Chapter 4

Architecture of Relative Temperature Sensor

To solve the inaccuracy problem of *absolute* temperature under process variations, we propose a *relative* temperature senor. Different from *absolute* temperature sensor which is a single component consisting of both *BJT* and *CORE* placed at selected hot spot locations, our *relative* temperature sensor divides the sensor to two types of components, *BJT* and *CORE*. In this design, only type of *BJT* is placed at selected locations for hot spots, while *CORE* is placed at other location where temperature fluctuation is small.

Fig. 4.1 shows the block diagram of *relative* temperature sensor which consists of a number of *BJT*s and *CORE*. *CORE* includes a constant current source generator, an Analog-to-Digital converter (ADC) as well as a subtractor. Architecturally, ADC consists of a Sigma-Delta modulator and a decimation filter. A number of *BJT*s can share one *CORE*. Moreover, one special *BJT* will be located at reference location which acts as a temperature reference. In the following, we will denote *BJT*s placed at hot spot and reference location as *HBJT* and *RBJT*, respectively, for clarity.

Operationally, *CORE* supplies constant current into *HBJT*s and *RBJT* which deliver voltage V_{EB} to ADC of *CORE*. ADC then converts analog voltage V_{EB} to a digital temperature output. The outputs of ADC will be fed to a subtractor which produces temperature difference between *HBJT*s and *RBJT*, i.e., the temperature difference between hot spots

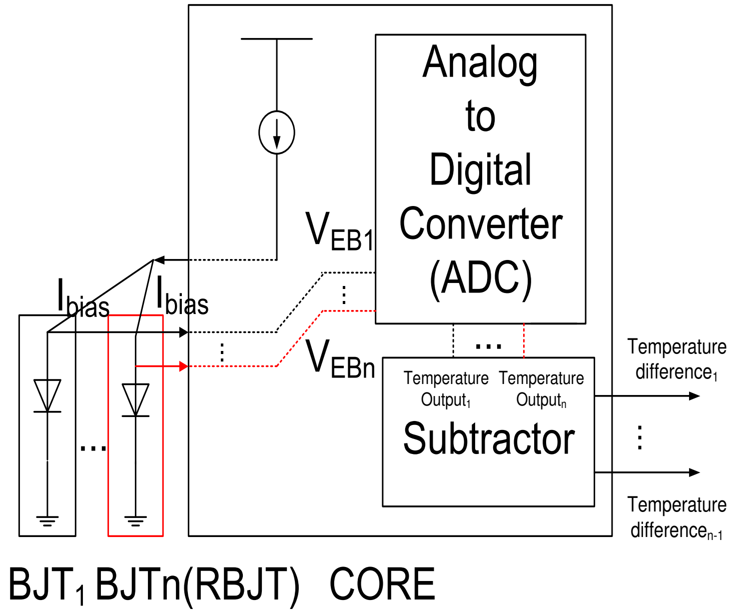

Figure 4.1: Block diagram of relative temperature sensor

and reference location. Finally, *Digital Out* outputs temperature difference data in digital format.

A limited number of *HBJT*s can share one *RBJT* and one *CORE*, which is set to 4 in our design. In other words, there are 6 components in a cluster- 4 *HBJT*s, 1 *RBJT* and 1 *CORE*. Fig. 4.2 shows a placement of *relative* temperature sensors where *HBJT*, *RBJT* and *CORE* are represented as rectangle, star and triangle, respectively. In this figure, H_1, H_2, H_3, H_4 (*HBJT*s) share R (*RBJT*) and C (*CORE*) in a cluster. In our design, in order to avoid the complex temperature-dependent behavior, *RBJT* and *CORE* are required to be placed at a location where temperature fluctuation is small.

There are several advantages of this *relative* temperature sensor. First, because temperature difference is computed, we could eliminate errors from process variations, alleviate impacts caused by curvature of relationship between voltage and current in *BJT*, nonlinearity of the circuit to temperature. Second, based on a typical 45nm technology, the area ratio of *BJT* to *CORE* is about 1:80. Since only *BJT*s are placed at hot spots and *CORE*s are shared by many *BJT*s, area overhead of temperature sensor can be substantially reduced. Third, both *CORE* and *RBJT* are placed at a temperature stable location. Henceforth, accurate temperature difference is able to be measured because temperature fluctuation impacts on

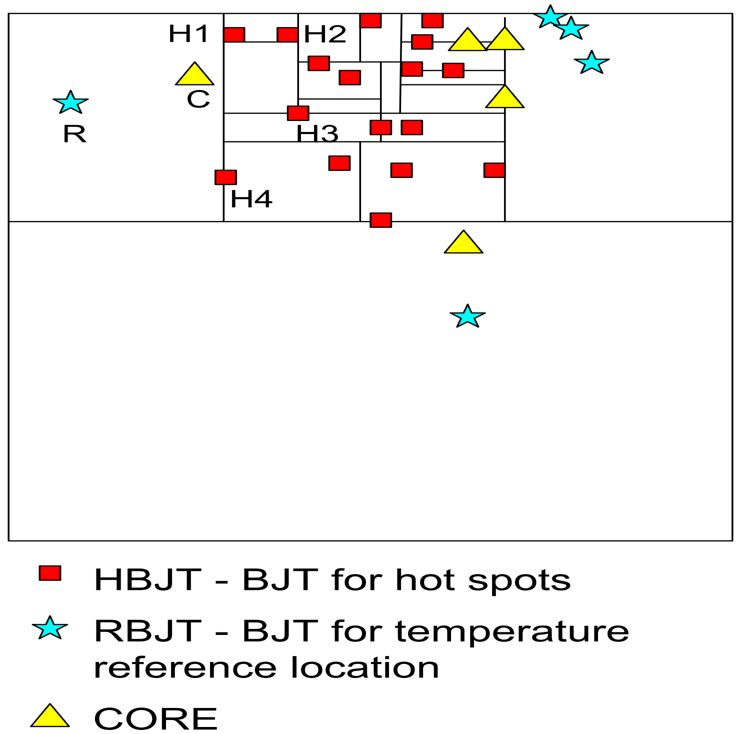

Figure 4.2: Placement of relative temperature sensor

circuitry is minimized. Fourth, without external calibration, our *relative* temperature sensor is able to obtain the same degree of accuracy as does the externally calibrated *absolute* temperature sensor.