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AMENDMENT 4
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Identification cards — Test methods —

Part 6:
Proximity cards

AMENDMENT 4: Bit rates of fc/8, fc/4 and fc/2 and frame size from 512 to 4096 bytes

Cartes d'identification — Méthodes d'essai —

Partie 6: Cartes de proximité

AMENDEMENT 4: Débits binaires de fc/8, fc/4 et fc/2 et tailles de trame allant de 512 à 4096 octets

Reference number
ISO/IEC 10373-6:2011/Amd.4:2012(E)

Foreword

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Amendment 4 to ISO/IEC 10373-6:2011 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 17, *Cards and personal identification*.

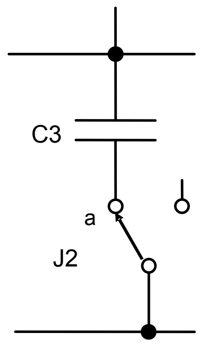
Identification cards — Test methods —

Part 6: **Proximity cards**

AMENDMENT 4: Bit rates of fc/8, fc/4 and fc/2 and frame size from 512 to 4096 bytes

Page 10, Figure 5

Replace component "C3" in Figure 5 with the following:



Page 11, 5.4.2

Add the following two paragraphs at the end of 5.4.2:

"Position 'a' of J2 shall be used for testing bit rates of *fc*/128, *fc*/64, *fc*/32 and *fc*/16.

Position 'b' of J2 shall be used for testing bit rates of *fc*/8, *fc*/4 and *fc*/2."

Page 16, 7.1.4.1

Replace paragraph with the following:

"This test is used to determine the index of modulation of the PCD field as well as the rise and fall times and the overshoot values as defined in ISO/IEC 14443-2 for all supported PCD to PICC bit rates."

Page 17, 7.1.4.2

Replace step g) with the following:

g) Repeat steps c) to f) for various positions within the operating volume and all supported PCD to PICC bit rates.

Page 17, 7.1.5.1

Replace paragraph with the following:

"This test is used to verify that a PCD correctly detects the load modulation of a PICC which conforms to ISO/IEC 14443-2 for PICC to PCD bit rates of *fc*/128, *fc*/8, *fc*/4 and *fc*/2, if supported."

Page 17, 7.1.5.2

Replace step h) with the following:

h) Repeat steps b) to g) for various positions within the operating volume for PICC to PCD bit rates of *fc*/128, *fc*/8, *fc*/4 and *fc*/2, if supported.

Page 18, 7.2.1.1

Delete NOTE and replace first sentence of paragraph with the following:

"The purpose of this test is to determine the load modulation amplitude V_{LMA} of the PICC within the operating field range [H_{min}, H_{max}] as specified in ISO/IEC 14443-2 for PICC to PCD bit rates of *fc*/128, *fc*/8, *fc*/4 and *fc*/2, if supported."

Page 18, 7.2.1.2

Replace second paragraph of Step 2 with the following:

"A REQA or a REQB command sequence as defined in ISO/IEC 14443-3 shall be sent by the Test PCD to obtain a signal or load modulation response from the PICC when testing PICC transmission at a bit rate of *fc*/128. An S(PARAMETERS) sequence as defined in ISO/IEC 14443-4 and an I-block shall be sent by the Test PCD to obtain a signal or load modulation response from the PICC when testing optional PICC transmission bit rates of *fc*/8, *fc*/4 and *fc*/2."

Add Note 1 after second paragraph of Step 2 and renumber subsequent Notes:

"NOTE 1 No load modulation test is required for bit rates of *fc*/64, *fc*/32 and *fc*/16 because these bit rates use the same subcarrier frequency of *fc*/128."

Page 19, 7.2.2.2

Replace 7.2.2.2 heading text with the following:

"PICC Type A for bit rates of *fc*/128, *fc*/64, *fc*/32 and *fc*/16"

Page 20, 7.2.2.3

Replace 7.2.2.3 heading text with the following:

"PICC Type B for bit rates of *fc*/128, *fc*/64, *fc*/32 and *fc*/16"

Page 20, 7.2.2.3.1

Replace first paragraph with the following:

"Three test conditions are defined with timings at the border of the PICC modulation waveform timing parameters zone defined in ISO/IEC 14443-2, 9.1.2:"

Replace last dash text with the following:

— minimum and maximum modulation index *m* for the associated field strength applied (see ISO/IEC 14443-2, 9.1.2).

Page 20, 7.2.2.3.2

Replace second, third and fourth paragraph with the following:

"For each optional PCD to PICC bit rate supported by the PICC, the PICC shall operate under the conditions defined in 7.2.2.3.1 after selection of that optional bit rate. This PICC shall respond correctly to an I-block transmitted at that optional bit rate."

Page 20

Renumber existing subclause 7.2.2.4 to 7.2.2.5 and add new subclause 7.2.2.4:

7.2.2.4 PICC Type A or Type B for bit rates of *fc*/8, *fc*/4 and *fc*/2

See 7.2.2.3.

Page 23, Annex A

Replace all occurrences of "for bit rates of *fc*/64, *fc*/32 and *fc*/16" with "for bit rates higher than *fc*/128".

Page 27, Table A.1

Replace "From *fc*/128 to *fc*/16" with "All bit rates".

Page 34

Add new subclause E.2.1 and move second sentence of E.2 and Figure E.2 to this subclause:

E.2.1 Sampling for bit rates of *fc*/128, *fc*/64, *fc*/32 and *fc*/16

Page 35

Add new subclause E.2.2:

E.2.2 Sampling for bit rates of *fc*/8, *fc*/4 and *fc*/2

The time and voltage data of a PCD frame containing short and long modulation pulses (preferably a complete S(DESELECT) command) as illustrated in Figure E.3, with at least 20 carrier periods before the first and after the last modulation pulse, shall be transferred to a suitable computer.

