



Getting Started

**8xC166 and C167 Family
Microcontroller Development Tools**

User's Guide 12.97

Information in this document is subject to change without notice and does not represent a commitment on the part of the manufacturer. The software described in this document is furnished under license agreement or nondisclosure agreement and may be used or copied only in accordance with the terms of the agreement. It is against the law to copy the software on any medium except as specifically allowed in the license or nondisclosure agreement. The purchaser may make one copy of the software for backup purposes. No part of this manual may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or information storage and retrieval systems, for any purpose other than for the purchaser's personal use, without written permission.

Copyright © 1997-1998 Keil Elektronik GmbH and Keil Software, Inc.
All rights reserved.

Keil C166™ and dScope-166™ are trademarks of Keil Elektronik GmbH.
Microsoft®, MS-DOS®, and Windows™ are trademarks or registered trademarks of Microsoft Corporation.
IBM®, PC®, and PS/2® are registered trademarks of International Business Machines Corporation.

Every effort was made to ensure accuracy in this manual and to give appropriate credit to persons, companies, and trademarks referenced herein.

Preface

This manual is an introduction to the Keil Software development tools for the 8xC166 and C167 family of microcontrollers. It introduces new users and interested readers to our product line. With nothing more than this book, you should be able to successfully run and use our tools. This user's guide contains the following chapters.

“Chapter 1. Introduction” gives an overview of this user's guide.

“Chapter 2. Installation” describes how to install the software and how to setup an operating environment for the tools.

“Chapter 3. Product Line” discusses the different products that we offer for the 8xC166 and C167 family of microcontrollers. Read this chapter to determine which product provides the tools you need.

“Chapter 4. Development Tools” describes the major features of the C compiler, assembler, debugger, and integrated programming environment.

“Chapter 5. Writing Programs” shows you how to access the special on-chip peripherals of the 8xC166 and C167 microcontrollers using the C166 C compiler.

“Chapter 6. Creating Applications” describes how to create source files, compile and fix syntax errors, create project files, make projects, and create HEX files.

“Chapter 7. Testing Programs” describes how you use the dScope debugger to simulate and test your entire application.

“Chapter 8. Tutorial” discusses several of the example programs available with the Keil 166 development tools.

“Chapter 9. Command Reference” briefly describes the commands and controls available in the Keil 166 development tools.

“Chapter 10. Evaluation Boards” reviews several evaluation boards available from Keil Software and other third-party vendors.

NOTE

This manual assumes that you are familiar with Microsoft Windows and the hardware and instruction set of the 8xC166 and C167 microcontrollers.

Document Conventions

This document uses the following conventions:

Examples	Description
README.TXT	Bold capital text is used for the names of executable programs, data files, source files, environment variables, and commands you enter at the MS-DOS command prompt. This text usually represents commands that you must type in literally. For example: <div style="text-align: center;"> CLS DIR BL51.EXE </div> Note that you are not required to enter these commands using all capital letters.
Courier	Text in this typeface is used to represent information that displays on screen or prints at the printer. This typeface is also used within the text when discussing or describing command line items.
<i>Variables</i>	Text in italics represents information that you must provide. For example, <i>projectfile</i> in a syntax string means that you must supply the actual project file name. Occasionally, italics are also used to emphasize words in the text.
Elements that repeat...	Ellipses (...) are used to indicate an item that may be repeated.
Omitted code . . .	Vertical ellipses are used in source code listings to indicate that a fragment of the program is omitted. For example: <pre>void main (void) { . . . while (1);</pre>
[Optional Items]	Optional arguments in command-line and option fields are indicated by double brackets. For example: C51 TEST.C PRINT [(filename)]
{ opt1 opt2 }	Text contained within braces, separated by a vertical bar represents a group of items from which one must be chosen. The braces enclose all of the choices and the vertical bars separate the choices. One item in the list must be selected.
Keys	Text in this sans serif typeface represents actual keys on the keyboard. For example, "Press Enter to continue."
Point	Move the mouse until the mouse pointer rests on the item desired.
Click	Quickly press and release a mouse button while pointing at the item to be selected.
Drag	Press the left mouse button while on a selected item. Then, hold the button down while moving the mouse. When the item to be selected is at the desired position, release the button.
Double-Click	Click the mouse button twice in rapid succession.

