D177	CN2-2
$G^{\#}_{5}$	T_{14}	U2-9	D178	CN1-12	D179	CN1-8	D180	CN2-1
A_5	T_{15}	U2-7	D181	CN1-15	D182	CN1-11	D183	CN2-4
$A^{\#}_{5}$	T_{15}	U2-7	D184	CN1-14	D185	CN1-10	D186	CN2-3
B_5	T_{15}	U2-7	D187	CN1-13	D188	CN1-9	D189	CN2-2
C_6	T_{15}	U2-7	D190	CN1-12	D191	CN1-8	D192	CN2-1
$C^{\#}_{6}$	T_{16}	U3-15	D193	CN1-15	D194	CN1-11	D195	CN2-4
D_6	T_{16}	U3-15	D196	CN1-14	D197	CN1-10	D198	CN2-3
$D^{\#}_{6}$	T_{16}	U3-15	D199	CN1-13	D200	CN1-9	D201	CN2-2
E_6	T_{16}	U3-15	D202	CN1-12	D203	CN1-8	D204	CN2-1
F_6	T_{17}	U3-14	D205	CN1-15	D206	CN1-11	D207	CN2-4
$F^{\#}_{6}$	T_{17}	U3-14	D208	CN1-14	D209	CN1-10	D210	CN2-3
G_6	T_{17}	U3-14	D211	CN1-13	D212	CN1-9	D213	CN2-2
$G^{\#}_{6}$	T_{17}	U3-14	D214	CN1-12	D215	CN1-8	D216	CN2-1
A_6	T_{18}	U3-13	D217	CN1-15	D218	CN1-11	D219	CN2-4
$A^{\#}_{6}$	T_{18}	U3-13	D220	CN1-14	D221	CN1-10	D222	CN2-3
B_6	T_{18}	U3-13	D223	CN1-13	D224	CN1-9	D225	CN2-2
C_7	T_{18}	U3-13	D226	CN1-12	D227	CN1-8	D228	CN2-1
$C^{\#}_{7}$	T_{19}	U3-12	D229	CN1-15	D230	CN1-11	D231	CN2-4
D_7	T_{19}	U3-12	D232	CN1-14	D233	CN1-10	D234	CN2-3
$D^{\#}_{7}$	T_{19}	U3-12	D235	CN1-13	D236	CN1-9	D237	CN2-2
E_7	T_{19}	U3-12	D238	CN1-12	D239	CN1-8	D240	CN2-1
F_7	T_{20}	U3-11	D241	CN1-15	D242	CN1-11	D243	CN2-4
$F^{\#}_{7}$	T_{20}	U3-11	D244	CN1-14	D245	CN1-10	D246	CN2-3
G_7	T_{20}	U3-11	D247	CN1-13	D248	CN1-9	D249	CN2-2
$G^{\#}_{7}$	T_{20}	U3-11	D250	CN1-12	D251	CN1-8	D252	CN2-1
A_7	T_{21}	U3-10	D253	CN1-15	D254	CN1-11	D255	CN2-4
$A^{\#}_{7}$	T_{21}	U3-10	D256	CN1-14	D257	CN1-10	D258	CN2-3
B_7	T_{21}	U3-10	D259	CN1-13	D260	CN1-9	D261	CN2-2
C_8	T_{21}	U3-10	D262	CN1-12	D263	CN1-8	D264	CN2-1

