CRC VERIFICATION

A CRC can be used to protect a set of bits to be sent. And a CRC can be used to verify the integrity of a set of bits that were received. Popular applications are single cycle data (SCD) CRC verification and device configuration protection/verification.

There are different algorithmic approaches to calculate a CRC:

- bit-by-bit CRC calculation
- table-driven CRC calculation
- each with and without augmented zero bytes

The user decides which is best for his application due to performance and timing requirements.

ATTENTION!
The listed software (code and its documentation) is provided by iC-Haus GmbH "AS IS".
See Software disclaimer on page 9.

CONFIGURATION FOR 6 BIT CRC

Listing 1: Parameter for 6 bit CRC

```c
// CRC Parameter for 6 bit CRC used by BiSS (for example iC-LGC)
// changed by iC-Haus 2013

const int order = 6;
const unsigned long polynom = 0x03; // => 0x43 without leading 1
const int direct = 1;
const unsigned long crcinit = 0x0000;
const unsigned long crcxor = 0x003f;
const int refin = 0;
const int refout = 0;
```

If a CRC start value is used the value `crcinit` must be set to the correct value.
For the 16 bit BiSS C CRC used by iC-LGC the CRC parameters must be changed (default values are for CRC-32).

Listing 2: Parameter for 16 bit CRC

```
// CRC Parameter for 16 bit CRC used by BiSS (for example iC-LGC)
// changed by iC-Haus 2013

const int order = 16;
const unsigned long polynom = 0x90d9;
const int direct = 1;
const unsigned long crcinit = 0x0000;
const unsigned long crcxor = 0xffff;
const int refin = 0;
const int refout = 0;
```

If a CRC start value is used the value `crcinit` must be set to the correct value.

EXAMPLE 6 BIT CRC

This example shows the output of the C algorithms for a BiSS C SCD data frame with 12 bits (Data "010011010101") without the calculated 6 bit CRC value. For this example the data section of the source code was changed like this:

Listing 3: Data string for 6 bit CRC example

```
// Data string for 12 bit BiSS C data frame
// changed by iC-Haus 2013

const unsigned char string[] = {0x04, 0xD5};
```

CRC test
---------

Parameters:
- polynom : 0x3
- order : 6
- crcinit : 0x0 direct, 0x0 nondirect
- crcxor : 0x3F
- refin : 0
- refout : 0

- data string : '0x04' '0xD5' (2 bytes)

Results:
- crc bit by bit : 0x1c
- crc bit by bit fast : 0x1c
EXAMPLE 16 BIT CRC

This example shows the output of the C algorithms for a BiSS C SCD data frame with 40 bits (12 bit MT + 20 bit ST + 1 bit Err + 1 bit Warn + 6 bit LC) without the calculated 16 bit CRC value. For this example the data section of the source code was changed like this:

Listing 4: Data string for 16 bit CRC example

// Data character string

//const unsigned char string[] = {"123456789"};
const unsigned char string[] = {0xD9, 0xCF, 0xE0, 0xC0, 0xDA};

CRC test
--------

Parameters:
polynom : 0x90d9
order : 16
crcinit : 0x0 direct, 0x0 nondirect
crcxor : 0xFFFF
relin : 0
refout : 0
data string : '0xD9', '0xCF', '0xE0', '0xC0', '0xDA' (5 bytes)

Results:
crc bit by bit : 0x5F29
crc bit by bit fast : 0x5F29
crc table : 0x5F29
crc table fast : 0x5F29

CONFIGURATION CRC

A CRC can be used to verify the integrity of a bigger set of bits. Some devices require a CRC to protect/verify a configuration subset.

Example application: iC-LGC CRC of configuration data:

<table>
<thead>
<tr>
<th>Addr</th>
<th>Bit 7</th>
<th>Bit 6</th>
<th>Bit 5</th>
<th>Bit 4</th>
<th>Bit 3</th>
<th>Bit 2</th>
<th>Bit 1</th>
<th>Bit 0</th>
</tr>
</thead>
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<tr>
<td>0x32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CRCCFG(15:8): CRC of configuration data, high byte</td>
</tr>
<tr>
<td>0x33</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CRCCFG(7:0): CRC of configuration data, low byte</td>
</tr>
</tbody>
</table>

Table 1: Register layout

ATTENTION!
A checksum is not a CRC and just adds all address or byte values. Some configuration data and BANK wide content are only checksum protected.
Listing 5: Example source code for 16 bit CRC