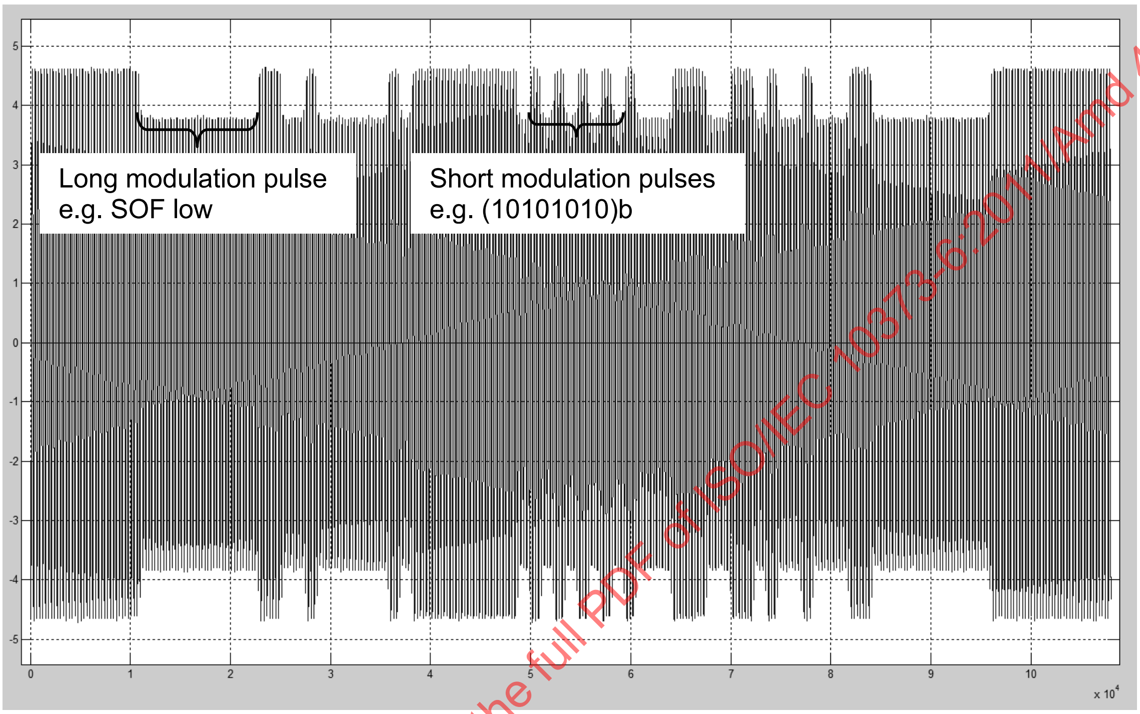


Figure E.3 — Modulation pulses

Page 35

Add new subclause E.3.1 and move existing paragraph of E.3 and Figure E.3 to this subclause:

E.3.1 Filtering for bit rates of *fc*/128, *fc*/64, *fc*/32 and *fc*/16

Page 35

Add new subclause E.3.2:

E.3.2 Filtering for bit rates of *fc*/8, *fc*/4 and *fc*/2

A 4th order, Butterworth type band pass filter with center frequency of 13,56 MHz and 15 MHz 3-dB bandwidth shall be used for filtering the DC and higher harmonic components.

Page 36

Add new subclause E.5.1 and move existing paragraph of E.5 and Figure E.4 to this subclause:

E.5.1 Envelope smoothing for bit rates of *fc*/128, *fc*/64, *fc*/32 and *fc*/16

Page 36

Add new subclause E.5.2:

E.5.2 Envelope smoothing for bit rates of *fc*/8, *fc*/4 and *fc*/2

No smoothing of signal envelope shall be applied.

Page 36, E.6

Add the following paragraph and figure after the paragraph:

For bit rates of *fc*/8, *fc*/4 and *fc*/2 the minimum value of modulation index *m* shall be determined within the complete PCD frame (see Figure E.5.). The PCD frame shall contain (10101010)b.

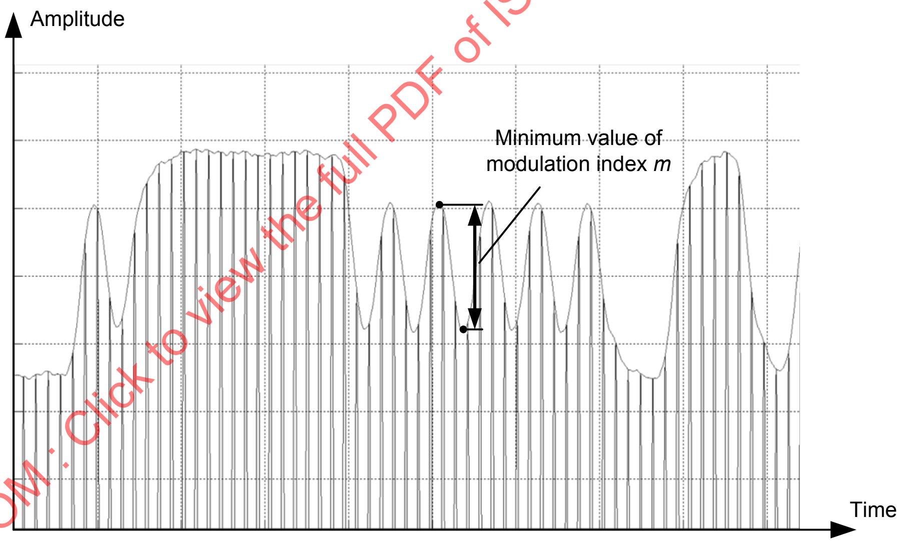


Figure E.5 — Minimum value of modulation index *m*

Page 36, E.7

Add at the end of paragraph:

For bit rates of *fc*/8, *fc*/4 and *fc*/2 the timings shall be determined at positions with long modulation pulse positions e.g. t_f at transition to SOF low and t_r at transition to EOF high.

