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Embedded Systems Development Using Keil uVision 4 and LPC214x Microcontroller

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Abstract
The research paper examines embedded systems development through the combination of Keil uVision 4 Integrated Development Environment (IDE) and LPC214x microcontroller in detail. This paper demonstrates basic GPIO control of LPC214x microcontroller through a practical example that shows GPIO configuration alongside delay generation and Keil uVision 4 development and debugging methods. The paper examines Keil uVision 4's role in embedded systems development by discussing its features alongside its capabilities to simplify code writing and compilation and debugging for ARM-based microcontrollers. The paper presents images which demonstrate Keil uVision 4 interface alongside code execution and hardware setup pictures.

1. Introduction
Modern technology depends on embedded systems which operate as a fundamental element throughout home appliances and industrial machinery but also smaller electronic devices. The LPC214x series of microcontrollers functions as a popular choice for embedded systems because of its ARM7 architecture and its combination of high performance and low power consumption and extensive peripheral capabilities. Keil uVision 4 serves as a widely used integrated development environment for ARM-based microcontroller development and debugging tasks. This paper investigates an embedded program for the LPC214x microcontroller developed through Keil uVision 4 while exploring its essential tools and concepts.

2. Overview of Keil uVision 4
Keil uVision 4 functions as a robust IDE specifically designed to develop embedded systems. The platform delivers a complete suite for developing code and debugging ARM-based

microcontrollers through its writing and compilation features. The main characteristics of Keil uVision 4 consist of:

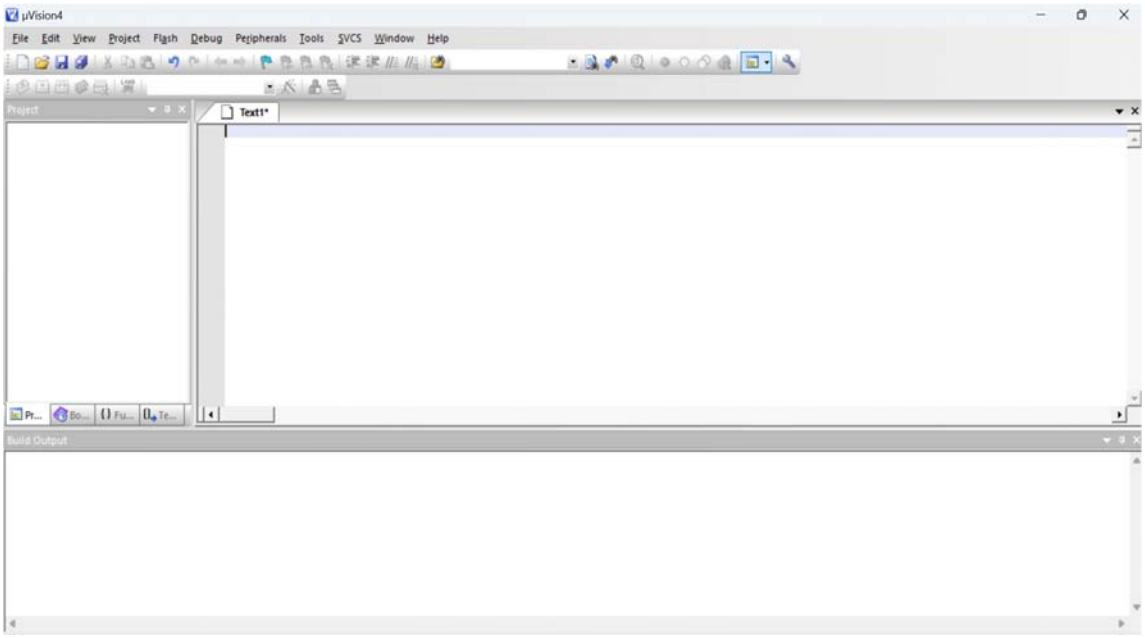

Figure 1 Open and work in Keil uVision 4 IDE Software

- The development environment provides users with a friendly interface to create and handle their code.
- The compiler implements ARM architecture to supply performance enhancements and exceptional code size optimization.
- Debugger: Allows step-by-step execution, breakpoints, and real-time variable monitoring.
- Simulator: Enables testing of code without physical hardware.
- The tool provides project management features for simplifying the organization of source code files together with libraries and configuration settings.

