FAMU/FSU College of Engineering

Department of Electrical and Computer Engineering

Concept Generation

Team 303 Software Defined Radio

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Date: October 16, 2020

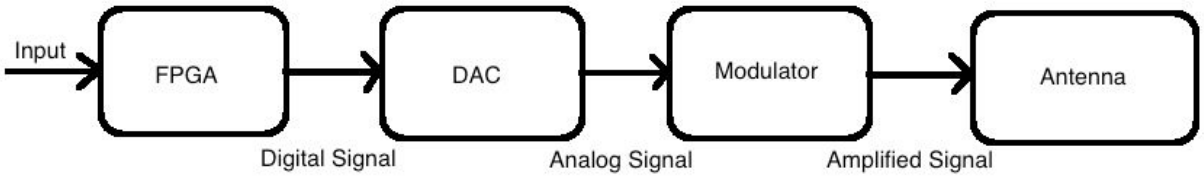
100 Concepts

1. Software radio transmitter (SRT) designed using Verilog HDL language
2. SRT using VHDL language
3. SRT using PCB program KiCAD
4. SRT using PCB program SolidWorks Electrical Schematic
5. SRT using PCB program Advanced Circuits
6. SRT using PCB program OrCAD PCB Designer
7. SRT using PCB program Circuit Studio
8. SRT using Xilinx Vivado
9. SRT using Xilinx ISE Design Studio
10. SRT using Advanced Design System (ADS)
11. SRT using LTspice simulation software
12. SRT using iCircuit simulation software
13. SRT using NI Circuit Suite Power Pro simulation software
14. SRT using Ktechlab simulation software
15. SRT using Tina-TI simulation software
16. SRT using Circuit Simulator simulation software
17. SRT using Multisim simulation software
18. SRT using single-side PCB
19. SRT using double-side PCB
20. SRT using single-layer PCB
21. SRT using multi-layer PCB
22. SRT using flexible PCB
23. SRT using rigid PCB
24. SRT using rigid-flex PCB
25. SRT using aluminum backed PCB
26. SRT using 3.3V Switcher Regulator (TPS561201DDCR)
27. SRT using 3.3V Switcher Regulator (LM3671MF)
28. SRT using 1.2V Switcher Regulator (TPS561201DDCR)
29. SRT using 1.2V Switcher Regulator (LM3671MF)
30. SRT using 5V Switcher Regulator (TPS561201DDCR)
31. SRT using 5V Switcher Regulator (LM1086IT)
32. SRT using 5V Switcher Regulator (MC33063APE4)
33. SRT using +/- 5V Split Rail Switcher Regulator (LTC338EMSE)
34. SRT using +/- 5V Split Rail Switcher Regulator (TPS3808G18DBVTG4)
35. SRT using +/- 5V Split Rail Switcher Regulator (TPS54240QDGQRQ1)
36. SRT using Oscillator SIT8103AI-23-33E-100.00000X
37. SRT using 3.3V Linear Regulator (ADP-121AUJZ30R7)
38. SRT using 3.3V Linear Regulator (LM1117MP)
39. SRT using 3.3V Linear Regulator (LT1086CT)
40. SRT using 3V Linear Regulator (ADP-121AUJZ230R7)
41. SRT using 3V Linear Regulator (LP2950CZ)
42. SRT using -3V Linear Regulator (ADP7182AUJZ-3-.0-R7)

