NEC

# User's Manual

# μSAP77016-B04

## G.723.1 Speech Codec Middleware

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## Target Devices

μPD77018
μPD77018A
μPD77019
μPD77110
μPD77111
μPD77112
μPD77113
μPD77114
μPD77116

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**[MEMO]**

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- Device availability
- Ordering information
- Product release schedule
- Availability of related technical literature
- Development environment specifications (for example, specifications for third-party tools and components, host computers, power plugs, AC supply voltages, and so forth)
- Network requirements

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## Major Revisions in This Edition

| Page | Description |
|---|---|
| Throughout | Addition of $\mu$PD77113 and 77114 to target devices |
| p.27 | Addition of description to **2.3.1 Extraction parameters for G.723.1 ANNEX A functions** |
| p.28 | Addition of description to **2.3.2 Extraction parameters for G.723.1 ANNEX C functions** |
| p.33 | Addition of description to **2.4.2 (2) SID frame compression format** |

**The mark ⋆ shows major revised points.**

**[MEMO]**

# INTRODUCTION

**Readers**

This manual has been prepared for users who design and develop application systems using the μPD77016 Family.

**The μPD77016 Family includes the following: μPD77015, 77016, 77017, 77018, 77018A, 77019, 77110, 77111, 77112, 77113, 77114, and 77116[Note]. The target devices of this manual, however, only include the μPD77018, 77018A, 77019, 77110, 77111, 77112, 77113, 77114, and 77116.**

**Note** Under development

**Purpose**

The manual is intended to give users an understanding of how to use the middleware that is used for support when designing or developing application systems using the μPD77016 Family.

**Organization**

This manual is broadly divided into the following sections.

Chapter 1 Outline
Chapter 2 Library Specifications
Chapter 3 Installation
Appendix Sample Program Source

**How to Read This Manual**

It is assumed that the readers of this manual have general knowledge of electrical engineering, logic circuits, microcontrollers, and C language.

To learn the hardware functions of the μPD7701× Family
→ Refer to the **μPD7701× Family User's Manual Architecture**

To learn the hardware functions of the μPD77111 Family
→ Refer to the **μPD77111 Family User's Manual Architecture**

To learn the instruction functions of the μPD77016 Family
→ Refer to the **μPD77016 Family User's Manual Instructions**

**Conventions**

| | |
|---|---|
| Data significance: | Higher digits on the left and lower digits on the right |
| Active low representation: | $\overline{\times\times\times}$ (overscore over pin or signal name) |
| **Note**: | Footnote for item marked with **Note** in the text |
| **Caution**: | Information requiring particular attention |
| **Remark**: | Supplementary information |
| Numerical representation: | Binary···××××  or 0b×××× |
| | Decimal···×××× |
| | Hexadecimal···0x×××× |

**Related Documents** The related documents listed below may include preliminary versions. However, preliminary versions are not marked as such.

**Documents Related to Devices**

| Document Name / Part Number | Pamphlet | Data Sheet | User's Manual | | Application Note |
|---|---|---|---|---|---|
| | | | Architecture | Instructions | Basic Software |
| μPD77016 | U12395E | U10891E | U10503E | U13116E | U11958E |
| μPD77015 | | U10902E | | | |
| μPD77017 | | | | | |
| μPD77018 | | | | | |
| μPD77018A | | U11849E | | | |
| μPD77019 | | | | | |
| μPD77019-013 | | U13053E | | | |
| μPD77110 | | U12801E | Under preparation | | |
| μPD77111 | | | | | |
| μPD77112 | | | | | |
| μPD77113 | | U14373E | | | |
| μPD77114 | | | | | |
| μPD77116 | — | U14624E | — | — | — |

**Documents Related to Development Tools**

| Document Name | | Document No. |
|---|---|---|
| IE-77016-98, IE-77016-PC User's Manual | Hardware | U13044E |
| IE-77016-CM-LC User's Manual | | U14139E |
| RX77016 User's Manual | Function | U14397E |
| | Configuration Tool | U14404E |
| RX77016 Application Note | HOST API | U14371E |

**Caution The documents listed above are subject to change without notice. Be sure to use the latest documents when designing.**

**CONTENTS**

## LIST OF FIGURES



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# CHAPTER 1 OUTLINE

## 1.1 Middleware

Middleware is the name given to a group of software that has been tuned so that it draws out the maximum performance of the processor and enables processing that is conventionally performed by hardware to be performed by software. The concept of middleware was introduced with the development of a new high-performance processor, the DSP, in order to facilitate operation of the environments integrated in the system.

By providing appropriate speech codec and image data compression/decompression-type middleware, NEC is offering users the kind of technology essential in the realization of a multimedia system for the μPD77016 Family, and is continuing promotion of system development.

The μSAP77016-B04 is a middleware product that provides ITU-T[Note]-recommended G.723.1 speech compression and decompression functions (including the recommended additions ANNEX A and ANNEX C). Unless otherwise stated, when describing this middleware, it is assumed the speech codec used is G.723.1.

**Note** International Telecommunication Union-Telecommunication Standardization Sector

## 1.2 G.723.1 Speech Codec

The G.723.1 speech codec is the 5.3 Kbps or 6.3 Kbps speech compression/decompression codec recommended by ITU-T, and is an algorithm for coding speech data that use ACELP and MP-MLQ.

By means of a telephone band filter (the ITU-T recommended G.712), the G.723.1 speech codec samples band-restricted analog input signals at 8 kHz. The digital signals that are obtained by converting this sampled data into 16-bit linear PCM data are then designed so that they operate as encoder inputs. Similarly, it is necessary to return the signals to analog form to output them from the decoder.

Signals in other I/O formats, such as the 64 Kbps PCM data prescribed by the ITU-T-recommended G.711, must be converted into 16-bit linear PCM data before coding, and converted back from 16-bit linear PCM data to a suitable format after decoding. The bit-string that is passed from the encoder to the decoder is defined by the ITU-T recommended G.723.1.

**Remark** ACELP: Algebraic Code Excited Linear Prediction
MP-MLQ: Multi-Pulse Maximum Likelihood Quantization

## 1.3 G.723.1 ANNEX A Speech Codec

ANNEX A, which is an additional recommendation to the ITU-T recommended G.723.1, is the silence compression function of the G.723.1, and is used in addition to the standard G.723.1 speech codec. Speech codecs with an additional silence compression function and those without an additional silence compression function cannot, however, be interconnected. The purpose of the silence compression function is to raise the total compression rate and reduce the bit rate by raising the compression rate in the parts where there is silence.

## 1.4 G.723.1 ANNEX C Speech Codec

ANNEX C, which is an additional recommendation to the ITU-T recommended G.723.1, is the variable bit rate channel codec of the G.723.1 speech codec, and is used in addition to the standard G.723.1 and ANNEX A. The bit rate supported by ANNEX C is 0.7 Kbps to 14.3 Kbps.

ANNEX C is designed as a part of the ITU-T H.324 Family, which is aimed at multimedia in mobile communications. Using this standard, the G.723.1 can be adapted to all wire and wireless transmission systems, although ANNEX C does not define a standard for functions that rely on transmission systems such as interleave or burst formatting systems.

## 1.5 System Outline

### 1.5.1 Features

- Compression coding at 5.3 and 6.3 Kbps (variable bit rate for ANNEX C)
- High bit-rate speech coding
- Codes and decodes 240 samples/frames at an 8 kHz sampling frequency
- All speech I/O data is 16-bit linear data

### 1.5.2 Operating environment

★ **(1) Target DSPs**

μPD77018
μPD77018A
μPD77019
μPD77110
μPD77111
μPD77112
μPD77113
μPD77114
μPD77116 (Under development)

**(2) Required memory**

**Table 1-1. Required Memory Capacity**

| Memory | Type | ANNEX A [Word] | ANNEX C [Word] |
|---|---|---|---|
| Instruction memory | – | 5.6 K | 7.9 K |
| X memory | RAM[Note] | 2.1 K | 2.2 K |
| | ROM | 3.9 K | 5.6 K |
| Y memory | RAM[Note] | 2.0 K | 2.0 K |
| | ROM | 5.6 K | 6.5 K |

**Note** The scratch area within the RAM area is X: 1024 words, Y: 1024 words in ANNEX A, and X: 1108 words, Y: 284 words in ANNEX C.

**(3) Software tools (Windows™)**

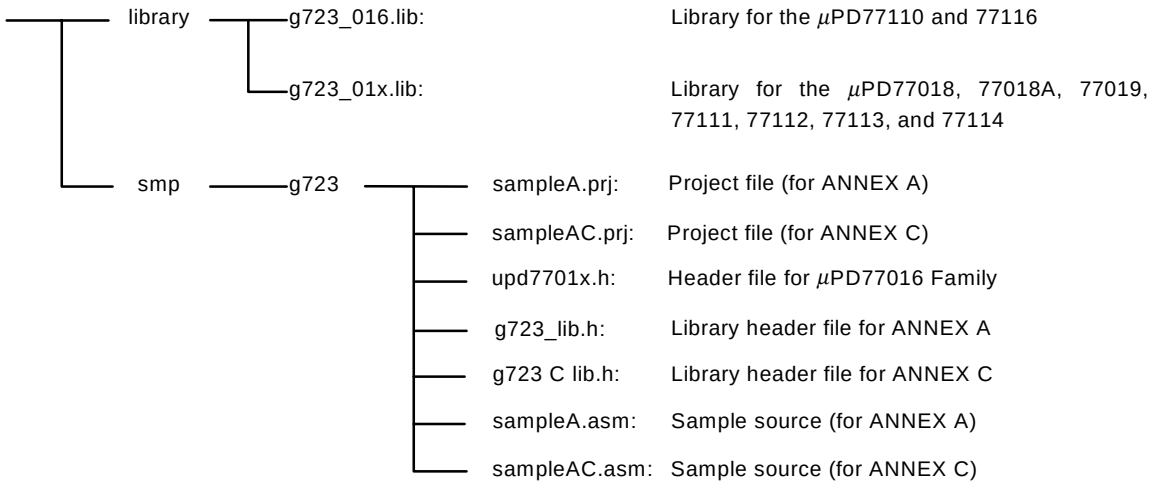
DSP tools: WB77016 (Workbench)
HSM77016 (High-speed simulator)

### 1.5.3 Performance

[Conditions] DSP: μPD77016 Family (33 MIPS when operating at 33 MHz)
[Necessary MIPS value for execution of a 1-frame process in real-time (30 ms)]
(G.723.1 ANNEX A) Compression processing: 17.5 MIPS Decompression processing: 1.5 MIPS
(G.723.1 ANNEX C) Compression processing: +1 MIPS Decompression processing: +1.5 MIPS

### 1.5.4 Directory configuration

The directory configuration of this middleware is shown below.