Keil uVision 4 serves both academic and industrial purposes because it provides strong features and supports numerous ARM microcontrollers.

3. Code Analysis

The provided code demonstrates the control of a GPIO pin on the LPC214x microcontroller. Below is a detailed analysis of the code:

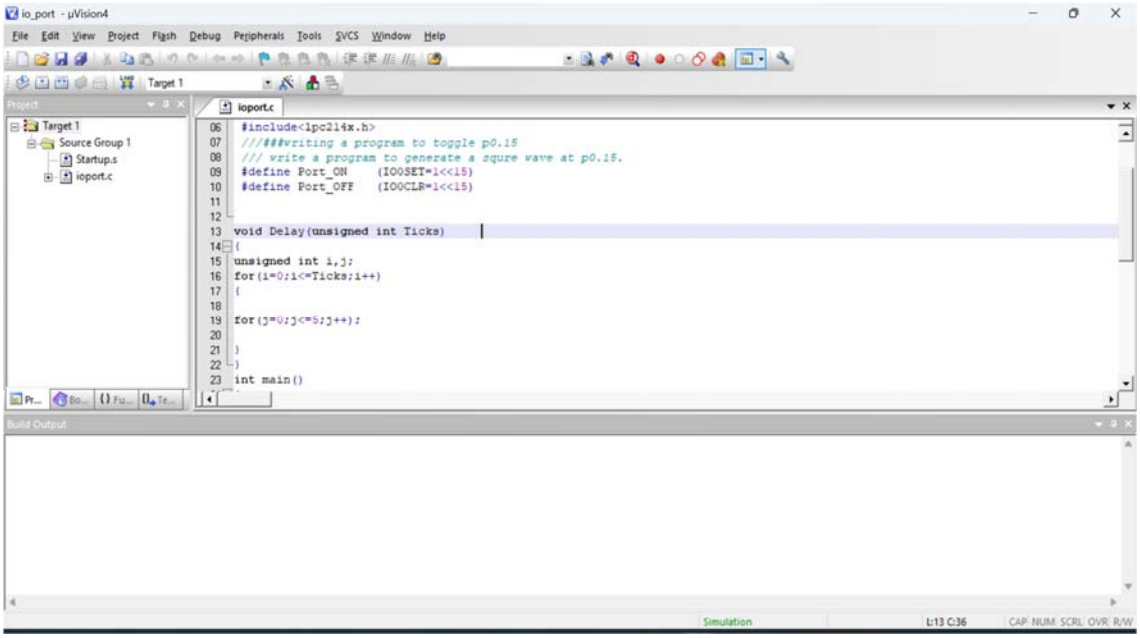

Figure 2 Coding writing in Software

3.1. Code Overview

```
#include <lpc214x.h>
#define Port_ON    (IO0SET=1<<15)
#define Port_OFF   (IO0CLR=1<<15)
void Delay(unsigned int Ticks)
{
   unsigned int i,j;
   for(i=0;i<=Ticks;i++)
   {
      for(j=0;j<=5;j++);
   }
}
int main()
{
   PINSEL0 = 0x00000000;
   PINSEL1 = 0x00000000;
   PINSEL2 = 0x00000000;
   IO0DIR = 0x00008000;
   while(1)
   {
      Port_ON;
      Delay(10);
      Port_OFF;
      Delay(10);
   }
```

```
}
```

3.2. Code Explanation

1. **Header File Inclusion**:
   ```
   #include <lpc214x.h>
   ```

The lpc214x.h header file contains definitions for the LPC214x microcontroller's registers and peripherals, simplifying access to hardware features.

2. **Macro Definitions**:
   ```
   #define Port_ON    (IO0SET=1<<15)
   #define Port_OFF   (IO0CLR=1<<15)
   ```

These macros define actions to set (Port_ON) and clear (Port_OFF) bit 15 of GPIO port 0. IO0SET and IO0CLR are registers used to set and clear GPIO pins, respectively.

3. **Delay Function**:
   ```
   void Delay(unsigned int Ticks)
   {
      unsigned int i,j;
      for(i=0;i<=Ticks;i++)
      {
         for(j=0;j<=5;j++);
      }
   }
   ```

   The Delay function generates a software-based delay by executing nested loops. The delay duration is controlled by the Ticks parameter.