43. SRT using -3V Linear Regulator (LP2950CZ)
44. SRT using Buffer (SI330F-B00214-GMR)
45. SRT using FPGA (XC6SLX9-TQG144) [-3, -2 speeds]
46. SRT using DAC (MAX5852-ETL)
47. SRT using Op-Amp Level Shift (LT1818CS5-TRMPBF)
48. SRT using ADC (TI-ADC3442IRTQT)
49. SRT using ADC (STMicroelectronics-ADC120IPT)
50. SRT using ADC (TI-ADC128S102CIMTX/NOPB)
51. SRT using Maxim Integrated (MAX11662AUB+T)
52. SRT using Maxim Integrated (MAX11111ATB+T)
53. SRT using Maxim Integrated (MAX1195ECM+D)
54. SRT using Maxim Integrated (MX7847AR+T)
55. SRT using Renesas Electronics (ISLA118P50)
56. SRT using Analog Devices (LTC1198-2ACS8#PBF)
57. SRT using Analog Devices (AD9286BCPZ-500)
58. SRT using Analog Devices (AD9288BSTZ-100)
59. SRT using Analog Devices (ADCLK914BCPZ-R7)
60. SRT using Analog Devices (ADCLK944BCPZ-R7)
61. SRT using Analog Devices (ADCLK846BCPZ)
62. SRT using Analog Devices (ADCLK948BCPZ)
63. SRT using Analog Devices (ADCLK925BCPZ-R7)
64. SRT using Analog Devices (ADCLK905BCPZ-R7)
65. SRT using Analog Devices (ADCLK954BCPZ-REEL7)
66. SRT using Analog Devices (ADCLK846BCPZ-REEL7)
67. SRT using Analog Devices (ADCLK854BCPZ-REEL7)
68. SRT using DAC (TI- DAC80508MCYZFT)
69. SRT using DAC (TI- DAC80508ZCYZFT)
70. SRT using DAC (TI- DAC80508ZYZFT)
71. SRT using DAC (TI- DAC80508MYZFT)
72. SRT using Low-Pass filtering
73. SRT using a Modulator
74. SRT using JTAG to USB
75. SRT using hand-soldering
76. SRT using surface mount components
77. SRT using soft soldering
78. SRT using silver soldering
79. SRT using brazing
80. SRT using through-hole components
81. SRT using machine soldering
82. SRT using active low-pass filter
83. SRT using passive low-pass filter
84. SRT using low-pass filter that used op-amp
85. SRT using low-pass filter that used transistor
86. SRT using low-pass filter that used RLC
87. SRT using low-pass filter that used RC

88. SRT using low-pass filter that used LC
89. SRT using low-pass filter that used RL
90. SRT using power supply
91. SRT using car battery as power source
92. SRT using AA batteries as power source
93. SRT using AAA batteries as power source
94. SRT using C batteries as power source
95. SRT using D batteries as power source
96. SRT using Coin Cell batteries as power source
97. SRT using resistor as a voltage regulator
98. SRT using RAM for memory in FPGA
99. SRT using ROM for memory in FPGA
100. SRT using shift registers for memory in FPGA

Medium Fidelity Concept



COMPARISON OF SDR DESIGN APPROACHES

	GPP	DSP	FPGA
Computation	Fixed Arithmetic Engines	Fixed Arithmetic Engines	User Configurable Logic
Execution	Sequential	Partially Parallel	Highly Parallel
Throughput	Low	Medium	High
Data Rate	Low	Medium	High
Data Width	Limited by Bus Width	Limited by Bus Width	High
Programmability	Easy	Easy	Moderate
Complex Algorithms	Easy	Easy	Moderate
I/O	Dedicated Ports	Dedicated Ports	User Configurable Ports
Cost	Moderate	Low	Moderate
Power Efficiency	Low	Moderate	High
Form Factor	Large	Medium	Small

HLS TOOLS

	Xilinx Vivado HLS [86]	Intel FPGA SDK for OpenCL [119]	Cadence Stratus High-level Synthesis [128]	Synopsys Synphony C Compiler [129]	Maxeler MaxCompiler [120]
Input	C/C++/SystemC	C/C++/SystemC	C/C++/SystemC	C/C++	MaxJ
Output	VHDL/Verilog/SystemC	VHDL/Verilog	VHDL/Verilog	VHDL/Verilog/SystemC	VHDL
Testbench	Yes	No	Yes	Yes	No
Optimizations	Yes	Yes	Yes	Yes	Yes
Compatibility	Xilinx FPGA	Intel FPGA	All	All	All

