玉柴发动机锁车功能与车载终端匹配技术要求—核心算法部分

编写：陈中柱

校对：刘小林

审核：安利强

批准：陈俊红

广西玉柴机器股份有限公司工程研究院
电控系统研发部
2016.07.28

Guangxi Yuchai Machinery Co., Ltd.
地址（Add）：中国广西玉林市天桥西路 88 号/ No. 88, Tianqiao West Road, Yulin City, Guangxi, China
电话（Tel）：+86 775 3228168　　传真（Fax）：+86 775 3288168　　邮编（P.C.）：537005

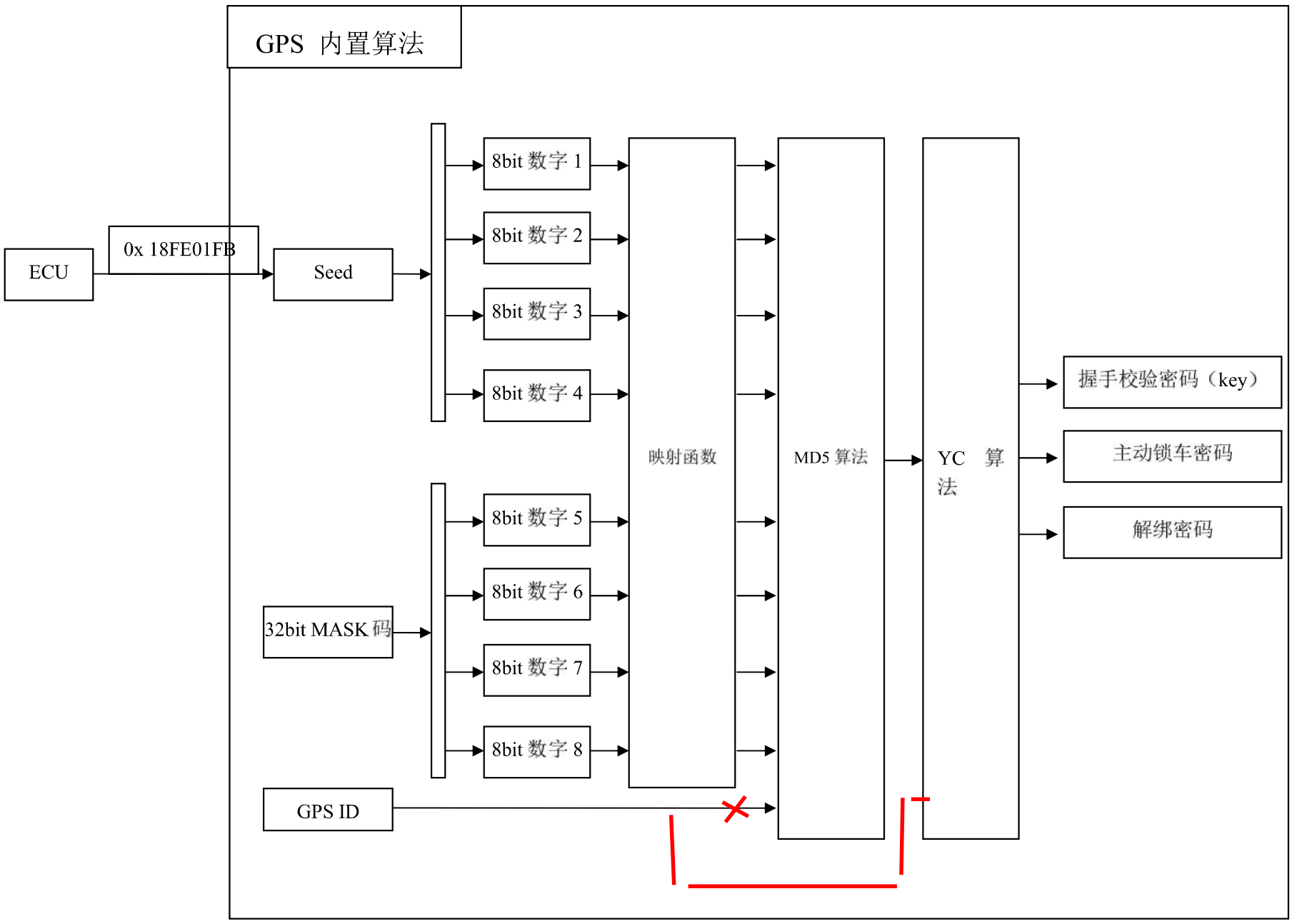
版本修订

序号	修订时间	修订内容	修订后版本	修订人
1	2016/12/31	1. 修正算法实例，原实例有错	V2.4	陈中柱

1.算法

下图是从 seed 生成 key 的算法过程，GPS 需要内置下列算法，方使得 GPS 和 ECU 计算的 key 一模一样。

算法简图： seed -----> key



1. seed→8bit 数字 1，8bit 数字 2，8bit 数字 3，8bit 数字 4

	Seed																													
位置	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	8bit 数字 1								8bit 数字 2								8bit 数字 3								8bit 数字 4							

