

C LANGUAGE DEVELOPMENT SYSTEM

Introl-C/6809 is a powerful C language compiler system that is designed to facilitate the development of high-efficiency software for the 6809. The Introl-C package includes a C Compiler, 6809 Relocating Assembler, Linker, Loader, Library Manager, and Standard Library. It has been in the field since early 1982 and has gained widespread acceptance among users for its reliable and comprehensive support of the C language as well as its ease of use. Its ability to generate exceptionally compact, fast executing code has long distinguished the Introl-C implementation as being the most efficient high level language that is available for the 6809 and has resulted in Introl-C's widespread use in the industrial community for development of process control software. Programs developed using Introl-C are typically within 15 to 20% or less of the size and speed of programs written entirely in 6809 assembler. For the particular case of the Eratosthenes Sieve Benchmark, the p/n UC6809 resident Introl-C Compiler, for example, produces a 176 byte compiled module, a total program size of 2007 bytes, and a program execute time of 8 seconds on a 2 Mhz 6809.

Code produced under Introl-C is re-entrant, relocatable, and ROMable and may be installed on any 6809 target, including ROM-based systems. No fees or royalties of any type are imposed on object code programs developed using the compiler. Introl-C/6809 is available as resident software for 6809-based hosts running UniFlex, Flex, or OS9. Cross-software versions of Introl-C are available for PDP-11 based hosts running UNIX (or any of the UNIX look-alikes such as TNIX, VENIX, etc), PDP-11 based hosts running RSX11M, and also for IBM PC hosts running PC DOS or MDOS.

Introl-C is designed to the standard C language specification defined by Kernighan & Ritchie and supports all features of the language except fields, doubles, and the #if and the #line preprocessor directives (all other preprocessor directives, including #ifdef and #ifndef, are fully supported). Extensions to the standard language include provisions to permit nesting of comments, use of separate name spaces for all union and structure member names, and provision to allow symbol names up to 90 significant characters in length. Most C source programs developed using Introl-C are directly usable as input to standard UNIX C compilers.

User interface is designed for ease of use permitting C source files to be converted into executable outputs with a minimum of effort on the part of the programmer. For example, a single command line entry of the form:

```
icc filename [options]
```

will cause a C source file to be fully compiled and assembled to produce a relocatable object module. Similarly, relocatable modules may be linked and automatically loaded to produce an executable output via a simple command line entry of the form:

```
ilink file1 [file2 file3 ...] [options]
```

Numerous options are supported to permit versatile, user-controlled alteration of the standard compilation, assembly, linking and loading processes. Option specifications, however, are generally required only for specialized circumstances since the defaults for unused options are designed to select standard conditions that "make sense" for the great majority of program development situations.

The C Compiler is a 4-pass program that generates an optimized assembly language file as its output. In normal use, the 4 sequential compilation passes execute automatically and are followed by automatic execution of the included Assembler, thus resulting in a fully compiled, fully assembled relocatable object module as the result of a typical compiler call. The intermediate assembly language file generated by the C Compiler is available to the user, however. Compile time options include capability for the user to selectively place data of a given type under any of 16 different location counters (ie "segments"), ability to generate either position-dependent or position-independent code and/or data, and capabilities for specifying #define pre-processor directives directly on the compiler call line. The 16 location counters provided by Introl-C, and the features for generating either position-dependent or position-independent code and data, allow significant flexibility when finished programs are to be placed in ROM.

The included R09 Assembler is a full-featured 6809 Relocating Assembler. Although nominally furnished to provide automatic assembly of the C Compiler's output, the Assembler may also be called directly by the user for converting user-written assembler text files into relocatable object modules. The Assembler supports all addressing modes of the 6809, recognizes all standard opcodes, and will accept arbitrarily complex assembly-type input expressions. A unique feature of the Introl Assembler is its assignment of a user-definable "class" identifier to each module it produces which is used (in combination with the module's name) for identification purposes by the Linker. This feature allows the user to create (and the Linker to distinguish between) multiple versions of identically-named C support functions within the Standard Library, for example, and provides the basis for a powerful and convenient link-time capability for tailoring the link process to minimize runtime overhead in the final program.

