KS10 FPGA CPU Debugging with Xilinx ChipScope

ChipScope

Xilinx ChipScope is an embedded Logic Analyzer that can be added to an FPGA that allows signals that are internal to the FPGA to be captured and transferred to a host computer for analysis.

ChipScope has been integrated into the KS10 FPGA CPU to verify that the Microsequencer, Microcode, ALU, and CPU are operating as expected.

In order to test the KS10 CPU, the ChipScope Integrated Logic Analyzer acquires and buffers data from a number of sources inside the CPU. More specifically, these signals are:

- the Reset Signal (**rst**),
- the Microcode (Control ROM) Address (**cromADDR[0:11]**),
- the ALU Output Bus (**dp[0:35]**),
- the ALU Input Bus (**dbus[0:35]**), and
- the debug data port of the ALU (**debugDATA[0:35]**).

The signals are all concatenated into a single 121-bit bus which is implemented as follows:

wire [120:0] TRIG0 = {rst, cromADDR[0:11], dp[0:35], dbus[0:35], debugDATA[0:35]};

The ICON module, ILA module, and VIO module are instantiated into the KS10 CPU module as follows:

```
//
// ChipScope Pro Integrated Controller (ICON)
//

wire [35:0] control0;
wire [35:0] control1;

chipscope_cpu_icon uICON (
    .CONTROL0  (control0),
    .CONTROL1  (control1)
);


//
// ChipScope Pro Virtual Input/Output (VIO)
//

chipscope_cpu_vio uVIO (
    .CONTROL   (control0),
    .ASYNC_IN  (debugADDR),
    .ASYNC_OUT (debugADDR)
);


//
// ChipScope Pro Integrated Logic Analyzer (ILA)
//

wire [120:0] TRIG0 = {rst, cromADDR[0:11], dp[0:35], dbus[0:35], debugDATA[0:35]};

chipscope_cpu_ila uILA (
    .CLK       (clk),
    .CONTROL   (control1),
    .TRIG0     (TRIG0)
);
```

Figure 1 - ChipScope Module Instantiation

The ALU contains 16 registers.   The contents of any one of these 16 registers can be selected onto the debugDATA[0:35] bus by asserting an address on debugADDR[0:3] signals. Here we have used a ChipScope Virtual Input/Output (VIO) module to control the addressing. This allows ChipScope to select which register contents are captured by the ILA.

Trigger Setup

When the KS10 FPGA is held in reset, the Microcode Address (cromADDR) is held at zero and the KS10 FPGA repeated executes the micro-instruction at address zero until the reset signal is negated. We will the Microcode Address to trigger ChipScope to begin acquiring data.

The figure below illustrates how ChipScope is configured to trigger when the Microcode Address transitions to non-zero.
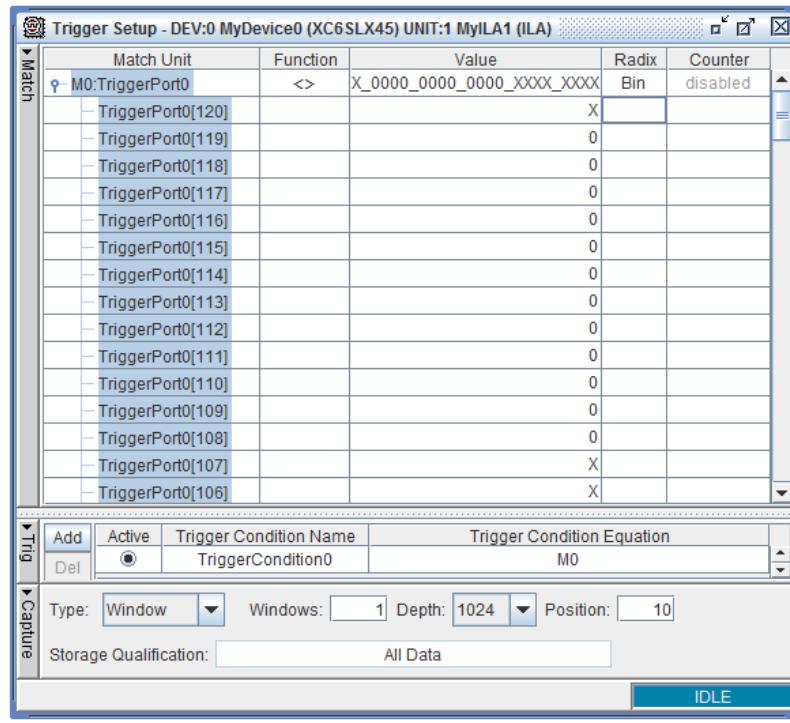

Figure 2 - Trigger Configuration

In the example above, the note that the cromADDR is bits 108:119 of the TriggerPort0.   TriggerCondition0 is activated when TriggerPort0[108:119] <> 000000000000.   ChipScope is also configured to acquire 1024 samples with 10 samples before the trigger.

VIO Setup

The ALU registers can only be read one-at-a-time. A VIO Asynchronous Output is used to select the ALU debug register output.   The Asynchronous Output is also fed back to the Asynchronous Input as a loopback indication.
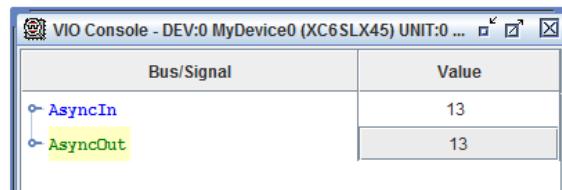
Figure 3 – VIO Configuration

Note: Register 13 (decimal) shown above is the XWD1 register of the ALU.

Acquiring Data

In order to acquire data, ChipScope must detect the transition from the KS10 reset state to the unreset state.

The **Master Reset On** console command is used to force KS10 CPU into the reset state.

```
KS10>
KS10> mr on
KS10 is reset
KS10>
```

Once the KS10 is held in reset, ChipScope may be armed to trigger by clicking the "ARM Trigger Button".   This is illustrated below
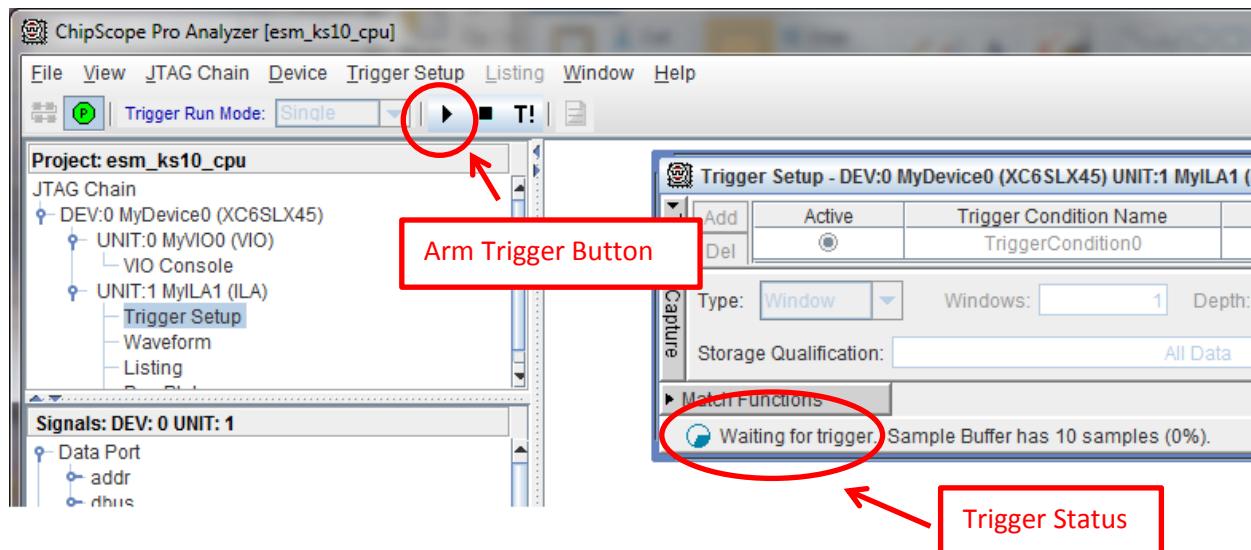
Figure 4 - ChipScope Trigger Armed

Note that the Trigger Status is indicating that ChipScope is "Waiting for trigger".

