Sliding mode control (SMC) structures have a number of positive properties that caused its popularity over last few decades. The discrete version – *Discrete Sliding Mode Control* (DSMC) succeeds the commonly-known properties of the continuous-time sliding mode control systems and the following can be distinguished among them: robustness over internal and external disturbances, excellent dynamics, system rank reduction, simplicity of implementation, natural application in control of power electronics elements (in case of direct control of inverter transistors). However the continuous SMC have some drawbacks, as risk of steady-state error appearance and phenomenon called chattering, i.e. visible, unfavourable oscillations of the controlled variables. This occurrence introduces harmful mechanical vibrations and loud acoustic noise. One of the most important reason of chattering is a discrete implementation of the systems, designed using continuous-time approach. The discrete sliding mode control DSMC methods differ from the continuous-time based SMC methods with the following:
– *No chattering.* Sliding mode discrete control does not cause the chattering, so it can be named chattering-free, especially, when the sampling time of the system is long.
– *Zigzag motion around the switching line.* The phase trajectory does not exactly slides on the switching line, but stays in its vicinity. According to the above, the DSMC are sometimes referred to as quasi-SMC.
– *Constant frequency operation.* It is naturally ensured by the microprocessor usage.
– *Choice of the model discretization method.*
– *Sampling time is directly taken into account.* Discrete control structures allow to take into direct account the sampling time of the microprocessor – it is possible to obtain the control signals and regulator gains equations dependent on the sampling time value. It can be helpful for example in the design of industrial inverters, that allow user to choose the sampling frequency, depending on the application.
– *Sliding mode existence condition is more complicated.* The existence condition for sliding motion for continuous-time systems, written in discrete form is not a sufficient condition in digital system – it is only the necessary condition.
Modern control system for induction motor drive require state variable knowledge, which are hardly measured, as stator or rotor flux values, electromagnetic torque or rotor speed. All these state variables of the induction motor have been estimated recently using continuous-time based state estimators. However these variables can be also estimated using discrete sliding mode observers (DSMO).
Thus the main goal of this project is the development and testing (in simulation and laboratory experiments) of the discrete sliding-mode control and state estimation algorithms and structures for an induction motor drive. The scope of the project will contain the following problems to be solved:
- discrete sliding-mode control (DSCM) algorithms of all state variables of the induction motor drive: stator current (which is equivalent to the electromagnetic torque control for vector methods), speed and position;
- discrete sliding-mode state variable estimators of the induction motor, with special attention focused on the control structures without speed measurement (speed-sensorless systems).

The state estimators and control structures are strongly connected in the modern drive systems and have many similar features (as both are based on the same mathematical model of the motor), however their role is different. Thus these both systems will be developed and analyzed under the proposed research work. In this project a cooperation of the discrete control structures with classical (continuous) and discrete state estimators of the induction motor will be analyzed and their robustness to drive system parameter changes will be tested and evaluated.
In this research project a fundamental research will be realized, connected with discrete sliding-mode control and estimation algorithms, taking advantage of detailed simulation research as well as their experimental verification at the laboratory test bench.
Under this project the following issues will be realized:
1. Critical analysis of the sliding-mode continuous and discrete control and state estimation methods applied for induction motor drives.
2. Development of chosen algorithms and structures for discrete sliding-mode control of electromagnetic torque, speed and position of the induction motor.
3. Comparative analysis of the chosen state variable estimators stability and their application in the discrete sliding-mode control structures.
4. Development and analysis of the discrete sliding-mode observers for state variable estimation of the induction motor.
5. Detailed simulation tests of the developed control structures and state estimators.
6. Development of the DSP implementation of chosen algorithms for discrete control and state estimation of the induction motor.
7. Realization of experimental tests and elaboration of the obtained results.

Obtained research results will allow to create control systems having all positive properties of continuous-time sliding mode control, listed above, simultaneously taking into consideration the discrete nature of modern control structures. Developing of the discrete control structures will allow in future to design the industrial voltage source inverters ensuring the excellent operational properties of supplied induction motors. Additionally they will enable the user to choose the switching frequency of the inverter, depending on the power of the motor. Similarly, the estimators designed in a discrete-time manner, will allow creating effective systems determining essential state variable including angular speed, taking into consideration the digital way of work of modern, microprocessor control structure. It will allow to decrease negative effects resulting from the discrete implementation of continuous-time based systems.
Results of the research work realized in the project will be presented during well-recognized international (e.g. ISIE, IECON, EPE, IFAC) and domestic (e.g. SENE, MMAR) conferences. The most interesting and valuable issues will be published in well-known international (e.g. IEEE Transactions on Industrial Electronics, IEEE Transactions on Industrial Informatics, International Journal of Control) and Polish journals (e.g. Bulletin of the Polish Academy of Sciences – Technical Sciences, Przegląd Elektrotechniczny). The part of this project results (mainly concerned the DSMC algorithms and structures for IM drive) will be presented as a part of habilitation dissertation of the project Co-investigator (1), while the part connected with state variables estimators will be included in the thesis of PhD student, whose scholarship is planned to be financed under this project.