Library files g723_016.lib and g723_01x.lib are included in the following object file. Note that g723_016.lib cannot be used for the μPD77016, and g723_01x.lib cannot be used for the μPD77015 and 77017.

- g723aenc.rel (G.723.1 ANNEX A Encoder)
- g723adec.rel (G.723.1 ANNEX A Decoder)
- g723acom.rel (G.723.1 ANNEX A Encoder and Decoder shared section)
- g723cenc.rel (G.723.1 ANNEX C Encoder)
- g723cdec.rel (G.723.1 ANNEX C Decoder)
- g723ccom.rel (G.723.1 ANNEX C Encoder and Decoder shared section)

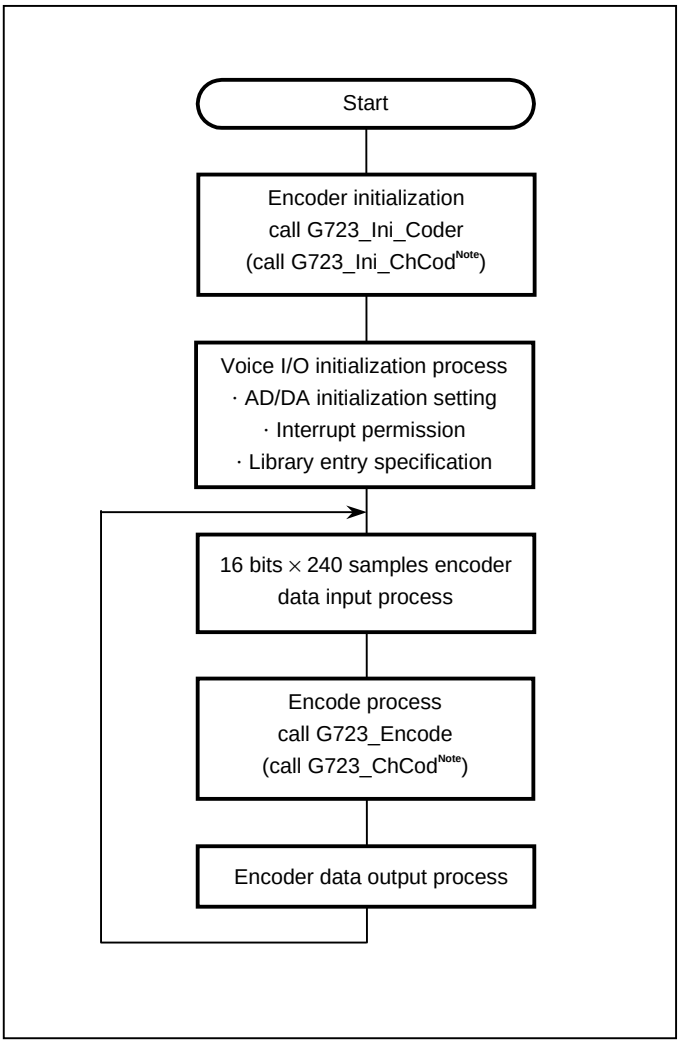
# CHAPTER 2 LIBRARY SPECIFICATIONS

This chapter describes the function specifications and call conventions of this middleware.

## 2.1 G.723.1 Speech Codec Processing Flow

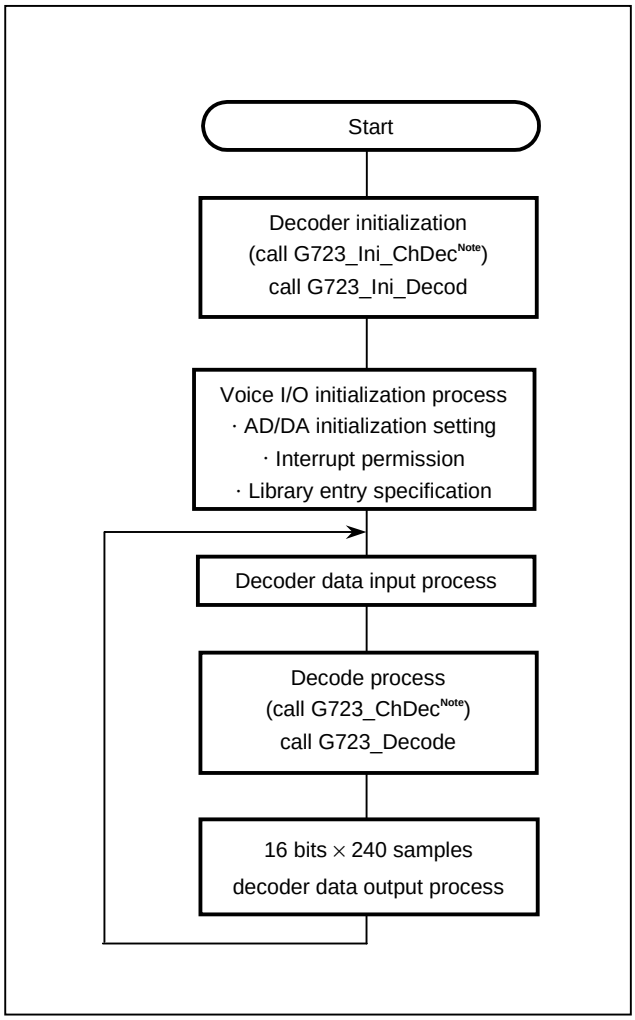
The processing flow of applications that use this middleware is shown in Figures 2-1 and 2-2 below.

**Figure 2-1. Application Processing Flow (Encoder)**




**Note** "G723_Ini_ChCod" and "G723_ChCod" are functions for ANNEX C. Be sure to call and use G723_Ini_ChCod and G723_ChCod after G723_Ini_Coder and G723_Encode only when ANNEX C is used.

**Figure 2-2. Application Processing Flow (Decoder)**




**Note** "G723_Ini_ChDec" and "G723_ChDec" are functions for ANNEX C. Be sure to call and use G723_Ini_ChDec and G723_ChDec before G723_Ini_Decode and G723_Decode only when ANNEX C is used.

## 2.2 Function Specifications

### 2.2.1 Encoder initialization functions

The encoder initialization functions set each encoder constant and initialize the coefficient table and the delay buffer.

#### (1) Scratch area initialization function

**[Classification]** Scratch area initialization process
**[Function name]** G723_Start_Codec
**[Function outline]** Clears the scratch area used by G.723.1 ANNEX A to 0.
**[Format]** call G723_Start_Codec
**[Argument]** None
**[Return value]** None
**[Function]** Clears the scratch area used by G.723.1 ANNEX A to 0.
**[Registers used]** R0, DP0, DP4
**[Hardware resource]**

| | |
|---|---|
| Maximum stack level: | 0 |
| Maximum loop stack level: | 1 |
| Maximum number of repeat: | 0 |
| Maximum number of cycles: | 4000 |

### (2) Encoder for G.723.1 ANNEX A initialization function

**[Classification]** Encoder initialization process

**[Function name]** G723_Ini_Coder

**[Function outline]** Initializes the RAM area and sets the parameters used by G.723.1 ANNEX A encoder.

**[Format]** call G723_Ini_Coder

**[Argument]** Top address of the X/Y static variable area

Example
```
r0l= StaticAreaX                        ;
*IOArea+G723_STATIC_X_PTR:x = r0l       ;
r0l= StaticAreaY                        ;
*IOArea+G723_STATIC_Y_PTR:x = r0l       ;
dp0=IOArea                              ;
```

**[Return value]** None

**[Function]** Initializes the G.723.1 ANNEX A encoder and sets the parameters.

**[Registers used]** R0, R6, R7, DP0, DP4

**[Hardware resource]**

| | |
|---|---|
| Maximum stack level: | 2 |
| Maximum loop stack level: | 1 |
| Maximum number of repeat: | 256 |
| Maximum number of cycles: | 2000 |

### (3) Encoder for G.723.1 ANNEX C initialization function

**[Classification]** Encoder initialization process

**[Function name]** G723_Ini_ChCod

**[Function outline]** Initializes the RAM area and sets the parameters used by G.723.1 ANNEX C encoder.

**[Format]** call G723_Ini_ChCod

**[Argument]** Top address of the I/O buffer and each set parameter

Example
```
clr(r0);
/*...*/ *EncLineBuff+12:x = r0h;
/*...*/ *EncLineBuff+13:x = r0h;
/*---*/ dp0 = LibEntry;
r0l = C_StaticAreaX;
/*...*/ *dp0++ = r0l;
r0l = C_StaticAreaY;
/*...*/ *dp0++ = r0l;
r0l = EncLineBuff;
/*...*/ *dp0++ = r0l;    // Input buffer
r0l = EncChanBuff;
/*...*/ *dp0++ = r0l;    // Output buffer
r0l = 1;
/*...*/ *dp0++ = r0l;    // EncodeSW (0:off 1:on)
r0l = 1;
/*...*/ *dp0++ = r0l;    // High/Low select (0:low 1:high)
/*---*/ dp4 = BitrateConfig;
/* */   *dp0++ = r0h;    // number of octets(dummy access)
/* */ r0 = *dp4++;
rep 6;
        /* */dp0++ = r0h         r0 = *dp4++;
/*---*/ dp0 = LibEntry;
```

**[Return value]** None

**[Function]** Initializes the G.723.1 ANNEX C encoder and sets the parameters.

**[Registers used]** R0, DP0, DP1, DP4

**[Hardware resource]**

| | |
|---|---|
| Maximum stack level: | 0 |
| Maximum loop stack level: | 0 |
| Maximum number of repeat: | 15 |
| Maximum number of cycles: | 34 |

### 2.2.2 Decoder initialization functions

The decoder initialization functions set each decoder constant and initialize the coefficient table and the delay buffer.