The **Master Reset Off** command is given to the Console as shown below.   This un-resets KS10 CPU and begins execution.

```
KS10>
KS10> mr off
KS10 is unreset
KS10>
```

When the KS10 begins execution, ChipScope will begin acquiring data.   Again, this is illustrated below.
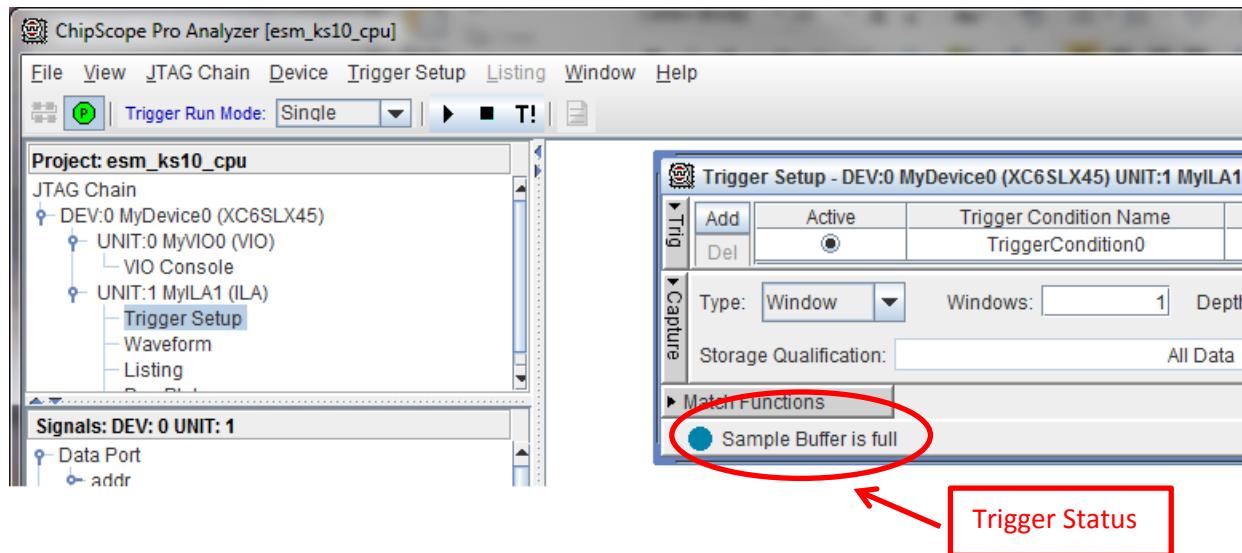
Figure 5 - ChipScope Buffer Full

Note that the Trigger Status is indicating that the ChipScope Sample Buffer is full.

Tracing the KS10 Initialization

Once the data was captured by ChipScope, the data was exported from ChipScope as tab delimited ASCII, post-processed by a tiny AWK script, and pasted into this document.

The following data was acquired by the ChipScope tool.   The bulk of the instructions are executed to calculate a power-of-ten table.   This is also used as a power-on selftest.   This calculation begins at about clock 22 and continues to about clock 636.

Table 1 - KS10 Microinstruction Trace

Clk	ADDR (octal)	dp (octal)	dbus (octal)	T1 Register (octal)	BR Register (octal)	ARX Register (octal)	Comment
0	0000	377777377777	377777377777	000000000000	330656232670	000000000001	KS10 in reset
1	0000	377777377777	377777377777	000000000000	330656232670	000000000001	Note: The ALU registers are not cleared by reset.
2	0000	377777377777	377777377777	000000000000	330656232670	000000000001	The data in the BR and ARX register is left over
3	0000	377777377777	377777377777	000000000000	330656232670	000000000001	from the previous run.
4	0000	377777377777	377777377777	000000000000	330656232670	000000000001	
5	0000	377777377777	377777377777	000000000000	330656232670	000000000001	
6	0000	377777377777	377777377777	000000000000	330656232670	000000000001	
7	0000	377777377777	377777377777	000000000000	330656232670	000000000001	
8	0000	377777377777	377777377777	000000000000	330656232670	000000000001	
9	0000	377777377777	377777377777	000000000000	330656232670	000000000001	KS10 is still in reset
10	0002	377777377777	377777377777	000000000000	330656232670	000000000001	First microinstruction after reset. ADDR != 0
11	0013	377777377777	377777377777	000000000000	330656232670	000000000001	
12	0053	777777777777	000001000001	000000000000	330656232670	000000000001	
13	0061	777777777777	777777777777	000000000000	330656232670	000000000001	
14	0071	000001000001	000001000001	000000000000	330656232670	000000000001	
15	0003	000000000001	000001000001	000000000000	330656232670	000000000001	
16	0100	000000376000	376000376000	000000000000	330656232670	000000000001	
17	0106	000000376000	000000376000	000000000000	330656232670	000000000001	
18	0110	000000000000	000000000000	000000000000	330656232670	000000000001	
19	0125	000000000000	000000000000	000000000000	330656232670	000000000001	
20	0131	000000000000	000000000000	000000000000	330656232670	000000000001	
21	0162	000000000000	000000000000	000000000000	330656232670	000000000001	
22	0212	000000000000	000000000000	000000000000	330656232670	000000000001	
23	0214	000000000000	000000000000	000000000000	330656232670	000000000001	Start power-of-tens table
24	0223	000000000000	000000000000	000000000000	330656232670	000000000001	
25	0226	000000000001	000000000001	000000000000	330656232670	000000000001	
26	0235	000000000000	000000000000	000000000000	330656232670	000000000001	
27	0242	000000000001	000000000001	000000000000	330656232670	000000000001	
28	0244	000000000000	000000000000	000000000000	330656232670	000000000001	
29	0311	000344000344	000344000344	000000000000	330656232670	000000000001	
30	0323	000373000373	000373000373	000000000000	330656232670	000000000001	
31	0010	000373000374	000373000374	000000000000	330656232670	000000000001	
32	0560	000000000001	000000000001	000000000000	330656232670	000000000001	
33	0620	000000000000	000000000000	000000000000	330656232670	000000000001	
34	0621	000000000000	000000000000	000000000000	000000000000	000000000001	
35	0622	000000000000	000000000000	000000000000	000000000000	000000000001	
36	2140	000000000002	000000000002	000000000000	000000000000	000000000001	
37	0626	000000000000	000000000000	000000000000	000000000000	000000000002	
38	0621	000000000000	000000000000	000000000000	000000000000	000000000002	
39	0622	000000000000	000000000000	000000000000	000000000000	000000000002	
40	2140	000000000004	000000000004	000000000000	000000000000	000000000002	
41	0626	000000000000	000000000000	000000000000	000000000000	000000000004	

