

MMBasic Structures User Manual

Introduction

Structures (also known as User-Defined Types) allow you to group related variables of different types together under a single name. This is useful for organizing complex data such as coordinates, records, or any collection of related values. Structures are available on PicoMite RP2350 builds.

Defining a Structure Type

Use the "TYPE...END TYPE" block to define a new structure type:

```
Type typename
  member1 As type
  member2 As type
  ...
End Type
```

Supported Member Types

- "INTEGER" - 64-bit signed integer
- "FLOAT" - 64-bit floating point number
- "STRING" - String up to 255 characters (use "LENGTH n" to specify maximum length)

Examples

Simple structure:

```
Type Point
  x As INTEGER
  y As INTEGER
End Type
```

Structure with mixed types:

```
Type Person
  age As INTEGER
  height As FLOAT
  name As STRING
End Type
```

Structure with string length specified:

```
Type Record
  id As INTEGER
  description As STRING LENGTH 100
End Type
```

Declaring Structure Variables

Use "DIM" to declare variables of a structure type:

```
Dim variablename As typename
```

Examples

Simple structure variable:

```
Type Point
  x As INTEGER
  y As INTEGER
End Type

Dim p As Point
Dim origin As Point
```

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Multiple variables:

```
Dim p1 As Point, p2 As Point, p3 As Point
```

Accessing Structure Members

Use the dot (".") notation to access individual members:

```
variablename.membername
```

Examples

Setting values:

```
Dim p As Point
p.x = 100
p.y = 200
```

Reading values:

```
Print p.x, p.y
result = p.x + p.y
```

Using in expressions:

```
distance = Sqr(p.x * p.x + p.y * p.y)
```

Arrays of Structures

You can create arrays where each element is a structure:

```
Dim arrayname(size) As typename
```

Examples

Declaring an array of structures:

```
Dim points(10) As Point
```

Accessing array elements:

```
points(0).x = 10
points(0).y = 20
points(1).x = 30
points(1).y = 40

Print points(0).x, points(0).y
```

Using variable indices:

```
For i = 0 To 10
    points(i).x = i * 10
    points(i).y = i * 20
Next i
```

Multi-dimensional arrays:

```
Dim grid(10, 10) As Point
grid(5, 5).x = 100
grid(5, 5).y = 200
```

Initializing Structures

Structures can be initialized when declared using parentheses with comma-separated values:

```
Dim variablename As typename = (value1, value2, ...)
```

Values must be provided in the order the members are defined in the TYPE block.

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Examples

Simple structure initialization:

```
Type Point
  x As INTEGER
  y As INTEGER
End Type

Dim p As Point = (100, 200)
' p.x = 100, p.y = 200
```

Structure with string:

```
Type Person
  age As INTEGER
  height As FLOAT
  name As STRING
End Type

Dim person1 As Person = (25, 1.75, "Alice")
```

Array of structures initialization:

```
Dim points(2) As Point = (10, 20, 30, 40, 50, 60)
' points(0).x = 10, points(0).y = 20
' points(1).x = 30, points(1).y = 40
' points(2).x = 50, points(2).y = 60
```

Values are assigned sequentially: all members of element 0, then all members of element 1, etc.

Copying Structures

Use the "STRUCT COPY" command to copy all members from one structure to another:

```
Struct Copy source To destination
```

Both variables must be of the same structure type.

Copying Single Structures

```
Dim src As Point, dst As Point
src.x = 100
src.y = 200

Struct Copy src To dst
' dst.x = 100, dst.y = 200
```

Copying Entire Arrays

You can copy entire structure arrays using empty parentheses:

```
Struct Copy sourceArray() To destinationArray()
```

Requirements:

- Both arrays must be the same structure type
- The destination array must be at least as large as the source array
- Both must use the "()" syntax, or both must be single elements
- Only the source elements are copied (extra destination elements are preserved)

Example:

```
Dim src(2) As Point
src(0).x = 10 : src(0).y = 11
src(1).x = 20 : src(1).y = 21
src(2).x = 30 : src(2).y = 31
```

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```
Dim dst(4) As Point ' Larger destination is OK
Struct Copy src() To dst()
' dst(0), dst(1), dst(2) now contain copies from src
' dst(3), dst(4) are unchanged
```

Example - Same size arrays:

```
Dim original(10) As Person
' ... populate array ...