#include <string.h>
#include <stdio.h>

// CRC parameters (default values are for CRC-32):
const int order = 32;
const unsigned long polynom = 0x4c11db7;
const int direct = 1;
const unsigned long crcinit = 0xffffffff;
const unsigned long crcxor = 0xffffffff;
const int refin = 1;
const int refout = 1;

// CRC Parameter for 16 bit CRC used by BiSS (for example iC-LGC)
const int order = 16;
const unsigned long polynom = 0x90d9;
const int direct = 1;
const unsigned long crcinit = 0x0000;
const unsigned long crcxor = 0xffff;
const int refin = 0;
const int refout = 0;

// 'order' [1..32] is the CRC polynomial order, counted without the leading '1' bit
// 'polynom' is the CRC polynomial without leading '1' bit
// 'direct' [0,1] specifies the kind of algorithm: 1=direct, no augmented zero bits
// 'crcinit' is the initial CRC value belonging to that algorithm
// 'crcxor' is the final XOR value
// 'refin' [0,1] specifies if a data byte is reflected before processing (UART) or not
// 'refout' [0,1] specifies if the CRC will be reflected before XOR

// Data string for 40 bit BiSS C data frame
const unsigned char string[] = "123456789";

// internal global values:
unsigned long crcmask;
unsigned long crchighbit;
unsigned long crcinit_direct;
unsigned long crcinit_nondirect;
unsigned long crcctab[256];
unsigned long reflect(unsigned long crc, int bitnum) {
    // reflects the lower 'bitnum' bits of 'crc'
    unsigned long i, j = 1, crcout = 0;
    for (i = (unsigned long)1 << (bitnum - 1); i; i >>= 1) {
        if (crc & i) crcout |= j;
        j <<= 1;
    }
    return (crcout);
}

void generate_crc_table() {
    // make CRC lookup table used by table algorithms
    int i, j;
    unsigned long bit, crc;
    for (i = 0; i < 256; i++) {
        crc = (unsigned long)i;
        if (refin) crc = reflect(crc, 8);
        crc <<= order - 8;
        for (j = 0; j < 8; j++) {
            bit = crc & crchighbit;
            crc <<= 1;
            if (bit) crc ^= polynom;
        }
        if (refin) crc = reflect(crc, order);
        crc = crcmask;
        crctab[i] = crc;
    }
}

unsigned long crctablefast(unsigned char *p, unsigned long len) {
    // fast lookup table algorithm without augmented zero bytes, e.g. used in pkzip.
    // only usable with polynom orders of 8, 16, 24 or 32.
    unsigned long crc = crcinit_direct;
    if (refin) crc = reflect(crc, order);
    if (!refin) while (len--) crc = (crc << 8) ^ crctab[((crc >> (order - 8)) & 0xff) ^ *p++];
    else while (len--) crc = (crc >> 8) ^ crctab[crcc & 0xff] ^ *p++;
    if (!refout ^ refin) crc = reflect(crc, order);
    crc = crcxor;
    crc = crcmask;
    return (crc);
}

unsigned long crctable(unsigned char *p, unsigned long len) {
    // normal lookup table algorithm with augmented zero bytes.
    // only usable with polynom orders of 8, 16, 24 or 32.
    unsigned long crc = crcinit_nondirect;
if (refin) crc = reflect(crc, order);

if (!refin) while (len--) {  
crc = ((crc << 8) | (*p++) ^ crctab[crc >> (order-8)] & 0xff];
else while (len--) {  
crc = ((crc >> 8) | (*p++ << (order-8))) ^ crctab[crc & 0xff];
}

if (refin) while (++len < order/8) {  
crc = (crc << 8) & crctab[(crc >> (order-8)) & 0xff];
else while (++len < order/8) {  
crc = (crc >> 8) & crctab[crc & 0xff];
}

if (refout ^ refin) {  
crc = reflect(crc, order);
}

crc = crcxor;
crc = crcmask;
return(crc);
}

unsigned long crcbitbybit(unsigned char *p, unsigned long len) {

// bit by bit algorithm with augmented zero bytes.
// does not use lookup table, suited for polynom orders between 1...32.

unsigned long i, j, c, bit;
unsigned long crc = crcinit_nondirect;

for (i=0; i<len; i++) {
    c = (unsigned long)*p++;
    if (refin) c = reflect(c, 8);
    for (j=0x80; j>>=1) {
        bit = crc & crchighbit;
        crc <<= 1;
        if (c & j) crc |= 1;
        if (bit) crc ^= polynom;
    }
}

for (i=0; i<order; i++) {
    bit = crc & crchighbit;
    crc <<= 1;
    if (bit) crc ^= polynom;
}

if (refout) crc = reflect(crc, order);
crc = crcxor;
crc = crcmask;
return(crc);
}

unsigned long crcbitbybitfast(unsigned char *p, unsigned long len) {

// fast bit by bit algorithm without augmented zero bytes.
// does not use lookup table, suited for polynom orders between 1...32.