Page 38

Add after line "`double b; //Type B`":

```
"double bVHBR; //Bit rates of fc/8, fc/4 and fc/2"
```

Page 53

Replace function "createtime" with:

```
"void createtime(TIMES *new, double tr, double tf, double b, double bVHBR, double
trstartind, double trendind, double tfstartind, double tfendind, double t1,
double t1startind, double t1start, double t1endind, double t2, double t2startind,
double t2start, double t3, double t3end, double t3endind, double t4, double
t4endind, double t5, double t5startind, double t6, double t6end, double t6endind,
double a, double tploone)"
```

Add after line "`new->b=b;`":

```
"new->bVHBR=bVHBR;"
```

Page 59

Add following function:

```
// Finds the value of m_min for bit rates of fc/8, fc/4 and fc/2

void Mminfinder(double *env, double Hmax, double Hmin, double *HmaxVHBR, TIMES
*timeres, int numsamples)
{
    int i=0;
    int j=0;
    double compare_hi=0.0;
    double compare_lo=0.0;
    double compare=0.0;
    double difference=0.0;
    int going_up=0;
    double ampl=0.0;
    double ampl_max=0.0;     // represents the amplitude (Hmax-b), and indirectly
"m".
    double m_deviation=0.0; // countermeasure 1: m_min < 0.2*m is not considered
    double Hmax_cm=0.0;     // countermeasure 2: m_min does not start or end on
borders
    double b_cm=0.0;
    double mmin=0.0;
    double mmin_cum=0.0;

    // Skip all zeros
    while (env[j]==0)
        j++;

    // where do we start?
    difference=env[j]-env[j+1];
    if (difference<0)
    {
        going_up=1; // going up
        compare_lo=env[j];
    }
    else if (difference>0)
    {
        going_up=0; // going down
        compare_hi=env[j];
    }
    compare=env[j];

    ampl_max=(Hmax-Hmin);
    m_deviation=ampl_max*0.2;
    Hmax_cm=Hmax*0.95;
    b_cm=Hmin*1.05;
    timeres->bVHBR=0;

    for (i=j; i<=numsamples-j; i++)
    {
        if (going_up==0)  // GOING DOWN
        {
            if (compare>=env[i])
            {
                compare=env[i];
            }
            else if (compare<env[i])
            {
                compare=env[i];
                compare_lo=env[i];
                going_up=1;  // change direction
                ampl=(compare_hi-compare_lo);
                mmin=(ampl/(compare_hi+compare_lo))*100;
                if (ampl>m_deviation && ampl<ampl_max && (compare_hi<Hmax_cm ||
compare_lo>b_cm))  //Countermeasures
                {
                    *HmaxVHBR=compare_hi;
                    timeres->bVHBR=compare_lo;
                    ampl_max=ampl;
                }
            }
        }
        if (going_up==1)  // GOING UP
        {
            if (compare<=env[i])
            {
                compare=env[i];
            }
            else if (compare>env[i])
            {
                compare=env[i];
                compare_hi=env[i];
                going_up=0;  // change direction
                ampl=(compare_hi-compare_lo);
                mmin=(ampl/(compare_hi+compare_lo))*100;
                if (ampl>m_deviation && ampl<ampl_max && (compare_hi<Hmax_cm ||
compare_lo>b_cm))  //Countermeasures
                {
                    *HmaxVHBR=compare_hi;
                    timeres->bVHBR=compare_lo;
                    ampl_max=ampl;
                    mmin_cum=mmin;
                }
            }
        }
    }
    if (*HmaxVHBR==0 || timeres->bVHBR==0)  // in case Waveform has only two
levels (typical 1M7) Mmin=M
    {
        *HmaxVHBR=Hmax;
        timeres->bVHBR=Hmin;
    }
}
```

Page 59

Replace function "envfilt" with the following:

```
int envfilt(int rate, double *output, double *toutput, int filterlength, double
tini, double tend, int lengthp, double *envelope)
```

Page 60

Replace line "`LinearConvolution(cof, output, envelope, lengthf, lengthp);`" with the following:

```
    if (rate==106 || rate==212 || rate==424 || rate==848)
    {
        LinearConvolution(cof, output, envelope, lengthf, lengthp);
    }

    else if (rate==1700 || rate==3400 || rate==6800)
    {
        cof[0]=1;
        for (xx=1; xx<2000; xx++)
            cof[xx]=0;
        lengthf=1;
        LinearConvolution(cof, output, envelope, lengthf, lengthp);
    }
```

Page 62

Add in function "tfinder" after line " `int i=0;`" the following:

```
    double *toutput2=NULL;
    int counter=0;
    int rev_counter=0;
    int VHBR_step=0;
    double VHBR_tr=0.0;
    double VHBR_tf=0.0;
    double tr_accum=0.0;
    double tf_accum=0.0;
    int tr_counter=0;
    int tf_counter=0;
    double t_one_sample=0.0;
    double tlo=0.0;
    double vlo=0.0;
    double thi=0.0;
    double vhi=0.0;

    toutput2=toutput;
```