2. 32bit MASK 码 →8bit 数字 5，8bit 数字 6，8bit 数字 7，8bit 数字 8

	32bit MASK 码																													
位置	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	8bit 数字 5								8bit 数字 6								8bit 数字 7								8bit 数字 8							

注：MASK 码由玉柴提供，用于管理客户，具体数字需咨询玉柴。

例子：

SEED=0x11223344

MASK=0x55667788

序号	数字 1	数字 2	数字 3	数字 4	数字 5	数字 6	数字 7	数字 8
对应内容	0x44	0x33	0x22	0x11	0x88	0x77	0x66	0x55

对应

3. 映射函数原型：

void get_rand_str(unsigned char rand[],unsigned char new[],int number)

地址（Add）：中国广西玉林市天桥西路 88 号/ No. 88, Tianqiao West Road, Yulin City, Guangxi, China
电话（Tel）：+86 775 3228168　　传真（Fax）：+86 775 3288168　　邮编（P.C.）：537005

```
{
        char str[64] = "0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz";
        str[62]=0;
        str[63]=0;
        int pointer;
        for(pointer=0;pointer< number;pointer++)
            {
                for(;rand[pointer]>=62;)
                    {
                        rand[pointer]=rand[pointer]-62;
                    }
                new[pointer]=str[rand[pointer]];
            }
}
//function of mapping relation
```

原理：每个 8bit 数字，调用一次映射函数，然后可以对应一个 str 数组的字符。举例：10 对应字符”A”，63 对应”1”，140 对应”G”。

4. MD5 算法

分为 header 和 main

Header 部分：

```
/* POINTER defines a generic pointer type */
typedef unsigned char * POINTER;

/* MD5 context. */
typedef struct {
 uint32 state[4];                                   /* state (ABCD) */
 uint32 count[2];        /* number of bits, modulo 2^64 (lsb first) */
 unsigned char buffer[64];                         /* input buffer */
} MD5_CTX;

void MD5Init (MD5_CTX *context);
void MD5Update (MD5_CTX *context, unsigned char *input, unsigned int inputLen);
void MD5Final (unsigned char digest[16], MD5_CTX *context);
```

main 部分：

```
/* Constants for MD5Transform routine.*/
#define S11 7
#define S12 12
#define S13 17
#define S14 22
#define S21 5
#define S22 9
#define S23 14
#define S24 20
#define S31 4
#define S32 11
#define S33 16
#define S34 23
#define S41 6
#define S42 10
#define S43 15
#define S44 21

static void MD5_memcpy (POINTER output, POINTER input, unsigned int len);
static void MD5Transform (uint32 state[4], unsigned char block[64]);
static void Encode (unsigned char *output, uint32 *input, unsigned int len);
static void MD5_memset (POINTER output, int value, unsigned int len);
static void Decode (uint32 *output, unsigned char *input, unsigned int len);

static unsigned char PADDING[64] = {
    0x80, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
    0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
    0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
};
```