unsigned long i, j, c, bit;
unsigned long crc = crcinit_direct;

for (i=0; i<len; i++) {
    c = (unsigned long)*p++;
    if (refin) c = reflect(c, 8);
    for (j=0x80; j>>=1) {
        bit = crc & crchighbit;
    }

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int main() {
    // test program for checking four different CRC computing types that are:
    // crcbit(), crcbitfast(), crctable() and crctablefast(), see above.
    // parameters are at the top of this program.
    // Result will be printed on the console.

    int i;
    unsigned long bit, crc;

    // at first, compute constant bit masks for whole CRC and CRC high bit
    crcmask = {{((unsigned long)1<<(order-1))-1)<<1}|1;
    crchighbit = (unsigned long)1<<(order-1);

    // check parameters
    if (order < 1 || order > 32) {
        printf("ERROR, invalid order, it must be between 1..32.\n\n");
        return(0);
    }

    if (polynom != (polynom & crcmask)) {
        printf("ERROR, invalid polynom.\n\n");
        return(0);
    }

    if (crcinit != (crcinit & crcmask)) {
        printf("ERROR, invalid crcinit.\n\n");
        return(0);
    }

    if (crcxor != (crcxor & crcmask)) {
        printf("ERROR, invalid crcxor.\n\n");
        return(0);
    }

    // generate lookup table
    generate_crc_table();
    printf(" CRCTAB\n\n");
    for (i=0;i<256;i++)
        printf("%X, \n\nctab[i]);
    printf("\n\n");

    // compute missing initial CRC value
    if (!direct) {
        crcinit_nondirect = crcinit;
        crc = crcinit;
        for (i=0; i<order; i++) {
bit = crc & crchighbit;
    crc<<= 1;
    if (bit) crc ^= polynom;
    crcmask;
    crcinit_direct = crc;
}

else {
    crcinit_direct = crcinit;
    crc = crcinit;
    for (i=0; i<order; i++) {
        bit = crc & 1;
        if (bit) crc ^= polynom;
        crc >>= 1;
        if (bit) crc |= crchighbit;
    }
    crcinit_nondirect = crc;
}

// call CRC algorithms using the CRC parameters above and print result to the console

printf("\n");
printf("CRC\n");
printf("--------\n");
printf("\n");
printf("Parameters:\n");
printf("\n");
printf("polynom: 0x%x\n", polynom);
printf("order: %d\n", order);
printf("crcinit_direct: 0x%x, crcinit_nondirect: 0x%x\n", crcinit_direct, crcinit_nondirect);
printf("crcxor: 0x%x, crcxor\n", crcxor);
printf("refin: %d\n", refin);
printf("refout: %d\n", refout);
printf("\n");
printf("data_string: %s (%d bytes)\n", string, strlen(string));
printf("\n");
printf("Results:\n");
printf("\n");

printf("crcbitbybit: 0x%x\n", crcbitybit((unsigned char *)string, strlen(string)));
printf("crcbitbybitfast: 0x%x\n", crcbitybitfast((unsigned char *)string, strlen(string)));
if (!order) printf("crc_table: 0x%x\n", crcetable((unsigned char *)string, strlen(string)));
if (!order) printf("crc_tablefast: 0x%x\n", crcetablefast((unsigned char *)string, strlen(string)));

return (0);
}
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RELATED DOCUMENTS

- BiSS website -
  → http://www.ichaus.de/product/BiSS Interface

- BiSS C protocol description -
  → http://www.ichaus.de/BiSS-C_en

- iC-LGC Product page -
  → http://www.ichaus.de/iC-LGC

- MB3U Product page -
  → http://www.ichaus.de/MB3U

- MB4U Product page - Specification -
  → http://www.ichaus.de/MB4U

- MB5U Product page - Specification -
  → http://www.ichaus.de/MB5U

- BiSS Reader GUI - GUI software for Windows PC -
  → http://www.ichaus.de/BiSS_gui_rte

- BiSS Interface DLL - Library Description -
  → http://www.ichaus.de/biss1sl_interface

REVISION HISTORY

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* Release Date format: YYYY-MM-DD