#### (1) Decoder for G.723.1 ANNEX A initialization function

**[Classification]** Decoder initialization process

**[Function name]** G723_Ini_Decod

**[Function outline]** Initializes the RAM area and sets the parameters used by G.723.1 ANNEX A decoder.

**[Format]** call G723_Ini_Decod

**[Argument]** Top address of the X/Y static variable area

Example
```
r0l= StaticAreaX                        ;
*IOArea+G723_STATIC_X_PTR:x = r0l       ;
r0l= StaticAreaY                        ;
*IOArea+G723_STATIC_Y_PTR:x = r0l       ;
dp0=IOArea                              ;
```

**[Return value]** None

**[Function]** Initializes the G.723.1 ANNEX A decoder and sets the parameters.

**[Registers used]** R0, R1, R6, R7, DP0, DP4, DP5

**[Hardware resource]**

| | |
|---|---|
| Maximum stack level: | 2 |
| Maximum loop stack level: | 1 |
| Maximum number of repeat: | 145 |
| Maximum number of cycles: | 1000 |

### (2) Decoder for G.723.1 ANNEX C initialization function

**[Classification]** Decoder initialization process

**[Function name]** G723_Ini_ChDec

**[Function outline]** Initializes the RAM area and sets the parameters used by G.723.1 ANNEX C decoder.

**[Format]** call G723_Ini_ChDec

**[Argument]** Top address of the I/O buffer and each set parameter

Example
```
clr(r0);
/*---*/ dp0 = LibEntry + G723C_LIBENTRY_DECOFS;
r0l = DecLineBuff;
/*...*/ *dp0++ = r0l;   // Output buffer
r0l = DecChanBuff;
/*...*/ *dp0++ = r0l;   // Input buffer
/*   */ *dp0++ = r0h;   // clear error flag
/*---*/ dp4 = BitrateConfig;
/* */   *dp0++ = r0h;   // reserved
/* */   r0 = *dp4++;
rep 6;
        /* */   *dp0++ = r0h    r0 = *dp4++;
/*---*/ dp0 = LibEntry;
```

**[Return value]** None

**[Function]** Initializes the G.723.1 ANNEX C decoder and sets the parameters.

**[Registers used]** R0, DP0, DP1, DP4

**[Hardware resource]**

| | |
|---|---|
| Maximum stack level: | 0 |
| Maximum loop stack level: | 0 |
| Maximum number of repeat: | 15 |
| Maximum number of cycles: | 34 |

### 2.2.3 Encoder functions

Encoder functions generate the signals that compress the 240 items of sampled speech data that were input into 189, 159, or 32 bits. Note that in ANNEX C this is a variable rate.

#### (1) Encoder function for G.723.1 ANNEX A

**[Classification]** Encoder processing section

**[Function name]** G723_Encode

**[Function outline]** Compresses the 240 16-bit samples into 189, 159, or 32 bits

**[Format]** call G723_Encode

**[Argument]** Top address of the I/O buffer and each set parameter

```
Example  r0l= EncPcmBuff                        ; set IO parameter
         *IOArea+G723_ENC_BUFF_PTR:x = r0l      ;
         r0l= EncLineBuff                       ;
         *IOArea+G723_VOUT_PTR:x= r0l           ;
         *IOArea+G723_USE_VAD:x= ???            ; 0)VAD off, 1)VAD on
         *IOArea+G723_USE_HP:x= ???             ; 0)Hpf off, 1)Hpf on
         *IOArea+G723_WRK_RATE_E:x= ???         ; 0)6.3kbps, 1)5.3kbps
         dp0=IOArea                             ;
```

**[Return value]** Frame type and number of clipped subframes

```
Example  ??? = *IOArea+G723_E_FRAME_TYPE:x   ; 0)NoTx ,1)Active ,2)SID
         ??? = *IOArea+G723_COUNT_CLIP:x     ; clipped sub-frames 0..3
```

Compressed data: output buffers set by arguments

**[Function]** Compresses the input data from the codec (240 samples × 16 bits) into 189, 159, or 32 bits.

**[Registers used]** R0, R1, R2, R3, R4, R5, R6, R7, DP0, DP1, DP2, DP3, DP4, DP5, DP6, DP7, DN0, DN1, DN2, DN3, DN4, DN5, DN6, DN7, DMX, DMY

**[Hardware resource]**

| | |
|---|---|
| Maximum stack level: | 7 |
| Maximum loop stack level: | 4 |
| Maximum number of repeat: | 256 |
| Maximum MIPS value: | 17.5 |

### (2) Encoder function for G.723.1 ANNEX C

**[Classification]** Encoder processing section

**[Function name]** G723_ChCod

**[Function outline]** Channel codes the data that was compressed by G723_Encode

**[Format]** call G723_ChCod

**[Argument]** Top address of the I/O buffer and each set parameter

Example
```
clr(r0);
/*...*/ *EncLineBuff+12:x = r0h;
/*...*/ *EncLineBuff+13:x = r0h;
/*---*/ dp0 = LibEntry;
r0l = C_StaticAreaX;
/*...*/ *dp0++ = r0l;
r0l = C_StaticAreaY;
/*...*/ *dp0++ = r0l;
r0l = EncLineBuff;
/*...*/ *dp0++ = r0l;    // Input buffer
r0l = EncChanBuff;
/*...*/ *dp0++ = r0l;    // Output buffer
r0l = 1;
/*...*/ *dp0++ = r0l;    // EncodeSW (0:off 1:on)
r0l = 1;
/*...*/ *dp0++ = r0l;    // High/Low select (0:low 1:high)
/*---*/ dp4 = BitrateConfig;
/* */   *dp0++ = r0h;    // number of octets(dummy access)
/* */ r0 = *dp4++;
rep 6;
        /* */dp0++ = r0h         r0 = *dp4++;
/*---*/ dp0 = LibEntry;
```

**[Return value]** Number of octets: r2l

Compressed data: output buffers set by arguments

**[Function]** Compresses the input data from the codec (240 samples × 16 bits) at a variable rate

**[Registers used]** R0, R1, R2, R3, R4, R5, R6, R7, DP0, DP1, DP2, DP3, DP4, DP5, DP6, DP7, DN0, DN1, DN2, DN3, DN4, DN5, DN6, DN7, DMX, DMY

**[Hardware resource]**

| | |
|---|---|
| Maximum stack level: | 3 |
| Maximum loop stack level: | 2 |
| Maximum number of repeat: | 636 |
| Maximum MIPS value: | 1.0 |

### 2.2.4 Decoder functions

Decoder functions decompress the signals that were compressed into 189, 159, or 32 bits back into 240 samples × 16 bits speech data.

#### (1) Decoder function for G.723.1 ANNEX A

**[Classification]** Decoder processing section

**[Function name]** G723_Decode

**[Function outline]** Decompresses the 189, 159, or 32 bits back into 240 16-bit samples

**[Format]** call G723_Decode

**[Argument]** Top address of the I/O buffer and each set parameter

```
Example  r0l= DecPcmBuff                    ; set IO parameter
         *IOArea+G723_DEC_BUFF_PTR:x = r0l ;
         r0l= DecLineBuff                   ;
         *IOArea+G723_VINP_PTR:x= r0l       ;
         *IOArea+G723_USE_PF:x= ???         ; 0)Psf off, 1)Psf on
         *IOArea+G723_CRC_RESULT:x = ???    ;CRC_result,0)Normal,else)Err

         dp0=IOArea                         ;
```

**[Return value]** Frame type, work rate, and number of error frames

```
Example  ???= *IOArea+G723_D_FRAME_TYPE:x  ; 0)NoTx ,1)Active ,2)SID
         ???= *IOArea+G723_WRK_RATE_D:x    ; 0)6.3kbps, 1)5.3kbps
         ???= *IOArea+ERR_FRM_COUNT:x      ; Num of Error frame 0..0x7ff
```

Decompressed data: output buffers set by arguments

**[Function]** Decompresses the data that was compressed into 189, 159, or 32 bits back into speech data (240 samples × 16 bits)

**[Registers used]** R0, R1, R2, R3, R4, R5, R6, R7, DP0, DP1, DP2, DP3, DP4, DP5, DP6, DP7, DN0, DN1, DN2, DN3, DN4, DN5, DN6, DN7, DMX

**[Hardware resource]**

| | |
|---|---|
| Maximum stack level: | 4 |
| Maximum loop stack level: | 3 |
| Maximum number of repeat: | 240 |
| Maximum MIPS value: | 1.5 |