The Linker accepts any number of relocatable modules as input and produces a single relocatable module as its output. Multiple-pass linking is supported. The Linker also supports "partial linking", wherein several component modules of an overall program may be linked together to form a single resultant "partially linked" module which may then be reused as input in subsequent linking operations. Linked programs up to 64K in size may be produced.

Although a specific host-related Loader is supplied with each Introl-C software package, any of four different types of Introl Loaders are potentially usable with any of the Introl-C compiler systems: a FLD Loader, which generates a file of output load records in hex format (Motorola S Records, Intel Hex, Tektronix Hex, or Extended Tektronix Hex formats); a ULD Loader, which generates outputs that are executable under UniFlex; a FLD Loader, which generates outputs executable under Flex; and an OLD Loader, which generates outputs executable under OS9. The loader supplied with P/N XC6809, RC6809, and PC6809 cross-software packages is the HLD Loader; the ULD Loader is supplied with the P/N UC6809 package; the FLD Loader is supplied with the P/N FC6809 package; and the OLD Loader is supplied with the P/N OC6809 package. Any of these several Loader types, however, is also optionally available, at extra cost, as a "cross-loader" for use with any resident or cross-software version of Introl-C. The HLD loader is particularly useful when developing software for standalone, ROM-based applications.

The Standard Library contains an extensive collection of C programming support functions, including I/O and arithmetic functions not directly performed by the 6809. Only those library functions actually required for program execution are extracted by the Linker, resulting in minimum runtime overhead in developed programs. The library furnished with each of the several resident versions of Introl-C is host-O.S.-specific in nature whereas the library supplied with cross-software versions is operating-system-independent and is tailored for use in standalone-target applications. Standard Library source code is available as an extra cost option.

The Library Manager provides convenient and versatile capabilities for adding, deleting, and modifying Standard Library functions, thus permitting unique libraries of C support functions of any type to be created by the user. All library functions are stored in linkable format, thus avoiding any need for recompiling them before each use. The Library Manager, in combination with the Linker, significantly reduces development times for large programs by allowing individual parts of the program to be independently developed and compiled with a minimum of effort.

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6809 RESIDENT AND CROSS MACRO ASSEMBLERS

Introl's M09 resident and cross macro assemblers are designed to translate MC6809 assembly language source programs into 6809 machine code. All M09 assembler packages include the Introl M09 Relocating Macro Assembler, the ILINK Linker, a Loader, and the LIBMAN Library Manager. Resident versions of the M09 software package are available for use on 6809-based microcomputers running under UniFlex, Flex, or OS9. Cross-software versions are available for use on PDP-11 based development systems running UNIX or RSX-11M, and also for IBM PC hosts running PCDOS.

The Assembler is a full-featured relocating macro assembler that accepts a 6809 assembly language text file as input and produces a relocatable object file as its output. The included Linker and Loader permit any number of assembled modules and/or library modules to be linked together and then loaded to produce a single resultant output file in an executable format. The Library Manager provides convenient and versatile features for the user to create, and maintain, libraries of assembled modules. Resident assembler packages incorporate a host-specific Loader (ULD, FLD, or OLD, as applicable) that produces output files which are executable under the assembler's host operating system. M09 cross-assembler packages incorporate a hex-type Loader (HLD) which generates a file of output load records in any of several hex formats: Motorola S Records, Intel Hex, Tektronix Hex, or Extended Tektronix Hex format, at user option. Introl's HLD, ULD, FLD, and OLD Cross-Loader packages are optionally usable with any version of M09, and are available from Introl at extra cost. The M09 Macro Assembler is fully compatible, both in source format and object output, with the R09 Relocating Assembler that is supplied with the Introl-C/6809 C Compiler system.