Page 65

Replace line "`createtime(timeres,0,0,0,0,0,0,0,t1,……,0,0,0,0);`" with:

```
"createtime(timeres,0,0,0,0,0,0,0,0,t1,t1startind,t1start,t1endind,t2,t2startind,
t2start,t3,t3end,t3endind,t4,t4endind,0,0,0,0,0,0,0);"
```

Page 67

Replace line "`createtime(timeres,0,0,0,0,0,0,0,……,a,tploone);`" with:

```
"createtime(timeres,0,0,0,0,0,0,0,0,t1,t1startind,t1start,t1endind,0,0,0,0,0,0,0,
0,t5,t5startind,t6,t6end,t6endind,a,tploone);"
```

Page 67

Replace complete code for '`case B`' with:

```
       {
           switch (rate)
           {
               case 106:
               case 212:
               case 424:
               case 848:
               {
                   B_low=b+0.1*(Hmax-b);          // Calculates target
                   flag=localizador(envc,toutput,B_low,&crosses,env_length);    //
Finds target
                   if (flag>=2)
                   {
                       crosses_WORK=crosses;
                       tploone=crosses_WORK->time;             // Temporary values
are stored for future use
                       while (x_improv<flag)
                       {
                           tplotwo=crosses_WORK->time;         // Temporary values
are stored for future use
                           vplotwo=crosses_WORK->volt;
                           crosses_WORK=crosses_WORK->sig;
                           x_improv++;
                       }
```

```
                    freelist(crosses);
                }
                else
                {
                    fprintf(stdout,"Monotony not fulfilled\n");
                }

                B_hi=Hmax-0.1*(Hmax-b);        // Calculates target
                flag=localizador(envc,toutput,B_hi,&crosses2,env_length);    //
Finds target
                if (flag>=2)
                {
                    x_improv=0;
                    flag_improv=0;
                    crosses_WORK=crosses2;
                    while (x_improv<flag)
                    {
                        if (crosses_WORK->time<tploone)
                        {
                            tphione=crosses_WORK->time;       // Temporary values
are stored for future use
                            vphione=crosses_WORK->volt;
                        }

                        if (crosses_WORK->time>tplotwo && flag_improv==0)
                        {
                            tphitwo=crosses_WORK->time;       // Temporary values
are stored for future use
                            vphitwo=crosses_WORK->volt;
                            flag_improv=1;
                        }
                            crosses_WORK=crosses_WORK->sig;
                            x_improv++;
                    }
                    freelist(crosses2);
                }

                else
                {
                    fprintf(stdout,"Monotony not fulfilled\n");
                }

                tf=tploone-tphione;     // Definitive values are calculated and
stored for display
                tr=tphitwo-tplotwo;
                tfstartind=tphione;     // Other important values for the coming
functions
                tfendind=tploone;
                trstartind=tplotwo;
                trendind=tphitwo;


   createtime(timeres,tr,tf,b,0,trstartind,trendind,tfstartind,tfendind,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0);
            }
            break;

            case 1700:
            case 3400:
            case 6800:
            {
                B_low=b+0.1*(Hmax-b);          // Calculates target
                B_hi=Hmax-0.1*(Hmax-b);        // Calculates target

                flag=localizador(envc,toutput,B_low,&crosses,env_length);
                flag2=localizador(envc,toutput,B_hi,&crosses2,env_length);

                tfstartind=crosses2->time;     // Reused as start point for
overshoot
                tfendind=crosses->time;        // and undershoot

                // LOCATE ADJACENT POINTS
                while (crosses->sig!=NULL && crosses2->sig!=NULL)
                {
                    tlo=crosses->time;
                    thi=crosses2->time;
                    if (thi<tlo)             // FALLING EDGE
                    {
                        if (crosses2->sig->time < tlo)         // Discard Point
                            crosses2=crosses2->sig;
                        else if (crosses2->sig->time > tlo)    // Analysis tf
                        {
                            vlo=crosses->volt;
                            vhi=crosses2->volt;
                            while (toutput2[counter]==0)      // set counters
                            {
                                counter++;
                                rev_counter++;
                            }
                            t_one_sample=toutput2[counter+2]-toutput2[counter+1];
                            while (toutput2[counter]<=thi)       // set counters
                            {
                                counter++;
                                rev_counter++;
                            }
                            while (toutput2[rev_counter]<=tlo)   // set counters
                                rev_counter++;

                            while (vlo<vhi)
                            {
                                vlo=envc2[rev_counter-VHBR_step];
                                vhi=envc2[counter+VHBR_step];
                                VHBR_step++;
                            }
                            if (vlo==vhi)
                                VHBR_step=VHBR_step*2;
                            else if (vlo>vhi)
                                VHBR_step=VHBR_step*2-1;

                            VHBR_tf=VHBR_step*t_one_sample;
                            tf_counter++;
                            tf_accum=tf_accum+VHBR_tf;

                            VHBR_step=0.0;   // Reset Counters
                            VHBR_tf=0.0;
                            counter=0;
                            rev_counter=0;
                            crosses2=crosses2->sig;
                        }
                    }

                    else if (tlo<thi)          // RISING EDGE
                    {
                        if (crosses->sig->time < thi)        // Discard Point
                            crosses=crosses->sig;
                        else if (crosses->sig->time > thi)       // Analysis tr
                        {
                            vlo=crosses->volt;
                            vhi=crosses2->volt;
                            while (toutput2[counter]==0)      // set counters
                            {
                                counter++;
                                rev_counter++;
                            }
                            t_one_sample=toutput2[counter+2]-toutput2[counter+1];
                            while (toutput2[counter]<=tlo)       // set counters
                            {
                                counter++;
                                rev_counter++;
                            }
                            while (toutput2[rev_counter]<=thi)   // set counters
                                rev_counter++;

                            while (vlo<vhi)
                            {
                                vhi=envc2[rev_counter-VHBR_step];
                                vlo=envc2[counter+VHBR_step];
                                VHBR_step++;
                            }
                            if (vlo==vhi)
                                VHBR_step=VHBR_step*2;
                            else if (vlo>vhi)
                                VHBR_step=VHBR_step*2-1;

                            VHBR_tr=VHBR_step*t_one_sample;
                            tr_counter++;
                            tr_accum=tr_accum+VHBR_tr;

                            VHBR_step=0.0;       // Reset Counters
                            VHBR_tr=0.0;
                            counter=0;
                            rev_counter=0;
                            crosses=crosses->sig;
                        }
                    }
                }
                // Calculate and Save Parameters
                tf=tf_accum/tf_counter;    // Definitive values are calculated
and stored for display
                tr=tr_accum/tr_counter;    // Reused as end point for overshoot
                trendind=crosses2->time;
                trstartind=crosses->time;


   createtime(timeres,tr,tf,b,0,trstartind,trendind,tfstartind,tfendind,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0);
             }
             break;
         }
      }
      break;
   }
}
```