4. **Main Function**:

- **Pin Configuration**:
  ```
  PINSEL0 = 0x00000000;
  PINSEL1 = 0x00000000;
  PINSEL2 = 0x00000000;
  ```
  These lines configure the pins of the microcontroller as GPIO by clearing the Pin Function Select registers (PINSEL0, PINSEL1, and PINSEL2).

  - **GPIO Direction Configuration**:
    ```
    IO0DIR = 0x00008000;
    ```
    This line sets bit 15 of GPIO port 0 as an output by setting the corresponding bit in the IO0DIR register.

  - **Main Loop**:
    ```
    while(1)
    {
       Port_ON;
    ```

```
    Delay(10);
    Port_OFF;
    Delay(10);
}
```

The infinite loop toggles bit 15 of GPIO port 0 on and off with a delay between each state change.

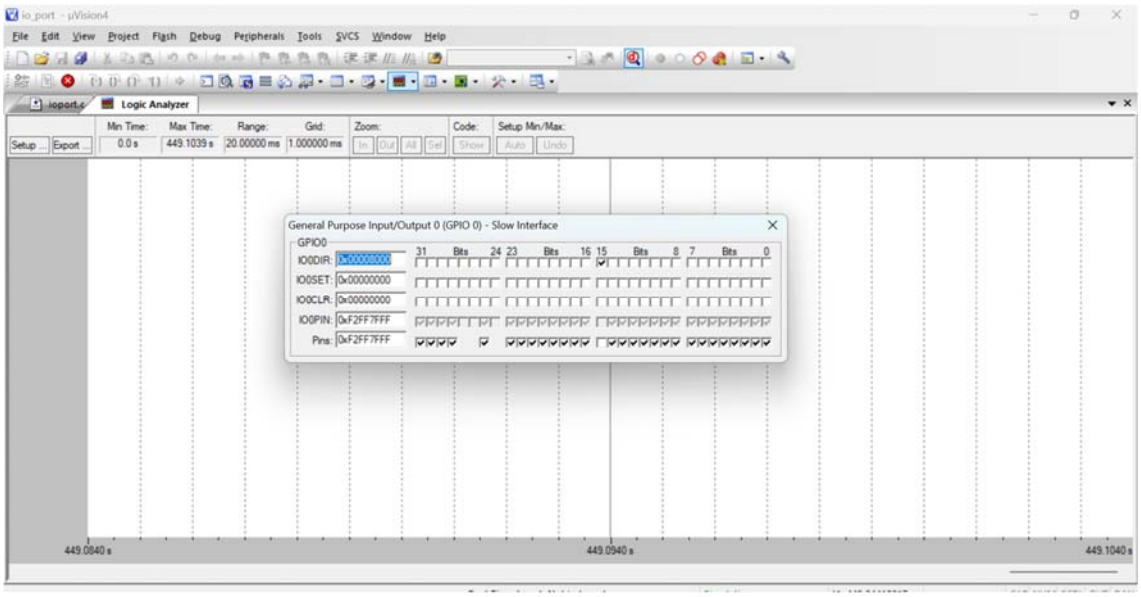

Figure 3 15 bit of GPIO port 0 on and off (Blinking)

4. Significance of Keil uVision 4 in Code Development

The development and debugging process for the provided code heavily depends on Keil uVision 4 software.

1. The IDE enables code writing through features such as syntax highlighting and auto-completion and error detection which results in error-free code.
2. Keil uVision 4 transforms written code into machine language which enables operation on the LPC214x microcontroller.
3. The system contains a built-in debugger tool which delivers sequential control of the code execution while enabling developers to view register values during actual runtime through the use of breakpoints.
4. Through simulation the development environment allows code testing without physical hardware which shortens development duration and reduces expenses.

5. Applications

GPIO control serves as the fundamental building block in embedded applications since the demonstrated code functions as a basic example.

- The code demonstrates LED blinking operations for status indication purposes.

- The GPIO pins can be controlled through toggling operations to drive motors.
- The code demonstrates how to interface sensors through reading and writing data.
- Communication Protocols: Implementing protocols like UART, SPI, and I2C.