M09 supports macros and conditional assembly, recognizes the standard opcodes recognized by Motorola assemblers, and supports the complete instruction set and all addressing modes of the 6809. The Assembler accepts assembly type input expressions that are arbitrarily complex. Parentheses are allowed in expressions to modify the evaluation order of operators. Symbols may be of any length, with the first 100 characters being significant and retained by the assembler. Assembly time expressions may be used in the operand of any assembler opcode or directive. Symbols and constants may be used interchangeably in an expression. All results of expressions at assembly time are 32-bit truncated integers.

The following assembly time options are supported by the M09 Assembler:

- a - Place all symbols except those beginning with a "?" character in the object file.
- c - Send Assembler's output listing to console.
- f - Force listing of all conditionally excluded code.
- i - Include all included files in output listing.
- j - Include symbols beginning with a "?" character in the output listing.
- l=(filename) - Place output listing in specified file.
- m - Include all macro-expansion-generated code in the output listing.
- n - Don't produce an output listing.
- O=(filename) - Explicitly assign name to the relocatable output file.
- p(digit)=(value) - Pass parameters to macro program being assembled.
- q=(class) - Assign numeric class identifier to the relocatable output module.
- s - Suppress listing of the symbol table.
- U - Force all undefined symbols to default to imported symbols.
- X - Don't generate an object module.
- y=(pathname) - Search "pathname" for macro files after searching current working area.
- z - Delete input file after Assembler has finished using it.

Assembly time expression operators supported:

- unary minus (twos complement)	& bitwise and
~ not (ones complement)	^ bitwise exclusive or
* multiplication	| bitwise inclusive or
/ division	> greater than
% mod (remainder)	< less than
+ addition	>= greater than or equal to
- subtraction	<= less than or equal to
<< shift left	== equal to
>> shift right	!= not equal to

Assembler directives supported:

comm - Common Area	if - Numeric Conditional Assembly
dc - Define Data Constant	ifn - Numeric Conditional Assembly
ds - Define Data Storage	ifc - String Compare Conditional Assembly
else - Conditional Assembly Else	ifnc - String Non-Compare Conditional Assembly
endif - End Of Conditional Assembly	import - External Symbol Reference
endm - End Of Macro Text	lib - Load A Disk File
end - End Of Assembly	list - Terminate Previous Nolist Directive
equ - Equate Symbol With A Value	loc - Select Location Counter
err - Programmer-Generated Error	macro - Define A Macro
exitm - Exit From Macro	nolist - Turn Off The Listing
export - External Symbol Definition	offset - Absolute Offset From An Origin
fcb - Form Constant Byte	repeat - Repeat The Next line
fcc - Form Constant Character	rmb - Reserve Memory Bytes
fdb - Form Double Byte Constant	set - Set Symbol To A Value
ident - Identify Module	syn - Equate Labels

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INTROL-C PRICE LIST

1-YEAR
MAINTENANCE

PART NO. PRODUCT DESCRIPTION PRICE DOMESTIC/FOREIGN

INTROL-C/6809 COMPILER PACKAGES

(All packages include ICC Compiler, R09 Assembler, ILINK Linker, LIBMAN Library Manager; resident compilers include applicable host-compatible Loader and Standard Library; cross-compilers include HLD Loader and STA09 Standard Library.

UC6809-UFX09	Resident compiler package for 6809/UniFlex host	\$425	\$100/\$135
FC6809-FIX09	Resident compiler package for 6809/Flex host	\$425	\$100/\$135
0C6809-05909	Resident compiler package for 6809/059 host	\$425	\$100/\$135
XC6809-UNX11	Cross-compiler package for POP-11/UNIX host	\$2500	\$500/\$550
RC6809-RSX11	Cross-compiler package for POP-11/RSX11M host	\$2500	\$500/\$550
PC6809-PCDOS	Cross-compiler package for IBM PC/PCDOS host	\$750	\$200/\$235
MAN-C6809	Manual only (Specify compiler type)	\$75	NA
MANEX-C6809	Additional Manual (Specify compiler type)	\$35	NA

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LIBRARY SOURCE CODE PACKAGES