Page 71

Replace:

```
"while (index_samples<=samples)
{
if (env2[index_samples]>above)"
```

with:

```
"while (env2[index_samples]!=0)
{
if (env2[index_samples]>above)"
```

Page 72

Replace:

```
"while (toutput[index_samples]<(timesp->trstartind))
{
if (env2[index_samples]<above_b && env2[index_samples]!=0)"
```

with:

```
"while (env2[index_samples]!=0)
{
if (env2[index_samples]<above_b)"
```

Page 72

Replace function declaration "display" with the following:

```
"void display(char type, int rate, SHOOTREADER *shootreader2, TIMES *timesp,
double Hmax, double m, double mmin)"
```

Page 73

Replace line "`fprintf(stdout,”Type B – Bitrate %d\n", rate);`" with the following:

```
"if (rate<=848)
    fprintf(stdout,"Type B – bit rate %d\n", rate);
else
    fprintf(stdout,"Type VHBR – bit rate %d\n", rate);"
```

Page 74

Add after line " `fprintf(stdout,"m = %f %% \n",m);`":

```
"if((rate==1700 || rate==3400 || rate==6800))
    fprintf(stdout,"m_min = %f %% \n", mmin);"
```

Page 74

Replace function "main" with the following:

```
 int main (int argc, char *argv[])

{
    char type;
    int rate;
    char voltstr[25];           // intermediate char array to modify the voltage
values
    char timestr[25];           // intermediate char array to modify the time
values
    double snum=0;
    double tnum=0;
    double t=0;
    int filterlength=0;
    double Hmax=0;
    double HmaxVHBR=0;
    double Hmin=0;
    double Hmax2=0;
    double Hmin2=0;
    FILE *pointfile=NULL;
    FILE *input_u2=NULL;
    FILE *poutput=NULL;
    double m=0.0;
    double mmin=0.0;
    int length=0;
    double val=0;
    int posval=0;
    int negval=0;
    double tini=0;
    double tfin=0;
    int samples=0;
    int out_i=0;
    int length_total=0;
    int sample_ini=0;
    int sample_end=0;
    int flag_cut=0;
    int samplesp=0;
    int fi=0;                 // Filter generic index
    double b1=0;              // Filter parameters
    double b2=0;
    double b3=0;
    double b4=0;
    double b5=0;
    double a1=0;
    double a2=0;
    double a3=0;
    double a4=0;
    double a5=0;
    double freq1=0;
    double freq2=0;
    double as[5]={0};
    double bs[5]={0};
    double t0=0;
    double tlast=0;
    int lineskip=0;
    double *voutput=malloc (sizeof(double)*MAX_SAMPLES);
    double *toutput=malloc (sizeof(double)*MAX_SAMPLES);
    double *envelope=malloc (sizeof(double)*MAX_SAMPLES);
    double *vfilter=malloc (sizeof(double)*MAX_SAMPLES);
    double *tfilter=malloc (sizeof(double)*MAX_SAMPLES);
    TIMES *timesp=(TIMES *)malloc(sizeof(TIMES));
    TIMES *timesp2=(TIMES *)malloc(sizeof(TIMES));
    SHOOTREADER *shootreader2=(SHOOTREADER *)malloc(sizeof(SHOOTREADER));

    if (voutput!=NULL && toutput!=NULL && envelope!=NULL && vfilter!=NULL &&
tfilter!=NULL && timesp!=NULL && timesp2!=NULL && shootreader2!=NULL)
    {
        memset(voutput, 0, MAX_SAMPLES);
        memset(toutput, 0, MAX_SAMPLES);
        memset(envelope, 0, MAX_SAMPLES);
        memset(vfilter, 0, MAX_SAMPLES);
        memset(tfilter, 0, MAX_SAMPLES);

        type=*argv[1];
        rate=atoi(argv[2]);
        if (type!='A' && type!='B' && type!='V')
            fprintf(stdout, "Wrong Type (A, B or VHBR))");
        else if ((type=='A' || type=='B') && (rate!=106 && rate!=212 && rate!=424
&& rate!=848))
            fprintf(stdout, "Wrong bit rate (106, 212, 424, 848)");
        else if ((type=='V') && (rate!=1700 && rate!=3400 && rate!=6800))
            fprintf(stdout, "Wrong bit rate (1700, 3400, 6800)");
        else
        {
            if (type=='V')
                type='B';
                        pointfile=fopen(argv[3],"r");
            input_u2=fopen("pre_Hilbert.txt","w");             // modified-
intermediate amplitude vector

            if(pointfile!=NULL && input_u2!=NULL)
            {
                //1. LOAD DATA + CHECKING DATA (WITHOUT FILTER)
                for (lineskip=0; lineskip<10; lineskip++)      // Skips the first 10
lines which are the header of csv files
                {
                    skip_line (pointfile);
                }
                read_line (pointfile,voltstr, timestr);
                t0=atof(timestr);
                while (!feof(pointfile))                     // Reading the lines of
the voltage input file
                {
                    if (voltstr[0]!='\0')
                    {
                        snum=atof(voltstr);
                        tnum=atof(timestr);
                        if(snum<0)
                            negval++;
                        else
                            posval++;
                        vfilter[samplesp]=snum;
                        tfilter[samplesp]=tnum;
                        samplesp++;
                        read_line (pointfile,voltstr, timestr);
                    }
                    tlast=tfilter[samplesp-1];
                }
                samplesp=samplesp+3;

                samplesp=datacheck(posval, negval, samplesp, tlast, pointfile);

                tlast=tfilter[samplesp];

                //2. DATA FILTER BANDWIDTH (10 MHz OR 20 MHz DEPENDING ON BIT RATE)
                if (rate==106 || rate==212 || rate==424 || rate==848)
                {
                    freq1=8.56e6/(1/(2*((tlast-t0)/(samplesp-1))));
                    freq2=18.56e6/(1/(2*((tlast-t0)/(samplesp-1))));
                }
                else if (rate==1700 || rate==3400 || rate==6800)
                {
                    freq1=6.06e6/(1/(2*((tlast-t0)/(samplesp-1))));
                    freq2=21.06e6/(1/(2*((tlast-t0)/(samplesp-1))));
                }

                butterworth_coeffs(freq1, freq2, as, bs);
                b1=bs[0];
                b2=bs[1];
                b3=bs[2];
                b4=bs[3];
                b5=bs[4];
                a1=as[0];
                a2=as[1];
                a3=as[2];
                a4=as[3];
                a5=as[4];

                for (fi=0; fi<samplesp; fi++)