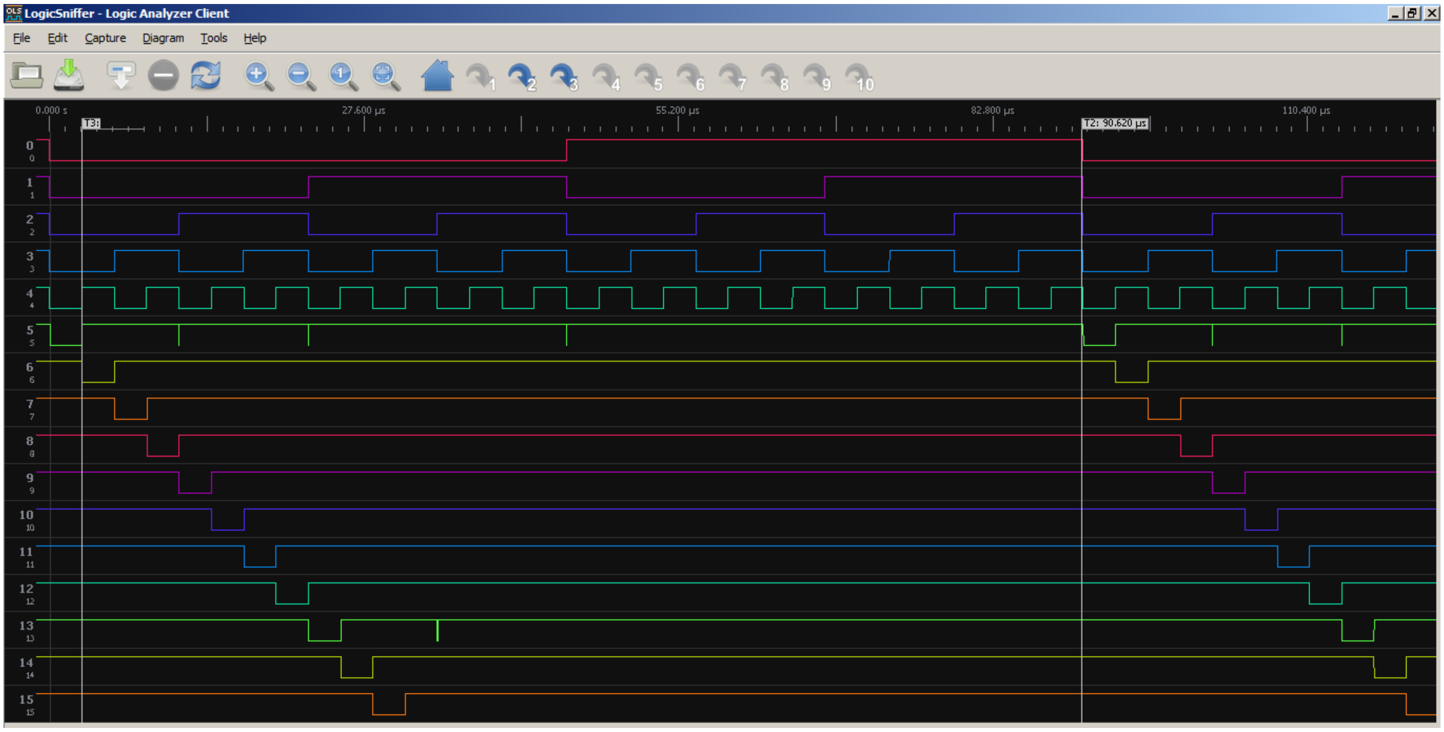


Figure 1: Logic analyzer screen shot showing clock signals from the main board on channels 0-4, and the first 9 of 22 time slot signals decoded. The clock signals go through a simple binary count, and the time slot signals are excited (negative-going) in sequence. Rescan rate is just over 11 kHz (see cursor T2 at 90.62 uS).

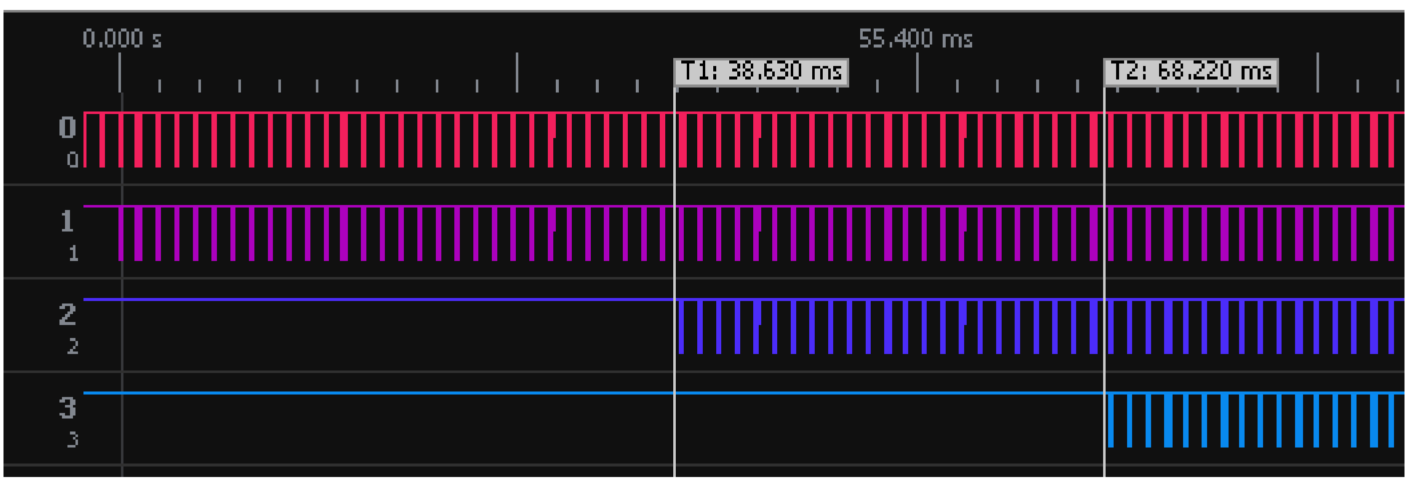


Figure 2: Shows clock signal T9, as applied to the common of keyswitch C_4, and the signal appearing on the first, second and third contacts of the C_4 keyswitch as the key is pressed slowly with a resulting midi velocity of 4 out of 127 (pretty soft).

This C_4 key shows a drop of 11.4 mm from up to keybed. Taking key-up as zero, the first contact is made at about 5 mm depression, and the third at about 10 mm. With this difference of 5 mm, traveled in 68.22 ms (see cursor T2 in the diagram, the key velocity is .005m/.06822 s, or .073 meters/second.

