

SternFA

Stern/Bally MPU based on FPGA

Software Version x.04

user manual

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Important remark

By using SternFA it is possible to damage your pinball machine. As this is a private project with NO commercial interest the author accepts no liability for any damage that may arise by using SternFA!

1. Introduction

SternFA use a (low cost) FPGA which emulates the hardware of a Stern MPU

SternFA is a 100% hobby project. This makes the solution cheap, depending on where you buy your components it is possible to create your Stern replacement MPU for less than 80€.

What do you need?

- Basic soldering skills (SMD components can be ordered pre-assembled I most shops)
- Possibility to read/write micro SD cards
- A PC with an USB port in order to be able to program the FPGA

2. Quickstart

1. Download latest versions of the SD card Image and the FPGA program from lisy.dev
2. Write the image to a SD card
3. Program the FPGA
 - a. 2.xx for Cyclone IV v3
 - b. 3.xx for Cyclone IV v4
 - c. 4.xx for Cyclone 10
4. Configure switch 'game select' according to your pinball (Appendix A)
5. Replace your original Stern MPU with SternFA
6. Switch the Game ON
7. Enjoy

Documentation on how to program your board for the first time can be found on my website.

3. Installation

SternFA boards have the same connectors and same mounting holes as the original Bally/Stern MPUs, so replacing of the board can be done in seconds.

4. Dip Switch Settings

4.1. DIP Switch S1: game select

Here you can select what game SternFA should run. This depends on the roms placed on the SD card. See Appendix A for a full list and Chapter 'SD card' for an explanation of the structure of the SD card content.

4.2. DIP Switch S2: options

Default setting is all ,OFF'

4.2.1. S2-Dip1 -> Zero Cross Emulator

Bally MPU need to have a 'Zero Cross' signal in order to work properly, this signal is coming from the 12Volt power supply. The existence of this signal is checked during boot. With dip 1 to ,ON' SternFA will emulate this signal, so for testing on the bench you only need 5 Volt supply. Note that timing is different with emulated zero cross!

4.2.2. S2-Dip2 -> Save nvram content to eeprom

SternFA does use an eeprom to save the nvram content (e.g. Highscores and extended settings). Each game has its own area on the eeprom. For bench testing dip2 can be set momentarily to ON, which results in SternFA saving the current nvram content to eeprom. During normal gameplay nvram content is saved automatically by test switch, game over really and credit button.

4.2.3. S2-Dip3 -> force Bally game

With SternFA you can also run all games running on BallyFA by using the BallyFA rom SD image. Set this option to ON in this case (otherwise all games with a game number <32 will run with double CPU clock speed). **The Stern SD image provided do include Stern and Bally games, for this you do not need to activate this option.** See Appendix or pdf file provided for a list of game numbers.

4.2.4. S2-Dip4 -> anti Flicker for games with LEDs

With dip4 to ,ON' SternFA changes the timing of the Zero Cross signal. Bally games are know for 'flickering' LEDs; usually each LED needs a resistor in parallel to solve this. With this option LEDs will be 'flicker free' without the additional resistors.

4.2.5. S2-Dip5 -> not used

Not implemented yet.

4.2.6. S2-Dip6 -> init nvram

With dip6 to ,ON' SternFA during boot will initialize the nvram ram for the selected game to zero. This is useful if you want to reset ALL ram content.

5. boot sequence

5.1. phase 1: init

Immediately after switching on the pinball with SternFA inserted you will see the following output on the display of your pinball machine

Player 1: version of the FPGA program running

Player 2: value of selected game on S1 (with a leading '2' in case a game with MPU200 is selected)

Player 3: lisy.dev unique identifier for FPGA based MPUs

Player 4: show the value of the option DIP bank

Credit Display: counter, counts down from 5 ... 1

5.2. phase 2: SD card read

SternFA tries to read the SD card content, if this fails the red LED 'SD card error' will go ON. **The first digit of status display will then show the error reason.** '1' means CRC error with data read; '2' means that there is a general problem with the SD card (no data read)

5.3. phase 3: program execution

The code indicated by the Dip switch 'game select' is read from the SD card and executed. This starts the normal Bally boot sequence by blinking the green 'Bally' LED. If the code runs (regular interrupts are seen) the green 'ON' LED will go ON.