Dim backup(10) As Person
Struct Copy original() To backup()
```

Sorting Structure Arrays

Use the "STRUCT SORT" command to sort an array of structures in-place based on any member field:

```
Struct Sort array(), membername [, flags]
```

Parameters

- "array()" - The structure array to sort (must include empty parentheses)
- "membername" - The name of the member field to sort by
- "flags" - Optional flags to modify sort behavior (can be combined by adding):

Value	Description
:-----:	-----
0	Default: ascending sort, case-sensitive
1	Reverse sort (descending order)
2	Case-insensitive sort (strings only)
4	Empty strings sort to end of array (strings only)

Flags can be combined by adding values (e.g., 3 = descending + case-insensitive).

Examples

Sort by integer field (ascending):

```
Type Person
  age As INTEGER
  name As STRING
End Type

Dim people(3) As Person
people(0).age = 35 : people(0).name = "Charlie"
people(1).age = 25 : people(1).name = "Alice"
people(2).age = 45 : people(2).name = "David"
people(3).age = 30 : people(3).name = "Bob"

Struct Sort people(), age
' Result: Alice(25), Bob(30), Charlie(35), David(45)
```

Sort by string field:

```
Struct Sort people(), name
' Result: Alice, Bob, Charlie, David
```

Reverse sort (descending):

```
Struct Sort people(), age, 1
' Result: David(45), Charlie(35), Bob(30), Alice(25)
```

Case-insensitive string sort:

```
Struct Sort people(), name, 2
```

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Combine flags (reverse + case-insensitive):

```
Struct Sort people(), name, 3
' 3 = 1 + 2 (reverse + case insensitive)
```

Empty strings at end:

```
Struct Sort people(), name, 4
' Non-empty strings sorted first, empty strings at end
```

Notes

- The entire structure is moved during sorting, not just the sort key
- All other member values are preserved with their corresponding records
- The sort is performed in-place (no additional array is created)
- Array members within structures cannot be used as sort keys
- Supports INTEGER, FLOAT, and STRING member types

Clearing Structures

Use the "STRUCT CLEAR" command to reset all members of a structure to their default values (0 for numbers, empty string for strings):

```
Struct Clear variable
Struct Clear array()
```

Examples

Clear a single structure:

```
Dim p As Point
p.x = 100
p.y = 200

Struct Clear p
' p.x = 0, p.y = 0
```

Clear an entire array of structures:

```
Dim people(10) As Person
' ... populate array ...

Struct Clear people()
' All elements reset to defaults
```

Swapping Structures

Use the "STRUCT SWAP" command to exchange the contents of two structure variables:

```
Struct Swap var1, var2
```

Both variables must be of the same structure type. This is useful when implementing sorting algorithms or reordering records.

Examples

```
Dim a As Point, b As Point
a.x = 10 : a.y = 20
b.x = 30 : b.y = 40

Struct Swap a, b
' Now: a.x = 30, a.y = 40, b.x = 10, b.y = 20
```

Swapping array elements:

```
Dim people(5) As Person
```

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```
' ... populate array ...  
  
Struct Swap people(2), people(4)  
' Elements 2 and 4 are exchanged
```

Printing Structures

Use the "STRUCT PRINT" command to display all members of a structure for debugging:

```
Struct Print variable  
Struct Print array()  
Struct Print array(index)
```

Forms

- "Struct Print variable" - Print a single structure variable
- "Struct Print array()" - Print all elements of a structure array
- "Struct Print array(n)" - Print a specific element of a structure array

Examples

Print a single structure:

```
Dim p As Person  
p.name = "Alice"  
p.age = 25  
p.height = 1.65  
  
Struct Print p
```

Output:

```
Person:  
  .name = "Alice"  
  .age = 25  
  .height = 1.65
```

Print an array element:

```
Dim people(10) As Person  
' ... populate array ...  
  
Struct Print people(0)
```