Guangxi Yuchai Machinery Co., Ltd.
地址（Add）：中国广西玉林市天桥西路 88 号/ No. 88, Tianqiao West Road, Yulin City, Guangxi, China
电话（Tel）：+86 775 3228168　　传真（Fax）：+86 775 3288168　　邮编（P.C.）：537005

```
/* F, G, H and I are basic MD5 functions.
*/
#define F(x, y, z) (((x) & (y)) | ((~x) & (z)))
#define G(x, y, z) (((x) & (z)) | ((y) & (~z)))
#define H(x, y, z) ((x) ^ (y) ^ (z))
#define I(x, y, z) ((y) ^ ((x) | (~z)))

/* ROTATE_LEFT rotates x left n bits.
*/
#define ROTATE_LEFT(x, n) (((x) << (n)) | ((x) >> (32-(n))))

/* FF, GG, HH, and II transformations for rounds 1, 2, 3, and 4.
Rotation is separate from addition to prevent recomputation.
*/
#define FF(a, b, c, d, x, s, ac) { \
      (a) += F ((b), (c), (d)) + (x) + (uint32)(ac); \
      (a) = ROTATE_LEFT ((a), (s)); \
      (a) += (b); \
      }
#define GG(a, b, c, d, x, s, ac) { \
      (a) += G ((b), (c), (d)) + (x) + (uint32)(ac); \
      (a) = ROTATE_LEFT ((a), (s)); \
      (a) += (b); \
      }
#define HH(a, b, c, d, x, s, ac) { \
      (a) += H ((b), (c), (d)) + (x) + (uint32)(ac); \
      (a) = ROTATE_LEFT ((a), (s)); \
      (a) += (b); \
      }
#define II(a, b, c, d, x, s, ac) { \
      (a) += I ((b), (c), (d)) + (x) + (uint32)(ac); \
      (a) = ROTATE_LEFT ((a), (s)); \
      (a) += (b); \
      }

/* MD5 initialization. Begins an MD5 operation, writing a new context.
  */
void MD5Init (MD5_CTX *context)                                          /* context */
{
      context->count[0] = context->count[1] = 0;
      /* Load magic initialization constants.
      */
      context->state[0] = 0x67452301;
      context->state[1] = 0xefcdab89;
      context->state[2] = 0x98badcfe;
      context->state[3] = 0x10325476;
}

/* MD5 block update operation. Continues an MD5 message-digest
   operation, processing another message block, and updating the
   context.
  */
void MD5Update (MD5_CTX *context, unsigned char *input, unsigned int inputLen)

{
      unsigned int i, index, partLen;

      /* Compute number of bytes mod 64 */
      index = (unsigned int)((context->count[0] >> 3) & 0x3F);

      /* Update number of bits */
      if ((context->count[0] += ((uint32)inputLen << 3))
            < ((uint32)inputLen << 3))
            context->count[1]++;
```

```
    context->count[1] += ((uint32)inputLen >> 29);

    partLen = 64 - index;

    /* Transform as many times as possible.
    */
    if (inputLen >= partLen) {
        MD5_memcpy((POINTER)&context->buffer[index], (POINTER)input, partLen);
        MD5Transform (context->state, context->buffer);

        for (i = partLen; i + 63 < inputLen; i += 64)
            MD5Transform (context->state, &input[i]);

        index = 0;
    }
    else
        i = 0;

    /* Buffer remaining input */
    MD5_memcpy((POINTER)&context->buffer[index], (POINTER)&input[i],inputLen-i);
}

/* MD5 finalization. Ends an MD5 message-digest operation, writing the
   the message digest and zeroizing the context.
  */
void MD5Final (unsigned char digest[16], MD5_CTX *context)
{
    unsigned char bits[8];
    unsigned int index, padLen;

    /* Save number of bits */
    Encode (bits, context->count, 8);

    /* Pad out to 56 mod 64.
    */
    index = (unsigned int)((context->count[0] >> 3) & 0x3f);
    padLen = (index < 56) ? (56 - index) : (120 - index);
    MD5Update (context, PADDING, padLen);

    /* Append length (before padding) */
    MD5Update (context, bits, 8);

    /* Store state in digest */
    Encode (digest, context->state, 16);

    /* Zeroize sensitive information.
    */
    MD5_memset ((POINTER)context, 0, sizeof (*context));
}

/* MD5 basic transformation. Transforms state based on block.
  */
static void MD5Transform (uint32 state[4], unsigned char block[64])
{
    uint32 a = state[0], b = state[1], c = state[2], d = state[3], x[16];

    Decode (x, block, 64);

    /* Round 1 */
    FF (a, b, c, d, x[ 0], S11, 0xd76aa478); /* 1 */
    FF (d, a, b, c, x[ 1], S12, 0xe8c7b756); /* 2 */
    FF (c, d, a, b, x[ 2], S13, 0x242070db); /* 3 */
    FF (b, c, d, a, x[ 3], S14, 0xc1bdceee); /* 4 */
    FF (a, b, c, d, x[ 4], S11, 0xf57c0faf); /* 5 */
    FF (d, a, b, c, x[ 5], S12, 0x4787c62a); /* 6 */
```