(Note that in this diagram, because of the long time span and resulting lower sample rate, not every timing pulse is seen, while the following two figures show each pulse.)

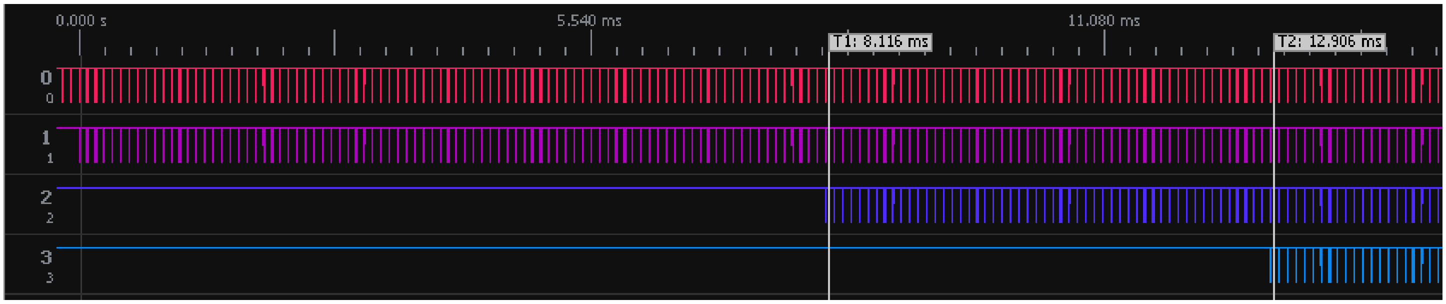


Figure 3: Same as figure 2, but with medium keypress and midi velocity of 70 out of 127. Key velocity 0.387 m/s.

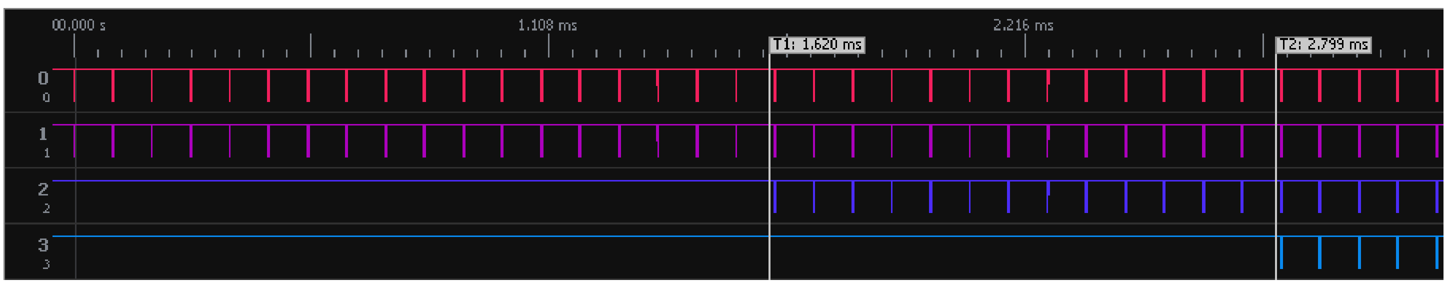


Figure 4: Same as figure 2, but with medium keypress and midi velocity of 126 out of 127 (pretty hard). Key velocity 1.78 m/s (about 4 mph).

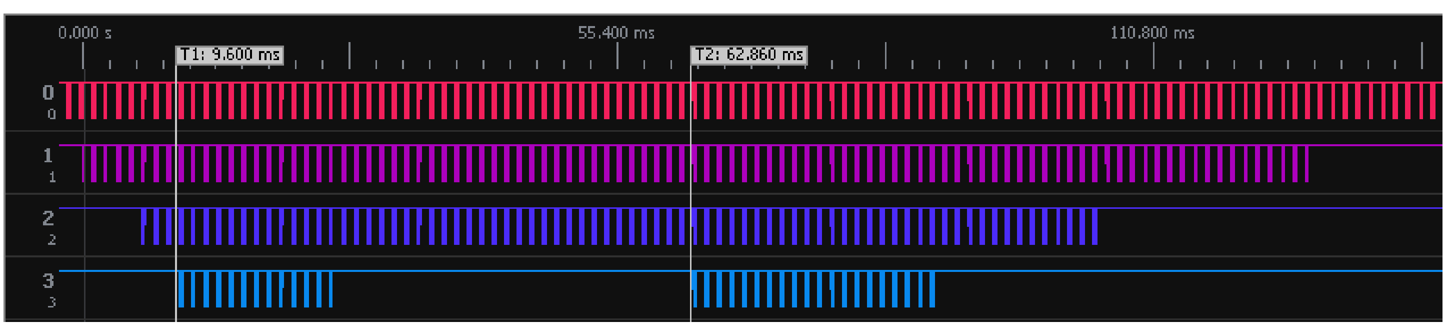


Figure 5: Velocity midi 90, played staccato, showing bounce off third contact.