Contents

Chapter 1. Introduction.....	1
Manual Topics	2
Changes to the Documentation	2
Evaluation Kits and Production Kits.....	3
Types of Users	3
Requesting Assistance.....	4
Chapter 2. Installation.....	5
System Requirements.....	5
Making Backups	6
Installation Details	6
Directory Structure	7
Maximizing System Performance	8
Chapter 3. Product Line.....	9
Software Development Cycle	9
Tool Kit Introduction	12
Comparison Chart.....	15

Chapter 1. Introduction

Thank you for allowing Keil Software to provide you with software development tools for the 8xC166 and C167 family of microprocessors. With the Keil tools, you can generate embedded applications for the 8xC166, C167, C165, C163, C161, and C164 microcontrollers as well as future derivatives.

NOTE

*Throughout this manual we refer to these tools as the **166** development tools. However, they are not limited to just the 8xC166 devices.*

The Keil Software 166 development tools listed below are the programs you use to compile your C code, assemble your assembler source files, link your program together, create HEX files, and debug your target program. Each of these programs is described in more detail in “Chapter 4. Development Tools” on page 17.

- C166 ANSI Optimizing C Cross Compiler (creates relocatable object modules from your C source code),
- A166 Macro Assembler (creates relocatable object modules from your 8xC166 or C167 assembler source code),
- L166 Linker/Locator (combines relocatable object modules created by the compiler and assembler into the final absolute object module),
- LIB166 Library Manager (combines object modules into a library which may be used by the linker),
- OH166 Object-HEX Converter (creates Intel HEX files from absolute object modules),
- dScope-166 for Windows™ Source-Level Debugger and Simulator,
- μVision-166 for Windows™ Integrated Development Environment.

The tools are combined into the kits described in “Chapter 3. Product Line” on page 9. They are designed for the professional software developer, but any level of programmer can use them to get the most out of the 166 hardware.

Manual Topics

This manual discusses a number of topics including how to:

- Install the software on your system (see “Chapter 2. Installation” on page 5) and fine tune it for maximum performance (see “Maximizing System Performance” on page 8),
- Select the best tool kit for your application (see “Chapter 3. Product Line” on page 9),
- Use the 166 development tools (see “Chapter 4. Development Tools” on page 17),
- Access the on-chip peripherals and special features of the 166 using the C166 C Compiler (see “Chapter 5. Writing Programs” on page 33),
- Create full applications using the μ Vision-166 integrated development environment (see “Chapter 6. Creating Applications” on page 67),
- Debug and simulate target programs using the dScope-166 debugger (see “Chapter 7. Testing Programs” on page 69),
- Run the included sample programs (see “Chapter 8. Tutorial” on page 71).

NOTE

If you want to get started immediately, you may do so by installing the software (refer to “Chapter 2. Installation” on page 5) and running the sample programs (refer to “Chapter 8. Tutorial” on page 71).

Changes to the Documentation

Last minute changes and corrections to the software and manuals are listed in the **README.TXT** file which is included in the root directory of your installation. Take the time to read this file to determine if there are any changes that may impact your installation.

Evaluation Kits and Production Kits

Keil Software provides two types of kits in which our tools are delivered.

The **PK166 Evaluation Kit** includes evaluation versions of our 166 tools along with this user's guide. The tools in the evaluation kit let you generate applications up to 4 Kbytes in size. You may use this kit to evaluate the effectiveness of our 166 tools and to generate small target applications.