Clk	ADDR (octal)	dp (octal)	dbus (octal)	T1 Register (octal)	BR Register (octal)	ARX Register (octal)	Comment
42	0561	000000000000	000000000000	000000000000	000000000000	000000000004	
43	2140	000000000005	000000000001	000000000000	000000000000	000000000004	
44	0565	000000000000	000000000000	000000000000	000000000000	000000000005	
45	0600	000000000000	000000000000	000000000000	000000000000	000000000005	
46	0621	000000000000	000000000000	000000000000	000000000000	000000000005	
47	0622	000000000000	000000000000	000000000000	000000000000	000000000005	
48	2140	000000000012	000000000012	000000000000	000000000000	000000000005	
49	0626	000000000000	000000000000	000000000000	000000000000	000000000012	
50	0601	000000000000	000000000000	000000000000	000000000000	000000000012	[BR,ARX] = 10^1
51	2140	000000000012	000000000012	000000000000	000000000000	000000000012	
52	0605	000000000000	000000000000	000000000000	000000000000	000000000012	
53	3333	000000000012	000000000012	000000000000	000000000000	000000000012	
54	0012	000000000000	000000000000	000000000000	000000000000	000000000012	
55	0324	000000000000	000000000000	000000000000	000000000000	000000000012	
56	0334	000344000345	000344000345	000000000000	000000000000	000000000012	
57	0224	000000000012	000000000012	000000000000	000000000000	000000000012	
58	0323	000000000000	000000000000	000000000000	000000000000	000000000012	
59	0010	000373000375	000373000375	000000000000	000000000000	000000000012	
60	0560	000000000012	000000000012	000000000000	000000000000	000000000012	
61	0620	000000000000	000000000000	000000000000	000000000000	000000000012	
62	0621	000000000000	000000000000	000000000000	000000000000	000000000012	
63	0622	000000000000	000000000000	000000000000	000000000000	000000000012	
64	2140	000000000024	000000000024	000000000000	000000000000	000000000012	
65	0626	000000000000	000000000000	000000000000	000000000000	000000000024	
66	0621	000000000000	000000000000	000000000000	000000000000	000000000024	
67	0622	000000000000	000000000000	000000000000	000000000000	000000000024	
68	2140	000000000050	000000000050	000000000000	000000000000	000000000024	
69	0626	000000000000	000000000000	000000000000	000000000000	000000000050	
70	0561	000000000000	000000000000	000000000000	000000000000	000000000050	
71	2140	000000000062	000000000012	000000000000	000000000000	000000000050	
72	0565	000000000000	000000000000	000000000000	000000000000	000000000062	
73	0600	000000000000	000000000000	000000000000	000000000000	000000000062	
74	0621	000000000000	000000000000	000000000000	000000000000	000000000062	
75	0622	000000000000	000000000000	000000000000	000000000000	000000000062	
76	2140	000000000144	000000000144	000000000000	000000000000	000000000062	
77	0626	000000000000	000000000000	000000000000	000000000000	000000000144	
78	0601	000000000000	000000000000	000000000000	000000000000	000000000144	[BR,ARX] = 10^2
79	2140	000000000144	000000000144	000000000000	000000000000	000000000144	
80	0605	000000000000	000000000000	000000000000	000000000000	000000000144	
81	3333	000000000144	000000000144	000000000000	000000000000	000000000144	
82	0012	000000000000	000000000000	000000000000	000000000000	000000000144	
83	0324	000000000000	000000000000	000000000000	000000000000	000000000144	
84	0334	000344000346	000344000346	000000000000	000000000000	000000000144	
85	0224	000000000144	000000000144	000000000000	000000000000	000000000144	
86	0323	000000000000	000000000000	000000000000	000000000000	000000000144	

Clk	ADDR (octal)	dp (octal)	dbus (octal)	T1 Register (octal)	BR Register (octal)	ARX Register (octal)	Comment
87	0010	000373000376	000373000376	000000000000	000000000000	000000000144	
88	0560	000000000144	000000000144	000000000000	000000000000	000000000144	
89	0620	000000000000	000000000000	000000000000	000000000000	000000000144	
90	0621	000000000000	000000000000	000000000000	000000000000	000000000144	
91	0622	000000000000	000000000000	000000000000	000000000000	000000000144	
92	2140	000000000310	000000000310	000000000000	000000000000	000000000144	
93	0626	000000000000	000000000000	000000000000	000000000000	000000000310	
94	0621	000000000000	000000000000	000000000000	000000000000	000000000310	
95	0622	000000000000	000000000000	000000000000	000000000000	000000000310	
96	2140	000000000620	000000000620	000000000000	000000000000	000000000310	
97	0626	000000000000	000000000000	000000000000	000000000000	000000000620	
98	0561	000000000000	000000000000	000000000000	000000000000	000000000620	
99	2140	000000000764	000000000144	000000000000	000000000000	000000000620	
100	0565	000000000000	000000000000	000000000000	000000000000	000000000764	
101	0600	000000000000	000000000000	000000000000	000000000000	000000000764	
102	0621	000000000000	000000000000	000000000000	000000000000	000000000764	
103	0622	000000000000	000000000000	000000000000	000000000000	000000000764	
104	2140	000000001750	000000001750	000000000000	000000000000	000000000764	
105	0626	000000000000	000000000000	000000000000	000000000000	000000001750	
106	0601	000000000000	000000000000	000000000000	000000000000	000000001750	[BR,ARX] = 10^3
107	2140	000000001750	000000001750	000000000000	000000000000	000000001750	
108	0605	000000000000	000000000000	000000000000	000000000000	000000001750	
109	3333	000000001750	000000001750	000000000000	000000000000	000000001750	
110	0012	000000000000	000000000000	000000000000	000000000000	000000001750	
111	0324	000000000000	000000000000	000000000000	000000000000	000000001750	
112	0334	000344000347	000344000347	000000000000	000000000000	000000001750	
113	0224	000000001750	000000001750	000000000000	000000000000	000000001750	
114	0323	000000000000	000000000000	000000000000	000000000000	000000001750	
115	0010	000373000377	000373000377	000000000000	000000000000	000000001750	
116	0560	000000001750	000000001750	000000000000	000000000000	000000001750	
117	0620	000000000000	000000000000	000000000000	000000000000	000000001750	
118	0621	000000000000	000000000000	000000000000	000000000000	000000001750	
119	0622	000000000000	000000000000	000000000000	000000000000	000000001750	
120	2140	000000003720	000000003720	000000000000	000000000000	000000001750	
121	0626	000000000000	000000000000	000000000000	000000000000	000000003720	
122	0621	000000000000	000000000000	000000000000	000000000000	000000003720	
123	0622	000000000000	000000000000	000000000000	000000000000	000000003720	
124	2140	000000007640	000000007640	000000000000	000000000000	000000003720	
125	0626	000000000000	000000000000	000000000000	000000000000	000000007640	
126	0561	000000000000	000000000000	000000000000	000000000000	000000007640	
127	2140	000000011610	000000001750	000000000000	000000000000	000000007640	
128	0565	000000000000	000000000000	000000000000	000000000000	000000011610	
129	0600	000000000000	000000000000	000000000000	000000000000	000000011610	
130	0621	000000000000	000000000000	000000000000	000000000000	000000011610	
131	0622	000000000000	000000000000	000000000000	000000000000	000000011610	

Clk	ADDR (octal)	dp (octal)	dbus (octal)	T1 Register (octal)	BR Register (octal)	ARX Register (octal)	Comment
132	2140	000000023420	000000023420	000000000000	000000000000	000000011610	
133	0626	000000000000	000000000000	000000000000	000000000000	000000023420	
134	0601	000000000000	000000000000	000000000000	000000000000	000000023420	[BR,ARX] = 10^4
135	2140	000000023420	000000023420	000000000000	000000000000	000000023420	
136	0605	000000000000	000000000000	000000000000	000000000000	000000023420	
137	3333	000000023420	000000023420	000000000000	000000000000	000000023420	
138	0012	000000000000	000000000000	000000000000	000000000000	000000023420	
139	0324	000000000000	000000000000	000000000000	000000000000	000000023420	
140	0334	000344000350	000344000350	000000000000	000000000000	000000023420	
141	0224	000000023420	000000023420	000000000000	000000000000	000000023420	
142	0323	000000000000	000000000000	000000000000	000000000000	000000023420	
143	0010	000373000400	000373000400	000000000000	000000000000	000000023420	
144	0560	000000023420	000000023420	000000000000	000000000000	000000023420	
145	0620	000000000000	000000000000	000000000000	000000000000	000000023420	
146	0621	000000000000	000000000000	000000000000	000000000000	000000023420	
147	0622	000000000000	000000000000	000000000000	000000000000	000000023420	
148	2140	000000047040	000000047040	000000000000	000000000000	000000023420	
149	0626	000000000000	000000000000	000000000000	000000000000	000000047040	
150	0621	000000000000	000000000000	000000000000	000000000000	000000047040	
151	0622	000000000000	000000000000	000000000000	000000000000	000000047040	
152	2140	000000116100	000000116100	000000000000	000000000000	000000047040	
153	0626	000000000000	000000000000	000000000000	000000000000	000000116100	
154	0561	000000000000	000000000000	000000000000	000000000000	000000116100	
155	2140	000000141520	000000023420	000000000000	000000000000	000000116100	
156	0565	000000000000	000000000000	000000000000	000000000000	000000141520	
157	0600	000000000000	000000000000	000000000000	000000000000	000000141520	
158	0621	000000000000	000000000000	000000000000	000000000000	000000141520	
159	0622	000000000000	000000000000	000000000000	000000000000	000000141520	
160	2140	000000303240	000000303240	000000000000	000000000000	000000141520	
161	0626	000000000000	000000000000	000000000000	000000000000	000000303240	
162	0601	000000000000	000000000000	000000000000	000000000000	000000303240	[BR,ARX] = 10^5
163	2140	000000303240	000000303240	000000000000	000000000000	000000303240	
164	0605	000000000000	000000000000	000000000000	000000000000	000000303240	
165	3333	000000303240	000000303240	000000000000	000000000000	000000303240	
166	0012	000000000000	000000000000	000000000000	000000000000	000000303240	
167	0324	000000000000	000000000000	000000000000	000000000000	000000303240	
168	0334	000344000351	000344000351	000000000000	000000000000	000000303240	
169	0224	000000303240	000000303240	000000000000	000000000000	000000303240	
170	0323	000000000000	000000000000	000000000000	000000000000	000000303240	
171	0010	000373000401	000373000401	000000000000	000000000000	000000303240	
172	0560	000000303240	000000303240	000000000000	000000000000	000000303240	
173	0620	000000000000	000000000000	000000000000	000000000000	000000303240	
174	0621	000000000000	000000000000	000000000000	000000000000	000000303240	
175	0622	000000000000	000000000000	000000000000	000000000000	000000303240	
176	2140	000000606500	000000606500	000000000000	000000000000	000000303240	

