

WILHELM GEHRKE

# Fortran 90

## Language Guide



Springer

Wilhelm Gehrke

2-005-373

# Fortran 90 Language Guide



Springer

London Berlin Heidelberg New York

Paris Tokyo Hong Kong

Barcelona Budapest

# CONTENTS

<b>1</b>	<b>SOURCE FORM</b>	<b>1-1</b>
1.1	Fixed Source Form . . . . .	1-2
1.2	Free Source Form . . . . .	1-4
1.3	Embedding of Program Lines by INCLUDE . . . . .	1-6
1.4	Classification of Fortran Statements . . . . .	1-7
1.5	Statement Ordering . . . . .	1-8
<b>2</b>	<b>TYPE CONCEPT</b>	<b>2-1</b>
2.1	Intrinsic Types . . . . .	2-1
2.1.1	Integer Type . . . . .	2-1
2.1.2	Real Type and Double Precision Real Type . . . . .	2-2
2.1.3	Complex Type . . . . .	2-3
2.1.4	Logical Type . . . . .	2-4
2.1.5	Character Type . . . . .	2-4
2.2	Derived Types . . . . .	2-5
2.2.1	Derived Type Definition . . . . .	2-5
2.2.2	Type Component Definition . . . . .	2-7
2.2.3	Private and Public Derived Type Definitions . . . . .	2-9
2.2.4	Structure Objects . . . . .	2-11
<b>3</b>	<b>LEXICAL TOKENS</b>	<b>3-1</b>
3.1	Scoping Units . . . . .	3-1
3.2	Keywords . . . . .	3-1
3.3	Names . . . . .	3-2
3.4	Operators . . . . .	3-3
3.5	Statement Labels . . . . .	3-3
3.6	Literal Constants . . . . .	3-3
3.6.1	Integer Literal Constants . . . . .	3-4
3.6.2	Real Literal Constants . . . . .	3-4
3.6.3	Double Precision Real Literal Constants . . . . .	3-5
3.6.4	Complex Literal Constants . . . . .	3-5
3.6.5	Logical Literal Constants . . . . .	3-6
3.6.6	Character Literal Constants . . . . .	3-7
3.6.7	Binary, Octal, and Hexadecimal Literal Constants . . . . .	3-8

<b>4</b>	<b>Data Objects</b>	<b>4-1</b>
4.1	Constants . . . . .	4-2
4.2	Variables . . . . .	4-3
4.3	Scalars . . . . .	4-4
	4.3.1 Character Substrings . . . . .	4-4
4.4	Arrays . . . . .	4-6
	4.4.1 Inner Structure of Arrays . . . . .	4-8
4.5	Structure Components . . . . .	4-10
4.6	Automatic Variables . . . . .	4-12
4.7	Association . . . . .	4-12
	4.7.1 Name Association . . . . .	4-12
	4.7.2 Pointer Association . . . . .	4-14
	4.7.3 Storage Association . . . . .	4-14
4.8	Definition Status . . . . .	4-16
<b>5</b>	<b>POINTERS</b>	<b>5-1</b>
5.1	Pointer Processing . . . . .	5-2
	5.1.1 Creation of Pointer Targets . . . . .	5-2
	5.1.2 Association Status . . . . .	5-3
	5.1.3 Deallocation of Pointer Targets . . . . .	5-5
	5.1.4 Nullification of Pointer Associations . . . . .	5-6
<b>6</b>	<b>ARRAY PROCESSING</b>	<b>6-1</b>
6.1	Array Declaration . . . . .	6-1
	6.1.1 Explicit-Shape Arrays . . . . .	6-2
	6.1.2 Assumed-Shape Arrays . . . . .	6-2
	6.1.3 Assumed-Size Arrays . . . . .	6-3
6.2	Reference and Use . . . . .	6-4
	6.2.1 Whole Arrays . . . . .	6-4
	6.2.2 Array Elements . . . . .	6-5
	6.2.3 Array Sections . . . . .	6-6
	6.2.3.1 Subscript-Triplet . . . . .	6-9
	6.2.3.2 Vector-Subscript . . . . .	6-11
	6.2.3.3 Array Sections of Substrings . . . . .	6-12
6.3	Memory Management and Dynamic Control . . . . .	6-13
	6.3.1 Automatic Arrays . . . . .	6-14
	6.3.2 Allocatable Arrays . . . . .	6-14
	6.3.3 Array Pointers . . . . .	6-16
6.4	Construction of Array Values . . . . .	6-18
6.5	Operations on Arrays . . . . .	6-19
	6.5.1 Array Expressions . . . . .	6-20
	6.5.2 Array Subprograms . . . . .	6-21
	6.5.3 Array Assignments . . . . .	6-21