### (2) Decoder function for G.723.1 ANNEX C

**[Classification]** Decoder process section

**[Function name]** G723_ChDec

**[Function outline]** Performs channel decoding, and creates the code that extracts the G723_Decode function

**[Format]** call G723_ChDec

**[Argument]** Top address of the I/O buffer and each set parameter

Example
```
clr(r0);
/*---*/ dp0 = LibEntry + G723C_LIBENTRY_DECOFS;
r0l = DecLineBuff;
/*...*/ *dp0++ = r0l;          // Output buffer
r0l = DecChanBuff;
/*...*/ *dp0++ = r0l;          // Input buffer
/*   */ *dp0++ = r0h;          // clear error flag
/*---*/ dp4 = BitrateConfig;
/* */   *dp0++ = r0h;          // reserved
/* */   r0 = *dp4++;
rep 6;
        /* */   *dp0++ = r0h    r0 = *dp4++;
/*---*/ dp0 = LibEntry;
```

**[Return value]** mode (0: 6.3 K, 1: 5.3 K, 2: SID): r0l
Final address of bit stream + 1: r1l
Decompressed data: output buffers set by arguments

**[Function]** Decompresses the data that was compressed by a variable rate back into speech data (240 samples × 16 bits)

**[Registers used]** R0, R1, R2, R3, R4, R5, R6, R7, DP0, DP1, DP2, DP3, DP4, DP5, DP6, DP7, DN0, DN1, DN2, DN3, DN4, DN5, DN6, DN7, DMX

**[Hardware resource]**

| | |
|---|---|
| Maximum stack level: | 4 |
| Maximum loop stack level: | 3 |
| Maximum number of repeat: | 15 |
| Maximum MIPS value: | 1.5 |

### 2.2.5 Version acquisition function

The version acquisition function returns the version of the library.

| | | |
|---|---|---|
| **[Classification]** | Version information acquisition | |
| **[Function name]** | G723_GetVersion | |
| **[Function outline]** | Restores the version of the library | |
| **[Format]** | call G723_GetVersion | |
| **[Argument]** | None | |
| **[Return value]** | R0H | Major version number |
| | R0L | Minor version number |
| **[Function]** | Returns the version number of this middleware with a 32-bit value. | |
| | Example | If R0 = 0x00’0x0001’0x0100 |
| | | then Version: V1.01 |
| **[Registers used]** | R0 | |

## 2.3 Description of External Interface

The parameters that extract functions G723_Encode and G723_Decode for G.723.1 ANNEX A, and functions G723_ChCod and G723_ChDec for G.723.1 ANNEX C at the time that each function is called are described here.

### ★ 2.3.1 Extraction parameters for G.723.1 ANNEX A functions

Secure scratch areas as follows. Scratch areas X and Y require "align at 0x20".

- Scratch area X: 1024-word area labeled as "lib_Scratch _x" in the X memory
- Scratch area Y: 1024-word area labeled as "lib_Scratch _y" in the Y memory

Secure static areas as follows. Static area X requires "align at 0x20" and static area Y requires "align at 0x200".

- Make the address of "lib_Scratch _x" the same as that of "lib_Scratch _y".

**Table 2-1. Extraction Parameters for G.723.1 ANNEX A Functions**

| Function | Classification | Symbol[Note 6] (Offset Address) | Setting Value |
|---|---|---|---|
| Encoder/Decoder Shared Parameters | | | |
| Static X memory area | Control input[Note 1] | G723_STATIC_X_PTR | X memory addresses |
| Static Y memory area | Control input[Note 1] | G723_STATIC_Y_PTR | Y memory addresses |
| Encoder Parameters | | | |
| Encoder input buffer | Control input | G723_ENC_BUFF_PTR | X memory addresses |
| Encoder output buffer | Control input | G723_VOUT_PTR | X memory addresses |
| Coding bit rate | Control input | G723_WRK_RATE_E | 0: 6.3 Kbps, 1: 5.3 Kbps |
| VAD control | Control input[Note 2] | G723_USE_VAD | 0: VAD OFF, 1: VAD ON |
| Preprocessing HPF control | Control input[Note 2] | G723_USE_HP | 0: HPF OFF, 1: HPF ON |
| Encode frame type | Status output | G723_E_FRAME_TYPE | 0: No transfer, 1: Active, 2: SID |
| Number of clipped frames | Status output | G723_COUNT_CLIP | 0 to 3 |
| Decoder Parameters | | | |
| Decoder output buffer | Control input | G723_DEC_BUFF_PTR | X memory addresses |
| Decoder input buffer | Control input | G723_VINP_PTR | X memory addresses |
| Postprocessing filter control | Control input[Note 3] | G723_USE_PF | 0: Filter OFF, 1: Filter ON |
| CRC flag | Control input | G723_CRC_RESULT | 0: Normal, else: Error |
| Decode frame type | Status output | G723_D_FRAME_TYPE | 0: No transfer, 1: Active, 2: SID |
| Decode bit rate | Status output[Note 4] | G723_WRK_RATE_D | 0: 6.3 Kbps, 1: 5.3 Kbps |
| Frame error count | Status output[Note 5] | G723_ERR_FRM_COUNT | 0 to 0x7FFF |

**Notes 1.** Cannot be changed following G723_Start_Codec.

**2.** Cannot be changed during encoding.

**3.** Cannot be changed during decoding.

**4.** Valid only when there are active frames.

**5.** Reset to 0 if normal frame acknowledged.

**6.** Symbols show the value offset from the value of DP0 when each function is called.

### ★2.3.2 Extraction parameters for G.723.1 ANNEX C functions

Secure scratch areas as follows. Scratch areas X and Y require "align at 0x20".

- Scratch area X: 1108-word area labeled as "lib_Scratch _x" in the X memory
- Scratch area Y: 1024-word area labeled as "lib_Scratch _y" in the Y memory

Secure a scratch area consistent with whichever is larger: ANNEX A or ANNEX C (x indicates ANNEX C and y indicates ANNEX A).

**Table 2-2. Extraction Parameters for G.723.1 ANNEX C Functions (1/2)**

| Function | Classification | Symbol[Note 4] (Offset Address) | Setting Value |
|---|---|---|---|
| Encoder/Decoder Shared Parameters | | | |
| Static X memory area | Control input[Note 1] | G723C_LibStatic_X | X memory addresses |
| Static Y memory area | Control input[Note 1] | G723C_LibStatic_Y | Y memory addresses |
| Encoder Parameters | | | |
| Encoder input buffer | Control input | G723C_LibEncInBuffer | X memory addresses |
| Encoder output buffer | Control input | G723C_LibEncOutBuffer | X memory addresses |
| Coding drive control | Control input | G723C_LibEncoderSW | 0: OFF, 1: ON |
| High-level/low-level switch | Control input[Note 2] | G723C_LibEncHighLow | 0: Low-level, 1: High-level |
| Coding result data size | Control input | G723C_LibEncOutSize | Number of bits |
| Channel upper rate when coding at 6.3 Kbps | Control input[Note 3] | G723C_LibEncULim63 | Number of bps |
| Channel lower rate when coding at 6.3 Kbps | Control input[Note 3] | G723C_LibEncLLim63 | Number of bps |
| Channel upper rate when coding at 5.3 Kbps | Control input[Note 3] | G723C_LibEncULim53 | Number of bps |
| Channel lower rate when coding at 5.3 Kbps | Control input[Note 3] | G723C_LibEncLLim53 | Number of bps |
| Channel upper rate when coding at SID | Control input[Note 3] | G723C_LibEncULimSID | Number of bps |
| Channel lower rate when coding at SID | Control input[Note 3] | G723C_LibEncLLimSID | Number of bps |

**Notes 1.** Cannot be changed following G723_Start_Codec.

**2.** The high-level/low-level switch is common to 6.3 Kbps, 5.3 Kbps, and SID.

**3.** The values set for the upper and lower channel rate limits must be within the following range when encoding/decoding:
For 6.3 Kbps: Above 7034 and below 20634
For 5.3 Kbps: Above 6000 and below 17534
For SID: Above 1600 and below 4334

**4.** Symbols show the value offset from the value of DP0 when each function is called.

**Table 2-2. Extraction Parameters for G.723.1 ANNEX C Functions (2/2)**

| Function | Classification | Symbol[Note 3] (Offset Address) | Setting Value |
|---|---|---|---|
| Decoder Parameters | | | |
| Decoder output buffer | Control input | G723C_LibDecOutBuffer | X memory addresses |
| Decoder input buffer | Control input | G723C_LibDecInBuffer | X memory addresses |
| Decode result error display | Status output[Note 1] | G723C_LibDecErrorInfo | Bit 2: FII, Bit 1: EFI, Bit 0: BFI |
| Reserved | – | G723C_LibDecReserved | – |
| Channel upper rate when decoding at 6.3 Kbps | Control input[Note 2] | G723C_LibDecULim63 | Number of bps |
| Channel lower rate when decoding at 6.3 Kbps | Control input[Note 2] | G723C_LibDecLLim63 | Number of bps |
| Channel upper rate when decoding at 5.3 Kbps | Control input[Note 2] | G723C_LibDecULim53 | Number of bps |
| Channel lower rate when decoding at 5.3 Kbps | Control input[Note 2] | G723C_LibDecLLim53 | Number of bps |
| Channel upper rate when decoding at SID | Control input[Note 2] | G723C_LibDecULimSID | Number of bps |
| Channel lower rate when decoding at SID | Control input[Note 2] | G723C_LibDecLLimSID | Number of bps |

**Notes 1.** When decoding, input the value from the decode result error display as the CRC value of the code data for decoding. The decoding processing of the frames that correspond to this error display is the frame compensation process.