Appendix A 'game select'

No	game select (v098)								Game	Remark
	S1	S2	S3	S4	S5	S6	S7	S8		
0	off	off	off	off	off	off	off	off	Meteor	Stern MPU-200
1	on	off	off	off	off	off	off	off	Galaxy	Stern MPU-200
2	off	on	off	off	off	off	off	off	Ali	Stern MPU-200
3	on	on	off	off	off	off	off	off	Big Game	Stern MPU-200
4	off	off	on	off	off	off	off	off	Seawitch	Stern MPU-200
5	on	off	on	off	off	off	off	off	Cheetah	Stern MPU-200
6	off	on	on	off	off	off	off	off	Quicksilver	Stern MPU-200
7	on	on	on	off	off	off	off	off	Stargazer	Stern MPU-200
8	off	off	off	on	off	off	off	off	Nine Ball	Stern MPU-200
9	on	off	off	on	off	off	off	off	Iron Maiden	Stern MPU-200
10	off	on	off	on	off	off	off	off	Viper	Stern MPU-200
11	on	on	off	on	off	off	off	off	Dragonfist	Stern MPU-200
12	off	off	on	on	off	off	off	off	Cue	Stern MPU-200
13	on	off	on	on	off	off	off	off	Flight 2000	Stern MPU-200
14	off	on	on	on	off	off	off	off	Freefall	Stern MPU-200
15	on	on	on	on	off	off	off	off	Lightning	Stern MPU-200
16	off	off	off	off	on	off	off	off	Split Second	Stern MPU-200
17	on	off	off	off	on	off	off	off	Catacomb	Stern MPU-200
18	off	on	off	off	on	off	off	off	Orbitor 1	Stern MPU-200
19	on	on	off	off	on	off	off	off	Meteor	Stern MPU-200 Freeplay
20	off	off	on	off	on	off	off	off	Galaxy	Stern MPU-200 Freeplay
21	on	off	on	off	on	off	off	off	Ali	Stern MPU-200 Freeplay
22	off	on	on	off	on	off	off	off	Big Game	Stern MPU-200 Freeplay
23	on	on	on	off	on	off	off	off	Seawitch	Stern MPU-200 Freeplay
24	off	off	off	on	on	off	off	off	Cheetah	Stern MPU-200 Freeplay
25	on	off	off	on	on	off	off	off	Quicksilver	Stern MPU-200 Freeplay
26	off	on	off	on	on	off	off	off	Stargazer	Stern MPU-200 Freeplay
27	on	on	off	on	on	off	off	off	Nine Ball	Stern MPU-200 Freeplay
28	off	off	on	on	on	off	off	off	Iron Maiden	Stern MPU-200 Freeplay
29	on	off	on	on	on	off	off	off	Viper	Stern MPU-200 Freeplay
30	off	on	on	on	on	off	off	off	Dragonfist	Stern MPU-200 Freeplay
31	on	on	on	on	on	off	off	off	Cue	Stern MPU-200 Freeplay
32	off	off	off	off	off	on	off	off	Flight 2000	Stern MPU-200 Freeplay
33	on	off	off	off	off	on	off	off	Freefall	Stern MPU-200 Freeplay
34	off	on	off	off	off	on	off	off	Lightning	Stern MPU-200 Freeplay
35	on	on	off	off	off	on	off	off	Split Second	Stern MPU-200 Freeplay