<b>7</b>	<b>EXPRESSIONS</b>	<b>7-1</b>
7.1	Numeric Intrinsic Expressions . . . . .	7-3
7.2	Relational Intrinsic Expressions . . . . .	7-7
7.2.1	Numeric Relational Intrinsic Expressions . . . . .	7-8
7.2.2	Character Relational Intrinsic Expressions . . . . .	7-9
7.3	Logical Intrinsic Expressions . . . . .	7-10
7.4	Character Intrinsic Expressions . . . . .	7-12
7.5	Defined Expressions . . . . .	7-14
7.5.1	Defined Operators and Extended Intrinsic Operators	7-15
7.5.1.1	Nonextended Defined Operator . . . . .	7-17
7.5.1.2	Extended Defined Operator . . . . .	7-18
7.5.1.3	Extended Intrinsic Operator . . . . .	7-18
7.6	Common Rules for Expressions . . . . .	7-19
7.6.1	Precedence of Operators . . . . .	7-19
7.6.2	Interpretation of Expressions . . . . .	7-20
7.6.3	Evaluation of Expressions . . . . .	7-21
7.7	Special Expressions . . . . .	7-23
7.7.1	Constant Expressions . . . . .	7-23
7.7.2	Initialization Expressions . . . . .	7-24
7.7.3	Specification Expressions . . . . .	7-25
<b>8</b>	<b>ASSIGNMENTS</b>	<b>8-1</b>
8.1	ASSIGN Statement . . . . .	8-1
8.2	Intrinsic Assignment Statements . . . . .	8-2
8.2.1	Numeric Assignment Statement . . . . .	8-3
8.2.2	Logical Assignment Statement . . . . .	8-4
8.2.3	Character Assignment Statement . . . . .	8-4
8.2.4	Assignment Statement for Derived Types . . . . .	8-5
8.3	Defined Assignment Statements . . . . .	8-6
8.3.1	Nonextended Defined Assignment . . . . .	8-8
8.3.2	Extended Defined Assignment . . . . .	8-9
8.4	Masked Array Assignments . . . . .	8-10
8.4.1	WHERE Statement . . . . .	8-10
8.4.2	WHERE Construct Statement, ELSEWHERE State- ment, and END WHERE Statement . . . . .	8-11
8.4.2.1	WHERE Constructs . . . . .	8-11
8.4.3	Common Rules for Masked Array Assignments . . . . .	8-12
8.5	Pointer Assignment Statement . . . . .	8-13
<b>9</b>	<b>DECLARATIONS AND SPECIFICATIONS</b>	<b>9-1</b>
9.1	Attributes . . . . .	9-2
9.1.1	ALLOCATABLE Attribute . . . . .	9-3