Print entire array:

```
Struct Print people()
```

Output:

```
Person array (11 elements):  
[0]:  
  .name = "Alice"  
  .age = 25  
  .height = 1.65  
[1]:  
  .name = "Bob"  
  .age = 30  
  .height = 1.80  
...
```

Notes

- Array members are printed as comma-separated values
- Strings are displayed with surrounding quotes
- Useful for debugging and inspecting structure contents

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Searching Structure Arrays

Use the "STRUCT(FIND, ...)" function to search a structure array for an element with a matching member value:

```
index = Struct(FIND, array(), membername$, value [, start])
```

Parameters

- "FIND" - The subfunction name
- "array()" - The structure array to search (must include empty parentheses)
- "membername\$" - The name of the member field to search (as a string)
- "value" - The value to search for (must match the member's type)
- "start" - Optional. The index to start searching from (default: first element)

Return Value

- Returns the index of the first matching element (starting from "start")
- Returns -1 if no match is found

Examples

Find by integer:

```
Type Person
  age As INTEGER
  name As STRING
End Type

Dim people(10) As Person
' ... populate array ...

idx = Struct(FIND, people(), "age", 35)
If idx >= 0 Then
  Print "Found at index"; idx; ": "; people(idx).name
Else
  Print "Not found"
EndIf
```

Find by string:

```
idx = Struct(FIND, people(), "name", "Alice")
If idx >= 0 Then
  Print "Alice is at index"; idx
EndIf
```

Find by float:

```
idx = Struct(FIND, people(), "height", 1.75)
```

Iterate through all matches using start parameter:

```
' Find all people aged 30
idx = Struct(FIND, people(), "age", 30)
Do While idx >= 0
  Print "Found at index"; idx; ": "; people(idx).name
  idx = Struct(FIND, people(), "age", 30, idx + 1)
Loop
```

Notes

- Search is performed linearly from the start position
- Only the first match (from the start position) is returned
- Use the start parameter to iterate through multiple matches
- For strings, comparison is case-sensitive and exact

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- Array members within structures cannot be searched
- The member name is passed as a string (can be a variable)

Getting Array Bounds

Use the "STRUCT(SIZE, ...)" function to get the upper bound of a structure array dimension:

```
upperBound = Struct(SIZE, array() [, dimension])
```

Parameters

- "SIZE" - The subfunction name
- "array()" - The structure array (must include empty parentheses)
- "dimension" - Optional. Which dimension to query (1-based, default: 1)

Return Value

- Returns the upper bound of the specified dimension

Examples

Basic usage (1D array):

```
Dim points(9) As Point
bound = Struct(SIZE, points()) ' Returns 9
```

Multi-dimensional array:

```
Dim grid(4, 7) As Point
dim1 = Struct(SIZE, grid(), 1) ' Returns 4
dim2 = Struct(SIZE, grid(), 2) ' Returns 7
```

Default dimension:

```
Dim data(10, 20) As Person
bound = Struct(SIZE, data()) ' Returns 10 (first dimension)
```

Use in loops:

```
Dim people(n) As Person
' ... populate array ...

For i = 0 To Struct(SIZE, people())
    Print people(i).name
Next i
```

Notes

- Similar to the standard BOUND() function but for structure arrays
- Dimension numbering is 1-based (1 = first dimension, 2 = second, etc.)
- If dimension is omitted, returns the bound of the first dimension

Saving and Loading Structures

Structures can be saved to and loaded from files in binary format. This is useful for persisting data between program runs or exchanging data.

STRUCT SAVE

Writes structure data to an already-open file:

```
Struct Save #filenumber, variable
Struct Save #filenumber, array()
```

The file must be opened before using "STRUCT SAVE". You manage the file opening and closing.

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STRUCT LOAD

Reads structure data from an already-open file:

```
Struct Load #filenumber, variable
Struct Load #filenumber, array()
```

The file must be opened before using "STRUCT LOAD". The structure variable must already be declared.