36	off	off	on	off	off	on	off	off	Catacomb	Stern MPU-200 Freeplay
37	on	off	on	off	off	on	off	off	Orbitor 1	Stern MPU-200 Freeplay
38	off	on	on	off	off	on	off	off	NOT USED	
39	on	on	on	off	off	on	off	off	NOT USED	
40	off	off	off	on	off	on	off	off	NOT USED	
41	on	off	off	on	off	on	off	off	NOT USED	
42	off	on	off	on	off	on	off	off	NOT USED	
43	on	on	off	on	off	on	off	off	NOT USED	
44	off	off	on	on	off	on	off	off	NOT USED	
45	on	off	on	on	off	on	off	off	NOT USED	
46	off	on	on	on	off	on	off	off	NOT USED	
47	on	on	on	on	off	on	off	off	NOT USED	
48	off	off	off	off	on	on	off	off	NOT USED	
49	on	off	off	off	on	on	off	off	NOT USED	
50	off	on	off	off	on	on	off	off	NOT USED	
51	on	on	off	off	on	on	off	off	NOT USED	
52	off	off	on	off	on	on	off	off	NOT USED	
53	on	off	on	off	on	on	off	off	NOT USED	
54	off	on	on	off	on	on	off	off	NOT USED	
55	on	on	on	off	on	on	off	off	NOT USED	
56	off	off	off	on	on	on	off	off	NOT USED	
57	on	off	off	on	on	on	off	off	NOT USED	
58	off	on	off	on	on	on	off	off	NOT USED	
59	on	on	off	on	on	on	off	off	NOT USED	
60	off	off	on	on	on	on	off	off	NOT USED	
61	on	off	on	on	on	on	off	off	NOT USED	
62	off	on	on	on	on	on	off	off	NOT USED	
63	on	on	on	on	on	on	off	off	NOT USED	
64	off	off	off	off	off	off	on	off	Pinball	Stern
65	on	off	off	off	off	off	on	off	Stingray	Stern
66	off	on	off	off	off	off	on	off	Stars	Stern
67	on	on	off	off	off	off	on	off	Memory Lane	Stern
68	off	off	on	off	off	off	on	off	Lectronamo	Stern
69	on	off	on	off	off	off	on	off	Wild Fyre	Stern
70	off	on	on	off	off	off	on	off	Nugent	Stern
71	on	on	on	off	off	off	on	off	Dracula	Stern
72	off	off	off	on	off	off	on	off	Trident	Stern
73	on	off	off	on	off	off	on	off	Hot Hand	Stern
74	off	on	off	on	off	off	on	off	Magic	Stern
75	on	on	off	on	off	off	on	off	Cosmic Princess	Stern
76	off	off	on	on	off	off	on	off	Pinball	Stern Freeplay
77	on	off	on	on	off	off	on	off	Stingray	Stern Freeplay