**2.** The values set for the upper and lower channel rate limits must be within the following range when encoding/decoding:

For 6.3 Kbps: Above 7034 and below 20634
For 5.3 Kbps: Above 6000 and below 17534
For SID: Above 1600 and below 4334

**3.** Symbols show the value offset from the value of DP0 when each function is called.

## 2.4 I/O Data Format

The I/O data format of the ITU-T-recommended G.723.1 is outlined here.

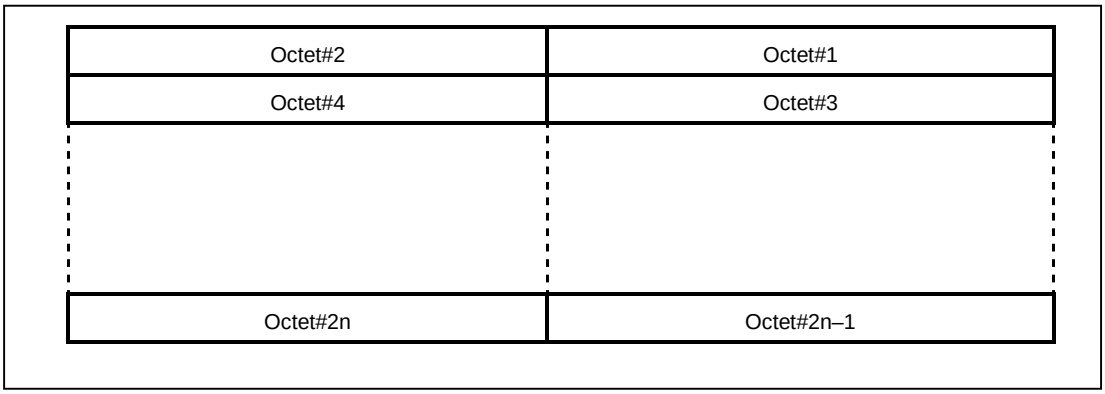
### 2.4.1 Encoder input/decoder output data format

Input the encoder-input data, which is PCM data that has been sampled at 8 kHz, in a 16-bit × 240-sample format. The decoder output data is output in the form of 16-bit × 240-sample PCM data that has been sampled at 8 kHz.

### 2.4.2 Encoder output/decoder input data format

The format of compressed data for encoder output and decoder input is as follows.

**Figure 2-3. Compressed Data Frame Format**




**Remark** 2n: Frame byte number.

**Table 2-3. Bit Rate and Frame Byte Number of G.723.1 ANNEX A Compressed Data**

| Bit Rate | Frame Byte Number |
|---|---|
| 6.3 Kbps | 24 |
| 5.3 Kbps | 20 |
| SID | 4 |

**Table 2-4. Bit Rate and Frame Byte Number of G.723.1 ANNEX C Compressed Data**

| Bit Rate | Frame Byte Number |
|---|---|
| 6.3 Kbps | 27 to 78 |
| 5.3 Kbps | 23 to 66 |
| SID | 6 to 17 |

**(1) Compression format of active frame data**

The formats of the 6.3 Kbps speech compression data (189-bit data) and the 5.3 Kbps speech compression data (159-bit data), which are the encoder function output and decoder function input respectively, are shown in Tables 2-5 and 2-6 below. Refer to ITU-T Recommendations for compression data details.

**Table 2-5. 6.3 Kbps Speech Compression Data Format**

| TRANSMITTED OCTETS | PARx_By, …, … |
|---|---|
| 1 | LPC_B5 to LPC_B0, VADFLAG_B0, RATEFLAG_B0 |
| 2 | LPC_B13 to LPC_B6 |
| 3 | LPC_B21 to LPC_B14 |
| 4 | ACL0_B5 to ACL0_B0, LPC_B23, LPC_B22 |
| 5 | ACL2_B4 to ACL2_B0, ACL1_B1, ACL1_B0, ACL0_B6 |
| 6 | GAIN0_B3 to GAIN0_B0, ACL3_B1, ACL3_B0, ACL2_B6, ACL2_B5 |
| 7 | GAIN0_B11 to GAIN0_B4 |
| 8 | GAIN1_B7 to GAIN1_B0 |
| 9 | GAIN2_B3 to GAIN2_B0, GAIN1_B11 to GAIN1_B8 |
| 10 | GAIN2_B11 to GAIN2_B4 |
| 11 | GAIN3_B7 to GAIN3_B0 |
| 12 | GRID3_B0, GRID2_B0, GRID1_B0, GRID0_B0, GAIN3_B11 to GAIN3_B8 |
| 13 | MSBPOS_B6 to MSBPOS_B0, UB [Note] |
| 14 | POS0_B1, POS0_B0, MSBPOS_B12 to MSBPOS_B7 |
| 15 | POS0_B9 to POS0_B2 |
| 16 | POS1_B2, POS1_B0, POS0_B15 to POS0_B10 |
| 17 | POS1_B10, POS1_B3 |
| 18 | POS2_B3 to POS2_B0, POS1_B13 to POS1_B11 |
| 19 | POS2_B11 to POS2_B4 |
| 20 | POS3_B3 to POS3_B0, POS2_B15 to POS2_B12 |
| 21 | POS3_B11 to POS3_B4 |
| 22 | PSIG0_B5 to PSIG0_B0, POS3_B13, POS3_B12 |
| 23 | PSIG2_B2 to PSIG2_B0, PSIG1_B4 to PSIG1_B0 |
| 24 | PSIG3_B4 to PSIG3_B0, PSIG2_B5 to PSIG2_B3 |

**Note** UB designates an unused bit (value 0).

**Table 2-6. 5.3 Kbps Speech Compression Data Format**

| TRANSMITTED OCTETS | PARx_By, …, … |
|---|---|
| 1 | LPC_B5 to LPC_B0, VADFLAG_B0, RATEFLAG_B0 |
| 2 | LPC_B13 to LPC_B6 |
| 3 | LPC_B21 to LPC_B14 |
| 4 | ACL0_B5 to ACL0_B0, LPC_B23, LPC_B22 |
| 5 | ACL2_B4 to ACL2_B0, ACL1_B1, ACL1_B0, ACL0_B6 |
| 6 | GAIN0_B3 to GAIN0_B0, ACL3_B1, ACL3_B0, ACL2_B6, ACL2_B5 |
| 7 | GAIN0_B11 to GAIN0_B4 |
| 8 | GAIN1_B7 to GAIN1_B0 |
| 9 | GAIN2_B3 to GAIN2_B0, GAIN1_B11 to GAIN1_B8 |
| 10 | GAIN2_B11 to GAIN2_B4 |
| 11 | GAIN3_B7 to GAIN3_B0 |
| 12 | GRID3_B0, GRID2_B0, GRID1_B0, GRID0_B0, GAIN3_B11 to GAIN3_B8 |
| 13 | POS0_B7 to POS0_B0 |
| 14 | POS1_B3 to POS1_B0, POS0_B11 to POS0_B8 |
| 15 | POS1_B11 to POS1_B4 |
| 16 | POS2_B7 to POS2_B0 |
| 17 | POS3_B3 to POS3_B0, POS2_B11 to POS2_B8 |
| 18 | POS3_B11 to POS3_B4 |
| 19 | PSIG1_B3 to PSIG1_B0, PSG0_B3 to PSG0_B0 |
| 20 | PSIG3_B3 to PSIG3_B0, PSIG2_B3 to PSIG2_B0 |

**(2) SID frame compression format**

The format of the 32-bit inactive frame data, which is the encoder function output and decoder function input, is shown in Table 2-7 below. Refer to ITU-T Recommendations for compressed data details.

★ Note, however, that "0x3" is returned to "TRANSMITTED OCTETS = 1" and "0x0" to "TRANSMITTED OCTETS = 2 to 4" when G723_E_FRAME_TYPE = 0 or G723_D_FRAME_TYPE = 0.

**Table 2-7. Bit Allocation of SID Data**

| TRANSMITTED OCTETS | PARx_By, … |
|---|---|
| 1 | LPC_B5 to LPC_B0, VADFLAG_B0, RATEFLAG_B0 |
| 2 | LPC_B13 to LPC_B6 |
| 3 | LPC_B21 to LPC_B14 |
| 4 | GAIN_B5 to GAIN_B0, LPC_B23, LPC_B22 |

**(3) G.723.1 ANNEX C (channel codec) additional compression data format**

The format of ANNEX C data, which is the encoder function output and decoder function input, is shown in Table 2-8 below. Refer to ITU-T Recommendations for compressed data details.

**Table 2-8. Bit Allocation of ANNEX C Compression Data**

| TRANSMITTED OCTETS | Channel Bit |
|---|---|
| 1 | UCB[7], UCB[6], UCB[5], UCB[4] , UCB[3], UCB[2], UCB[1], UCB[0] |
| 2 | U[2], U[1], U[0], UCB[12], UCB[11], UCB[10], UCB[9] ,UCB[8] |
| 3 | U[10], U[9], U[8], U[7], U[6], U[5], U[4], U[3] |
| Mp/8 + 2 | …, …, U[Mp], U[Mp–1], U[Mp–2], …, …, … |
| : | : |
| $M_{All}/8 + 2$ | UB, UB ,UB, $U[M_{All}–1]$, $U[M_{All}–2]$, $U[M_{All}–3]$, $U[M_{All}–4]$, $U[M_{All}–5]$ |

**Remark** UB designates an unused bit (value 0).

The bit rate of a protected bit string is $(M_{All} + 13) \times 1000/30$ bps.