9.1.2	DATA Attribute . . . . .	9-4
9.1.3	DIMENSION Attribute . . . . .	9-4
9.1.4	EXTERNAL Attribute . . . . .	9-5
9.1.5	INTENT Attribute . . . . .	9-5
9.1.6	INTRINSIC Attribute . . . . .	9-6
9.1.7	OPTIONAL Attribute . . . . .	9-7
9.1.8	PARAMETER Attribute . . . . .	9-7
9.1.9	POINTER Attribute . . . . .	9-8
9.1.10	PRIVATE Attribute . . . . .	9-8
9.1.11	PUBLIC Attribute . . . . .	9-9
9.1.12	SAVE Attribute . . . . .	9-9
9.1.13	TARGET Attribute . . . . .	9-10
9.2	Type Declaration Statements . . . . .	9-11
9.2.1	INTEGER Statement . . . . .	9-13
9.2.2	REAL Statement . . . . .	9-14
9.2.3	DOUBLE PRECISION Statement . . . . .	9-14
9.2.4	COMPLEX Statement . . . . .	9-15
9.2.5	LOGICAL Statement . . . . .	9-15
9.2.6	CHARACTER Statement . . . . .	9-16
9.2.6.1	Character Length . . . . .	9-17
9.2.7	TYPE Declaration Statement . . . . .	9-18
9.3	Attribute Specification Statements . . . . .	9-19
9.3.1	ALLOCATABLE Statement . . . . .	9-19
9.3.2	DATA Statement . . . . .	9-19
9.3.2.1	Implied-DO . . . . .	9-22
9.3.3	DIMENSION Statement . . . . .	9-23
9.3.4	EXTERNAL Statement . . . . .	9-23
9.3.5	INTENT Statement . . . . .	9-24
9.3.6	INTRINSIC Statement . . . . .	9-24
9.3.7	OPTIONAL Statement . . . . .	9-24
9.3.8	PARAMETER Statement . . . . .	9-25
9.3.9	POINTER Statement . . . . .	9-26
9.3.10	PRIVATE Statement . . . . .	9-26
9.3.11	PUBLIC Statement . . . . .	9-27
9.3.12	SAVE Statement . . . . .	9-28
9.3.13	TARGET Statement . . . . .	9-30
9.4	Additional Specification Statements . . . . .	9-30
9.4.1	COMMON Statement . . . . .	9-30
9.4.2	EQUIVALENCE Statement . . . . .	9-35
9.4.2.1	EQUIVALENCE and COMMON . . . . .	9-39
9.4.3	IMPLICIT Statement . . . . .	9-39
9.4.4	NAMelist Statement . . . . .	9-43

<b>10 EXECUTION CONTROL</b>	<b>10-1</b>
10.1 GO TO Statements . . . . .	10-2
10.1.1 Unconditional GO TO Statement . . . . .	10-2
10.1.2 Computed GO TO Statement . . . . .	10-2
10.1.3 Assigned GO TO Statement . . . . .	10-3
10.2 IF Statements . . . . .	10-3
10.2.1 Arithmetic IF Statement . . . . .	10-4
10.2.2 Logical IF Statement . . . . .	10-4
10.3 IF Construct . . . . .	10-5
10.3.1 Simple IF Constructs . . . . .	10-6
10.3.2 Nested IF Constructs . . . . .	10-9
10.4 CASE Construct . . . . .	10-10
10.4.1 Simple CASE Constructs . . . . .	10-13
10.5 DO Construct . . . . .	10-14
10.5.1 DO Statement . . . . .	10-15
10.5.2 Do-Termination Statement . . . . .	10-15
10.5.3 Forms for DO Constructs . . . . .	10-16
10.5.4 Execution of a DO Construct . . . . .	10-17
10.5.4.1 Additional Details about Count Loops . . . . .	10-18
10.5.4.2 Additional Details about WHILE Loops . . . . .	10-19
10.5.4.3 Additional Details about Endless Loops . . . . .	10-20
10.5.4.4 CYCLE Statement, EXIT Statement . . . . .	10-20
10.5.5 Nested DO Constructs . . . . .	10-21
10.6 Nested Constructs . . . . .	10-22
10.7 CONTINUE Statement . . . . .	10-23
10.8 PAUSE Statement . . . . .	10-23
10.9 STOP Statement . . . . .	10-24
10.10 CALL, END, and RETURN Statements . . . . .	10-24
<b>11 INPUT/OUTPUT</b>	<b>11-1</b>
11.1 Records . . . . .	11-1
11.2 Files . . . . .	11-2
11.3 File Attribute of External Files . . . . .	11-2
11.3.1 File Names . . . . .	11-3
11.3.2 Access Methods . . . . .	11-3
11.3.2.1 Sequential Access . . . . .	11-3
11.3.2.2 Direct Access . . . . .	11-3
11.3.3 Form of a File . . . . .	11-5
11.3.4 File Position . . . . .	11-5
11.4 Units . . . . .	11-6
11.5 Preconnected Units and Predefined Files . . . . .	11-7
11.6 Input/Output Statements . . . . .	11-8

