Mistral documentation

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CHAPTER

ONE

THE CYCLONE V FPGA

1.1 The FPGAs

The Cyclone V is a series of FPGAs produced initially by Altera, now Intel. It is based on a series of seven dies with varying levels of capability, which is then derived into more than 400 SKUs with variations in speed, temperature range, and enabled internal hardware.

As pretty much every FPGA out there, the dies are organized in grids.

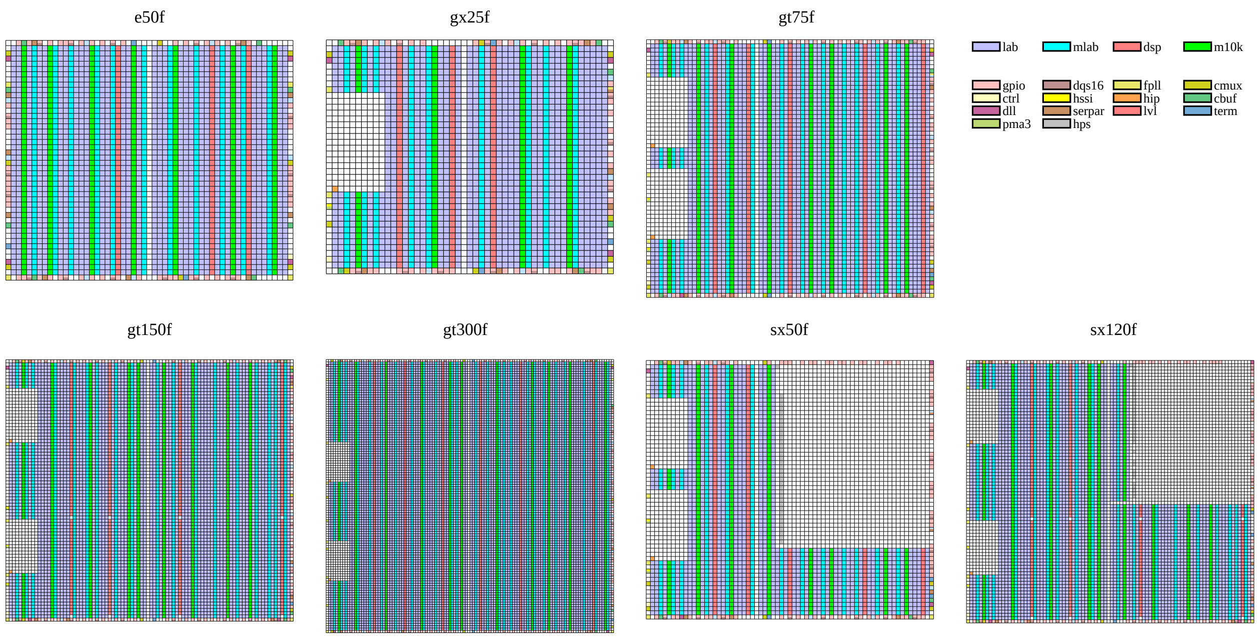

Fig. 1: Floor plan of the seven die types

The FPGA, structurally, is a set of logic blocks of different types communicating with each other either through direct links or through a large routing network that spans the whole grid.

Some of the logic blocks take visible floor space. Specifically, the notches on the left are the space taken by the high speed serial interfaces (hssi and pma3). Also, the top-right corner in the sx50f and sx120f variants is used to fit the hps, a dual-core arm.

1.2 Bitstream stucture

The bitstream is build from three rams:

- Option ram
- Peripheral ram
- Configuration ram

The option ram is composed of 32 blocks of 40 bits, of which only 12 are actually used. It includes the global configurations for the chip, such as the jtag user id, the programming voltage, the internal oscillator configuration, etc.

The peripheral ram stores the configuration of all the blocks situated on the borders of the chip, e.g. everything outside of labs, mlabs, dsps and m10ks. It is build of 13 to 16 blocks of bits that are sent through shift registers to the tiles.

The configuration ram stores the configuration of the labs, mlabs, dsps and m10ks, plus all the routing configuration. It also includes the programmable inverters which allows inverting essentially all the inputs to the peripheral blocks. It is organised as a rectangle of bits.

Die	Tiles	Pram	Cram
e50f	55x46	51101	4958x3928
gx25f	49x40	54083	3856x3412
gt75f	69x62	90162	6006x5304
gt150f	90x82	113922	7605x7024
gt300f	122x116	130828	10038x9948
sx50f	69x62	80505	6006x5304
sx120f	90x82	99574	7605x7024

1.3 Logic blocks

The logic blocks are of two categories, the inner blocks and the peripheral blocks. To a first approximation all the inner blocks are configured through configuration ram, and the peripheral blocks through the peripheral ram. It only matters where it comes to partial reconfiguration, because only the configuration ram can be dynamically modified. We do not yet support it though.

The inner blocks are:

- lab: a logic blocks group with 20 LUTs with 5 inputs and 40 Flip-Flops.
- mlab: a lab that can be reconfigured as 64*20 bits of ram
- dsp: a flexible multiply-add block
- m10k: a block of 10240 bits of dual-ported memory

The peripheral blocks are:

- gpio: general-purpose i/o, a block that controls up to 4 package pins
- dqs16: a block that manage differential input/output for 4 gpio blocks, e.g. up to 16 pins
- fpll: a fractional PLL
- cmux: the clock muxes that drive the clock part of the routing network
- ctrl: the control block with things like jtag
- hssi: the high speed serial interfaces

- hip: the pcie interfaces
- cbuf: a clock buffer for the dqs16
- dll: a delay-locked loop for the dqs16
- serpar: TODO
- lvl: TODO
- term: termination control blocks
- pma3: manages the channels of the hssi
- hmc: hardware memory controller, a block managing sdr/ddr ram interfaces
- hps: a series of 37 blocks managing the interface with the integrated dual-core arm

All of these blocks are configured similarly, through the setup of block muxes. They can be of 4 types: * Boolean * Symbolic, where the choice is between alphanumeric states * Numeric, where the choice is between a fixed set of numeric value * Ram, where a series of bits can be set to any value

Configuring that part of the FPGA consists of configuring the muxes associated to each block.

1.4 Routing network

A massive routing network is present all over the FPGA. It has two almost-disjoint parts. The data network has a series of inputs, connected to the outputs of all the blocks, and a series of outputs that go to data inputs of the blocks. The clock network consists of 16 global clocks signals that cover the whole FPGA, up to 88 regional clocks that cover an half of the FPGA, and when an hssi is present a series of horizontal peripheral clocks that are driven by the serial communications. Global and regional clock signals are driven by dedicated cmux blocks (not the fpll in particular, but they do have dedicated connections to the cmuxes).

These two networks join on data/clock muxes, which allow peripheral blocks to select for their clock-like inputs which network the signal should come from.

1.5 Programmable inverters

Essentially every output of the routing network that enters a peripheral block can optionally be inverted by activating the associated configuration bit.