The **166 Production Kits** (discussed in "Chapter 3. Product Line" on page 9) include the unlimited versions of our 166 tools along with this user's guide and the full manual set. The production kits also include 1 year of free technical support and product updates.

Types of Users

This manual addresses three types of users: evaluation users, new users, and experienced users.

Evaluation Users are those users who have not yet purchased the software but have requested the evaluation package to get a better feel for what the tools do and how they perform. The evaluation package includes evaluation tools that are limited to 4K along with several sample programs that provide real-world applications created for the 8xC166 and C167 microcontroller family. Even if you are only an evaluation user, take the time to read this manual. It explains how to install the software, provides you with an overview of the development tools, and introduces the sample programs.

New Users are those users who are purchasing 166 development tools for the first time. The included software provides you with the latest development tool technology, manuals, and sample programs. If you are new to the 166 or the tools, take the time to review the sample programs described in this manual. They provide a quick tutorial and help new or inexperienced users quickly get started.

Experienced Users are those users who have previously used the Keil 166 development tools and are now upgrading to the latest version. The software included with a product upgrade contains the latest development tools, sample programs, and a complete set of manuals.

Requesting Assistance

At Keil Software, we are dedicated to providing you with the best embedded development tools and documentation available. If you have suggestions or comments regarding any of the printed manuals accompanying this product, please contact us. If you think you have discovered a problem with the software, do the following before calling technical support.

1. Read the sections in this manual that pertain to the job or task you are trying to accomplish.
2. Make sure you are using the most current version of the software and utilities.
3. Isolate the problem to determine if it is a problem with the assembler, compiler, linker, library manager, or another development tool.
4. Further isolate software problems by reducing your code to a few lines.

If, after following these steps, you are still experiencing problems, report them to our technical support group. If you contact us by fax, be sure to include your name, your product serial number and version number, and telephone numbers (voice and fax) where we can reach you.

Try to be as detailed as possible when describing the problem you are having. The more descriptive your example, the faster we can find a solution. If you have a one-page code example demonstrating the problem, please fax it to us. However, please try to avoid sending long listings as this slows down our response to you.

NOTE

You can always get technical support, product updates, application notes, and sample programs from our world wide web site 24-hours a day.

<http://www.keil.com/>

Chapter 2. Installation

This chapter explains how to setup an operating environment and how to install the software on your hard disk. Before starting the installation program, you must do the following:

- Verify that your computer system meets the minimum requirements.
- Make a copy of the installation diskette for backup purposes.

NOTE

This chapter refers to various MS-DOS commands which may be used to customize your operating environment. If you are not familiar with these commands and other MS-DOS operations mentioned in this chapter, refer to your DOS user's guide.

System Requirements

There are minimum hardware and software requirements that must be satisfied to ensure that the compiler and utilities function properly.

For our Windows-based tools, you must have the following:

- 100% IBM compatible 386 or higher PC,
- Windows 3.1x, Windows 95, or Windows NT 4.x,
- 16 MB RAM minimum,
- Hard disk with 10 MB free disk space.

NOTE

The C compiler and utilities require that you have at least 20 files and 20 buffers defined in your CONFIG.SYS file.

Your CONFIG.SYS file should look similar to the following:

```
BUFFERS=20
FILES=20
SHELL=C:\COMMAND.COM /e:1024 /p
```

If you receive the message **out of environment space** from DOS, you may increase the amount of environment space by increasing the number **1024** in the above example. Refer to your DOS user's guide for more information.

Making Backups

We strongly suggest that you make a backup copy of the installation diskettes using the DOS `COPY` or `DISKCOPY` commands. Then, use the backup disks to install the software. Be sure to store the original disks in a safe place in case your backups are lost or damaged.

Installation Details

All of our products come with an installation program which allows easy installation of our software. To install Windows-based products...

- Insert the first product diskette into Drive A,
- Select the **Run...** command from the **File** menu in the Program Manager,
- Enter **A:SETUP** at the **Command Line** prompt,
- Select the **OK** button.