                {
                    if (fi<7 || fi>samplesp-7)
                        voutput[fi]=0;
                    else
                        voutput[fi]=(b1*vfilter[fi]+b2*vfilter[fi-1]+b3*vfilter[fi-
2]+
                            b4*vfilter[fi-3]+b5*vfilter[fi-4]-a2*voutput[fi-1]-
                            a3*voutput[fi-2]-a4*voutput[fi-3]-a5*voutput[fi-
4])/a1;
                }

                rewind (pointfile);
                lineskip=0;
                for (lineskip=0; lineskip<10; lineskip++)   // Skips the first 10
lines (header of csv files)
                {
                    skip_line (pointfile);
                }
                for (fi=0; fi<(samplesp-7); fi++)           // Reading the lines of
the voltage input file
```

```
            {
                val=voutput[fi];
                read_line (pointfile,voltstr,timestr);
                fprintf(input_u2,"%s,%f\n",timestr,val);
                length++;
            }

            //3. HILBERT TRANSFORM AND THE COMPLEX ENVELOPE
            rewind(input_u2);
            hilbert("pre_Hilbert.txt");          // performs Hilbert transform

            poutput=fopen("output.txt","r");     // Hilbert transform output
vector

            read_line (poutput,voltstr,timestr);
            tini=atof(timestr);
            rewind (poutput);

            if(poutput!=NULL)
            {
                while (!feof(poutput)) // Reading the lines of the voltage input
file */
                {
                    read_line (poutput,voltstr,timestr);
                    if (timestr[0]!='\0')
                    {
                        snum=atof(voltstr);
                        voutput[samples]=snum;
                        t=atof(timestr);
                        toutput[samples]=t;
                        samples++;//==>US  // Same variable as the one in
Hmaxfinder
                        tfin=t;
                    }
                }
            }
            else
                fprintf(stdout,"Error in Hilbert transform\n");
            fclose(poutput);

            //4. USING A SMOOTHING FILTER (MOV. AVG) TO REDUCE THE NOISE
            filterlength=3;
            length_total=envfilt(rate, voutput, toutput, filterlength, tini,
tfin, samples, envelope);

            //5. 100% OF H_INITIAL
            Hmaxfinder(envelope, &Hmax, &Hmin, length_total);

            //6. COMPUTING THE ISO BASED TIMES

    tfinder(type,envelope,toutput,tini,Hmax,Hmin,rate,length_total,timesp);

            //7. M_min FOR BIT RATES OF fc/8, fc/4 AND fc/2
            if (rate==1700 || rate==3400 || rate==6800)
                Mminfinder(envelope, Hmax, Hmin, &HmaxVHBR, timesp,
length_total);

            //8. CHECKING FOR ISO DEFINED MONOTONY
            if (rate==106 || rate==212 || rate==424 || rate==848)
                monocheck(envelope, toutput, Hmax, timesp, rate, type);
            out_i=0;
            while (out_i<MAX_SAMPLES)     // Finds how many zeros are at the 
beginning of vector envelope
            {
               if (envelope[out_i]==0 && flag_cut==0)
               {
                  sample_ini=out_i;
                  tini=toutput[sample_ini+1];
               }

               if (envelope[out_i]!=0)
               {
                  flag_cut=1;
                  sample_end=out_i;
                  tfin=toutput[sample_end];
               }
               out_i++;
            }

            samples=sample_end-sample_ini-1;      //==>US

            for (out_i=0; out_i<samples; out_i++)
            {
               voutput[out_i]=envelope[out_i+sample_ini+1];
               toutput[out_i]=toutput[out_i+sample_ini+1];
            }
            for (out_i=samples+1; out_i<MAX_SAMPLES; out_i++)
            {
               voutput[out_i]=0.0;
               toutput[out_i]=0.0;
            }

            tini=toutput[0];
            tfin=toutput[samples];

            //9. OVERSHOOT OF THE READER
            fprintf (stdout,"\n"); // 2nd set of functions, "New Line" printed 
for debug purposes
            if (rate==106 || rate==212 || rate==424 || rate==848)
            {
               filterlength=3;
               length_total=envfilt(rate, voutput, toutput, filterlength, tini, 
tfin, samples, envelope);     // 2nd Filtering to find the alternate envelope
               Hmaxfinder(envelope, &Hmax2, &Hmin2, length_total);

   tfinder(type,envelope,toutput,tini,Hmax2,Hmin2,rate,length_total, timesp2);
               monocheck(envelope, toutput, Hmax2, timesp2, rate, type);
        // The parameters of the alternate envelope are calculated
               overshoot(timesp2,Hmax2,envelope,toutput,rate,type,samples, 
shootreader2);   // This time the over- and undershoots are found
            }
            else if (rate==1700 || rate==3400 || rate==6800)
            {
               filterlength=3;
               length_total=envfilt(106, voutput, toutput, filterlength, tini, 
tfin, samples, envelope);     // 2nd Filtering to find the alternate envelope
               Hmaxfinder(envelope, &Hmax2, &Hmin2, length_total);
               overshoot(timesp,Hmax,envelope,toutput,rate,type,samples, 
shootreader2);   // This time the over- and undershoots are found
            }
            //10. MODULATION
            m=modulation(type, Hmax, timesp->b);
            if((type=='B') && (rate==1700 || rate==3400 || rate==6800))
               mmin=modulation(type,HmaxVHBR, timesp->bVHBR);

            //11. DISPLAY
            display(type, rate, shootreader2, timesp, Hmax, m, mmin);
         }
         else if (pointfile==NULL || input_u2!=NULL)
            fprintf(stdout,"file(s) could not be opened \n");

         fclose(pointfile);
         fclose(input_u2);
      }
   }

   else
      fprintf(stdout, "Memory could not be allocated");

   free (voutput);
   free (toutput);
   free (envelope);
   free (vfilter);
   free (tfilter);
   free (timesp);
   free (timesp2);
   free (shootreader2);

   return 0;
}
```