UFX09LS-(*)	Source code for UC6809 Standard library	\$400	\$100/\$135
FLX09LS-(*)	Source code for FC6809 Standard Library	\$400	\$100/\$135
0S909LS-(*)	Source code for 0C6809 Standard library	\$400	\$100/\$135
STA09LS-(*)	Source code for XC6809/PC6809/RC6809 (Standalone) Library	\$400	\$100/\$135

(*Note: Specify host O.S. format desired; ie whether UniFlex, Flex, 0S9, UNIX, RSX11M, or PC DOS)

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CROSS LOADER PACKAGES

(HLD Loaders include STA09 Standalone Library; others include targeted-host-compatible Library)

HLD-UFX09	HLD (hex format output) Loader for UC6809 compiler	\$150	\$30/\$40
HLD-FLX09	HLD (hex format output) Loader for FC6809 compiler	\$150	\$30/\$40
HLD-OS909	HLD (hex format output) Loader for 0C6809 compiler	\$150	\$30/\$40
ULD-FLX09	ULD (UniFlex format output) Cross-loader for FC6809 compiler	\$150	\$30/\$40
ULD-OS909	ULD (UniFlex format output) Cross-Loader for 0C6809 compiler	\$150	\$30/\$40
ULD-UNX11	ULD (UniFlex format output) Cross-Loader for XC6809 compiler	\$300	\$75/\$90
ULD-PCDOS	ULD (UniFlex format output) Cross-Loader for PC6809 compiler	\$225	\$50/\$65
ULD-RSX11	ULD (UniFlex format output) Cross-Loader for RC6809 compiler	\$300	\$75/\$90
FLD-UFX09	FLD (Flex format output) Cross-Loader for UC6809 compiler	\$150	\$30/\$40
FLD-OS909	FLD (Flex format output) Cross-Loader for 0C6809 compiler	\$150	\$30/\$40
FLD-UNX11	FLD (Flex format output) Cross-Loader for XC6809 compiler	\$300	\$75/\$90
FLD-PCDOS	FLO (Flex format output) Cross-Loader for PC6809 compiler	\$225	\$50/\$65
FLD-RSX11	FLO (Flex format output) Cross-Loader for RC6809 compiler	\$300	\$75/\$90
OLD-UFX09	OLD (OS9 format output) Cross-Loader for UC6809 compiler	\$150	\$30/\$40
OLD-FLX09	OLD (OS9 format output) Cross-Loader for FC6809 compiler	\$150	\$30/\$40
OLD-UNX11	OLD (OS9 format output) Cross-Loader for XC6809 compiler	\$300	\$75/\$90
OLD-PCDOS	OLD (OS9-format output) Cross-Loader for PC6809 compiler	\$225	\$50/\$65
OLD-RSX11	OLD (OS9 format output) Cross-Loader for RC6809 compiler	\$300	\$75/\$90

<u>PART NO</u>	<u>PRODUCT DESCRIPTION</u>	<u>PRICE</u>	<u>DOMESTIC/FOREIGN</u>
6809 MACRO RELOCATING ASSEMBLER PACKAGES			
(All packages include M09 Macro Relocating Assembler, ILINK Linker and LIBMAN Library Manager; resident assemblers include host-compatible Loader; cross-assemblers include HLD Loader.)			
M09-UFX09	6809 Macro Relocating Assembler (UniFlex-09 host)	\$250	\$65/\$80
M09-FLX09	6809 Macro Relocating Assembler (Flex-09 host)	\$250	\$65/\$80
M09-OS909	6809 Macro Relocating Assembler (OS9-09 host)	\$250	\$65/\$80
M09-UNX11	6809 Macro Relocating Cross-Assembler (PDP-11/UNIX host)	\$1200	\$250/\$300
M09-RSX11	6809 Macro Relocating Cross-Assembler (PDP-11/R SX11M host)	\$1200	\$250/\$300
M09-PCDOS	6809 Macro Relocating Cross-Assembler (IBM PC/PC DOS host)	\$375	\$100/\$135
MAN-M09	Manual only (Specify Macro Assembler type)	\$35	NA
MANEX-M09	Additional Manual (Specify Macro Assembler type)	\$20	NA