Then, follow the instructions displayed by the installation program.

Directory Structure

The installation program copies the development tools into subdirectories of the following base directories. The directory used depends on the kit being installed. Refer to “Evaluation Kits and Production Kits” on page 3 for more information about the different types of kits.

Directory	Description
\C166	166 production tools.
\C166EVAL	166 evaluation tools.

After creating the appropriate directory, the installation program copies the development tools into the subdirectories listed in the following table.

Subdirectory	Description
...\ASM	Assembler include files.
...\BIN	Executable files.
...\EXAMPLES	Sample applications.
...\RTX166	RTX166 Full files.
...\RTX_TINY	RTX166 Tiny files.
...\INC	C compiler include files.
...\LIB	C compiler library files and startup code.
...\MON166	Target monitor files.

This table lists a complete installation that includes the entire line of 166 development tools. Your installation may vary depending on the products you purchased.

Maximizing System Performance

There are two methods you can employ to improve performance of the C166 compiler and utilities. These techniques are generic and should help boost performance of most applications. You may:

- Provide a RAM disk for the compiler and utilities to use for temporary files,
- Use a disk cache to store the most recently accessed disk files.

Using a RAM Disk

If your computer has sufficient extended or expanded memory available, you should consider using a RAM disk. A RAM disk is a memory-based disk emulator. Because the contents of a RAM disk are stored in RAM, access is very fast.

If you are using a RAM disk, you can set the value of the `TMP` environment variables to the drive name of the RAM disk. This speeds up the execution of the many of the tools and utilities because they can use the RAM disk for temporary files.

A number of RAM disk software packages are available. `RAMDRIVE.SYS` and `VDISK.SYS` are the names of the RAM disk programs that are most commonly shipped with DOS. Refer to your DOS manual to learn how to install these programs.

Using a Disk Cache

A disk cache utilizes a large memory pool to temporarily store information read from disk. When the computer accesses the disk, it first checks the cache to see if the desired information is already in the cache. If it is, the information is read from the cache memory instead of from the disk. This is significantly faster than waiting for the disk drive to read the information.

Typically, software development involves an edit-compile-edit-compile... cycle. In these situations, a disk cache improves the performance of your editor, assembler, compiler, and linker. The editor, the compiler, source file, and object file can all be held in the cache, and disk accesses are kept to a minimum.

Version 5.0 and Version 6.0 of MS-DOS both come with a disk-caching utility called `SMARTDRV.SYS`. Refer to your DOS manual to learn how to install and use this program.

Chapter 3. Product Line

Keil Software provides the premier 166 development tools for the Siemens and SGS Thomson microcontrollers. We bundle our software development tools into different packages or tool kits.

A tool kit is comprised of several application programs that you use to create your 166 application. You may use an assembler to assemble your 166 assembly program, you may use a compiler to compile your C source code into an object file, and you may use a linker to create an absolute object module suitable for your in-circuit emulator.

Each tool kit we provide gives you a complete solution to the software development cycle.

Software Development Cycle

When you use the Keil Software tools, the project development cycle is roughly the same as it is for any other software development project.

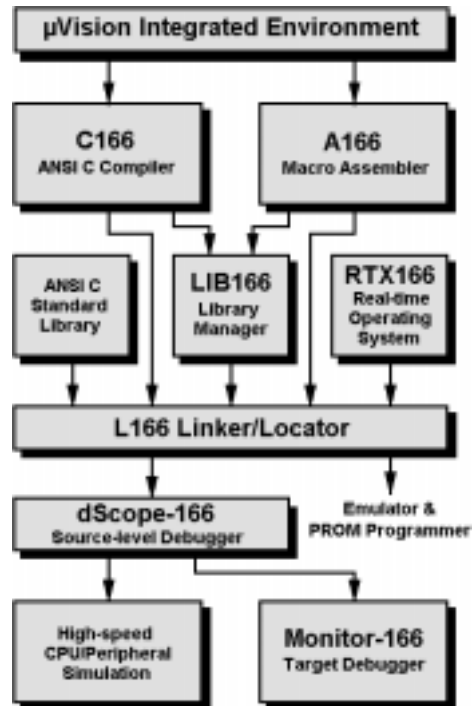
1. Create source files in C or assembly.
2. Compile or assemble source files.
3. Correct errors in source files.
4. Link object files from compiler and assembler.
5. Test linked application.