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Replace Annex F with the following:

Annex F
(informative)

Program for the evaluation of the spectrum

The following program written in C language gives an example for the calculation of the magnitude of the spectrum from the PICC.

```
/*************************************************************/
/***  This program calculates the Fourier coefficients      ***/
/***  of load modulated voltage of a PICC according         ***/
/***  the ISO/IEC 10373-6 Test methods                      ***/
/***  The coefficients are calculated at the frequencies:   ***/
/***    Carrier:         Fcm (=13.5600 for 13.56 MHz)       ***/
/***    Upper sideband: Fcm + fs                            ***/
/***    Lower sideband: Fcm - fs                            ***/
/***  fs is the subcarrier frequency and its value is:      ***/
/***  Fcm/16 for bit rates up to fc/16, Fcm/8 for a bit rate***/
/*** of fc/8, Fcm/4 for a bit rate of fc/4 or Fcm/2 for a   ***/
/*** bit rate of fc/2                                        ***/
/*************************************************************/
/*** Input:                                                  ***/
/***  File in CSV Format containing a table of two          ***/
/***  columns (time and test PCD output voltage vd, clause 7)***/
/***                                                         ***/
/***  data format of input-file:                             ***/
/***  -------------------------                              ***/
/***  - one data-point per line:                             ***/
/***    (time[seconds], sense-coil-voltage[volts])           ***/
/***  - contents in ASCII, no headers                        ***/
/***  - data-points shall be equidistant in time             ***/
/***  - modulation waveform centered                         ***/
/***    (max. tolerance: half of subcarrier cycle)           ***/
/***                                                         ***/
/***                                                         ***/
/***  example for spreadsheet file (start in next line):     ***/
/***   (time)       (voltage)                                ***/
/***  3.00000e-06,1.00                                       ***/
/***  3.00200e-06,1.01                                       ***/
/***  .....                                                  ***/
/*************************************************************/
/*** RUN:                                                    ***/
/***  "exefilename" [filename1[.csv] SubcarrierCode ]       ***/
/*************************************************************/
/*** ISO/IEC 10373-6 DFT CALCULATION                         ***/
/*** Version history:                                        ***/
/*** JUL 2000, version 1.1: original published version      ***/
/*** APR 2008, version 2.0: add the Bartlett window         ***/
/*** NOV 2008, version 2.1: published version with revision ***/
/*** SEP 2010, version 3.0: support higher subcarrier freq.  ***/
/*************************************************************/

#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <math.h>
```

```
#define MAX_SAMPLES 50000
#define MAX_POINTS 500
#define MAX_MOYENNE 200

double  pi;   /* pi=3.14.... */

/* Array for time and sense coil voltage vd */
double vtime[MAX_SAMPLES]; /* time array                         */
double vd[MAX_SAMPLES];    /* Array for different coil voltage */



/*****************************************************************/
/***    Read CSV File  Function                               ***/
/***                                                          ***/
/***    Description:                                          ***/
/***    This function reads the table of time and sense coil ***/
/***    voltage from a File in CSV Format                     ***/
/***                                                          ***/
/***    Input: filename                                       ***/
/***                                                          ***/
/***    Return: Number of samples  (sample Count)             ***/
/***            0  if an error occurred                       ***/
/***                                                          ***/
/***    Displays Statistics:                                  ***/
/***                                                          ***/
/***    Filename, SampleCount, Sample rate, Max/Min Voltage  ***/
/*****************************************************************/

int readcsv(char* fname)
{
   double a,b;
   double max_vd,min_vd;
   int i;
   FILE     *sample_file;

   /************ Open File ************************************/