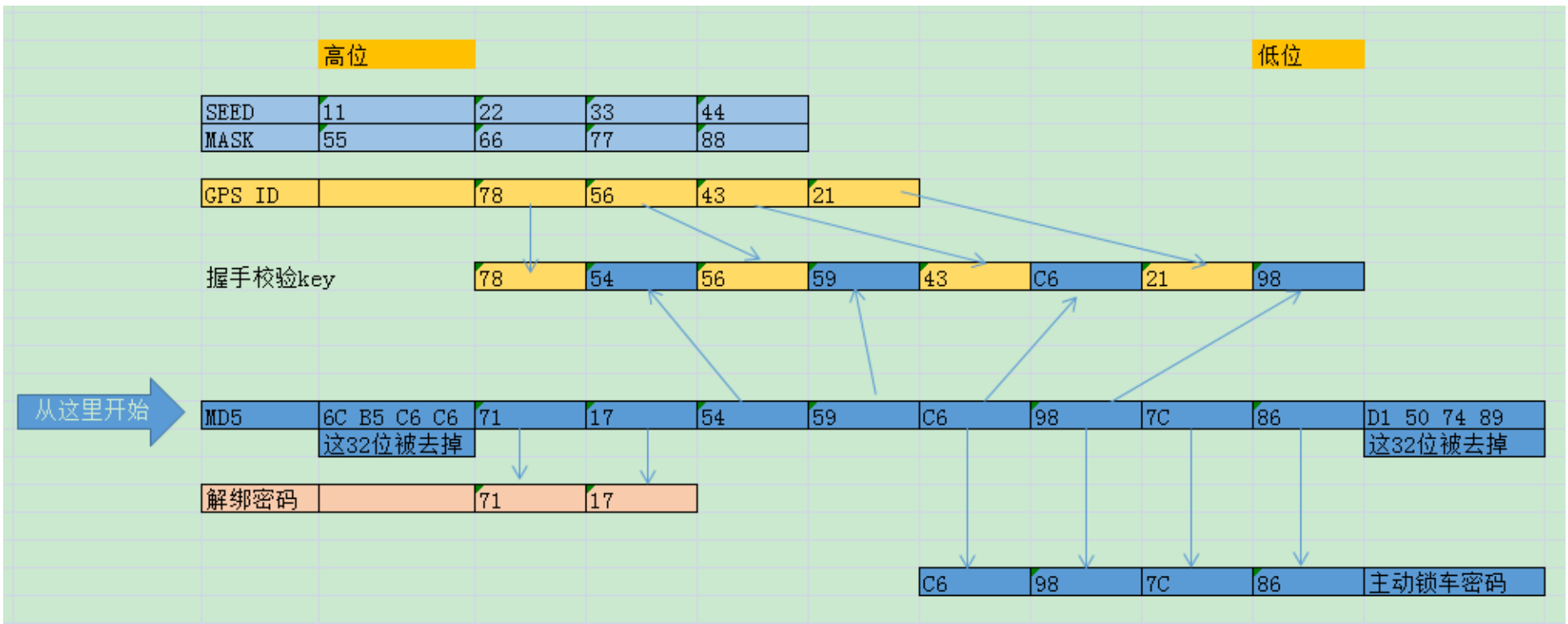
```
FF (c, d, a, b, x[ 6], S13, 0xa8304613); /* 7 */
FF (b, c, d, a, x[ 7], S14, 0xfd469501); /* 8 */
FF (a, b, c, d, x[ 8], S11, 0x698098d8); /* 9 */
FF (d, a, b, c, x[ 9], S12, 0x8b44f7af); /* 10 */
FF (c, d, a, b, x[10], S13, 0xffff5bb1); /* 11 */
FF (b, c, d, a, x[11], S14, 0x895cd7be); /* 12 */
FF (a, b, c, d, x[12], S11, 0x6b901122); /* 13 */
FF (d, a, b, c, x[13], S12, 0xfd987193); /* 14 */
FF (c, d, a, b, x[14], S13, 0xa679438e); /* 15 */
FF (b, c, d, a, x[15], S14, 0x49b40821); /* 16 */

/* Round 2 */
GG (a, b, c, d, x[ 1], S21, 0xf61e2562); /* 17 */
GG (d, a, b, c, x[ 6], S22, 0xc040b340); /* 18 */
GG (c, d, a, b, x[11], S23, 0x265e5a51); /* 19 */
GG (b, c, d, a, x[ 0], S24, 0xe9b6c7aa); /* 20 */
GG (a, b, c, d, x[ 5], S21, 0xd62f105d); /* 21 */
GG (d, a, b, c, x[10], S22,   0x2441453); /* 22 */
GG (c, d, a, b, x[15], S23, 0xd8a1e681); /* 23 */
GG (b, c, d, a, x[ 4], S24, 0xe7d3fbc8); /* 24 */
GG (a, b, c, d, x[ 9], S21, 0x21e1cde6); /* 25 */
GG (d, a, b, c, x[14], S22, 0xc33707d6); /* 26 */
GG (c, d, a, b, x[ 3], S23, 0xf4d50d87); /* 27 */
GG (b, c, d, a, x[ 8], S24, 0x455a14ed); /* 28 */
GG (a, b, c, d, x[13], S21, 0xa9e3e905); /* 29 */
GG (d, a, b, c, x[ 2], S22, 0xfcefa3f8); /* 30 */
GG (c, d, a, b, x[ 7], S23, 0x676f02d9); /* 31 */
GG (b, c, d, a, x[12], S24, 0x8d2a4c8a); /* 32 */

/* Round 3 */
HH (a, b, c, d, x[ 5], S31, 0xfffa3942); /* 33 */
HH (d, a, b, c, x[ 8], S32, 0x8771f681); /* 34 */
HH (c, d, a, b, x[11], S33, 0x6d9d6122); /* 35 */
HH (b, c, d, a, x[14], S34, 0xfde5380c); /* 36 */
HH (a, b, c, d, x[ 1], S31, 0xa4beea44); /* 37 */
HH (d, a, b, c, x[ 4], S32, 0x4bdecfa9); /* 38 */
HH (c, d, a, b, x[ 7], S33, 0xf6bb4b60); /* 39 */
HH (b, c, d, a, x[10], S34, 0xbebfbc70); /* 40 */
HH (a, b, c, d, x[13], S31, 0x289b7ec6); /* 41 */
HH (d, a, b, c, x[ 0], S32, 0xeaa127fa); /* 42 */
HH (c, d, a, b, x[ 3], S33, 0xd4ef3085); /* 43 */
HH (b, c, d, a, x[ 6], S34,    0x4881d05); /* 44 */
HH (a, b, c, d, x[ 9], S31, 0xd9d4d039); /* 45 */
HH (d, a, b, c, x[12], S32, 0xe6db99e5); /* 46 */
HH (c, d, a, b, x[15], S33, 0x1fa27cf8); /* 47 */
HH (b, c, d, a, x[ 2], S34, 0xc4ac5665); /* 48 */

/* Round 4 */
II (a, b, c, d, x[ 0], S41, 0xf4292244); /* 49 */
II (d, a, b, c, x[ 7], S42, 0x432aff97); /* 50 */
II (c, d, a, b, x[14], S43, 0xab9423a7); /* 51 */
II (b, c, d, a, x[ 5], S44, 0xfc93a039); /* 52 */