78	off	on	on	on	off	off	on	off	Stars	Stern Freeplay
79	on	on	on	on	off	off	on	off	Memory Lane	Stern Freeplay
80	off	off	off	off	on	off	on	off	Lectronamo	Stern Freeplay
81	on	off	off	off	on	off	on	off	Wild Fyre	Stern Freeplay
82	off	on	off	off	on	off	on	off	Nugent	Stern Freeplay
83	on	on	off	off	on	off	on	off	Dracula	Stern Freeplay
84	off	off	on	off	on	off	on	off	Trident	Stern Freeplay
85	on	off	on	off	on	off	on	off	Hot Hand	Stern Freeplay
86	off	on	on	off	on	off	on	off	Magic	Stern Freeplay
87	on	on	on	off	on	off	on	off	Cosmic Princess	Stern Freeplay
88	off	off	off	on	on	off	on	off	NOT USED	
89	on	off	off	on	on	off	on	off	NOT USED	
90	off	on	off	on	on	off	on	off	NOT USED	
91	on	on	off	on	on	off	on	off	NOT USED	
92	off	off	on	on	on	off	on	off	NOT USED	
93	on	off	on	on	on	off	on	off	NOT USED	
94	off	on	on	on	on	off	on	off	NOT USED	
95	on	on	on	on	on	off	on	off	NOT USED	
96	off	off	off	off	off	on	on	off	FREEDOM	Bally
97	on	off	off	off	off	on	on	off	NIGHTRIDER	Bally
98	off	on	off	off	off	on	on	off	EVELKNIEVEL	Bally
99	on	on	off	off	off	on	on	off	EIGHTBALL	Bally
100	off	off	on	off	off	on	on	off	POWERPLAY	Bally
101	on	off	on	off	off	on	on	off	MATAHARI	Bally
102	off	on	on	off	off	on	on	off	BLACKJACK	Bally
103	on	on	on	off	off	on	on	off	STRIKES_SPARES	Bally
104	off	off	off	on	off	on	on	off	LOSTWORLD	Bally
105	on	off	off	on	off	on	on	off	6MILLIONMAN	Bally
106	off	on	off	on	off	on	on	off	PLAYBOY	Bally
107	on	on	off	on	off	on	on	off	VOLTAN	Bally
108	off	off	on	on	off	on	on	off	SUPERSONIC	Bally
109	on	off	on	on	off	on	on	off	STARTREK	Bally
110	off	on	on	on	off	on	on	off	KISS	Bally
111	on	on	on	on	off	on	on	off	PARAGON	Bally
112	off	off	off	off	on	on	on	off	HARLEMGLOBE	Bally
113	on	off	off	off	on	on	on	off	DOLLYPARTON	Bally
114	off	on	off	off	on	on	on	off	FUTURESPA	Bally
115	on	on	off	off	on	on	on	off	NITROGROUND	Bally
116	off	off	on	off	on	on	on	off	SILVERBALLMANIA	Bally
117	on	off	on	off	on	on	on	off	SPACEINVADERS	Bally
118	off	on	on	off	on	on	on	off	ROLLINGSTONES	Bally
119	on	on	on	off	on	on	on	off	MYSTIC	Bally

120	off	off	off	on	on	on	on	off	HOTDOGGIN	Bally
121	on	off	off	on	on	on	on	off	VIKING	Bally
122	off	on	off	on	on	on	on	off	SKATEBALL	Bally
123	on	on	off	on	on	on	on	off	FRONTIER	Bally
124	off	off	on	on	on	on	on	off	XENON	Bally
125	on	off	on	on	on	on	on	off	FLASHGORDON	Bally
126	off	on	on	on	on	on	on	off	8BALLDELUXE	Bally
127	on	on	on	on	on	on	on	off	FIREBALLII	Bally
128	off	off	off	off	off	off	off	on	EMRYRON	Bally
129	on	off	off	off	off	off	off	on	FATHOM	Bally
130	off	on	off	off	off	off	off	on	MEDUSA	Bally
131	on	on	off	off	off	off	off	on	CENTAUR	Bally
132	off	off	on	off	off	off	off	on	ELEKTRA	Bally
133	on	off	on	off	off	off	off	on	VECTOR	Bally
134	off	on	on	off	off	off	off	on	MR_MRSPACMAN	Bally
135	on	on	on	off	off	off	off	on	SPECTRUM	Bally
136	off	off	off	on	off	off	off	on	SPEAKEASY	Bally
137	on	off	off	on	off	off	off	on	BMX	Bally
138	off	on	off	on	off	off	off	on	GRANDSLAM	Bally 2 player
139	on	on	off	on	off	off	off	on	GOLDBALL	Bally
140	off	off	on	on	off	off	off	on	XandOs	Bally
141	on	off	on	on	off	off	off	on	SPYHUNTER	Bally
142	off	on	on	on	off	off	off	on	KINGSOFSTEEL	Bally
143	on	on	on	on	off	off	off	on	BLACKPYRAMID	Bally
144	off	off	off	off	on	off	off	on	FIREBALCLASSIC	Bally
145	on	off	off	off	on	off	off	on	CYBERNAUT	Bally
146	off	on	off	off	on	off	off	on	NIGHTRIDER	Bally Freeplay
147	on	on	off	off	on	off	off	on	EVELKNIEVEL	Bally Freeplay
148	off	off	on	off	on	off	off	on	EIGHTBALL	Bally Freeplay
149	on	off	on	off	on	off	off	on	POWERPLAY	Bally Freeplay
150	off	on	on	off	on	off	off	on	MATAHARI	Bally Freeplay
151	on	on	on	off	on	off	off	on	BLACKJACK	Bally Freeplay
152	off	off	off	on	on	off	off	on	STRIKES_SPARES	Bally Freeplay
153	on	off	off	on	on	off	off	on	LOSTWORLD	Bally Freeplay
154	off	on	off	on	on	off	off	on	6MILLIONMAN	Bally Freeplay
155	on	on	off	on	on	off	off	on	PLAYBOY	Bally Freeplay
156	off	off	on	on	on	off	off	on	VOLTAN	Bally Freeplay
157	on	off	on	on	on	off	off	on	SUPERSONIC	Bally Freeplay
158	off	on	on	on	on	off	off	on	STARTREK	Bally Freeplay
159	on	on	on	on	on	off	off	on	KISS	Bally Freeplay
160	off	off	off	off	off	on	off	on	PARAGON	Bally Freeplay
161	on	off	off	off	off	on	off	on	HARLEMGLOBE	Bally Freeplay