**[MEMO]**

# CHAPTER 3 INSTALLATION

## 3.1 Installation Procedure

This middleware is only offered in a 3.5-inch (1.44 MB) floppy disk format. The procedure for installing this disk in the host machine is as follows.

(1) Set this disk in the floppy disk drive. Copy the file under a directory that uses software tools (C:\DSPTools, for example). An example of when the file was copied from A drive to C drive is shown below.

```
a:\>xcopy /s *.* c:\DSPTools <CR>
```

(2) Check that the file has been copied. Refer to **1.5.4 Directory configuration** for details of each directory.

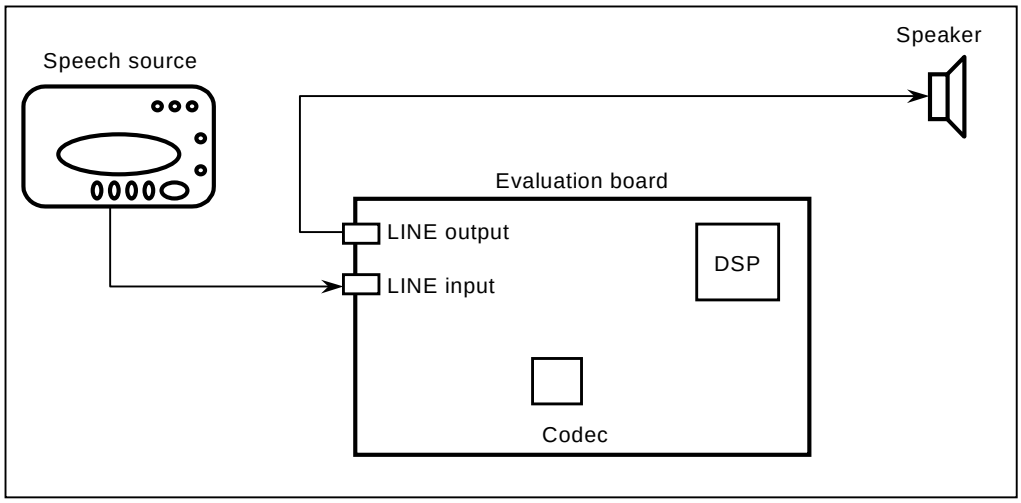
```
a:\>dir c:\DSPTools <CR>
```

## 3.2 Sample Creation Procedure

The sample program is installed in the sample directory (refer to **APPENDIX SAMPLE PROGRAM SOURCE** for details of the sampleA.asm and sampleAC.asm source programs).

The sample program is able to connect speech sources such as CDs and DATs with speakers, and compress/decompress the speech source in real time.

**Figure 3-1. Sample Program Evaluation System**



The following is an example of how to build a sample program for this middleware.

(1) Activate the WB77016 (workbench).

(2) Open the sampleA.prj (sampleAC.prj) project file.
**Example** Specify sampleA.prj (sampleAC.prj) with the Open Project command from the Project menu.

(3) Execute the build function and check that sampleA.lnk (sampleAC.lnk) has been created.
**Example** When the Build All command is selected from the Make menu, the sampleA.lnk (sampleAC.lnk) file is created.

(4) Download the program to the evaluation board.

## 3.3 Symbol Naming Conventions

The symbols, etc., in this library are allocated names in accordance with the conventions outlined below. Be careful not to duplicate these names when this middleware is being used in combination with other applications.

**Table 3-1. Symbol Names**

| Classification | Convention | |
|---|---|---|
| | G.723.1 ANNEX A | G.723.1 ANNEX C |
| Function name | G723_××× | G723_Ch××× |
| Macro, constant name | G723_××× | |
| Section name | __G723_××× | __G723_C××× |

# APPENDIX SAMPLE PROGRAM SOURCE

## A.1 For G.723.1 + ANNEX A (sampleA.asm)

```
/*------------------------------------------------------------------------- */
/* File Information                                                         */
/*------------------------------------------------------------------------- */
/* Name      : sampleA.asm                                                  */
/* Type      : ASM Programming Language source code                         */
/* Version   : V1.00                                                        */
/* Date      : 1998 June 10                                                 */
/* CPU       : uPD7701x Family                                              */
/* Assembler : WB77016 Ver2.21                                              */
/* About     : NEC uPD7701x Family G723.1 Speech CODEC Middle-Ware Library  */
/*             Sample program [1ch, OFF-LINE mode]                          */
/*------------------------------------------------------------------------- */
/* Copyright (c) NEC Corporation 1995,1996,1997,1998                        */
/* NEC CONFIDENTIAL AND PROPRIETAR                                          */
/* All rights reserved by NEC Coporation                                    */
/* Use of copyright notice does not evidence publication                    */
/*------------------------------------------------------------------------- */

/*---- include files ----*/
#include "uPD77016.h"
#include "g723_lib.h"

/*---- Global Variables ----*/
public   lib_Scratch_x                  /* Scrach area X */
public   lib_Scratch_y                  /* Scrach area Y */

/*---- Global Functions ----*/
extrn    G723_GetVersion                /* Get Version function */
extrn    G723_Start_Codec               /* Start G723 functions */
extrn    G723_Ini_Coder                 /* Initialize G723 Coder variables */
extrn    G723_Ini_Decod                 /* Initialize G723 Decoder variables */
extrn    G723_Encode                    /* Encode 1 Frame */
extrn    G723_Decode                    /* Decode 1 Frame */

$EJECT
/**/
/*************************************************************************/
/* Vector Table                                                          */
/*************************************************************************/
Vct_Ix   imseg at 0x0200
         call Init_Proc                                  ; reset
         jmp  G723_Proc                                  ;
         nop                                             ;
         nop                                             ;
         reti                                            ; not used
         nop                                             ;
         nop                                             ;
         nop                                             ;
         reti                                            ; not used
         nop                                             ;
```

```
nop                                     ;
nop                                     ;
reti                                    ; not used
nop                                     ;
nop                                     ;
nop                                     ;
reti                                    ; INT0
nop                                     ;
nop                                     ;
nop                                     ;
reti                                    ; INT1
nop                                     ;
nop                                     ;
nop                                     ;
reti                                    ; INT2
nop                                     ;
nop                                     ;
nop                                     ;
reti                                    ; INT3
nop                                     ;
nop                                     ;
nop                                     ;
reti                                    ; SI#1
nop                                     ;
nop                                     ;
nop                                     ;
reti                                    ; SO#1
nop                                     ;
nop                                     ;
nop                                     ;
reti                                    ; SI#2
nop                                     ;
nop                                     ;
nop                                     ;
reti                                    ; SO#2
nop                                     ;
nop                                     ;
nop                                     ;
reti                                    ; HOST IN
nop                                     ;
nop                                     ;
nop                                     ;
reti                                    ; HOST OUT
nop                                     ;
nop                                     ;
nop                                     ;
reti                                    ; not used
nop                                     ;
nop                                     ;
nop                                     ;
reti                                    ; not used
nop                                     ;
nop                                     ;
nop                                     ;
```

```
/*****************************************************************************/
/* G723 OFF-Line Process                                                     */
/*****************************************************************************/
Smp_Ix   imseg
Init_Proc:
         clr(r0)                                          ; No Wait
         *DWTR:x = r0l                                    ;
         *IWTR:x = r0l                                    ;

         r0l = HST_WAIT                                   ; Wait mode
         *HST:x = r0l                                     ;
         ret                                              ;

$EJECT
/**/
/*--------------------------------------------------------------------------- */
/* Scratch_Area / Static_Area / IO_Buffer                                     */
/*         !!! 'lib_Scratch_x' must be equal to 'lib_Scratch_y' !!!           */
/*--------------------------------------------------------------------------- */
Scratch_X  xramseg align at 0x020
lib_Scratch_x:
         ds        G723_SCRATCH_X_BUFSIZE

Scratch_Y  yramseg align at 0x020
lib_Scratch_y:
         ds        G723_SCRATCH_Y_BUFSIZE

Static_X   xramseg align at 0x020
StaticAreaX:
         ds        G723_STATIC_X_BUFSIZE

Static_Y   yramseg align at 0x200
StaticAreaY:
         ds        G723_STATIC_Y_BUFSIZE

IO_Area_X  xramseg
IOArea:
         ds        G723_IOTABLE_SIZE

IO_Buff_X  xramseg
EncPcmBuff:
         ds        G723_FRAME
DecPcmBuff:
         ds        G723_FRAME
EncLineBuff:
         ds        24/2
DecLineBuff:
         ds        24/2

/*--------------------------------------------------------------------------- */
/* Variables                                                                  */
/*--------------------------------------------------------------------------- */
Smp_Xe1  xramseg
WrkMode:
         ds        1
```

```
/*************************************************************************/
/* G723 OFF-Line Process                                                 */
/*************************************************************************/
Smp_Ix   imseg
G723_Proc:
         call G723_Start_Codec                          ; Need only for Simulation test

         r0l = *HDT:x                                   ; WrkMode 1)Cod ,2)Dec
         *WrkMode:x = r0l                               ;

;;       call G723_GetVersion                           ; Library Version
;;       *HDT:x = r0h                                   ; comment_out for
;;       *HDT:x = r0l                                   ;          Simulator Test

         r0l = StaticAreaX                              ;
         *IOArea+G723_STATIC_X_PTR:x = r0l              ; Static Area X
         r0l = StaticAreaY                              ;
         *IOArea+G723_STATIC_Y_PTR:x = r0l              ; Static Area Y

         r0l = EncPcmBuff                               ;
         *IOArea+G723_ENC_BUFF_PTR:x = r0l              ; PCM Buffer for Encode
         r0l = EncLineBuff                              ;
         *IOArea+G723_VOUT_PTR:x= r0l                   ; Code Buffer for Encode
         r0l = *HDT:x                                   ;
         *IOArea+G723_USE_HP:x= r0l                     ; UseHp  0)No , 1)UseHp
         r0l = *HDT:x                                   ;
         *IOArea+G723_USE_VAD:x= r0l                    ; UseVAD 0)No , 1)UseHp

         r0l = DecPcmBuff                               ;
         *IOArea+G723_DEC_BUFF_PTR:x = r0l              ; PCM buffer for Decode
         r0l = DecLineBuff                              ;
         *IOArea+G723_VINP_PTR:x = r0l                  ; Code buffer for Decode
         r0l = *HDT:x                                   ;
         *IOArea+G723_USE_PF:x= r0l                     ; UsePf  0)No , 1)UsePf

         r0l = *WrkMode:x                               ;
         r0 = r0 & 0x0001                               ;
         if( r0==0 ) jmp  INI_LBC_DEC                   ;
                /*---*/      dp0 = IOArea              ;
                call G723_Ini_Coder                     ;
                jmp  LBC_LOOP                           ;

         INI_LBC_DEC:
                /*---*/      dp0 = IOArea              ;
                call G723_Ini_Decod                     ;

         LBC_LOOP:
                r0 = *HDT:x                             ; Control 0)Stop, 1)Continue
                if( r0==0 ) jmp  LBC_END                ;

                r0l = *WrkMode:x                        ;
                r0 = r0 & 0x0001                        ;
                if( r0==0 ) jmp  LBC_DEC                ;
                         call GetPcmData                ;
                         r0l = *HDT:x                   ;
                         *IOArea+G723_WRK_RATE_E:x = r0l ; WrkRate 0)6.3, 1)5.3 [kbps]
```

```
                        /*---*/     dp0 = IOArea            ;
                        call G723_Encode                    ;

                        call PutLineData                    ;
;;                      r0l = *IOArea+G723_E_FRAME_TYPE:x   ; comment_out for
;;                      *HDT:x = r0l                        ;        Simulator Test
                        jmp  LBC_NEXT                       ;

        LBC_DEC:
                r0l = *WrkMode:x                            ;
                r0 = r0 & 0x0002                            ;
                if( r0==0 ) jmp  LBC_NEXT                   ;
                        call GetLineData                    ;
                        r0l = *HDT:x                        ;
                        *IOArea+G723_CRC_RESULT:x = r0l     ; CRC_result 0)Normal, else)Err

                        /*---*/     dp0 = IOArea            ;
                        call G723_Decode                    ;

                        call PutPcmData                     ;
;;                      r0l = *IOArea+G723_D_FRAME_TYPE:x   ; comment_out for
;;                      *HDT:x = r0l                        ;        Simulator Test
;;                      r0l = *IOArea+G723_WRK_RATE_D:x     ;
;;                      *HDT:x = r0l                        ;
;;                      r0l = *IOArea+G723_ERR_FRM_COUNT:x  ;
;;                      *HDT:x = r0l                        ;

        LBC_NEXT:
                jmp  LBC_LOOP                               ;

  LBC_END:
        jmp  $                                              ;

$EJECT
/**/
/*************************************************************************/
/* Input PCM data for Encode process                                     */
/*************************************************************************/
Smp_Ix   imseg
GetPcmData:
        /*---*/     dp0 = EncPcmBuff                        ;
        loop G723_FRAME {                                   ;
                r0l = *HDT:x                                ;
                /*    */     *dp0++ = r0l                   ;
        }
        ret                                                 ;

/*************************************************************************/
/* Output decoded PCM data                                               */
/*************************************************************************/
Smp_Ix   imseg
PutPcmData:
        /*---*/     dp0 = DecPcmBuff                        ;
        loop G723_FRAME {                                   ;
                /*    */     r0l = *dp0++                   ;
```

```
                *HDT: = r0l                                     ;
        }
        ret                                                     ;

/************************************************************************/
/* Input Code data for Decode process                                   */
/************************************************************************/
Smp_Ix   imseg
GetLineData:
        /*---*/     dp0 = DecLineBuff                           ;
        loop 24/2 {                                             ;
                r0l = *HDT:x                                    ;
                /*    */     *dp0++ = r0l                       ;
        }
        ret                                                     ;

/************************************************************************/
/* Output Encoded Code data                                             */
/************************************************************************/
Smp_Ix   imseg
PutLineData:
        /*---*/     dp0 = EncLineBuff                           ;
        loop 24/2 {                                             ;
                /*    */     r0l = *dp0++                       ;
                *HDT:x = r0l                                    ;
        }
        ret                                                     ;
end
```