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ORDERING INFORMATION

Introl software is available on the following floppy disk formats:

- UniFlex formats: 8" SSSD 77 track
- Flex formats: 8" SSSD 77 track; 5" DSDD 40 track; 5" SSSD 35 track
- OS9 formats: 8" SSSD 77 track; 5" DSDD 40 track; 5" SSSD 40 track
- PDP-11/UNIX formats: 8" RX01 Tar; 8" RX02 Tar; 8" Tektronix Tar
- PDP-11/R SX11M formats: 8" RT-11
- IBM PC/PC DOS formats: 5" DSDD

All prices are F.O.B. Milwaukee, Wisconsin, U.S.A. Prices and product specifications are subject to change without notice. All orders must be prepaid in U.S. funds drawn on a U.S. bank or shipped C.O.D. VISA and Master Card accepted. End users in Wisconsin, please add applicable Wisconsin State Sales Taxes. All domestic orders should include \$10.00 shipping and handling, \$25.00 for all overseas orders

Prices shown are for single-CPU use licenses. Site licensing and OEM licensing is also available.

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INTROL-C/6809 STANDARD LIBRARIES

(Representative Support Functions Provided)

STA09	UFX09	FLX09	OS909	LIB.	LIB.	LIB.	LIB.	FUNCTION	DESCRIPTION
	X							abs	integer absolute value
	X							access	determine accessibility of file
	X							acct	turn accounting on/off
	X							alarm	send alarm signal after specified time
X	X	X	X					alloc	allocate memory
X	X	X	X					atof	convert string to float
X	X	X	X					atoi	convert string to integer
X	X	X	X					atol	convert string to long
	X							brk	change core allocation
		X						cforkf	fork off a program
		X						chain	chain a new executable module from a C program
	X							chdir	change default directory
	X							chmod	change file access permission
	X							chown	change the owner of a file
	X							close	close a file
X	X	X	X					cprep	prepare environment for a C program
			X					crc	cycle redundancy count
X	X		X					creat	create a file
	X	X	X					cstart	runtime preparation routine
	X							dup	duplicate an open file descriptor
	X							dup2	duplicate an open file descriptor
X	X	X	X					ecvt	float to string conversion
	X	X	X					execl	execute a program
	X							execv	execute a program
	X	X	X					exit	exit a program with file cleanup
	X	X	X					_exit	exit a program without file cleanup
X	X	X	X					_extend	extend float
	X	X	X					fclose	close file
X	X	X	X					fcvt	float to string conversion
	X							fdopen	open a file
	X		X					fflush	flush file buffer
X	X	X	X					fgets	read file into string
	X							fdopen	open a file
	X		X					fork	spawn a new process
X	X	X	X					fprintf	formatted output Conversion
X	X	X	X					fputs	write a string to a file
X	X	X	X					free	free memory
X	X	X	X					fscanf	formatted input conversion
	X							fseek	seek to position in a stream
	X							fstat	get file status of open file
	X							ftell	tell the current position in a file
	X							ftime	current time
X	X	X	X					getc	get next character from a file
X	X	X	X					getchar	get a character from the standard input
	X							getegid	get effective group user id
	X							geteuid	get effective tiser id
	X							getgid	get group user id
	X		X					getpid	get process id
X	X	X	X					gets	read input into string
			X					getstat	get status of file or device id
	X		X					getuid	get user
	X							gtty	get status of file or device
X	X	X	X					index	find first occurrence of character
			X					intercept	intercept signals
	X							ioctl	control device
X	X	X	X					isalpha	test for alpha character
	X							isatty	test for terminal
X	X	X	X					isdigit	test for digit
X	X	X	X					islower	test for lower case
X	X	X	X					isspace	test for white space
X	X	X	X					isupper	test for upper case
X	X	X	X					itoa	convert integer to ASCII string
	X							kill	send a signal to a process
	X							link	link to a file
X	X	X	X					longjmp	non-local goto
	X		X					lseek	seek to a position in a file
X	X	X	X					malloc	allocate memory
X	X	X	X					max	return the maximum of two values
X	X	X	X					min	return the minimum of two values