The development cycle described above may be best illustrated by a block diagram (shown on the following page) of the complete 166 tool set.

μVision-166 IDE

The μVision integrated development environment combines a full-function editor with interactive error correction, option setup, project management, make facility, and on-line help.

You use μVision to create your source files and organize them into a project that defines your target application. μVision automatically compiles, assembles, and links your embedded application and provides a single focal point for your development efforts. External, third-party development tools can easily be integrated into the μVision environment.



166 Compiler & Assembler

Source files are created by the μVision IDE and are passed to the C166 compiler or A166 assembler. The compiler and assembler process source files and create relocatable object files. The Keil C166 C compiler is a full ANSI implementation of the C programming language. All standard features of the C language are supported. In addition, numerous features for direct support of the 166 environment have been added. The Keil A166 macro assembler supports the complete instruction sets of the 8xC166 and C167 derivatives.

LIB166 Library Manager

Object files created by the compiler and assembler may be used by the LIB166 library manager to create object libraries which are specially formatted, ordered program collections of object modules that the linker may process at a later time. When the linker processes a library, only those object modules in the library that are necessary to create the program are used.

L166 Linker/Locator

Object files created by the compiler and assembler and library files created by the library manager are processed by the linker to create an absolute object module. An absolute object file or module is an object file with no relocatable code. All the code in an absolute object file resides at fixed memory locations.

The absolute object file created by the linker may be used to program EPROM or other memory devices. The absolute object module may also be used with the dScope debugger/simulator or with an in-circuit emulator.

dScope-166 Debugger/Simulator

The dScope symbolic, source-level debugger/simulator is ideally suited for fast, reliable program debugging. The debugger contains a high-speed simulator and a target debugger that let you simulate an entire 166 system including on-chip peripherals and external hardware. By loading specific I/O drivers, you can simulate the attributes and peripherals of the 8xC166, C167, C165, C163, and C161 microcontrollers.

Monitor-166

dScope supports target debugging using Monitor-166. The monitor program is a program that resides in the memory of your target hardware and communicates with dScope using the serial port of the 166 and a COM port of your PC. With Monitor-166, dScope lets you perform source-level, symbolic debugging on your target hardware.

RTX166 Real-Time Operating System

The RTX166 real-time operating system is a multitasking kernel for the 166 family. The RTX166 real-time kernel simplifies the system design, programming, and debugging of complex applications where fast reaction to time critical events is essential. The kernel is fully integrated into the C166 compiler and is easy to use. Task description tables and operating system consistency are automatically controlled by the L166 linker/locator.

Tool Kit Introduction

The preceding block diagram shows the full extent of the Keil Software 166 development tools. The tools listed comprise the professional developer's kit (PK166) described on the following pages. In addition to the professional kit, Keil Software provides a number of other tool kits for the 166 developer. Each kit and its contents are described below. The most capable kit, the professional developer's kit, is described first.

C166 Professional Developer's Kit (PK166)

The C166 Professional Developer's Kit (part number PK166) includes everything the professional 166 developer needs to create sophisticated, embedded applications for the Siemens 8xC166, C167, C165, C163, C161, and C164 as well as the SGS Thomson C167, ST10F166, ST10R165, and ST10R163. This tool kit includes the following components:

- C166 Optimizing C Compiler,
- A166 Macro Assembler,
- L166 Linker/Locator,
- OH166 Object-HEX Converter,
- LIB166 Library Manager,
- Monitor-166 ROM Monitor and Terminal Program,
- dScope-166 Simulator/Debugger for Windows,
- μ Vision-166 Integrated Development Environment for Windows,
- RTX166 Tiny Real-time Operating System.