Examples

Save and load a single structure:

```
Dim p As Point
p.x = 100
p.y = 200

' Save
Open "point.dat" For Output As #1
Struct Save #1, p
Close #1

' Load
Dim p2 As Point
Open "point.dat" For Input As #1
Struct Load #1, p2
Close #1

Print p2.x, p2.y    ' Output: 100    200
```

Save and load an array of structures:

```
Dim people(100) As Person
' ... populate array ...

' Save to file
Open "people.dat" For Output As #1
Struct Save #1, people()
Close #1

' Load from file
Dim loadedPeople(100) As Person
Open "people.dat" For Input As #1
Struct Load #1, loadedPeople()
Close #1
```

Notes

- Data is saved in binary format (not human-readable)
- The structure type and array dimensions must match when loading
- Files should be opened in appropriate mode for the operation
- Multiple structures can be saved to the same file sequentially
- Error occurs if file is not open or is not a disk file

Structures in Subroutines and Functions

Passing Structures as Parameters

Structures are always passed ****by reference****, meaning the subroutine or function can modify the original structure:

```
Sub subname(parametername As typename)
...
End Sub
```

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Example - Read-only access:

```
Sub PrintPoint(pt As Point)
    Print "X:"; pt.x; " Y:"; pt.y
End Sub

Dim p As Point = (100, 200)
PrintPoint p
```

Example - Modifying the structure:

```
Sub DoublePoint(pt As Point)
    pt.x = pt.x * 2
    pt.y = pt.y * 2
End Sub

Dim p As Point = (10, 20)
DoublePoint p
Print p.x, p.y      ' Output: 20    40
```

Passing Array Elements

You can pass a single element of a structure array:

```
Dim points(10) As Point
points(5).x = 100
points(5).y = 200

PrintPoint points(5)
DoublePoint points(5)
```

Passing Structure Arrays

Use empty parentheses to pass an entire array of structures:

```
Sub ProcessPoints(pts() As Point)
    ' Access pts(0), pts(1), etc.
End Sub

Dim myPoints(10) As Point
ProcessPoints myPoints()
```

Example:

```
Sub SumAllPoints(pts() As Point, count%)
    Local total_x% = 0, total_y% = 0
    Local i%
    For i% = 0 To count% - 1
        total_x% = total_x% + pts(i%).x
        total_y% = total_y% + pts(i%).y
    Next i%
    Print "Total X:"; total_x%; " Total Y:"; total_y%
End Sub

Dim data(5) As Point
' ... initialize data ...
SumAllPoints data(), 6
```

Functions with Structure Parameters

```
Function Distance(pt As Point) As FLOAT
    Distance = Sqr(pt.x * pt.x + pt.y * pt.y)
End Function

Dim p As Point = (3, 4)
Print Distance(p)      ' Output: 5
```

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Functions Returning Structures

Functions can return structure values using "As typename" in the function declaration:

```
Function functionname(parameters) As typename
    functionname.member1 = value1
    functionname.member2 = value2
End Function
```

The function name acts as a local structure variable that is returned when the function exits.

Example - Creating a Point:

```
Function MakePoint(x%, y%) As Point
    MakePoint.x = x%
    MakePoint.y = y%
End Function

Dim p As Point
p = MakePoint(100, 200)
Print p.x, p.y      ' Output: 100      200
```

Example - Structure with multiple types:

```
Function CreatePerson(n$, a%, h!) As Person
    CreatePerson.name = n$
    CreatePerson.age = a%
    CreatePerson.height = h!
End Function

Dim employee As Person
employee = CreatePerson("Alice", 30, 1.68)
Print employee.name; " is"; employee.age; " years old"
```

Example - Factory function:

```
Function Origin() As Point
    Origin.x = 0
    Origin.y = 0
End Function

Dim startPoint As Point
startPoint = Origin()
```

Local Structures

Use "LOCAL" to declare structures that exist only within a subroutine or function:

```
Sub Example
    Local pt As Point
    pt.x = 100
    pt.y = 200
    ' pt is automatically freed when the sub exits
End Sub
```

Local Structure Arrays

```
Sub ProcessData
    Local tempPoints(10) As Point
    ' Use tempPoints...
End Sub
```

Local Structures with Initialization

```
Sub Example
    Local pt As Point = (50, 75)
    Print pt.x, pt.y
```

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```
End Sub
```

Nested Structures

Structures can contain other structures as members. The nested structure type must be defined before it is used in another structure.

Defining Nested Structures