## A.2 For G.723.1 + ANNEX A + ANNEX C (sampleAC.asm)

```
/*------------------------------------------------------------------------- */
/* File Information                                                         */
/*------------------------------------------------------------------------- */
/* Name      : sampleAC.asm                                                 */
/* Type      : ASM Programming Language source code                         */
/* Version   : V1.00                                                        */
/* Date      : 1998 Oct 10                                                  */
/* CPU       : uPD7701x Family                                              */
/* Assembler : WB77016 Ver2.21                                              */
/* About     : NEC uPD7701x Family G723.1 Speech CODEC Middle-Ware Library  */
/*             Sample program [1ch, OFF-LINE mode]                          */
/*------------------------------------------------------------------------- */
/* Copyright (c) NEC Corporation 1995,1996,1997,1998                        */
/* NEC CONFIDENTIAL AND PROPRIETARY                                         */
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/*------------------------------------------------------------------------- */

/*---- include files ----*/
#include  "uPD77016.h"
#include  "g723_lib.h"
#include  "g723clib.h"

/*---- Global Variables ----*/
public    lib_Scratch_x                 /* Scrach area X */
public    lib_Scratch_y                 /* Scrach area Y */

/*---- Global Functions ----*/
extrn     G723_GetVersion               /* Get Version function */
extrn     G723_Start_Codec              /* Start G723 functions */
extrn     G723_Ini_Coder                /* Initialize G723 Coder variables*/
extrn     G723_Ini_Decod                /* Initialize G723 Decoder variables */
extrn     G723_Encode                   /* Encode 1 Frame*/
extrn     G723_Decode                   /* Decode 1 Frame*/

$EJECT
/**/
/*************************************************************************/
/* Vector Table                                                          */
/*************************************************************************/
Vct_Ix   imseg at 0x0200
         call Init_Proc                                  ; reset
         jmp  G723_Proc                                  ;
         nop                                             ;
         nop                                             ;
         reti                                            ; not used
         nop                                             ;
         nop                                             ;
         nop                                             ;
         reti                                            ; not used
         nop                                             ;
         nop                                             ;
         nop                                             ;
         reti                                            ; not used
```

```
        nop                                                     ;
        nop                                                     ;
        nop                                                     ;
        reti                                                    ; INT0
        nop                                                     ;
        nop                                                     ;
        nop                                                     ;
        reti                                                    ; INT1
        nop                                                     ;
        nop                                                     ;
        nop                                                     ;
        reti                                                    ; INT2
        nop                                                     ;
        nop                                                     ;
        nop                                                     ;
        reti                                                    ; INT3
        nop                                                     ;
        nop                                                     ;
        nop                                                     ;
        reti                                                    ; SI#1
        nop                                                     ;
        nop                                                     ;
        nop                                                     ;
        reti                                                    ; SO#1
        nop                                                     ;
        nop                                                     ;
        nop                                                     ;
        reti                                                    ; SI#2
        nop                                                     ;
        nop                                                     ;
        nop                                                     ;
        reti                                                    ; SO#2
        nop                                                     ;
        nop                                                     ;
        nop                                                     ;
        reti                                                    ; HOST IN
        nop                                                     ;
        nop                                                     ;
        nop                                                     ;
        reti                                                    ; HOST OUT
        nop                                                     ;
        nop                                                     ;
        nop                                                     ;
        reti                                                    ; not used
        nop                                                     ;
        nop                                                     ;
        nop                                                     ;
        reti                                                    ; not used
        nop                                                     ;
        nop                                                     ;
        nop                                                     ;

/*************************************************************************/
/* G723 OFF-Line Process                                                 */
/*************************************************************************/
Smp_Ix   imseg
```

```
Init_Proc:
        clr(r0)                                          ; No Wait
        *DWTR:x = r0l                                    ;
        *IWTR:x = r0l                                    ;

        r0l = HST_WAIT                                   ; Wait mode
        *HST:x = r0l                                     ;
        ret                                              ;

$EJECT
/**/
/*------------------------------------------------------------------------- */
/* Scratch_Area / Static_Area / IO_Buffer                                   */
/*       !!! 'lib_Scratch_x' must be equal to 'lib_Scratch_y' !!!           */
/*------------------------------------------------------------------------- */
Scratch_X  xramseg align at 0x020
lib_Scratch_x:
;;      ds      G723_SCRATCH_X_BUFSIZE
        ds      G723C_SCRATCH_X_BUFSIZE                 ; is bigger than G723_SCRATCH_X_BUFSIZE

Scratch_Y  yramseg align at 0x020
lib_Scratch_y:
        ds      G723_SCRATCH_Y_BUFSIZE

Static_X   xramseg align at 0x020
StaticAreaX:    ds      G723_STATIC_X_BUFSIZE
C_StaticAreaX:  ds      G723C_STATIC_X_BUFSIZE          ; Annex C

Static_Y   yramseg align at 0x200
StaticAreaY:    ds      G723_STATIC_Y_BUFSIZE
C_StaticAreaY:  ds      G723C_STATIC_Y_BUFSIZE          ; Annex C

IO_Area_X  xramseg
IOArea:
        ds      G723_IOTABLE_SIZE
LibEntry:
        ds      G723C_LIBENTRY_SIZE                     ; Annex C

IO_Buff_X  xramseg
EncPcmBuff:
        ds      G723_FRAME
DecPcmBuff:
        ds      G723_FRAME
EncLineBuff:
        ds      24/2 + 2
DecLineBuff:
        ds      24/2 + 1

EncChanBuff:    ds      48                              ; Annex C
DecChanBuff:    ds      48                              ; Annex C

/*------------------------------------------------------------------------- */
/* Variables                                                                */
/*------------------------------------------------------------------------- */
Smp_Xe1  xramseg
WrkMode:
```

```
        ds     1

/*-------------------------------------------------------------*/
/*           Annex C initialization                            */
/*-------------------------------------------------------------*/
AnnexC_Const yramseg
BitrateConfig:
        dw        77, 27, 65,  23, 16, 6                  /* Channel rate limits */

InitC imseg
InitAnnexC:
        clr(r0);
        /*...*/      *EncLineBuff+12:x = r0h;
        /*...*/      *EncLineBuff+13:x = r0h;

        /*---*/      dp0 = LibEntry;
        r0l = C_StaticAreaX;