11.6.1	Input/Output Specifiers . . . . .	11-8
11.6.1.1	UNIT= Specifier . . . . .	11-9
11.6.1.2	FMT= Specifier . . . . .	11-9
11.6.1.3	NML= Specifier . . . . .	11-9
11.6.1.4	REC= Specifier . . . . .	11-10
11.6.1.5	ADVANCE= Specifier . . . . .	11-10
11.6.1.6	End-of-Record Condition and EOR= Specifier	11-10
11.6.1.7	IOSTAT= Specifier . . . . .	11-11
11.6.1.8	Error Conditions and ERR= Specifier . . . . .	11-12
11.6.1.9	End-of-File Condition and END= Specifier . .	11-13
11.6.1.10	SIZE= Specifier . . . . .	11-14
11.6.2	Input/Output Lists . . . . .	11-14
11.6.2.1	Implied-DO . . . . .	11-17
11.6.3	Data Transfer Statements . . . . .	11-19
11.6.3.1	Formatted Input/Output . . . . .	11-21
11.6.3.2	Unformatted Input/Output . . . . .	11-24
11.6.3.3	List-Directed Input/Output . . . . .	11-25
11.6.3.4	Internal Input/Output . . . . .	11-30
11.6.3.5	Namelist Input/output . . . . .	11-33
11.6.3.6	Nonadvancing Input/Output . . . . .	11-38
11.6.3.7	Printing . . . . .	11-40
11.6.4	File Status Statements . . . . .	11-41
11.6.4.1	OPEN Statement . . . . .	11-41
11.6.4.2	CLOSE Statement . . . . .	11-45
11.6.4.3	INQUIRE Statement . . . . .	11-46
11.6.5	File Positioning Statements . . . . .	11-51
<b>12</b>	<b>FORMATS</b>	<b>12-1</b>
12.1	Format Specification . . . . .	12-1
12.1.1	Format Specification in FORMAT Statement . . . . .	12-1
12.1.2	Character Format Specification . . . . .	12-2
12.2	Interaction between Input/Output List and Format . . . . .	12-3
12.2.1	Repeat Specification, Groups of Edit Descriptors . . .	12-4
12.2.2	Format Reversion . . . . .	12-4
12.3	Edit Descriptors . . . . .	12-5
12.3.1	A Edit Descriptors . . . . .	12-8
12.3.2	B Edit Descriptors . . . . .	12-9
12.3.3	Blank Control Edit Descriptors . . . . .	12-10
12.3.4	Character Constant Edit Descriptors . . . . .	12-11
12.3.5	Colon Edit Descriptor . . . . .	12-11
12.3.6	D Edit Descriptor . . . . .	12-12
12.3.7	E Edit Descriptors . . . . .	12-14