INTROL-C/6809 STANDARD LIBRARIES (cont'd)

<u>STA09</u>	<u>UFX09</u>	<u>FLX09</u>	<u>OS909</u>	<u>FUNCTION</u>	<u>DESCRIPTION</u>
<u>LIB.</u>	<u>LIB.</u>	<u>LIB.</u>	<u>LIB.</u>		
.....	X	.....	.....	mknod	make special file or directory
X	....	X	....	modf	return fractional part of a float
.....	X	.....	.....	mount	mount a file sub-system
X	....	X	....	movmem	copy a block of memory from one location to another
.....	X	.....	.....	nice	change program priority
.....	X	.....	X	open	open a file
.....	X	.....	.....	pause	stop until signal
.....	X	.....	.....	perror	print error message
.....	X	.....	.....	pipe	create an inter-process channel
X	....	X	....	printf	formatted output conversion
.....	X	.....	.....	profil	profile a process
.....	X	.....	.....	ptrace	process trace
X	....	X	....	putc	write a character to a file
X	....	X	....	putchar	write a character to the standard input
X	....	X	....	puts	write a string to standard output
.....	X	.....	X	read	read from a file
.....	X	.....	X	readln	read a line from a file
X	....	X	....	reverse	reverse a string in place
.....	X	.....	X	rewind	reset specified file to beginning
X	....	X	....	rindex	find last occurrence of character
X	....	X	....	sbrk	allocate memory
X	....	X	....	scanf	formatted input conversion
.....	X	.....	X	send	send a signal to a process
.....	X	.....	.....	setgid	set group user id
X	....	X	....	setjmp	non-local goto
.....	X	.....	X	setstat	set status of file or device
.....	X	.....	.....	setuid	set the effective user id
.....	X	.....	.....	signal	catch or ignore signals
.....	X	.....	X	sleep	suspend execution of process
X	....	X	....	sprintf	formatted output conversion
X	....	X	....	sscanf	formatted string conversion
.....	X	.....	.....	stat	get file status
.....	X	.....	.....	stime	set the system time and date
X	....	X	....	strcat	copy string
X	....	X	....	strcmp	compare strings lexicographically
X	....	X	....	strcpy	copy string
X	....	X	....	strlen	return string length
X	....	X	....	strncat	copy string
X	....	X	....	strncmp	compare strings lexicographically
X	....	X	....	strncpy	copy string
X	....	X	....	strsave	save string in memory
.....	X	.....	.....	stty	get status of file or device
.....	X	.....	.....	sync	update all disks
.....	X	.....	.....	syscall	C system call interface
.....	X	.....	.....	system	run a command string
.....	X	.....	X	tell	return the current file position
.....	X	.....	X	time	return the system time
.....	X	.....	.....	times	get process times
X	....	X	....	tolower	convert to lower case
X	....	X	....	toupper	convert to upper case
X	....	X	....	uldiv	unsigned long integer divide
X	....	X	....	ulmod	unsigned long modulo operation
X	....	X	....	ulmul	unsigned long multiply
.....	X	.....	.....	umask	set the default file access bits
.....	X	.....	.....	umount	unmount a file sub-system
X	....	X	....	_unext	unextend float
.....	X	.....	X	ungetc	push character back on input stream
.....	X	.....	X	unlink	delete file
.....	X	.....	X	wait	wait for child process to terminate
.....	X	.....	X	write	write to a file
.....	X	.....	X	writeln	write a line to a file

NOTE: The STA09 Library is included with cross-compiler packages and with HLD cross-loader packages; the UNX09 Library with UC6809 compilers and with ULD cross-loader packages; the FLX09 Library with FC6809 compilers and with FLD cross-loader packages; the OS909 Library with OC6809 compilers and with OLD cross-loader packages.

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