Clk	ADDR (octal)	dp (octal)	dbus (octal)	T1 Register (octal)	BR Register (octal)	ARX Register (octal)	Comment
177	0626	000000000000	000000000000	000000000000	000000000000	000000606500	
178	0621	000000000000	000000000000	000000000000	000000000000	000000606500	
179	0622	000000000000	000000000000	000000000000	000000000000	000000606500	
180	2140	000001415200	000001415200	000000000000	000000000000	000000606500	
181	0626	000000000000	000000000000	000000000000	000000000000	000001415200	
182	0561	000000000000	000000000000	000000000000	000000000000	000001415200	
183	2140	000001720440	000000303240	000000000000	000000000000	000001415200	
184	0565	000000000000	000000000000	000000000000	000000000000	000001720440	
185	0600	000000000000	000000000000	000000000000	000000000000	000001720440	
186	0621	000000000000	000000000000	000000000000	000000000000	000001720440	
187	0622	000000000000	000000000000	000000000000	000000000000	000001720440	
188	2140	000003641100	000003641100	000000000000	000000000000	000001720440	
189	0626	000000000000	000000000000	000000000000	000000000000	000003641100	
190	0601	000000000000	000000000000	000000000000	000000000000	000003641100	[BR,ARX] = 10^6
191	2140	000003641100	000003641100	000000000000	000000000000	000003641100	
192	0605	000000000000	000000000000	000000000000	000000000000	000003641100	
193	3333	000003641100	000003641100	000000000000	000000000000	000003641100	
194	0012	000000000000	000000000000	000000000000	000000000000	000003641100	
195	0324	000000000000	000000000000	000000000000	000000000000	000003641100	
196	0334	000344000352	000344000352	000000000000	000000000000	000003641100	
197	0224	000003641100	000003641100	000000000000	000000000000	000003641100	
198	0323	000000000000	000000000000	000000000000	000000000000	000003641100	
199	0010	000373000402	000373000402	000000000000	000000000000	000003641100	
200	0560	000003641100	000003641100	000000000000	000000000000	000003641100	
201	0620	000000000000	000000000000	000000000000	000000000000	000003641100	
202	0621	000000000000	000000000000	000000000000	000000000000	000003641100	
203	0622	000000000000	000000000000	000000000000	000000000000	000003641100	
204	2140	000007502200	000007502200	000000000000	000000000000	000003641100	
205	0626	000000000000	000000000000	000000000000	000000000000	000007502200	
206	0621	000000000000	000000000000	000000000000	000000000000	000007502200	
207	0622	000000000000	000000000000	000000000000	000000000000	000007502200	
208	2140	000017204400	000017204400	000000000000	000000000000	000007502200	
209	0626	000000000000	000000000000	000000000000	000000000000	000017204400	
210	0561	000000000000	000000000000	000000000000	000000000000	000017204400	
211	2140	000023045500	000003641100	000000000000	000000000000	000017204400	
212	0565	000000000000	000000000000	000000000000	000000000000	000023045500	
213	0600	000000000000	000000000000	000000000000	000000000000	000023045500	
214	0621	000000000000	000000000000	000000000000	000000000000	000023045500	
215	0622	000000000000	000000000000	000000000000	000000000000	000023045500	
216	2140	000046113200	000046113200	000000000000	000000000000	000023045500	
217	0626	000000000000	000000000000	000000000000	000000000000	000046113200	
218	0601	000000000000	000000000000	000000000000	000000000000	000046113200	[BR,ARX] = 10^7
219	2140	000046113200	000046113200	000000000000	000000000000	000046113200	
220	0605	000000000000	000000000000	000000000000	000000000000	000046113200	
221	3333	000046113200	000046113200	000000000000	000000000000	000046113200	

Clk	ADDR (octal)	dp (octal)	dbus (octal)	T1 Register (octal)	BR Register (octal)	ARX Register (octal)	Comment
222	0012	000000000000	000000000000	000000000000	000000000000	000046113200	
223	0324	000000000000	000000000000	000000000000	000000000000	000046113200	
224	0334	000344000353	000344000353	000000000000	000000000000	000046113200	
225	0224	000046113200	000046113200	000000000000	000000000000	000046113200	
226	0323	000000000000	000000000000	000000000000	000000000000	000046113200	
227	0010	000373000403	000373000403	000000000000	000000000000	000046113200	
228	0560	000046113200	000046113200	000000000000	000000000000	000046113200	
229	0620	000000000000	000000000000	000000000000	000000000000	000046113200	
230	0621	000000000000	000000000000	000000000000	000000000000	000046113200	
231	0622	000000000000	000000000000	000000000000	000000000000	000046113200	
232	2140	000114226400	000114226400	000000000000	000000000000	000046113200	
233	0626	000000000000	000000000000	000000000000	000000000000	000114226400	
234	0621	000000000000	000000000000	000000000000	000000000000	000114226400	
235	0622	000000000000	000000000000	000000000000	000000000000	000114226400	
236	2140	000230455000	000230455000	000000000000	000000000000	000114226400	
237	0626	000000000000	000000000000	000000000000	000000000000	000230455000	
238	0561	000000000000	000000000000	000000000000	000000000000	000230455000	
239	2140	000276570200	000046113200	000000000000	000000000000	000230455000	
240	0565	000000000000	000000000000	000000000000	000000000000	000276570200	
241	0600	000000000000	000000000000	000000000000	000000000000	000276570200	
242	0621	000000000000	000000000000	000000000000	000000000000	000276570200	
243	0622	000000000000	000000000000	000000000000	000000000000	000276570200	
244	2140	000575360400	000575360400	000000000000	000000000000	000276570200	
245	0626	000000000000	000000000000	000000000000	000000000000	000575360400	
246	0601	000000000000	000000000000	000000000000	000000000000	000575360400	[BR,ARX] = 10^8
247	2140	000575360400	000575360400	000000000000	000000000000	000575360400	
248	0605	000000000000	000000000000	000000000000	000000000000	000575360400	
249	3333	000575360400	000575360400	000000000000	000000000000	000575360400	
250	0012	000000000000	000000000000	000000000000	000000000000	000575360400	
251	0324	000000000000	000000000000	000000000000	000000000000	000575360400	
252	0334	000344000354	000344000354	000000000000	000000000000	000575360400	
253	0224	000575360400	000575360400	000000000000	000000000000	000575360400	
254	0323	000000000000	000000000000	000000000000	000000000000	000575360400	
255	0010	000373000404	000373000404	000000000000	000000000000	000575360400	
256	0560	000575360400	000575360400	000000000000	000000000000	000575360400	
257	0620	000000000000	000000000000	000000000000	000000000000	000575360400	
258	0621	000000000000	000000000000	000000000000	000000000000	000575360400	
259	0622	000000000000	000000000000	000000000000	000000000000	000575360400	
260	2140	001372741000	001372741000	000000000000	000000000000	000575360400	
261	0626	000000000000	000000000000	000000000000	000000000000	001372741000	
262	0621	000000000000	000000000000	000000000000	000000000000	001372741000	
263	0622	000000000000	000000000000	000000000000	000000000000	001372741000	
264	2140	002765702000	002765702000	000000000000	000000000000	001372741000	
265	0626	000000000000	000000000000	000000000000	000000000000	002765702000	
266	0561	000000000000	000000000000	000000000000	000000000000	002765702000	