   if (!strchr(fname, '.'))   strcat(fname, ".csv");

   if ((sample_file = fopen(fname, "r"))== NULL)
      {
          printf("Cannot open input file %s.\n",fname);
          return 0;
      }
   /***********************************************************/
   /* Read CSV File                                           */
   /***********************************************************/
   max_vd=-1e-9F;
   min_vd=-max_vd;
   i=0;

   while (!feof(sample_file))
      {
      if (i>=MAX_SAMPLES)
        {
        printf("Warning: File truncated !!!\n");
        printf("To much samples in file %s\b\n",fname);
        break;
        }
      fscanf(sample_file,"%Lf,%Lf\n", &a, &b);
      vtime[i] = a;
      vd[i] = b;
      if (vd[i]>max_vd) max_vd=vd[i];
      if (vd[i]<min_vd) min_vd=vd[i];
      i++;
      }
   fclose(sample_file);

   /************ Displays Statistics  ***********************/
   printf("\n**********************************************\n");

   printf("\nStatistics: \n");
   printf(" Filename    : %s\n",fname);
   printf(" Sample count: %d\n",i);
   printf(" Sample rate : %1.0f MHz\n",1e-6/(vtime[1]-vtime[0]));
   printf(" Max(vd)     : %4.0f mV\n",max_vd*1000);
   printf(" Min(vd)     : %4.0f mV\n",min_vd*1000);
   return i;
}/**************** End ReadCsv ***************/


/****************************************************************/
/***    DFT : Discrete Fourier Transformation                ***/
/****************************************************************/
/***    Description:                                         ***/
/***    This function calculate the Fourier coefficient      ***/
/***                                                         ***/
/***    Input: Number of samples                             ***/
/***           Carrier divider of the subcarrier             ***/
/***                                                         ***/
/***    Global Variables:                                    ***/
/***                                                         ***/
/***    Displays Results:                                    ***/
/***                                                         ***/
/***     Carrier coefficient                                 ***/
/***     Upper sideband coefficient                          ***/
/***     Lower sideband coefficient                          ***/
/***                                                         ***/
/****************************************************************/
void dft(int count, int CarrierDivider)
{
  double c0_real,c0_imag,c0_abs,c0_phase;
  double c1_real,c1_imag,c1_abs,c1_phase;
  double c2_real,c2_imag,c2_abs,c2_phase;
  int N_data,center,start;
  double w0,wu,wl;
  double Wb;        /* Bartlett window coefficient */

  int i,k;

  double fc;        /* add variable for carrier frequency */


  fc=13.56e6;

  w0=(double)(fc*2.0)*pi; /* carrier 13.56 MHz */
  wu=(double)(1.0+1.0/CarrierDivider)*w0; /* upper sideband 14.41 MHz */
  wl=(double)(1.0-1.0/CarrierDivider)*w0; /* lower sideband 12.71 MHz */
  c0_real=0; /* real part of the carrier fourier coefficient */
  c0_imag=0; /* imag part of the carrier fourier coefficient */
  c1_real=0; /* real part of the up. sideband fourier coefficient */
  c1_imag=0; /* imag part of the up. sideband fourier coefficient */
```

```
c2_real=0; /* real part of the lo. sideband fourier coefficient */
c2_imag=0; /* imag part of the lo. sideband fourier coefficient */

center=(count+1)/2; /* center address */

/********** signal selection ******************************/

/* Number of samples for six subcarrier periods */

N_data=(int)(0.5+6.0F*CarrierDivider/(vtime[2]-vtime[1])/fc);

/* Note: (vtime[2]-vtime[1]) is the scope sample rate */

start=center - (int) N_data / 2;

/****************** DFT ********************************/

for( i=0;i<=N_data-1;i++)
{
/* Bartlett window */
if ((N_data & 1) == 0)
{
  /* N_data is even */
  if (i < (int) N_data /2)
  {
    Wb=2.0F*i/(double)(N_data - 1);
  }
  else
  {
    Wb=2.0F*(N_data-i-1)/(double)(N_data - 1);
  }
}
else
{
  /*N_data is odd */
  if (i < (int) N_data /2)
  {
    Wb=2.0F*i/(double)(N_data - 1);
  }
  else
  {
    Wb=2.0F-2.0F*i/(double)(N_data - 1);
  }

}

k=i+start;

c0_real=c0_real+vd[k]*(double)cos(w0*vtime[k])*Wb;
c0_imag=c0_imag+vd[k]*(double)sin(w0*vtime[k])*Wb;
c1_real=c1_real+vd[k]*(double)cos(wu*vtime[k])*Wb;
c1_imag=c1_imag+vd[k]*(double)sin(wu*vtime[k])*Wb;
c2_real=c2_real+vd[k]*(double)cos(wl*vtime[k])*Wb;
c2_imag=c2_imag+vd[k]*(double)sin(wl*vtime[k])*Wb;
}

/****************** DFT scale *************************/

c0_real=4.0F*c0_real/(double) N_data;
c0_imag=4.0F*c0_imag/(double) N_data;
c1_real=4.0F*c1_real/(double) N_data;
```