6.Experimental Setup

To demonstrate the practical implementation of the code, the following setup is used:

1. **Hardware**:
    - LPC214x microcontroller board.

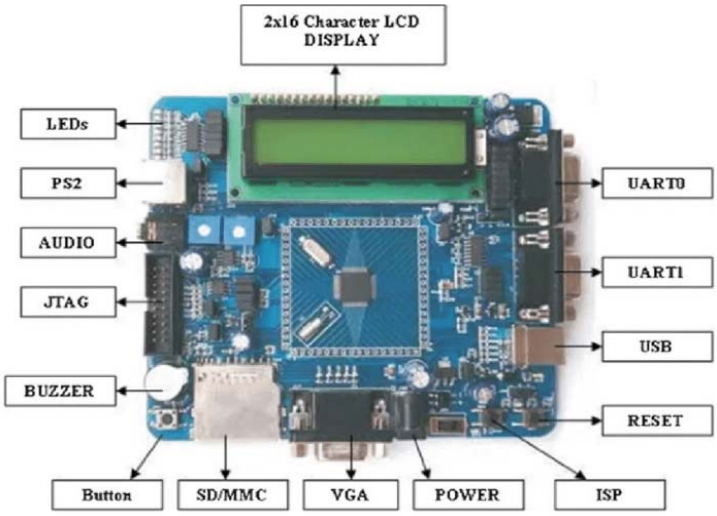

Figure 4 ARM7TDMI (LPC 2148) development board

    - LED connected to GPIO pin 15.
    - Power supply and connecting wires.

2. **Software**:
    - Keil uVision 4 IDE.
    - Flash magic for programming the microcontroller.

3. **Procedure**:
    i. Write the code in Keil uVision 4.

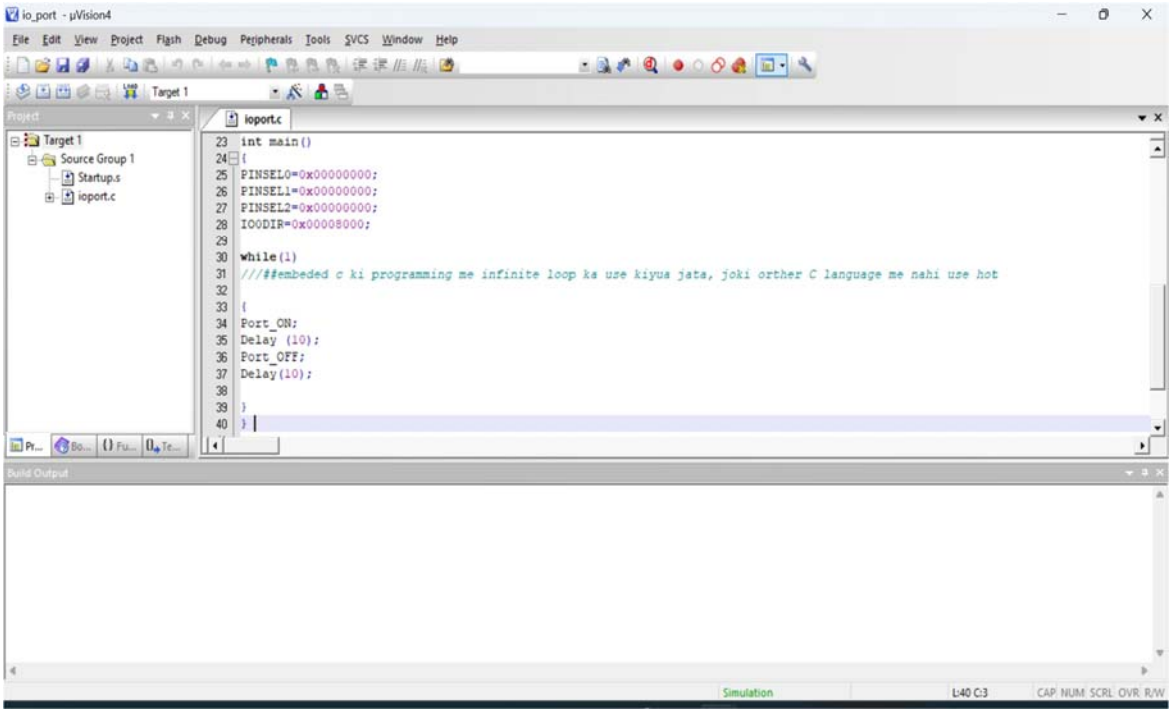

Figure 5 Write Code in Software

ii. Compile and debug the code.