Clk	ADDR (octal)	dp (octal)	dbus (octal)	T1 Register (octal)	BR Register (octal)	ARX Register (octal)	Comment
267	2140	003563262400	000575360400	000000000000	000000000000	002765702000	
268	0565	000000000000	000000000000	000000000000	000000000000	003563262400	
269	0600	000000000000	000000000000	000000000000	000000000000	003563262400	
270	0621	000000000000	000000000000	000000000000	000000000000	003563262400	
271	0622	000000000000	000000000000	000000000000	000000000000	003563262400	
272	2140	007346545000	007346545000	000000000000	000000000000	003563262400	
273	0626	000000000000	000000000000	000000000000	000000000000	007346545000	
274	0601	000000000000	000000000000	000000000000	000000000000	007346545000	[BR,ARX] = 10^9
275	2140	007346545000	007346545000	000000000000	000000000000	007346545000	
276	0605	000000000000	000000000000	000000000000	000000000000	007346545000	
277	3333	007346545000	007346545000	000000000000	000000000000	007346545000	
278	0012	000000000000	000000000000	000000000000	000000000000	007346545000	
279	0324	000000000000	000000000000	000000000000	000000000000	007346545000	
280	0334	000344000355	000344000355	000000000000	000000000000	007346545000	
281	0224	007346545000	007346545000	000000000000	000000000000	007346545000	
282	0323	000000000000	000000000000	000000000000	000000000000	007346545000	
283	0010	000373000405	000373000405	000000000000	000000000000	007346545000	
284	0560	007346545000	007346545000	000000000000	000000000000	007346545000	
285	0620	000000000000	000000000000	000000000000	000000000000	007346545000	
286	0621	000000000000	000000000000	000000000000	000000000000	007346545000	
287	0622	000000000000	000000000000	000000000000	000000000000	007346545000	
288	2140	016715312000	016715312000	000000000000	000000000000	007346545000	
289	0626	000000000000	000000000000	000000000000	000000000000	016715312000	
290	0621	000000000000	000000000000	000000000000	000000000000	016715312000	
291	0622	000000000000	000000000000	000000000000	000000000000	016715312000	
292	2140	035632624000	035632624000	000000000000	000000000000	016715312000	
293	0626	000000000000	000000000000	000000000000	000000000000	035632624000	
294	0561	000000000000	000000000000	000000000000	000000000000	035632624000	
295	2140	045201371000	007346545000	000000000000	000000000000	035632624000	
296	0565	000000000000	000000000000	000000000000	000000000000	045201371000	
297	0600	000000000000	000000000000	000000000000	000000000000	045201371000	
298	0621	000000000000	000000000000	000000000000	000000000000	045201371000	
299	0622	000000000000	000000000000	000000000000	000000000000	045201371000	
300	2140	112402762000	112402762000	000000000000	000000000000	045201371000	
301	0626	000000000000	000000000000	000000000000	000000000000	112402762000	
302	0601	000000000000	000000000000	000000000000	000000000000	112402762000	[BR,ARX] = 10^10
303	2140	112402762000	112402762000	000000000000	000000000000	112402762000	
304	0605	000000000000	000000000000	000000000000	000000000000	112402762000	
305	3333	112402762000	112402762000	000000000000	000000000000	112402762000	
306	0012	000000000000	000000000000	000000000000	000000000000	112402762000	
307	0324	000000000000	000000000000	000000000000	000000000000	112402762000	
308	0334	000344000356	000344000356	000000000000	000000000000	112402762000	
309	0224	112402762000	112402762000	000000000000	000000000000	112402762000	
310	0323	000000000000	000000000000	000000000000	000000000000	112402762000	
311	0010	000373000406	000373000406	000000000000	000000000000	112402762000	

Clk	ADDR (octal)	dp (octal)	dbus (octal)	T1 Register (octal)	BR Register (octal)	ARX Register (octal)	Comment
312	0560	112402762000	112402762000	000000000000	000000000000	112402762000	
313	0620	000000000000	000000000000	000000000000	000000000000	112402762000	
314	0621	000000000000	000000000000	000000000000	000000000000	112402762000	
315	0622	000000000000	000000000000	000000000000	000000000000	112402762000	
316	2140	225005744000	225005744000	000000000000	000000000000	112402762000	
317	0626	000000000000	000000000000	000000000000	000000000000	225005744000	
318	0621	000000000000	000000000000	000000000000	000000000000	225005744000	
319	0622	000000000000	000000000000	000000000000	000000000000	225005744000	
320	2141	452013710000	452013710000	000000000000	000000000000	225005744000	
321	3334	052013310000	377777377777	000000000000	000000000000	452013710000	
322	0626	000000000001	000000000001	000000000000	000000000000	052013710000	
323	0561	000000000000	000000000000	000000000000	000000000001	052013710000	
324	2140	164416672000	112402762000	000000000000	000000000001	052013710000	
325	0565	000000000000	000000000000	000000000000	000000000001	164416672000	
326	0600	000000000001	000000000000	000000000000	000000000001	164416672000	
327	0621	000000000000	000000000000	000000000000	000000000001	164416672000	
328	0622	000000000002	000000000002	000000000000	000000000001	164416672000	
329	2140	351035564000	351035564000	000000000000	000000000002	164416672000	
330	0626	000000000000	000000000000	000000000000	000000000002	351035564000	
331	0601	000000000000	000000000000	000000000000	000000000002	351035564000	[BR,ARX] = 10^11
332	2140	351035564000	351035564000	000000000000	000000000002	351035564000	
333	0605	000000000000	000000000000	000000000000	000000000002	351035564000	
334	3333	351035564000	351035564000	000000000000	000000000002	351035564000	
335	0012	000000000002	000000000002	000000000000	000000000002	351035564000	
336	0324	000000000002	000000000002	000000000000	000000000002	351035564000	
337	0334	000344000357	000344000357	000000000000	000000000002	351035564000	
338	0224	351035564000	351035564000	000000000000	000000000002	351035564000	
339	0323	000000000000	000000000000	000000000000	000000000002	351035564000	
340	0010	000373000407	000373000407	000000000000	000000000002	351035564000	
341	0560	351035564000	351035564000	000000000000	000000000002	351035564000	
342	0620	000000000002	000000000002	000000000000	000000000002	351035564000	
343	0621	000000000000	000000000000	000000000000	000000000002	351035564000	
344	0622	000000000004	000000000004	000000000000	000000000002	351035564000	
345	2141	722073350000	722073350000	000000000000	000000000004	351035564000	
346	3334	322073350000	377777377777	000000000000	000000000004	722073350000	
347	0626	000000000005	000000000005	000000000000	000000000004	322073350000	
348	0621	000000000000	000000000000	000000000000	000000000005	322073350000	
349	0622	000000000012	000000000012	000000000000	000000000005	322073350000	
350	2141	644166720000	644166720000	000000000000	000000000012	322073350000	
351	3334	244166320000	377777377777	000000000000	000000000012	644166720000	
352	0626	000000000013	000000000013	000000000000	000000000012	244166720000	
353	0561	000000000000	000000000000	000000000000	000000000013	244166720000	
354	2141	615224504000	351035564000	000000000000	000000000013	244166720000	
355	3334	215224104000	377777377777	000000000000	000000000013	615224504000	
356	0565	000000000014	000000000014	000000000000	000000000013	215224504000	