12.3.8	EN Edit Descriptors . . . . .	12-14
12.3.9	ES Edit Descriptors . . . . .	12-15
12.3.10	F Edit Descriptor . . . . .	12-15
12.3.11	G Edit Descriptors . . . . .	12-16
12.3.12	H Edit Descriptor . . . . .	12-17
12.3.13	I Edit Descriptors . . . . .	12-17
12.3.14	L Edit Descriptor . . . . .	12-18
12.3.15	O Edit Descriptors . . . . .	12-19
12.3.16	P Edit Descriptor, Scale Factor . . . . .	12-20
12.3.17	Sign Control Edit Descriptors . . . . .	12-22
12.3.18	Slash Edit Descriptor . . . . .	12-22
12.3.19	Tabulator Edit Descriptors . . . . .	12-23
12.3.20	X Edit Descriptor . . . . .	12-24
12.3.21	Z Edit Descriptors . . . . .	12-25
<b>13</b>	<b>PROGRAM UNITS AND SUBPROGRAMS</b>	<b>13-1</b>
13.1	Main Program . . . . .	13-1
13.2	Modules . . . . .	13-3
13.2.1	USE Statement . . . . .	13-4
13.3	Block Data Program Units . . . . .	13-6
13.4	Subprograms . . . . .	13-7
13.4.1	User-Defined Functions (except Statement Functions)	13-9
13.4.1.1	Function Definition . . . . .	13-10
13.4.1.2	Explicit Invocation of a Function, Function Reference . . . . .	13-13
13.4.1.3	Operator Functions . . . . .	13-15
13.4.2	User-Defined Subroutines . . . . .	13-16
13.4.2.1	Subroutine Definition . . . . .	13-16
13.4.2.2	Explicit Invocation of a Subroutine, CALL Statement . . . . .	13-18
13.4.2.3	Assignment Subroutines . . . . .	13-19
13.4.3	External Subprograms . . . . .	13-19
13.4.4	Internal Subprograms . . . . .	13-21
13.4.5	Module Subprograms . . . . .	13-23
13.4.6	Dummy Subprograms . . . . .	13-24
13.4.7	Statement Functions . . . . .	13-24
13.4.7.1	Statement Function Definition . . . . .	13-25
13.4.7.2	Invocation of a Statement Function . . . . .	13-26
13.4.8	Interface Blocks . . . . .	13-27
13.4.9	Overloaded Generic Subprogram Names . . . . .	13-31
13.4.10	Additional Entry Points, ENTRY Statement . . . . .	13-32
13.4.11	Return from the Invoked Subprogram . . . . .	13-34

13.5	Communication between Program Units and Subprograms . . .	13-36
13.5.1	Argument Lists . . . . .	13-37
13.5.1.1	Dummy Argument List . . . . .	13-37
13.5.1.2	Actual Argument List . . . . .	13-38
13.5.2	Argument Association . . . . .	13-39
13.5.2.1	Data Objects as Dummy Arguments . . . . .	13-41
13.5.2.2	Implicit Association of Two Dummy Arguments	13-42
13.5.2.3	Length of Character Dummy Arguments . . . . .	13-43
13.5.2.4	Scalar Arguments . . . . .	13-45
13.5.2.5	Dummy (Argument) Arrays . . . . .	13-45
13.5.2.6	Dummy (Argument) Pointers . . . . .	13-46
13.5.2.7	Sequence Association . . . . .	13-47
13.5.2.8	Assumed-Size Arrays . . . . .	13-49
13.5.2.9	Assumed-Shape Arrays . . . . .	13-49
13.5.2.10	Restrictions on the Association of Data Entities	13-49
13.5.2.11	Dummy Subprograms . . . . .	13-50
13.5.2.12	Asterisk Dummy Arguments . . . . .	13-50
13.5.3	Optional Dummy Arguments . . . . .	13-51
13.5.4	Dummy Argument with INTENT Attribute . . . . .	13-52
13.5.5	Common Blocks . . . . .	13-52
<b>14</b>	<b>INTRINSIC SUBPROGRAMS</b>	<b>14-1</b>
14.1	Intrinsic Functions . . . . .	14-1
14.1.1	Table of Intrinsic Functions . . . . .	14-3
14.2	Intrinsic Subroutines . . . . .	14-9
14.3	Intrinsic Subprogram Reference . . . . .	14-9
14.4	Intrinsic Subprogram Definitions . . . . .	14-10
14.4.1	Descriptions . . . . .	14-13
<b>A</b>	<b>CHARACTER SETS AND COLLATING SEQUENCES</b>	<b>A-1</b>
A.1	Processor-Dependent Character Sets . . . . .	A-1
A.2	ASCII Character Set . . . . .	A-1
<b>B</b>	<b>MODELS FOR NUMBERS</b>	<b>B-1</b>
B.1	Models for Integers . . . . .	B-1
B.2	Models for Reals . . . . .	B-1
B.3	Models for Bit Manipulation . . . . .	B-2
<b>C</b>	<b>INDEX</b>	<b>C-1</b>