The professional developer's kit can be configured for all 166 derivatives. The tools included in this kit run under Windows 3.1x, Windows 95, and Windows NT 4.x.

C166 Compiler Kit (CA166)

The C166 Compiler Kit (part number CA166) is the best choice for developers who need a C compiler but not a debugging system. The compiler kit includes everything you need to create embedded applications for the Siemens 8xC166, C167, C165, C163, C161, and C164 as well as the SGS Thomson C167, ST10F166, ST10R165, and ST10R163. This tool kit includes the following components:

- C166 Optimizing C Compiler,
- A166 Macro Assembler,
- L166 Linker/Locator,
- OH166 Object-HEX Converter,
- LIB166 Library Manager,
- μ Vision-166 Integrated Development Environment for Windows,
- RTX166 Tiny Real-Time Operating System.

The compiler kit is easily configured for all 166 derivatives. The tools included in this kit run under Windows 3.1x, Windows 95, and Windows NT 4.x.

A166 Assembler Kit (A166)

The A166 Assembler Kit (part number A166) includes an assembler and all the utilities you need to create embedded applications for the Siemens 8xC166, C167, C165, C163, C161, and C164s the SGS Thomson C167, ST10F166, ST10R165, and ST10R163. This tool kit includes the following components:

- A166 Macro Assembler,
- L166 Linker/Locator,
- OH166 Object-HEX Converter,
- LIB166 Library Manager,
- μ Vision-166 Integrated Development Environment for Windows.

The assembler kit is easy to configure for all 166 derivatives. The tools included in this kit run under Windows 3.1x, Windows 95, and Windows NT 4.x.

C161 Professional Developer's Kit (PK161)

The C161 Professional Developer's Kit (part number PK161) includes everything the professional 161 developer needs to create sophisticated, embedded applications for the Siemens C161. This tool kit provides support only for the C161 device. Other 166 family members are not supported. This tool kit includes the following components:

- C161 Optimizing C Compiler,
- A166 Macro Assembler,
- L166 Linker/Locator,
- OH166 Object-HEX Converter,
- LIB166 Library Manager,
- Monitor-166 ROM Monitor and Terminal Program,
- dScope-166 Simulator/Debugger for Windows,
- μ Vision-166 Integrated Development Environment for Windows,
- RTX166 Tiny Real-Time Operating System.

The tools included in this kit run under Windows 3.1x, Windows 95, and Windows NT 4.x.

NOTE

The C161 Professional Developer's Kit can be configured only for the Siemens C161. It does not support the 8xC166, C167, C165, C163, or C164.

RTX166 Real-Time Operating System (FR166)

The RTX166 Real-Time Operating Systems is a real-time kernel for the 166 family of microcontrollers. RTX166 Full provides a superset of the features found in RTX166 Tiny and includes CAN communication protocol interface routines.

Comparison Chart

The following table provides a check list of the features found in each 166 package. Tools are listed along the top and part numbers for specific kits are listed along the side. Use this cross reference to select the kit that best suits your needs.

Support	PK166	CA166	A166	PK161 [†]	FR166
A166 Assembler	✓	✓	✓	✓	
C166 Compiler	✓	✓		✓	
L166 Linker/Locator	✓	✓	✓	✓	
LIB166 Library Manager	✓	✓	✓	✓	
dScope Debugger	✓			✓	
µVision IDE	✓	✓	✓	✓	
RTX166 Tiny	✓	✓		✓	
RTX166 Full					✓

[†] The PK161 supports the C161 but does not include support for the 8xC166, C167, C165, C163, or C164.