162	off	on	off	off	off	on	off	on	DOLLYPARTON	Bally Freeplay
163	on	on	off	off	off	on	off	on	FUTURESPA	Bally Freeplay
164	off	off	on	off	off	on	off	on	NITROGROUND	Bally Freeplay
165	on	off	on	off	off	on	off	on	SILVERBALLMANIA	Bally Freeplay
166	off	on	on	off	off	on	off	on	SPACEINVADERS	Bally Freeplay
167	on	on	on	off	off	on	off	on	ROLLINGSTONES	Bally Freeplay
168	off	off	off	on	off	on	off	on	MYSTIC	Bally Freeplay
169	on	off	off	on	off	on	off	on	HOTDOGGIN	Bally Freeplay
170	off	on	off	on	off	on	off	on	VIKING	Bally Freeplay
171	on	on	off	on	off	on	off	on	SKATEBALL	Bally Freeplay
172	off	off	on	on	off	on	off	on	FRONTIER	Bally Freeplay
173	on	off	on	on	off	on	off	on	XENON	Bally Freeplay
174	off	on	on	on	off	on	off	on	FLASHGORDON	Bally Freeplay
175	on	on	on	on	off	on	off	on	8BALLDELUXE	Bally Freeplay
176	off	off	off	off	on	on	off	on	FIREBALLII	Bally Freeplay
177	on	off	off	off	on	on	off	on	EMRYRON	Bally Freeplay
178	off	on	off	off	on	on	off	on	FATHOM	Bally Freeplay
179	on	on	off	off	on	on	off	on	MEDUSA	Bally Freeplay
180	off	off	on	off	on	on	off	on	CENTAUR	Bally Freeplay
181	on	off	on	off	on	on	off	on	ELEKTRA	Bally Freeplay
182	off	on	on	off	on	on	off	on	VECTOR	Bally Freeplay
183	on	on	on	off	on	on	off	on	MR_MRSPACMAN	Bally Freeplay
184	off	off	off	on	on	on	off	on	SPECTRUM	Bally Freeplay
185	on	off	off	on	on	on	off	on	SPEAKEASY	Bally Freeplay
186	off	on	off	on	on	on	off	on	BMX	Bally Freeplay
187	on	on	off	on	on	on	off	on	GOLDBALL	Bally Freeplay
188	off	off	on	on	on	on	off	on	XandOs	Bally Freeplay
189	on	off	on	on	on	on	off	on	SPYHUNTER	Bally Freeplay
190	off	on	on	on	on	on	off	on	KINGSOFSTEEL	Bally Freeplay
191	on	on	on	on	on	on	off	on	BLACKPYRAMID	Bally Freeplay
192	off	off	off	off	off	off	on	on	FIREBALCLASSIC	Bally Freeplay
193	on	off	off	off	off	off	on	on	CYBERNAUT	Bally Freeplay
194	off	on	off	off	off	off	on	on	6MILLIONMAN	Bally 7digit mod
195	on	on	off	off	off	off	on	on	PLAYBOY	Bally 7digit mod
196	off	off	on	off	off	off	on	on	VOLTAN	Bally 7digit mod
197	on	off	on	off	off	off	on	on	SUPERSONIC	Bally 7digit mod
198	off	on	on	off	off	off	on	on	STARTREK	Bally 7digit mod
199	on	on	on	off	off	off	on	on	KISS	Bally 7digit mod
200	off	off	off	on	off	off	on	on	PARAGON	Bally 7digit mod
201	on	off	off	on	off	off	on	on	HARLEMGLOBE	Bally 7digit mod
202	off	on	off	on	off	off	on	on	DOLLYPARTON	Bally 7digit mod
203	on	on	off	on	off	off	on	on	FUTURESPA	Bally 7digit mod