Clk	ADDR (octal)	dp (octal)	dbus (octal)	T1 Register (octal)	BR Register (octal)	ARX Register (octal)	Comment
357	0600	000000000016	000000000002	000000000000	000000000014	215224504000	
358	0621	000000000000	000000000000	000000000000	000000000016	215224504000	
359	0622	000000000034	000000000034	000000000000	000000000016	215224504000	
360	2141	432451210000	432451210000	000000000000	000000000034	215224504000	
361	3334	032451210000	377777377777	000000000000	000000000034	432451210000	
362	0626	000000000035	000000000035	000000000000	000000000034	032451210000	
363	0601	000000000000	000000000000	000000000000	000000000035	032451210000	[BR,ARX] = 10^12
364	2140	032451210000	032451210000	000000000000	000000000035	032451210000	
365	0605	000000000000	000000000000	000000000000	000000000035	032451210000	
366	3333	032451210000	032451210000	000000000000	000000000035	032451210000	
367	0012	000000000035	000000000035	000000000000	000000000035	032451210000	
368	0324	000000000035	000000000035	000000000000	000000000035	032451210000	
369	0334	000344000360	000344000360	000000000000	000000000035	032451210000	
370	0224	032451210000	032451210000	000000000000	000000000035	032451210000	
371	0323	000000000000	000000000000	000000000000	000000000035	032451210000	
372	0010	000373000410	000373000410	000000000000	000000000035	032451210000	
373	0560	032451210000	032451210000	000000000000	000000000035	032451210000	
374	0620	000000000035	000000000035	000000000000	000000000035	032451210000	
375	0621	000000000000	000000000000	000000000000	000000000035	032451210000	
376	0622	000000000072	000000000072	000000000000	000000000035	032451210000	
377	2140	065122420000	065122420000	000000000000	000000000072	032451210000	
378	0626	000000000000	000000000000	000000000000	000000000072	065122420000	
379	0621	000000000000	000000000000	000000000000	000000000072	065122420000	
380	0622	000000000164	000000000164	000000000000	000000000072	065122420000	
381	2140	152245040000	152245040000	000000000000	000000000164	065122420000	
382	0626	000000000000	000000000000	000000000000	000000000164	152245040000	
383	0561	000000000000	000000000000	000000000000	000000000164	152245040000	
384	2140	204716250000	032451210000	000000000000	000000000164	152245040000	
385	0565	000000000000	000000000000	000000000000	000000000164	204716250000	
386	0600	000000000221	000000000035	000000000000	000000000164	204716250000	
387	0621	000000000000	000000000000	000000000000	000000000221	204716250000	
388	0622	000000000442	000000000442	000000000000	000000000221	204716250000	
389	2141	411634520000	411634520000	000000000000	000000000442	204716250000	
390	3334	011634120000	377777377777	000000000000	000000000442	411634520000	
391	0626	000000000443	000000000443	000000000000	000000000442	011634520000	
392	0601	000000000000	000000000000	000000000000	000000000443	011634520000	[BR,ARX] = 10^13
393	2140	011634520000	011634520000	000000000000	000000000443	011634520000	
394	0605	000000000000	000000000000	000000000000	000000000443	011634520000	
395	3333	011634520000	011634520000	000000000000	000000000443	011634520000	
396	0012	000000000443	000000000443	000000000000	000000000443	011634520000	
397	0324	000000000443	000000000443	000000000000	000000000443	011634520000	
398	0334	000344000361	000344000361	000000000000	000000000443	011634520000	
399	0224	011634520000	011634520000	000000000000	000000000443	011634520000	
400	0323	000000000000	000000000000	000000000000	000000000443	011634520000	
401	0010	000373000411	000373000411	000000000000	000000000443	011634520000	

Clk	ADDR (octal)	dp (octal)	dbus (octal)	T1 Register (octal)	BR Register (octal)	ARX Register (octal)	Comment
402	0560	011634520000	011634520000	000000000000	000000000443	011634520000	
403	0620	000000000443	000000000443	000000000000	000000000443	011634520000	
404	0621	000000000000	000000000000	000000000000	000000000443	011634520000	
405	0622	000000001106	000000001106	000000000000	000000000443	011634520000	
406	2140	023471240000	023471240000	000000000000	000000001106	011634520000	
407	0626	000000000000	000000000000	000000000000	000000001106	023471240000	
408	0621	000000000000	000000000000	000000000000	000000001106	023471240000	
409	0622	000000002214	000000002214	000000000000	000000001106	023471240000	
410	2140	047162500000	047162500000	000000000000	000000002214	023471240000	
411	0626	000000000000	000000000000	000000000000	000000002214	047162500000	
412	0561	000000000000	000000000000	000000000000	000000002214	047162500000	
413	2140	061017220000	011634520000	000000000000	000000002214	047162500000	
414	0565	000000000000	000000000000	000000000000	000000002214	061017220000	
415	0600	000000002657	000000000443	000000000000	000000002214	061017220000	
416	0621	000000000000	000000000000	000000000000	000000002657	061017220000	
417	0622	000000005536	000000005536	000000000000	000000002657	061017220000	
418	2140	142036440000	142036440000	000000000000	000000005536	061017220000	
419	0626	000000000000	000000000000	000000000000	000000005536	142036440000	
420	0601	000000000000	000000000000	000000000000	000000005536	142036440000	[BR,ARX] = 10^14
421	2140	142036440000	142036440000	000000000000	000000005536	142036440000	
422	0605	000000000000	000000000000	000000000000	000000005536	142036440000	
423	3333	142036440000	142036440000	000000000000	000000005536	142036440000	
424	0012	000000005536	000000005536	000000000000	000000005536	142036440000	
425	0324	000000005536	000000005536	000000000000	000000005536	142036440000	
426	0334	000344000362	000344000362	000000000000	000000005536	142036440000	
427	0224	142036440000	142036440000	000000000000	000000005536	142036440000	
428	0323	000000000000	000000000000	000000000000	000000005536	142036440000	
429	0010	000373000412	000373000412	000000000000	000000005536	142036440000	
430	0560	142036440000	142036440000	000000000000	000000005536	142036440000	
431	0620	000000005536	000000005536	000000000000	000000005536	142036440000	
432	0621	000000000000	000000000000	000000000000	000000005536	142036440000	
433	0622	000000013274	000000013274	000000000000	000000005536	142036440000	
434	2140	304075100000	304075100000	000000000000	000000013274	142036440000	
435	0626	000000000000	000000000000	000000000000	000000013274	304075100000	
436	0621	000000000000	000000000000	000000000000	000000013274	304075100000	
437	0622	000000026570	000000026570	000000000000	000000013274	304075100000	
438	2141	610172200000	610172200000	000000000000	000000026570	304075100000	
439	3334	210172200000	377777377777	000000000000	000000026570	610172200000	
440	0626	000000026571	000000026571	000000000000	000000026570	210172200000	
441	0561	000000000000	000000000000	000000000000	000000026571	210172200000	
442	2140	352230640000	142036440000	000000000000	000000026571	210172200000	
443	0565	000000000000	000000000000	000000000000	000000026571	352230640000	
444	0600	000000034327	000000005536	000000000000	000000026571	352230640000	
445	0621	000000000000	000000000000	000000000000	000000034327	352230640000	
446	0622	000000070656	000000070656	000000000000	000000034327	352230640000	