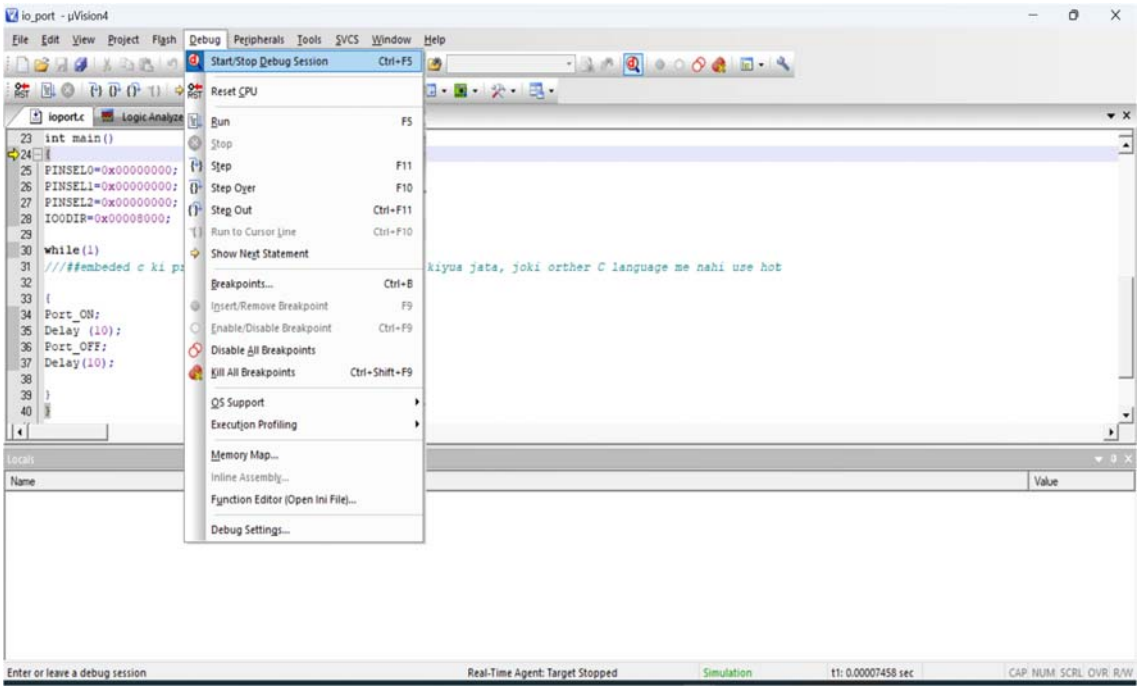

Figure 6 Compile and Debug the code

iii. After Compile and debug, Run the code.