        /*...*/      *dp0++ = r0l;
        r0l = C_StaticAreaY;
        /*...*/      *dp0++ = r0l;
        r0l = EncLineBuff;
        /*...*/      *dp0++ = r0l;                         // Input buffer
        r0l = EncChanBuff;
        /*...*/      *dp0++ = r0l;                         // Output buffer
        r0l = 1;
        /*...*/      *dp0++ = r0l;                         // EncodeSW (0:off 1:on)
        r0l = 1;
        /*...*/      *dp0++ = r0l;                         // High/Low select (0:low 1:high)
        /*---*/      dp4 = BitrateConfig;
        /*     */    *dp0++ = r0h;                         // number of octets(dummy access)
        /*     */    r0 = *dp4++;
        rep 6;
              /*      */    *dp0++ = r0h      r0 = *dp4++;

        /*---*/      dp0 = LibEntry;
        call G723_Ini_ChCod;

        clr(r0);
        /*---*/      dp0 = LibEntry + G723C_LIBENTRY_DECOFS;
        r0l = DecLineBuff;
        /*...*/      *dp0++ = r0l;                         // Output buffer
        r0l = DecChanBuff;
        /*...*/      *dp0++ = r0l;                         // Input buffer
        /*   */      *dp0++ = r0h;                         // clear error flag
        /*---*/      dp4 = BitrateConfig;
        /*     */    *dp0++ = r0h;                         // reserved
        /*     */    r0 = *dp4++;
        rep 6;
              /*      */    *dp0++ = r0h      r0 = *dp4++;

        /*---*/      dp0 = LibEntry;
        call G723_Ini_ChDec;

        ret;
```

```
/*************************************************************************/
/* G723 OFF-Line Process                                                 */
/*************************************************************************/
Smp_Ix   imseg
G723_Proc:
         call G723_Start_Codec                ; Need only for Simulation test

         r0l = *HDT:x                         ; WrkMode 1)Cod ,2)Dec
         *WrkMode:x = r0l                     ;

;;       call G723_GetVersion                 ; Library Version
;;       *HDT:x = r0h                         ; comment_out for
;;       *HDT:x = r0l                         ;        Simulator Test

         r0l = StaticAreaX                    ;
         *IOArea+G723_STATIC_X_PTR:x = r0l    ; Static Area X
         r0l = StaticAreaY                    ;
         *IOArea+G723_STATIC_Y_PTR:x = r0l    ; Static Area Y

         r0l = EncPcmBuff                     ;
         *IOArea+G723_ENC_BUFF_PTR:x = r0l    ; PCM Buffer for Encode
         r0l = EncLineBuff                    ;
         *IOArea+G723_VOUT_PTR:x = r0l        ; Code Buffer for Encode
         r0l = *HDT:x                         ;
         *IOArea+G723_USE_HP:x = r0l          ; UseHp  0)No , 1)UseHp
         r0l = *HDT:x                         ;
         *IOArea+G723_USE_VAD:x= r0l          ; UseVAD 0)No , 1)UseHp

         r0l = DecPcmBuff                     ;
         *IOArea+G723_DEC_BUFF_PTR:x = r0l    ; PCM buffer for Decode
         r0l = DecLineBuff                    ;
         *IOArea+G723_VINP_PTR:x = r0l        ; Code buffer for Decode
         r0l = *HDT:x                         ;
         *IOArea+G723_USE_PF:x = r0l          ; UsePf  0)No , 1)UsePf


;; Setup Lib-Entry for Annex C
         call InitAnnexC;

         r0l = *WrkMode:x                     ;
         r0 = r0 & 0x0001                     ;
         if( r0==0 ) jmp  INI_LBC_DEC         ;
                /*---*/      dp0 = IOArea     ;
                call G723_Ini_Coder           ;
                jmp  LBC_LOOP                 ;

          INI_LBC_DEC:
                /*---*/      dp0 = IOArea     ;
                call G723_Ini_Decod           ;
           LBC_LOOP:
                r0 = *HDT:x                   ; Control 0)Stop, 1)Continue
                if( r0==0 ) jmp  LBC_END      ;

                r0l = *WrkMode:x              ;
                r0 = r0 & 0x0001              ;
                if( r0==0 ) jmp  LBC_DEC      ;
```

```
                    call GetPcmData                    ;
                    r0l = *HDT:x                       ;
                    *IOArea+G723_WRK_RATE_E:x = r0l    ; WrkRate 0)6.3, 1)5.3 [kbps]

                    /*---*/     dp0 = IOArea           ;
                    call G723_Encode                   ;

                    /*---*/     dp0 = LibEntry         ; Annex C
                    call G723_ChCod                    ;

;                   call PutLineData                   ; comment for Annex C
                    call PutChannelData;

;;                  r0l = *IOArea+G723_E_FRAME_TYPE:x  ; comment_out for
;;                  *HDT:x = r0l                       ;         Simulator Test
                    jmp  LBC_NEXT                      ;

          LBC_DEC:
               r0l = *WrkMode:x                        ;
               r0 = r0 & 0x0002                        ;
               if( r0==0 ) jmp  LBC_NEXT               ;
;                     call GetLineData                 ;
                      call GetChannelData              ;

                      /*---*/     dp0 = LibEntry       ; Annex C
                      call G723_ChDec                  ;

;                     r0l = *HDT:x                     ;
                      r0l = *(LibEntry + G723C_LIBENTRY_ERRINFO):x;
                      *IOArea+G723_CRC_RESULT:x = r0l  ; CRC_result 0)Normal, else)Err

                      /*---*/     dp0 = IOArea         ;
                      call G723_Decode                 ;

                      call PutPcmData                  ;
;;                    r0l = *IOArea+G723_D_FRAME_TYPE:x ; comment_out for
;;                    *HDT:x = r0l                     ;       Simulator Test
;;                    r0l = *IOArea+G723_WRK_RATE_D:x  ;
;;                    *HDT:x = r0l                     ;
;;                    r0l = *IOArea+G723_ERR_FRM_COUNT:x ;
;;                    *HDT:x = r0l                     ;

          LBC_NEXT:
               jmp  LBC_LOOP                ;

  LBC_END:
         nop                                ;
         nop                                ;
         nop                                ;
         nop                                ;
         nop                                ;
         nop                                ;
         nop                                ;
         halt                               ;
```

```
$EJECT
/**/
/*************************************************************************/
/* Input PCM data for Encode process                                     */
/*************************************************************************/
Smp_Ix   imseg
GetPcmData:
        /*---*/     p0 = EncPcmBuff           ;
        loop G723_FRAME {                     ;
               r0l = *HDT:x                   ;
               /*    */      *dp0++ = r0l      ;
        }
        ret                                   ;

/*************************************************************************/
/* Output decoded PCM data                                               */
/*************************************************************************/
Smp_Ix   imseg
PutPcmData:
        /*---*/     dp0 = DecPcmBuff          ;
        loop G723_FRAME {                     ;
               /*    */      r0l = *dp0++      ;
               *HDT:x = r0l                   ;
        }
        ret                                   ;

/*************************************************************************/
/* Input Code data for Decode process                                    */
/*************************************************************************/
Smp_Ix       imseg
GetLineData:
        /*---*/     dp0 = DecLineBuff         ;
        loop 24/2 {                           ;
               r0l = *HDT:x                   ;
               /*    */      *dp0++ = r0l      ;
        }
        ret                                   ;

/*************************************************************************/
/* Output Encoded Code data                                              */
/*************************************************************************/
Smp_Ix   imseg
PutLineData:
        /*---*/     dp0 = EncLineBuff         ;
        loop 24/2 {                           ;
               /*    */      r0l = *dp0++      ;
               *HDT:x = r0l                   ;
        }
        ret                                   ;


/*=====================================================================**
 *           Annex C
 *=====================================================================*/
Smp_Ix   imseg
PutChannelData:
```

```
        /*---*/     p0 = EncChanBuff;
        clr(r0);
        /*...*/     r0l = *(LibEntry + G723C_LIBENTRY_OUTSIZE):x;
        r0 = r0 + 1;
        r0 = r0 srl 1;
        loop r0l {
               /*...*/      r0l = *dp0++;
               /*...*/      *HDT:x = r0l;
        }
        ret;

GetChannelData:
        /*---*/     dp0 = DecChanBuff;
        clr(r0);
        r0l = *HDT:x;                    /* r0l = the number of words */
        loop r0l {
               /*...*/      r0l = *HDT:x;
               /*...*/      *dp0++ = r0l;
        }
        ret;

end
```

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