Clk	ADDR (octal)	dp (octal)	dbus (octal)	T1 Register (octal)	BR Register (octal)	ARX Register (octal)	Comment
447	2141	724461500000	724461500000	000000000000	000000070656	352230640000	
448	3334	324461100000	377777377777	000000000000	000000070656	724461500000	
449	0626	000000070657	000000070657	000000000000	000000070656	324461500000	
450	0601	000000000000	000000000000	000000000000	000000070657	324461500000	[BR,ARX] = 10^15
451	2140	324461500000	324461500000	000000000000	000000070657	324461500000	
452	0605	000000000000	000000000000	000000000000	000000070657	324461500000	
453	3333	324461500000	324461500000	000000000000	000000070657	324461500000	
454	0012	000000070657	000000070657	000000000000	000000070657	324461500000	
455	0324	000000070657	000000070657	000000000000	000000070657	324461500000	
456	0334	000344000363	000344000363	000000000000	000000070657	324461500000	
457	0224	324461500000	324461500000	000000000000	000000070657	324461500000	
458	0323	000000000000	000000000000	000000000000	000000070657	324461500000	
459	0010	000373000413	000373000413	000000000000	000000070657	324461500000	
460	0560	324461500000	324461500000	000000000000	000000070657	324461500000	
461	0620	000000070657	000000070657	000000000000	000000070657	324461500000	
462	0621	000000000000	000000000000	000000000000	000000070657	324461500000	
463	0622	000000161536	000000161536	000000000000	000000070657	324461500000	
464	2141	651143200000	651143200000	000000000000	000000161536	324461500000	
465	3334	251143200000	377777377777	000000000000	000000161536	651143200000	
466	0626	000000161537	000000161537	000000000000	000000161536	251143200000	
467	0621	000000000000	000000000000	000000000000	000000161537	251143200000	
468	0622	000000343276	000000343276	000000000000	000000161537	251143200000	
469	2141	522306400000	522306400000	000000000000	000000343276	251143200000	
470	3334	122306000000	377777377777	000000000000	000000343276	522306400000	
471	0626	000000343277	000000343277	000000000000	000000343276	122306400000	
472	0561	000000000000	000000000000	000000000000	000000343277	122306400000	
473	2141	446770100000	324461500000	000000000000	000000343277	122306400000	
474	3334	046770100000	377777377777	000000000000	000000343277	446770100000	
475	0565	000000343300	000000343300	000000000000	000000343277	046770100000	
476	0600	000000434157	000000070657	000000000000	000000343300	046770100000	
477	0621	000000000000	000000000000	000000000000	000000434157	046770100000	
478	0622	000001070336	000001070336	000000000000	000000434157	046770100000	
479	2140	115760200000	115760200000	000000000000	000001070336	046770100000	
480	0626	000000000000	000000000000	000000000000	000001070336	115760200000	
481	0601	000000000000	000000000000	000000000000	000001070336	115760200000	[BR,ARX] = 10^16
482	2140	115760200000	115760200000	000000000000	000001070336	115760200000	
483	0605	000000000000	000000000000	000000000000	000001070336	115760200000	
484	3333	115760200000	115760200000	000000000000	000001070336	115760200000	
485	0012	000001070336	000001070336	000000000000	000001070336	115760200000	
486	0324	000001070336	000001070336	000000000000	000001070336	115760200000	
487	0334	000344000364	000344000364	000000000000	000001070336	115760200000	
488	0224	115760200000	115760200000	000000000000	000001070336	115760200000	
489	0323	000000000000	000000000000	000000000000	000001070336	115760200000	
490	0010	000373000414	000373000414	000000000000	000001070336	115760200000	
491	0560	115760200000	115760200000	000000000000	000001070336	115760200000	

Clk	ADDR (octal)	dp (octal)	dbus (octal)	T1 Register (octal)	BR Register (octal)	ARX Register (octal)	Comment
492	0620	000001070336	000001070336	000000000000	000001070336	115760200000	
493	0621	000000000000	000000000000	000000000000	000001070336	115760200000	
494	0622	000002160674	000002160674	000000000000	000001070336	115760200000	
495	2140	233740400000	233740400000	000000000000	000002160674	115760200000	
496	0626	000000000000	000000000000	000000000000	000002160674	233740400000	
497	0621	000000000000	000000000000	000000000000	000002160674	233740400000	
498	0622	000004341570	000004341570	000000000000	000002160674	233740400000	
499	2141	467701000000	467701000000	000000000000	000004341570	233740400000	
500	3334	067701000000	377777377777	000000000000	000004341570	467701000000	
501	0626	000004341571	000004341571	000000000000	000004341570	067701000000	
502	0561	000000000000	000000000000	000000000000	000004341571	067701000000	
503	2140	205661200000	115760200000	000000000000	000004341571	067701000000	
504	0565	000000000000	000000000000	000000000000	000004341571	205661200000	
505	0600	000005432127	000001070336	000000000000	000004341571	205661200000	
506	0621	000000000000	000000000000	000000000000	000005432127	205661200000	
507	0622	000013064256	000013064256	000000000000	000005432127	205661200000	
508	2141	413542400000	413542400000	000000000000	000013064256	205661200000	
509	3334	013542000000	377777377777	000000000000	000013064256	413542400000	
510	0626	000013064257	000013064257	000000000000	000013064256	013542400000	
511	0601	000000000000	000000000000	000000000000	000013064257	013542400000	[BR,ARX] = 10^17
512	2140	013542400000	013542400000	000000000000	000013064257	013542400000	
513	0605	000000000000	000000000000	000000000000	000013064257	013542400000	
514	3333	013542400000	013542400000	000000000000	000013064257	013542400000	
515	0012	000013064257	000013064257	000000000000	000013064257	013542400000	
516	0324	000013064257	000013064257	000000000000	000013064257	013542400000	
517	0334	000344000365	000344000365	000000000000	000013064257	013542400000	
518	0224	013542400000	013542400000	000000000000	000013064257	013542400000	
519	0323	000000000000	000000000000	000000000000	000013064257	013542400000	
520	0010	000373000415	000373000415	000000000000	000013064257	013542400000	
521	0560	013542400000	013542400000	000000000000	000013064257	013542400000	
522	0620	000013064257	000013064257	000000000000	000013064257	013542400000	
523	0621	000000000000	000000000000	000000000000	000013064257	013542400000	
524	0622	000026150536	000026150536	000000000000	000013064257	013542400000	
525	2140	027305000000	027305000000	000000000000	000026150536	013542400000	
526	0626	000000000000	000000000000	000000000000	000026150536	027305000000	
527	0621	000000000000	000000000000	000000000000	000026150536	027305000000	
528	0622	000054321274	000054321274	000000000000	000026150536	027305000000	
529	2140	056612000000	056612000000	000000000000	000054321274	027305000000	
530	0626	000000000000	000000000000	000000000000	000054321274	056612000000	
531	0561	000000000000	000000000000	000000000000	000054321274	056612000000	
532	2140	072354400000	013542400000	000000000000	000054321274	056612000000	
533	0565	000000000000	000000000000	000000000000	000054321274	072354400000	
534	0600	000067405553	000013064257	000000000000	000054321274	072354400000	
535	0621	000000000000	000000000000	000000000000	000067405553	072354400000	
536	0622	000157013326	000157013326	000000000000	000067405553	072354400000	

Clk	ADDR (octal)	dp (octal)	dbus (octal)	T1 Register (octal)	BR Register (octal)	ARX Register (octal)	Comment
537	2140	164731000000	164731000000	000000000000	000157013326	072354400000	
538	0626	000000000000	000000000000	000000000000	000157013326	164731000000	
539	0601	000000000000	000000000000	000000000000	000157013326	164731000000	[BR,ARX] = 10^18
540	2140	164731000000	164731000000	000000000000	000157013326	164731000000	
541	0605	000000000000	000000000000	000000000000	000157013326	164731000000	
542	3333	164731000000	164731000000	000000000000	000157013326	164731000000	
543	0012	000157013326	000157013326	000000000000	000157013326	164731000000	
544	0324	000157013326	000157013326	000000000000	000157013326	164731000000	
545	0334	000344000366	000344000366	000000000000	000157013326	164731000000	
546	0224	164731000000	164731000000	000000000000	000157013326	164731000000	
547	0323	000000000000	000000000000	000000000000	000157013326	164731000000	
548	0010	000373000416	000373000416	000000000000	000157013326	164731000000	
549	0560	164731000000	164731000000	000000000000	000157013326	164731000000	
550	0620	000157013326	000157013326	000000000000	000157013326	164731000000	
551	0621	000000000000	000000000000	000000000000	000157013326	164731000000	
552	0622	000336026654	000336026654	000000000000	000157013326	164731000000	
553	2140	351662000000	351662000000	000000000000	000336026654	164731000000	
554	0626	000000000000	000000000000	000000000000	000336026654	351662000000	
555	0621	000000000000	000000000000	000000000000	000336026654	351662000000	
556	0622	000674055530	000674055530	000000000000	000336026654	351662000000	
557	2141	723544000000	723544000000	000000000000	000674055530	351662000000	
558	3334	323544000000	377777377777	000000000000	000674055530	723544000000	
559	0626	000674055531	000674055531	000000000000	000674055530	323544000000	
560	0561	000000000000	000000000000	000000000000	000674055531	323544000000	
561	2141	510475000000	164731000000	000000000000	000674055531	323544000000	
562	3334	110475000000	377777377777	000000000000	000674055531	510475000000	
563	0565	000674055532	000674055532	000000000000	000674055531	110475000000	
564	0600	001053071060	000157013326	000000000000	000674055532	110475000000	
565	0621	000000000000	000000000000	000000000000	001053071060	110475000000	
566	0622	002126162140	002126162140	000000000000	001053071060	110475000000	
567	2140	221172000000	221172000000	000000000000	002126162140	110475000000	
568	0626	000000000000	000000000000	000000000000	002126162140	221172000000	
569	0601	000000000000	000000000000	000000000000	002126162140	221172000000	[BR,ARX] = 10^19
570	2140	221172000000	221172000000	000000000000	002126162140	221172000000	
571	0605	000000000000	000000000000	000000000000	002126162140	221172000000	
572	3333	221172000000	221172000000	000000000000	002126162140	221172000000	
573	0012	002126162140	002126162140	000000000000	002126162140	221172000000	
574	0324	002126162140	002126162140	000000000000	002126162140	221172000000	
575	0334	000344000367	000344000367	000000000000	002126162140	221172000000	
576	0224	221172000000	221172000000	000000000000	002126162140	221172000000	
577	0323	000000000000	000000000000	000000000000	002126162140	221172000000	
578	0010	000373000417	000373000417	000000000000	002126162140	221172000000	
579	0560	221172000000	221172000000	000000000000	002126162140	221172000000	
580	0620	002126162140	002126162140	000000000000	002126162140	221172000000	
581	0621	000000000000	000000000000	000000000000	002126162140	221172000000	