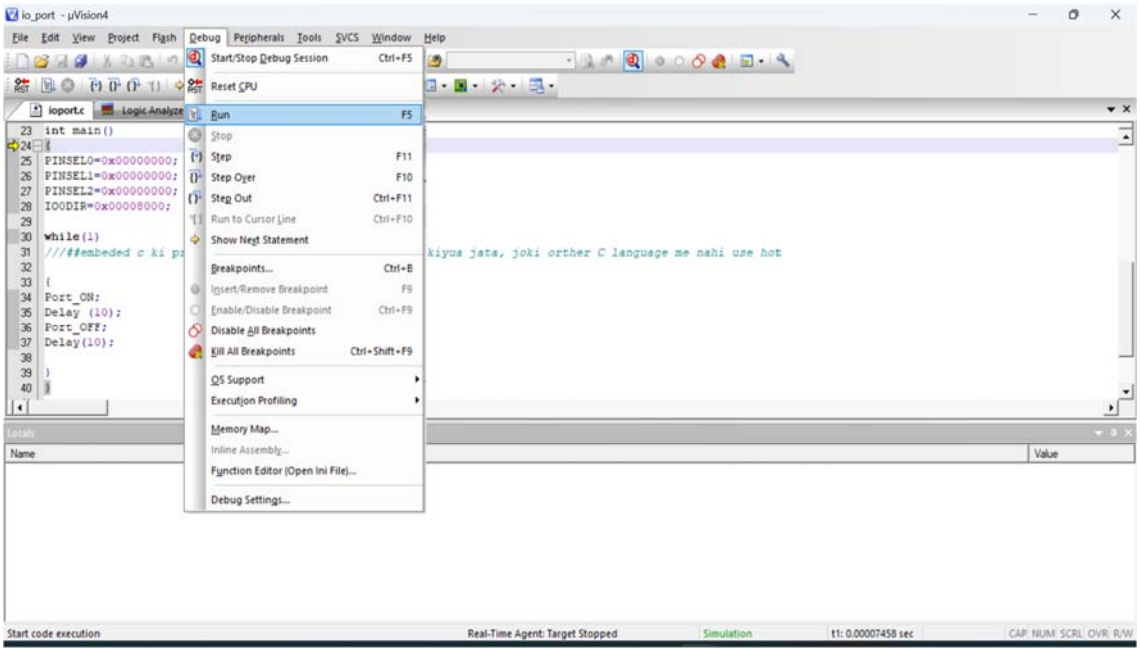

Figure 7 After Compile and Debug Run the code

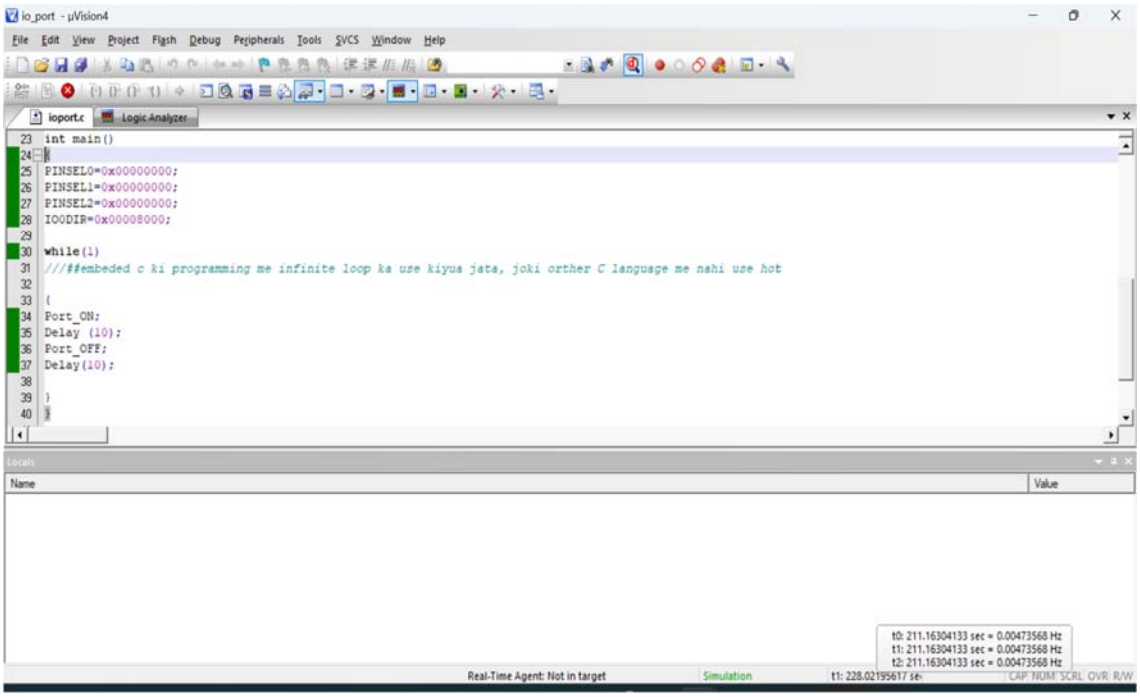

Figure 8 Measurement with a time and a corresponding frequency value in Hertz

✓ **Measurements**:

- The graph contains data points that show measurements between time (275.53272225 sec) and frequency (0.00362933 Hz).
- The time value 275.53272225 sec appears identical in every entry which indicates a measurement that remains static or repeats.
- The frequency value 0.00362933 Hz demonstrates a very low frequency that could represent either a prolonged system delay or a slow periodic occurrence.