II (a, b, c, d, x[12], S41, 0x655b59c3); /* 53 */
II (d, a, b, c, x[ 3], S42, 0x8f0ccc92); /* 54 */
II (c, d, a, b, x[10], S43, 0xffeff47d); /* 55 */
II (b, c, d, a, x[ 1], S44, 0x85845dd1); /* 56 */
II (a, b, c, d, x[ 8], S41, 0x6fa87e4f); /* 57 */
II (d, a, b, c, x[15], S42, 0xfe2ce6e0); /* 58 */
II (c, d, a, b, x[ 6], S43, 0xa3014314); /* 59 */
II (b, c, d, a, x[13], S44, 0x4e0811a1); /* 60 */
II (a, b, c, d, x[ 4], S41, 0xf7537e82); /* 61 */
II (d, a, b, c, x[11], S42, 0xbd3af235); /* 62 */
II (c, d, a, b, x[ 2], S43, 0x2ad7d2bb); /* 63 */
II (b, c, d, a, x[ 9], S44, 0xeb86d391); /* 64 */
```

```
        state[0] += a;
        state[1] += b;
        state[2] += c;
        state[3] += d;

        /* Zeroize sensitive information.
        */
        MD5_memset ((POINTER)x, 0, sizeof (x));
}

/* Encodes input (uint32) into output (unsigned char). Assumes len is
   a multiple of 4.
 */
static void Encode (unsigned char *output, uint32 *input, unsigned int len)
{
        unsigned int i, j;

        for (i = 0, j = 0; j < len; i++, j += 4) {
                output[j] = (unsigned char)(input[i] & 0xff);
                output[j+1] = (unsigned char)((input[i] >> 8) & 0xff);
                output[j+2] = (unsigned char)((input[i] >> 16) & 0xff);
                output[j+3] = (unsigned char)((input[i] >> 24) & 0xff);
        }
}

/* Decodes input (unsigned char) into output (uint32). Assumes len is
   a multiple of 4.
 */
static void Decode (uint32 *output, unsigned char *input, unsigned int len)
{
        unsigned int i, j;

        for (i = 0, j = 0; j < len; i++, j += 4)
                output[i] = ((uint32)input[j]) | (((uint32)input[j+1]) << 8) |
                (((uint32)input[j+2]) << 16) | (((uint32)input[j+3]) << 24);
}

/* Note: Replace "for loop" with standard memcpy if possible.
 */

static void MD5_memcpy (POINTER output, POINTER input, unsigned int len)
{
        unsigned int i;

        for (i = 0; i < len; i++)
                output[i] = input[i];
        }

        /* Note: Replace "for loop" with standard memset if possible.
         */
        static void MD5_memset (POINTER output, int value, unsigned int len)
        {
                unsigned int i;

                for (i = 0; i < len; i++)
                        ((char *)output)[i] = (char)value;
        }
        /* Digests a string and prints the result.
*/
```

