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FUZZY LOGIC BASED CONTROL SYSTEM OF CONVERTER FOR POWERFUL SOUNDING PULSES GENERATOR

This thesis deals with the design of control system for powerful sounding pulses generator using Fuzzy Logic based decision structure and implementation using the 68HC12 microcontroller. Some practical cases with Fuzzy Tech are presented to check the proposed control performance. Conclusions of obtained results are presented.

Key words: fuzzy-controller, microprocessor realization, fuzzification, membership functions.

The purpose of article is to implement microprocessor realization of level higher harmonics fuzzy-controller, which determines the deviation from the nominal value of the selected parameter and leads it to the established norms.

Introduction. Fuzzy logic implementation is becoming increasingly important, and finding applications in diverse areas of current interest, such as control, pattern recognition, robotics, and other decision making applications. Fuzzy decision process offer a significant advantage over crisp decision process which is the ability to process different levels of truth instead of only 1 or O levels. Fuzzy Logic does not require precise inputs, it is inherently robust, and can process any reasonable number of inputs but system complexity increases rapidly with more inputs and outputs. Distributed processors would probably be easier to implement. Simple, plain-language IF X AND Y THEN Z rules are used to describe the desired system response in terms of linguistic variables rather than mathematical formulas. The number of these is dependent on the number of inputs, outputs, and the designer's control response goals. The new Motorola 68HC12 MCU has an embedded fuzzy logic instruction set. Using this instruction set, it can be implemented complex fuzzy logic systems using only a few hundred bytes of ROM that cycle compute in less than a millisecond.

In [1, 2] describes a method for designing a fuzzy controller in the control system of compensation inactive components of the total power device. Fuzzy controller implements a fuzzy inference procedure and makes it possible to obtain the required values of regulated and controlled process parameters, namely controls the amplitude level of selected harmonic current mains *k*i and brings it to the required value. This can be achieved by varying the voltage on the capacitor of the inverter Uc by control signals *delta*_Uc of additional output control circuit [1]. In the proposed control system based on fuzzy logic fuzzy controller input signals and output control actions are considered as linguistic variables, qualitatively characterized by the term-sets.

Each term is considered as a fuzzy set, and formalized using the membership function. Formation of the control action performed on the basis of linguistic control rules that establish means of natural language communication between the states of a dynamic system and manage the impact of the control system of the converter [2].

Hardware realization of fuzzy microcontroller fuzzy-controller can be done using special-purpose microcontrollers. As a special-purpose microcontroller with hardware support for fuzzy logic was selected microcontroller 68HC12 from Motorola.

The 68HC12 is a high-speed, 16-bit processing unit that has a programming model identical to that of the industry standard M68HC11 CPU. The 68HC12 instruction set is a proper superset of the M68HC11 instruction set, and M68HC11 source code is accepted by 68HC12 assemblers with no changes. The 68HC12 has full 16-bit data paths and can perform arithmetic operations up to 20 bits wide for high-speed math. An instruction queue buffers program information so the CPU has immediate access to at least three bytes of machine code at the start of every instruction.

A fuzzy inference kernel for the 68HC12 requires one-fifth as much code space, and executes fifteen times faster than a comparable kernel implemented on a typical midrange microcontroller. The 68HC12 includes four instructions that perform specific fuzzy logic tasks. In addition, several other instructions are especially useful in fuzzy logic programs. The overall C-friendliness of the instruction set also aids development of efficient fuzzy logic programs.

The four fuzzy logic instructions are MEM, which evaluates trapezoidal membership functions; REV and REVW, which perform unweighted or weighted MIN-MAX rule evaluation; and WAV, which performs weighted average defuzzification on singleton output membership functions.

Other instructions that are useful for custom fuzzy logic programs include MiNA, EMIND, MAXM, EMAXM, TBL, ETBL, and EMACS. For higher resolution fuzzy programs, the fast extended precision math instructions in the 68HC12 are also beneficial. Flexible indexed addressing modes help simplify access to fuzzy logic data structures stored as lists or tabular data structures in memory. A microcontroller based fuzzy logic control system has two parts. The first part is a fuzzy inference kernel which is executed periodically to determine system out-puts based on current system inputs. The second part of the system is a knowledge base which contains membership functions and rules.

The knowledge base can be developed by an application expert without any microcontroller programming experience. Membership functions are simply expressions of the expert's understanding of the linguistic terms that describe the system to be controlled. Rules are ordinary language statements that describe the actions a human expert would take to solve the application problem.