```
' Define inner structure first
Type Point
  x As INTEGER
  y As INTEGER
End Type

' Now define structure that contains Point
Type Line
  start As Point      ' Nested structure member
  finish As Point     ' Another nested member
  color As INTEGER
End Type
```

Accessing Nested Members

Use chained dot notation to access nested members:

```
Dim myLine As Line
myLine.start.x = 10
myLine.start.y = 20
myLine.finish.x = 100
myLine.finish.y = 200
myLine.color = 255

Print myLine.start.x      ' Prints 10
Print myLine.finish.y     ' Prints 200
```

Multiple Levels of Nesting

Structures can be nested to multiple levels:

```
Type Point
  x As INTEGER
  y As INTEGER
End Type

Type Box
  topLeft As Point
  bottomRight As Point
End Type

Type Scene
  boundary As Box      ' Box contains Points - 3 levels
  name As STRING LENGTH 20
End Type

Dim myScene As Scene
myScene.boundary.topLeft.x = 0
myScene.boundary.bottomRight.x = 640
myScene.name = "MainScene"

Print myScene.boundary.topLeft.x      ' Prints 0
```

Arrays with Nested Structures

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Arrays of structures containing nested structures work as expected:

```
Dim lines(10) As Line
lines(0).start.x = 1
lines(0).start.y = 2
lines(5).finish.x = 100
```

Arrays of Nested Structure Members

Structure members can be arrays of nested structures:

```
Type Point
  x As INTEGER
  y As INTEGER
End Type

Type Polygon
  vertices(9) As Point    ' Array of 10 nested Point structures
  color As INTEGER
End Type

Dim shape As Polygon
shape.vertices(0).x = 0
shape.vertices(0).y = 0
shape.vertices(1).x = 100
shape.vertices(1).y = 50
shape.color = 255
```

Complex Nesting Example

The most complex supported syntax combines all features:

```
Type InnerType
  values(9) As FLOAT      ' Array of floats
End Type

Type OuterType
  items(5) As InnerType    ' Array of nested structs, each with array
End Type

Dim data(3) As OuterType   ' Array of outer structs

' Access: array(i).array_member(j).array_member(k)
data(2).items(1).values(4) = 3.14159
Print data(2).items(1).values(4)    ' Prints 3.14159
```

This demonstrates:

- "data(2)" - Element 2 of the outer array
- ".items(1)" - Element 1 of the nested struct array member
- ".values(4)" - Element 4 of the innermost float array

LIST TYPE with Nested Structures

The "LIST TYPE" command shows nested structure types by name:

```
>LIST TYPE Line
TYPE LINE
  START AS Point    ' offset=0
  FINISH AS Point   ' offset=16
  COLOR AS INTEGER   ' offset=32
END TYPE            ' size=40 bytes
```

Limitations

- The nested type must be defined BEFORE the containing type

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- No self-referential structures (a type cannot contain itself)
- Maximum nesting depth: 8 levels (configurable via "MAX_STRUCT_NEST_DEPTH")

Multiple Structure Types

You can define multiple different structure types in your program:

```
Type Point
  x As INTEGER
  y As INTEGER
End Type

Type Rectangle
  left As INTEGER
  top As INTEGER
  width As INTEGER
  height As INTEGER
End Type

Type Line
  start As Point      ' Nested structure
  finish As Point
End Type

Dim p As Point
Dim r As Rectangle
Dim ln As Line
```

Best Practices

1. ****Define types at the start of your program**** - Place all TYPE definitions near the beginning, before any executable code.
2. ****Define nested types before containing types**** - Inner structures must be defined first.
3. ****Use meaningful names**** - Choose descriptive names for both types and members:

```
Type SensorReading
  timestamp As INTEGER
  temperature As FLOAT
  humidity As FLOAT
End Type
```

4. ****Initialize structures**** - Always initialize structure members before use, either with the initialization syntax or by assignment.
5. ****Use LOCAL for temporary structures**** - When a structure is only needed within a subroutine, declare it as LOCAL to automatically free memory.
6. ****Pass structures to subroutines**** - Rather than passing many individual parameters, group related data into a structure.

Limitations

- Maximum structure types: 32
- Maximum members per structure: 16
- Member names follow standard MMBasic variable naming rules
- Maximum nesting depth: 8 levels (configurable via "MAX_STRUCT_NEST_DEPTH")

Error Messages

Error	Cause
"Structure t...	The structure type name in DIM AS doesn't match any defined TYPE

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"Unknown str...	Accessing a member name that doesn't exist in the structure
"Structure t...	Trying to copy or pass structures of different types
"Expected a ...	A subroutine expected a structure but received something else
"Source must...	STRUCT COPY source is not a structure
"Destination...	STRUCT COPY destination is not a structure
"Not enough ...	Initialization list has fewer values than required
"Expected '(...	Missing opening parenthesis in initialization
"Expected a ...	STRUCT.FIND requires a structure array, not a single variable
"Member not ...	STRUCT.FIND or STRUCT SORT member name doesn't exist
"Cannot sear...	STRUCT.FIND cannot search members that are arrays
"Type mismat...	STRUCT.FIND search value type doesn't match member type
"Type mismat...	STRUCT.FIND search value is not a string but member is
"Expected #f...	STRUCT SAVE/LOAD requires a file number starting with #
"Invalid fil...	File number is outside valid range
"File not op...	STRUCT SAVE/LOAD file is not open
"Not a disk ...	STRUCT SAVE/LOAD requires a disk file, not serial port
"Cannot save...	STRUCT SAVE/LOAD requires whole structure, not member

Complete Example

```
' Define structure types
Type Point
  x As INTEGER
  y As INTEGER
End Type

Type Line
  name As STRING LENGTH 20
  startX As INTEGER
  startY As INTEGER
  endX As INTEGER
  endY As INTEGER
End Type

' Declare variables
Dim origin As Point = (0, 0)
Dim cursor As Point
Dim lines(10) As Line

' Initialize cursor
cursor.x = 100
cursor.y = 100

' Create some lines
lines(0).name = "Horizontal"
lines(0).startX = 0 : lines(0).startY = 50
lines(0).endX = 100 : lines(0).endY = 50

lines(1).name = "Vertical"
lines(1).startX = 50 : lines(1).startY = 0
lines(1).endX = 50 : lines(1).endY = 100

' Subroutine to calculate line length
Function LineLength(ln As Line) As FLOAT
  Local dx% = ln.endX - ln.startX
  Local dy% = ln.endY - ln.startY
  LineLength = Sqr(dx% * dx% + dy% * dy%)
End Function
```

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```
' Print line information
Sub PrintLine(ln As Line)
    Print ln.name; ": ("; ln.startX; ", "; ln.startY; ") to ("; ln.endX; ", "; ln.endY; ")"
    Print "    Length: "; LineLength(ln)
End Sub

' Display all lines
For i% = 0 To 1
    PrintLine lines(i%)
Next i%
```

Output:

```
Horizontal: (0,50) to (100,50)
    Length: 100
Vertical: (50,0) to (50,100)
    Length: 100
```

Quick Reference

Commands

Command	Description
`Type...End ...	Define a new structure type
`Dim var As ...	Declare a structure variable
`Dim arr(n) ...	Declare an array of structures
`Struct Copy...	Copy structure contents
`Struct Copy...	Copy entire structure array
`Struct Sort...	Sort array by member field
`Struct Clea...	Reset all members to defaults
`Struct Clea...	Reset all array elements to defaults
`Struct Swap...	Exchange contents of two structures
`Struct Prin...	Print structure contents for debugging
`Struct Prin...	Print all array elements
`Struct Save...	Save structure to open file
`Struct Save...	Save structure array to open file
`Struct Load...	Load structure from open file
`Struct Load...	Load structure array from open file

Functions

Function	Description
`Struct(FIND...	Find element with matching member value, returns index or -1
`Struct(SIZE...	Get upper bound of structure array dimension

Member Types

Type	Size	Description
`INTEGER`	8 bytes	64-bit signed integer
`FLOAT`	8 bytes	64-bit floating point
`STRING`	256 bytes	Default string (255 chars max)
`STRING LENGTH n`	n+1 bytes	String with specified max length