✓ **Observations:**

- The same time and frequency values throughout all entries indicate these measurements stem from a steady-state or repeated system condition.
- The low frequency measurement value (0.00362933 Hz) indicates that the observed event takes place at intervals of 275.53 seconds.

iv. Program the microcontroller using Flash Magic.

v. Observe the LED blinking on the hardware.

7. Results and Discussion

The program operates the GPIO pin which results in blinking LED behaviour. The Delay function controls the duration between which the system turns on and off. Program development through Keil uVision 4 provides an efficient solution that enables programmers to create code while performing debugging and running simulations effectively.

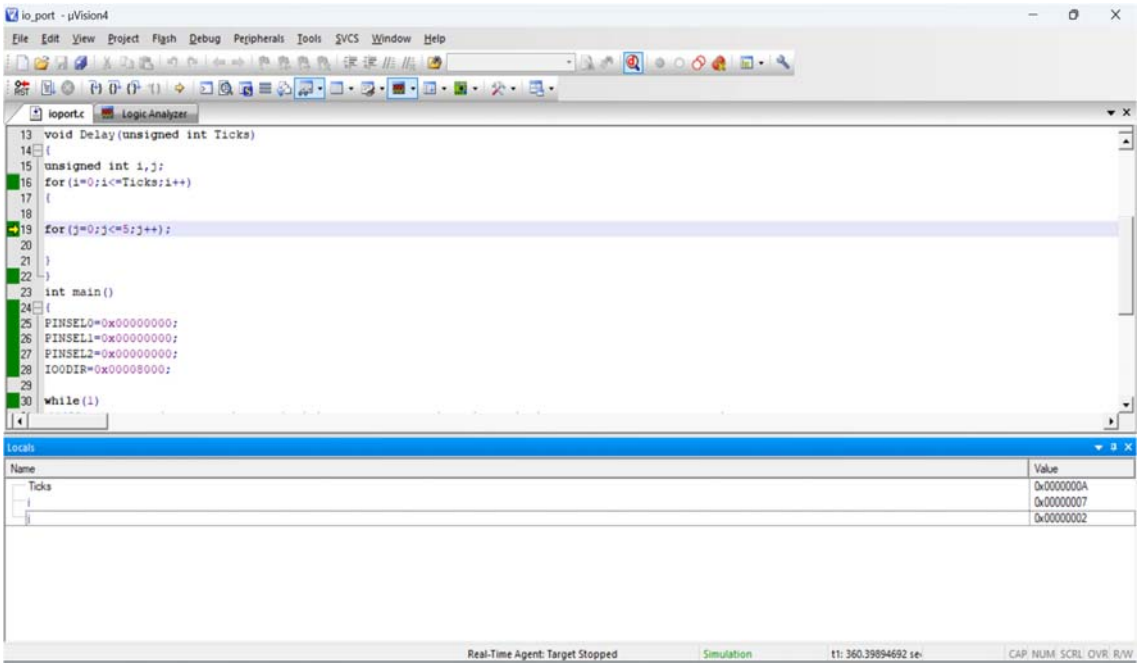

Figure 9 Ticks value represents timing or delay function in the system

- ✓ **Table**:
  - The table lists a parameter named "Ticks" with hexadecimal values: 0x0000000A, 0x0000007, and 0x0000002. These values might represent different settings or states related to a timing or delay function in the system.
- ✓ **Log Data**:
  - The log mentions "Real-Time Agent: Target Stopped," indicating that the target system in the simulation has stopped.
  - The timestamp "11: 360.38984692 s4" could represent a specific point in time during the simulation.

8. Conclusion

The paper shows how Keil uVision 4 serves as a development platform for embedded applications targeting the LPC214x microcontroller. The code example illustrates basic programming principles which include GPIO setup and delay creation and infinite loop execution. The development process becomes simpler through Keil uVision 4 which offers a complete environment for writing code and compiling and debugging applications. The embedded systems development knowledge acquired from this example enables developers to create advanced embedded systems through the use of Keil uVision 4.

9. Future Work

The next phase of research will investigate additional sophisticated capabilities of the LPC214x microcontroller.

- Interfacing with sensors and actuators.
- The implementation of UART, SPI and I2C communication protocols should be included.
- The developers need to create real-time operating systems that enable multitasking capabilities.

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