Clk	ADDR (octal)	dp (octal)	dbus (octal)	T1 Register (octal)	BR Register (octal)	ARX Register (octal)	Comment
582	0622	004254344300	004254344300	000000000000	002126162140	221172000000	
583	2141	442364000000	442364000000	000000000000	004254344300	221172000000	
584	3334	042364000000	377777377777	000000000000	004254344300	442364000000	
585	0626	004254344301	004254344301	000000000000	004254344300	042364000000	
586	0621	000000000000	000000000000	000000000000	004254344301	042364000000	
587	0622	010530710602	010530710602	000000000000	004254344301	042364000000	
588	2140	104750000000	104750000000	000000000000	010530710602	042364000000	
589	0626	000000000000	000000000000	000000000000	010530710602	104750000000	
590	0561	000000000000	000000000000	000000000000	010530710602	104750000000	
591	2140	326142000000	221172000000	000000000000	010530710602	104750000000	
592	0565	000000000000	000000000000	000000000000	010530710602	326142000000	
593	0600	012657072742	002126162140	000000000000	010530710602	326142000000	
594	0621	000000000000	000000000000	000000000000	012657072742	326142000000	
595	0622	025536165704	025536165704	000000000000	012657072742	326142000000	
596	2141	654304000000	654304000000	000000000000	025536165704	326142000000	
597	3334	254304000000	377777377777	000000000000	025536165704	654304000000	
598	0626	025536165705	025536165705	000000000000	025536165704	254304000000	
599	0601	000000000000	000000000000	000000000000	025536165705	254304000000	[BR,ARX] = 10^20
600	2140	254304000000	254304000000	000000000000	025536165705	254304000000	
601	0605	000000000000	000000000000	000000000000	025536165705	254304000000	
602	3333	254304000000	254304000000	000000000000	025536165705	254304000000	
603	0012	025536165705	025536165705	000000000000	025536165705	254304000000	
604	0324	025536165705	025536165705	000000000000	025536165705	254304000000	
605	0334	000344000370	000344000370	000000000000	025536165705	254304000000	
606	0224	254304000000	254304000000	000000000000	025536165705	254304000000	
607	0323	000000000000	000000000000	000000000000	025536165705	254304000000	
608	0010	000373000420	000373000420	000000000000	025536165705	254304000000	
609	0560	254304000000	254304000000	000000000000	025536165705	254304000000	
610	0620	025536165705	025536165705	000000000000	025536165705	254304000000	
611	0621	000000000000	000000000000	000000000000	025536165705	254304000000	
612	0622	053274353612	053274353612	000000000000	025536165705	254304000000	
613	2141	530610000000	530610000000	000000000000	053274353612	254304000000	
614	3334	130610000000	377777377777	000000000000	053274353612	530610000000	
615	0626	053274353613	053274353613	000000000000	053274353612	130610000000	
616	0621	000000000000	000000000000	000000000000	053274353613	130610000000	
617	0622	126570727426	126570727426	000000000000	053274353613	130610000000	
618	2140	261420000000	261420000000	000000000000	126570727426	130610000000	
619	0626	000000000000	000000000000	000000000000	126570727426	261420000000	
620	0561	000000000000	000000000000	000000000000	126570727426	261420000000	
621	2141	535724000000	254304000000	000000000000	126570727426	261420000000	
622	3334	135724000000	377777377777	000000000000	126570727426	535724000000	
623	0565	126570727427	126570727427	000000000000	126570727426	135724000000	
624	0600	154327115334	025536165705	000000000000	126570727427	135724000000	
625	0621	000000000000	000000000000	000000000000	154327115334	135724000000	
626	0622	330656232670	330656232670	000000000000	154327115334	135724000000	

Clk	ADDR (octal)	dp (octal)	dbus (octal)	T1 Register (octal)	BR Register (octal)	ARX Register (octal)	Comment
627	2140	273650000000	273650000000	000000000000	330656232670	135724000000	
628	0626	000000000000	000000000000	000000000000	330656232670	273650000000	
629	0601	000000000000	000000000000	000000000000	330656232670	273650000000	[BR,ARX] = 10^21
630	2140	273650000000	273650000000	000000000000	330656232670	273650000000	
631	0605	000000000000	000000000000	000000000000	330656232670	273650000000	
632	3333	273650000000	273650000000	000000000000	330656232670	273650000000	
633	0012	330656232670	330656232670	000000000000	330656232670	273650000000	
634	0324	330656232670	330656232670	000000000000	330656232670	273650000000	
635	0334	000344000371	000344000371	000000000000	330656232670	273650000000	
636	0225	273650000000	273650000000	000000000000	330656232670	273650000000	Check selftest results
637	0141	000000102026	330656330656	000000000000	330656232670	273650000000	Selftest Passed
638	3607	000000000000	000000000000	000000000000	330656232670	273650000000	
639	3610	000000000000	000000000000	000000000000	330656232670	273650000000	
640	3611	777777777777	777777777777	000000000000	330656232670	273650000000	
641	3612	000000000000	000000000000	000000000000	330656232670	273650000000	
642	0151	777777777777	777777777777	000000000000	330656232670	273650000000	
643	0343	000000000120	000120000120	000000000000	330656232670	273650000000	
644	0346	000000000000	000000000000	000000000120	330656232670	273650000000	[T1] <- 0120
645	0116	000000000000	000000000000	000000000120	330656232670	273650000000	
646	3674	000000000000	000000000000	000000000000	330656232670	273650000000	[T1] <- Halt Status Word (Success)
647	2474	000000000000	000000000000	000000000000	330656232670	000000000000	
648	3670	000000000001	000000000001	000000000000	330656232670	000000000000	
649	2475	000000000000	000000000000	000000000000	330656232670	000000000001	
650	0005	000000000000	000000000000	000000000000	330656232670	000000000001	Idle loop waiting for CONTINUE
651	0005	000000000000	000000000000	000000000000	330656232670	1	Still waiting for CONTINUE

Note: The math can be verified using the arbitrary precision **bc** calculator.   Most calculators cannot perform this calculation because they are limited to 64-bits.

Decoding the table above can be a little confusing especially due to the pipelining.

Some things to note:

- The ADDR field is the microcode address of the **NEXT** instruction.
- The ALU registers are updated on the clock after the bus data is present

For example, let's examine the micro-instruction 0151.   This instruction simply stores the constant 0120 into the ALU T1 register. This is given by the following microcode snippet.

```
U 0151, 0343,4751,1217,4374,4007,0700,0000,0000,0120 ; 2204  [T1]_0 XWD [120]    ;RH OF 120 CONTAINS START ADDRESS
                                                       ; 2205                     ; FOR SIMULATOR. FOR THE REAL
                                                       ; 2206                     ; MACHINE IT IS JUST DATA WITH
                                                       ; 2207                     ; GOOD PARITY.
```

The execution of the micro-instruction at address 0151 is illustrated below in detail.   See comments.

Table 2 - Micro-instruction Details

Clk	ADDR (octal)	dp (octal)	dbus (octal)	T1 Register (octal)	Comment
642	0151	777777777777	777777777777	000000000000	Instruction 0151 is next clock
643	0343	000000000120	000120000120	000000000000	The constant 0120 is on the busses
644	0346	000000000000	000000000000	000000000120	The bus contents is clocked into T1 register

I don't know if any of the KS10 instructions use the contents of this table or if it is just used to selftest the CPU.