204	off	off	on	on	off	off	on	on	NITROGROUND	Bally 7digit mod
205	on	off	on	on	off	off	on	on	SILVERBALLMANIA	Bally 7digit mod
206	off	on	on	on	off	off	on	on	SPACEINVADERS	Bally 7digit mod
207	on	on	on	on	off	off	on	on	ROLLINGSTONES	Bally 7digit mod
208	off	off	off	off	on	off	on	on	MYSTIC	Bally 7digit mod
209	on	off	off	off	on	off	on	on	HOTDOGGIN	Bally 7digit mod
210	off	on	off	off	on	off	on	on	VIKING	Bally 7digit mod
211	on	on	off	off	on	off	on	on	8BALLDELUXE	Special
212	off	off	on	off	on	off	on	on	EMBRYON	Special
213	on	off	on	off	on	off	on	on	VECTOR	Special
214	off	on	on	off	on	off	on	on	FATHOM	Special
215	on	on	on	off	on	off	on	on	NITROGROUND	Special w. Sirene Patch
216	off	off	off	on	on	off	on	on	Pinball	Stern
217	on	off	off	on	on	off	on	on	Stingray	Stern
218	off	on	off	on	on	off	on	on	Stars	Stern
219	on	on	off	on	on	off	on	on	Memory Lane	Stern
220	off	off	on	on	on	off	on	on	Pinball	Stern Freeplay
221	on	off	on	on	on	off	on	on	Stingray	Stern Freeplay
222	off	on	on	on	on	off	on	on	Stars	Stern Freeplay
223	on	on	on	on	on	off	on	on	Memory Lane	Stern Freeplay
224	off	off	off	off	off	on	on	on	Tigerrag	Bell Games
225	on	off	off	off	off	on	on	on	8BALLDELUXE	V32
226	off	on	off	off	off	on	on	on	SPEAKEASY 4Player	
227	on	on	off	off	off	on	on	on	SPEAKEASY 4Player	Freeplay
228	off	off	on	off	off	on	on	on	Saturn2	Bell Games
229	on	off	on	off	off	on	on	on	Lectronamo	Stern
230	off	on	on	off	off	on	on	on	Lectronamo	Stern Freeplay
231	on	on	on	off	off	on	on	on	World Defender	Bell Games
232	off	off	off	on	off	on	on	on	World Defender	Bell Games Freeplay
233	on	off	off	on	off	on	on	on	Baby Pacman	
234	off	on	off	on	off	on	on	on	Baby Pacman	Okaegi version
235	on	on	off	on	off	on	on	on	GRANDSLAM	4 player
236	off	off	on	on	off	on	on	on	GRANDSLAM	2 player freeplay
237	on	off	on	on	off	on	on	on	GRANDSLAM	4 player freeplay