5. GPSID 和 MD5 算法→YC 算法→握手校验密码，主动锁车密码，解绑密码，下面是实例，均为 16 进制：

seed：0x11223344，MASK：0x55667788，

	数字 1	数字 2	数字 3	数字 4	数字 5	数字 6	数字 7	数字 8
分拆 8 数字对应内容	0x44	0x33	0x22	0x11	0x88	0x77	0x66	0x55
对应的十进制	68	51	34	17	136	119	102	85
调用 char 函数后得到的字符	6	p	Y	H	C	v	e	N



另外提供十组基于 C 语言的算法例子：

十组密码　　C 语言格式：以下均为 16 进制，我就不加 0x 了

	GPSID	MASK	SEED	MD5 密码	握手校验密码	解绑密码	主动锁车密码
1	78 56 34 12	40 39 00 00	11 23 45 89	F9 54 F2 50 16 2A F1 53	F2 78 50 56 16 34 2A 12	F1 53	F9 54 F2 50
2	79 56 34 12	AB AA 02 13	22 14 38 23	F3 B1 F2 20 3D AA 31 FB	F2 79 20 56 3D 34 AA 12	31 FB	F3 B1 F2 20
3	80 56 34 12	CD 23 12 56	11 23 45 89	20 C6 BA F0 A3 76 B8 7D	BA 80 F0 56 A3 34 76 12	B8 7D	20 C6 BA F0
4	24 68 9A BC	80 56 34 12	11 23 45 89	55 5D 86 F3 30 BA 44 48	86 24 F3 68 30 9A BA BC	44 48	55 5D 86 F3
5	24 68 9A BC	22 14 38 23	11 23 45 89	48 10 C0 2E 7D 0F BF E5	C0 24 2E 68 7D 9A 0F BC	BF E5	48 10 C0 2E
6	24 68 9A BC	22 14 38 23	24 68 9A BC	27 F0 EA 50 29 BA 0C D5	EA 24 50 68 29 9A BA BC	0C D5	27 F0 EA 50
7	24 68 9A BC	22 14 38 23	78 56 34 12	AE 92 D1 AD A0 05 9D 10	D1 24 AD 68 A0 9A 05 BC	9D 10	AE 92 D1 AD
8	AB AA 02 13	AB AA 02 13	78 56 34 12	D9 BC 7E DE DA 12 1B 3D	7E AB DE AA DA 02 12 13	1B 3D	D9 BC 7E DE
9	AB AA 02 13	14 68 91 22	CD 23 12 56	2E F1 76 1C 8A D1 61 1A	76 AB 1C AA 8A 02 D1 13	61 1A	2E F1 76 1C
10	AB AA 02 13	CD 23 12 56	14 68 91 22	A1 E5 ED 2F EE A5 15 92	ED AB 2F AA EE 02 A5 13	15 92	A1 E5 ED 2F

6. 总线发送部分：由于总线采用的是 intel 型，但单片机变量存储是用的是 motorla 型，如上面的 seed：0x11223344，发送到总线却是

44　33　22　11　00　00　00　00

Guangxi Yuchai Machinery Co., Ltd.
地址（Add）：中国广西玉林市天桥西路 88 号/ No. 88, Tianqiao West Road, Yulin City, Guangxi, China
电话（Tel）：+86 775 3228168　　传真（Fax）：+86 775 3288168　　邮编（P.C.）：537005