Rules and membership functions cm be reduced to relatively simple data structures (the knowledge base) stored in nonvolatile memory. A fuzzy inference kernel cm be written by a programmer who does not know how the application system works. The only thing the programmer needs to do with knowledge base information is store it in the memory locations used by the kernel.

The design process begins by associating fuzzy sets with the input and output variables. These fuzzy sets are described by membership function of the type shown in figure below. These fuzzy set values are labeled. The shape of the membership functions are, in general, trapezoids that may have no top (triangles) or may have no vertical sides. A functional diagram of a fuzzy-controller is shown in the following figure.

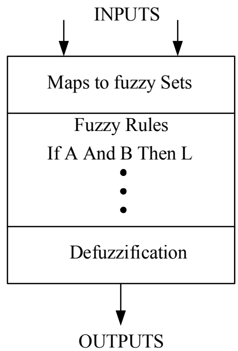

Fig. 1 – Functional Diagram of a Fuzzy Controller

The fuzzy controller shown above consists of three parts. The fuzzification of inputs. The processing of rules, and the defuzzification of the output. The inputs to a fuzzy controller are assigned to the fuzzy variables with a degree of membership given by the membership functions. After applying al1 of the fuzzy rules to a given set of input variables, the output will belong to more than one fuzzy set with different weights. The weighted output fuzzy sets are combined in a manner to be described below and then a centroid defuzzification process is used to obtain a single crisp output value.

The system structure identifies the fuzzy logic inference flow from the input variables to the output variables. The fuzzification in the input interfaces translates analog inputs into fuzzy values. The fuzzy inference takes place in rule blocks which contain the linguistic control rules. The output of these rule blocks are linguistic variables. The defuzzification in the output interfaces translates them into analog variables. The following figure shows the whole structure of this fuzzy system including input interfaces, rule blocks and output interfaces. The connecting 1ines symbolize the data flow. A Structure of the Fuzzy Logic System in Fuzzy Tech is shown in Fig.2

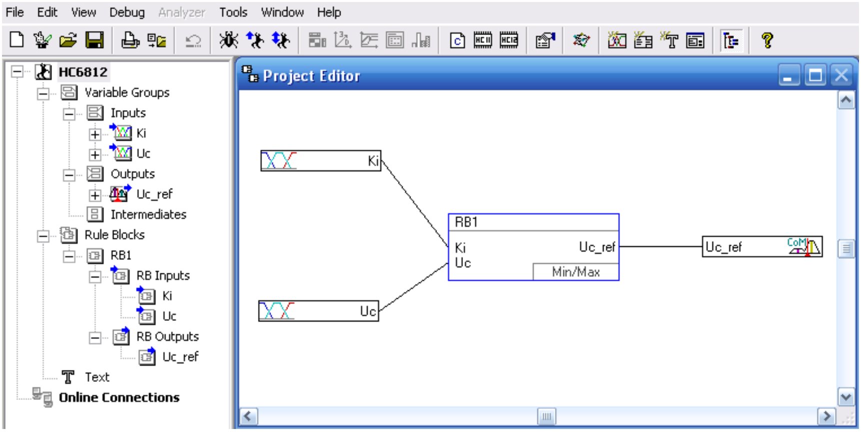

Fig. 2 – Structure of the Fuzzy Logic System

The appearance of interface Fuzzy Tech project in debug mode is shown in Fig. 3. View graphic table editor of fuzzy inference system is shown in Fig. 4.