DEVELOPMENT TOOLS AND PLATFORMS

	MATLAB & Simulink [130]	Vivado HLS & SDSoC [78]	LegUP [123]	GNU Radio [40]	LabView [131]	CUDA [48]
Input	MATLAB/Graphical	C/C++/SystemC	C	Graphical/Python/C++	Graphical	C/C++/Fortran/Python
Output	MATLAB/C++/RTL	C/RTL	C/RTL	C/RTL	C/RTL	Machine Code
Platform	GPP/GPU/DSP/FPGA	GPP/FPGA	GPP/FPGA	GPP/GPU/DSP/FPGA	GPP/GPU/DSP/FPGA	GPU
Licence	commercial	commercial	open-source	open-source	commercial	commercial

PCB Design Software

	Advanced Design System	KiCad	OrCAD	Altium Designer
PCB editing	Yes	Yes	Yes	Yes
Simulation	Yes	Yes	Yes	Yes
Platform	SuSE, RHEL	Unix, Linux	None	Wine
License	Commercial	Open-Source	Commercial	Commercial

High Fidelity Concepts

FPGA Boards

Spartan 6 devices:

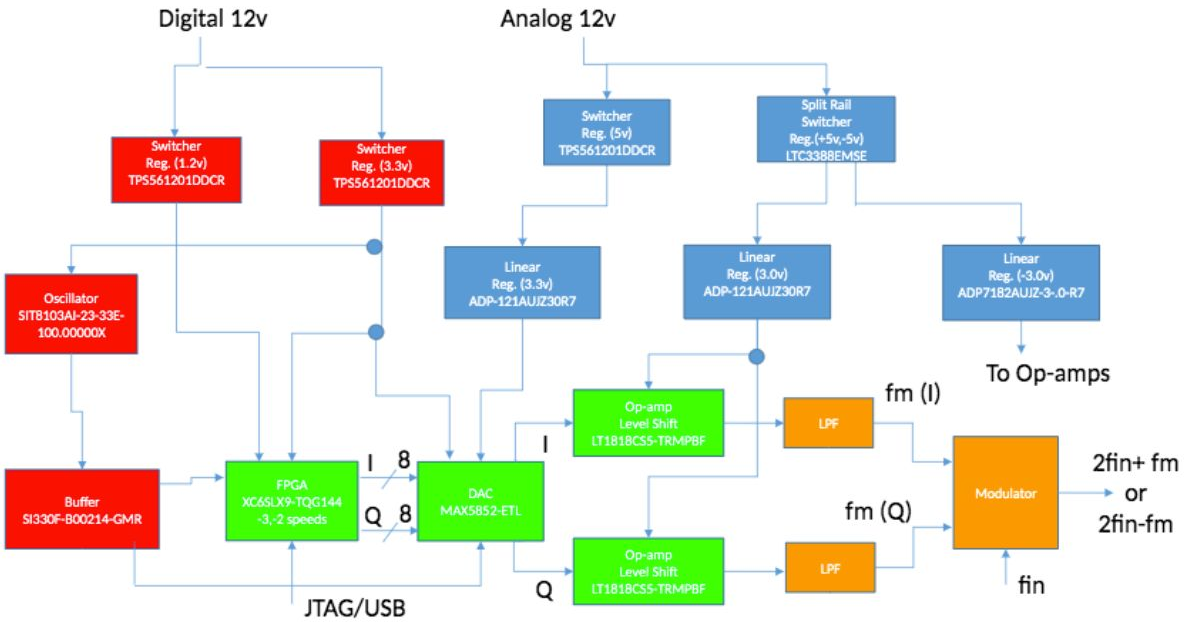
Device	Logic Cells(1)	Configurable Logic Blocks (CLBs)			DSP48A1 Slices(3)	Block RAM Blocks		CMTs(5)	Memory Controller Blocks (Max)(6)	Endpoint Blocks for PCI Express	Maximum GTP Transceivers	Total I/O Banks	Max User I/O
		Slices(2)	Flip-Flops	Max Distributed RAM (Kb)		18 Kb(4)	Max (Kb)						
XC6SLX4	3,840	600	4,800	75	8	12	216	2	0	0	0	4	132
XC6SLX9	9,152	1,430	11,440	90	16	32	576	2	2	0	0	4	200
XC6SLX16	14,579	2,278	18,224	136	32	32	576	2	2	0	0	4	232
XC6SLX25	24,051	3,758	30,064	229	38	52	936	2	2	0	0	4	266
XC6SLX45	43,661	6,822	54,576	401	58	116	2,088	4	2	0	0	4	358
XC6SLX75	74,637	11,662	93,296	692	132	172	3,096	6	4	0	0	6	408
XC6SLX100	101,261	15,822	126,576	976	180	268	4,824	6	4	0	0	6	480
XC6SLX150	147,443	23,038	184,304	1,355	180	268	4,824	6	4	0	0	6	576
XC6SLX25T	24,051	3,758	30,064	229	38	52	936	2	2	1	2	4	250
XC6SLX45T	43,661	6,822	54,576	401	58	116	2,088	4	2	1	4	4	296
XC6SLX75T	74,637	11,662	93,296	692	132	172	3,096	6	4	1	8	6	348
XC6SLX100T	101,261	15,822	126,576	976	180	268	4,824	6	4	1	8	6	498
XC6SLX150T	147,443	23,038	184,304	1,355	180	268	4,824	6	4	1	8	6	540

