This dissertation introduces a novel approach for a robust and real-time peak detection method by using the Automatic Multiscalc-Based Peak Detection (AMPD) algorithm and the Field Programmable Gate Array (FPGA) technology, which is often utilized as one of the operations of signal processing like sampling and conversion. It highlights the modification of the original AMPD algorithm to be an on-line method, and how it can be implemented on an FPGA, so that a pipelined structure in computing is extracted on hardware.

After presenting introduction and background in Chapter 1 and Chapter 2, I have explained how to modify the AMPD method in detail Chapter 3. The original AMPD method registered all input data before applying the algorithm in order to detect the peak points, but we used the stream (on-line) processing to perform real-time analysis, to reduce the amount of memory and to make a simple and effective pipeline design. I used different scales in order to highlight the success ratio. Test results show that peak sensitivity success rate is 84% that is very close the original. Thus, the optimum scaling for the on-line peak detection is obtained, and results compared with the original AMPD method are found very promising. One of the aims of this study is to obtain a fast implementation by reducing the calculation time and not to use additional memory. While the original algorithm with software execution takes 5.8 us, but the pipeline structural developed takes 320 ns.

In addition to above given contributions, an FPGA technology-based spline interpolation is also studied in this dissertation. Chapter 4 gives detail information about this FPGA technology-based spline interpolation. The spline curve makes it easy to build an interface that will allow designing and controlling the shape of complex curves and surfaces by using low-degree polynomials in each of the intervals and by choosing the polynomial piece such that they fit smoothly together. So that a highly sensitive real peak point estimation system is proposed by using the spline interpolation based on AMPD. For this reason, the data used is obtained from spline interpolation by means of AMPD peak values. To solve the spline interpolation, simultaneous equations are required to be solved. Based on the results obtained from this study, the maximum differences are observed between raw-peak data and fitted data
as 0.08 kV for L2-L1 phase-the-phase line voltages. In fact, this study shows that we estimated the correct peak points by using AMPD algorithm in my previous study. In this dissertation, the calculation process is simplified by using the fact that the data sampling interval is constant. Thus, to design a simple spline algorithm hardware, a circuit architecture is proposed for complementary in-line processing implemented on an FPGA. The reason of introducing the spline interpolation is to obtain precise peak point values even if the sampling frequency is relatively low. Therefore, in this study, the estimation of the real peak value of both low and high sampling frequency data is achieved.

In the last study in Chapter 5, we have optimized the latency and the peak sensitivity of a real-time peak detection method using the AMPD algorithm and FPGA technology. In here, I intendent to optimize the latency time of AMPD module designed. For this reason, I designed a pipeline structure named a window approach (WA) module. As described in Chapter 5, I reduced the peak calculation time to 90 ns. On the other hand, WA module increased the accuracy. That means, we have measured 400 ns latency time and 80% recall, but with the WA module latency time is reduced and recall is increased, however, detected peak points remain as same.

There are some difficulties faced during the study of peak detection algorithms available in the literature that have many free parameters, such as the window length of a threshold value, to be used in order to apply the algorithm to the signal, and to make the algorithm applicable. Besides, it is also challenging to detect the peak points of the periodic and the quasi-periodic signals. In conclusion (in Chapter 6), a new hardware-oriented algorithm based on existing algorithms (AMPD and spline) and evaluation of their effectiveness through FPGA implementation have been proposed in this study in detail. The detection of peak power capability in grid-based energy storage systems is an instantaneous state in terms of the loading capacity. The detection of wind power ramp events reduces the harmonization on long-term trend for wind turbines. The detection of peak load demand is very significant for decision making processes in the electricity sector. It is clear that all of these applications can benefit from the proposed peak point detection approaches with the reduced latency time for further power system planning, power security and supply reliability.