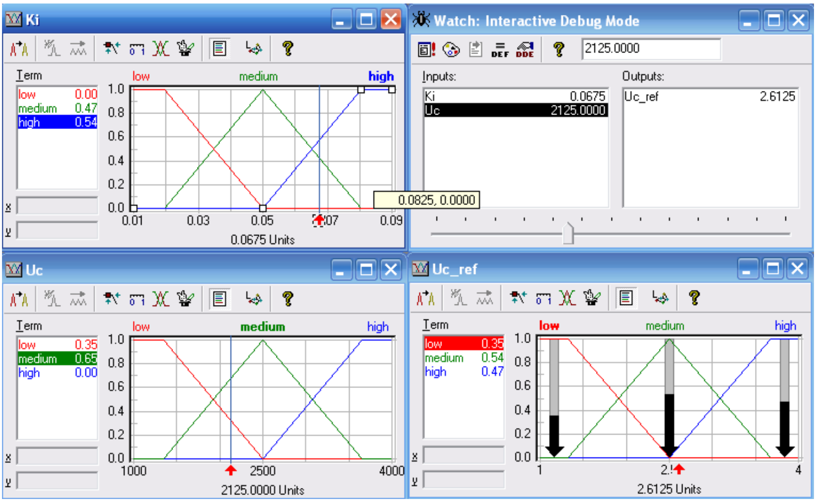

Fig. 3 – The appearance of interface Fuzzy Tech project

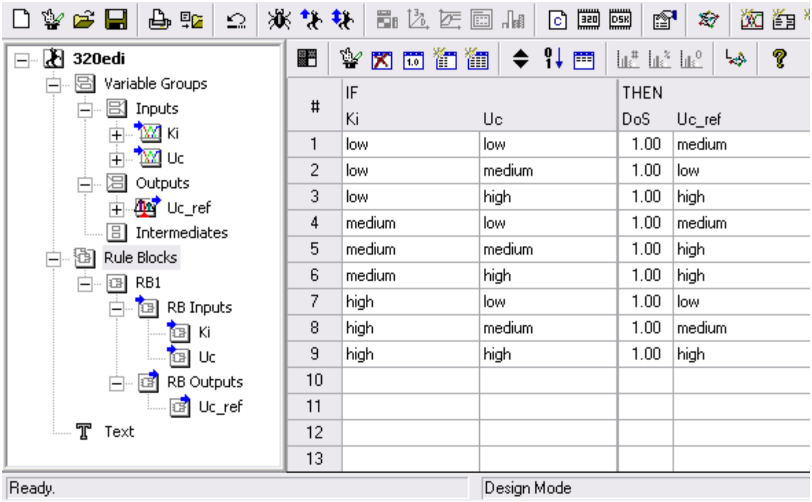

Fig. 4 – Table editor window block rules Fuzzy Tech fuzzy inference system

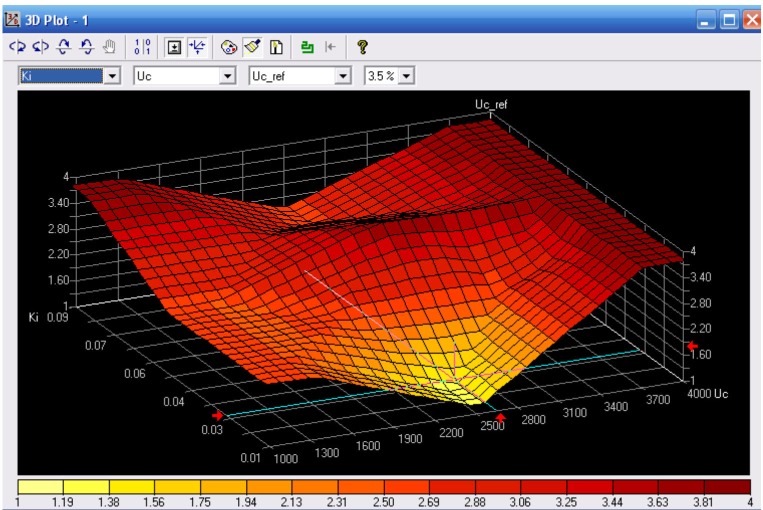

Fig. 5 – Three-dimensional surface of the fuzzy inference system

Software implementation of fuzzy-control loop mains current harmonics in Assembler and C language is realized in Fuzzy Tech code editor and based on fuzzy logic microcontroller Motorola 68HC12.

Summary and conclusion. This article is concerned with the design techniques for fuzzy logic and its implementation in the control system of converter for powerful sounding pulses generator. Due to the new series of microcontrollers 68HC12, which has dedicated instructions for programming and implementation of fuzzy logic it has become easy to write a smaller code which can overcome the memory constraints of earlier versions of microcontrollers. The Fuzzy Tech design software has made it very easy to design a control system using fuzzy logic. This design approach using fuzzy logic is practically feasible and many other applications are open venues for further research and future work.

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В статье описан вариант микропроцессорной реализации fuzzy-регулятора системы управления двухканальным компенсатором неактивных составляющих полной мощности для формирователя мощных зондирующих импульсов. Представлены результаты проектирования системы нечеткого логического вывода в программе Fuzzy Tech.

Ключевые слова: нечеткий регулятор, микропроцессорная реализация, фаззификация, функции принадлежнности.

У статті описаний варіант мікропроцесорної реалізації fuzzy-регулятора системи керування двоканальним компенсатором неактивних складових повної потужності для формувача потужних зондуючих імпульсів. Представлені результати проектування системи нечіткого логічного виводу в програмі Fuzzy Tech.

Ключові слова: нечіткий регулятор, мікропроцесорна реалізація, фазифікація, функції приналежності.