Comparison of different families for Xilinx series 7 FPGA boards:

Max. Capability	Spartan-7	Artix-7	Kintex-7	Virtex-7
Logic Cells	102K	215K	478K	1,955K
Block RAM(1)	4.2 Mb	13 Mb	34 Mb	68 Mb
DSP Slices	160	740	1,920	3,600
DSP Performance(2)	176 GMAC/s	929 GMAC/s	2,845 GMAC/s	5,335 GMAC/s
MicroBlaze CPU(3)	260 DMIPs	303 DMIPs	438 DMIPs	441 DMIPs
Transceivers	–	16	32	96
Transceiver Speed	–	6.6 Gb/s	12.5 Gb/s	28.05 Gb/s
Serial Bandwidth	–	211 Gb/s	800 Gb/s	2,784 Gb/s
PCIe Interface	–	x4 Gen2	x8 Gen2	x8 Gen3
Memory Interface	800 Mb/s	1,066 Mb/s	1,866 Mb/s	1,866 Mb/s
I/O Pins	400	500	500	1,200
I/O Voltage	1.2V–3.3V	1.2V–3.3V	1.2V–3.3V	1.2V–3.3V
Package Options	Low-Cost, Wire-Bond	Low-Cost, Wire-Bond, Bare-Die Flip-Chip	Bare-Die Flip-Chip and High-Performance Flip-Chip	Highest Performance Flip-Chip

Summary:
Spartan($) - Low cost, lowest power, high I/O performance with small PCB footprint
Artix($$) - Low power applications with high logic and DSP throughput
Kintex($$$) - Best price-performance
Virtex($$$$) - Highest system performance of different families

Specific Design Chosen



Morphological Chart

PCB Design Software	Altium Designer	PCB Artist	SolidWorks	Ultiboard	Diptrace	Xcircuit	Kicad
Power Control	Linear regulators	Switcher regulators	Series voltage regulator	Shunt voltage regulator	Op-Amps	Split Rail Switcher	
Electronic Circuit Sim. Software	Oregano	SPICE	Electric (VLSI)	TINA-TI	Qucs		
Modulation Methods	PSK	FSK	ASK	QAM			
User Input Methods	Hard coding or direct (digital input)	USB or JTAG (analog input requires ADC)					