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Identification cards — Contactless integrated circuit cards - Proximity cards — Part 2: Radio frequency power and signal interface

AMENDMENT 5
Bits rates of 3*fc*/4 and *fc*

Cartes d'identification — Cartes à circuit intégré - Cartes de proximité — Partie 2: Interface radio fréquence

AMENDEMENT 5
Débits binaires de 3 fc/4 et fc

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Foreword

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Amendment 4 to ISO/IEC 14443-2:2010 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 17, *Card and personal identification*.

Identification cards — Contactless integrated circuit cards - Proximity cards — Part 2: Radio frequency power and signal interface

Amendment 5: Bit rates higher than *fc*/2

Page3, Clause 4

Add the following symbols:

CAL	Calibration Sequence
EOF	End of frame
etu	Elementary time unit
PSK	Phase shift keying
SOF	Start of frame
SYNC	Synchronization Sequence
TSC	Training Sequence
VHBR	Very High Bit rates

Page 6 , 8.1.1

Replace paragraph with:

"The bit rate for the transmission during initialization and anticollision shall be *fc*/128 (~106 kbit/s).

The bit rate for the transmission after initialization and anticollision shall be one of the following:

— *fc*/128 (~106 kbit/s),

— *fc*/64 (~212 kbit/s),

— *fc*/32 (~424 kbit/s),

— *fc*/16 (~848 kbit/s),

— *fc*/8 (~1,695 Mbit/s),

— *fc*/4 (~3,39 Mbit/s),

— *fc*/2 (~6,78 Mbit/s),

— *3fc*/4 (~10,17 Mbit/s),

— *fc* (~13,56 Mbit/s)."

Page 14

Add new subclause

"**8.1.2.4 Modulation for bit rates of 3fc/4 and fc**

See 11.2"

Page 15

Add new subclause"

"**8.1.4 Bit representation and coding for bit rates of 3fc/4 and fc**

See 11.3"

Page 15, 8.2.1

Replace paragraph with:

"The bit rate for the transmission during initialization and anticollision shall be *fc*/128 (~106 kbit/s).

The bit rate for the transmission after initialization and anticollision shall be one of the following:

— *fc*/128 (~106 kbit/s),

— *fc*/64 (~212 kbit/s),

— *fc*/32 (~424 kbit/s),

— *fc*/16 (~848 kbit/s),

— *fc*/8 (~1,695 Mbit/s),

— *fc*/4 (~3,39 Mbit/s),

— *fc*/2 (~6,78 Mbit/s),

— *3fc*/4 (~10,17 Mbit/s),

— *fc* (~13,56 Mbit/s)."

"

Page 23, 9.1.2

"

Insert new subclause 9.1.2.1 with the following title and move all existing text of subclause 9.1.2 into this new subclause 9.1.2.1:

"**9.1.2.1: Modulation for bit rates of *fc*/128, *fc*/64, *fc*/32, *fc*/16, *fc*/8, *fc*/4 and *fc*/2** "

Insert new subclause 9.1.2.2 with the following title and content:

"**9.1.2.2: Modulation for bit rates of 3*fc*/4 and *fc***

See 11.2."

Page 24, 9.1.3

Add a subclause title 9.1.3.1 with a title "**Bit representation and coding for *fc*/128, *fc*/64, *fc*/32, *fc*/16, *fc*/8, *fc*/4 and *fc*/2**"

At the end of the subclause, add a new subclause with the following title and content

"**9.1.3.2 : Bit representing and coding for bit rate of 3*fc*/4 and *fc***

See 11.3."

Create a new clause 11 as follows:

11 Bit rates of 3*fc*/4 and *fc* from PCD to PICC

11.1 Modulation

11.1.1 Modulation parameters

For these bit rates, communication from PCD to PICC shall use the modulation principle of PSK of the RF carrier of the operating field.

The transmitted PSK constellation (see Annex A) can be characterized by two main parameters:

M: PSK modulation order. This equals the number of constellation points. It is a power of 2.

Φ_{Seg}: The portion of the circle used for modulation. It is the angle between the outermost constellation points.

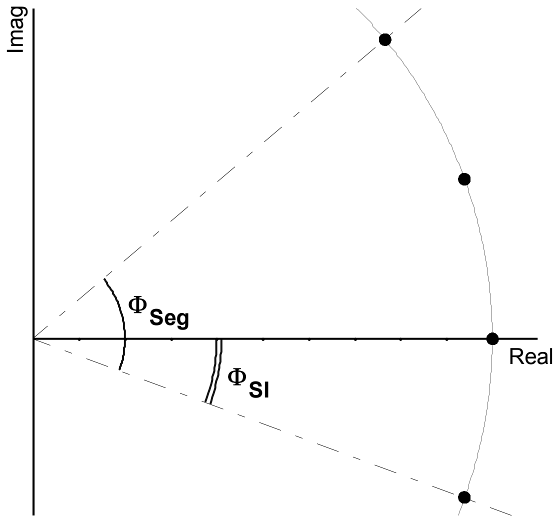


Figure 20 — PSK modulation parameter illustration

The symbol interval Φ_{SI} is defined by these parameters as:

$$\Phi_{SI} = \Phi_{Seg} /(M-1)$$

Figure 20 illustrates the definition of parameter Φ_{Seg} and the derived parameter Φ_{SI}.

The PCD shall generate a PSK modulation with parameter ΦSeg within the limits specified by Table12.

Table 12 — PCD transmission IQ segment parameters

PSK order M	Parameter	Min	Max
4	Φ_{Seg}	58	62
8	Φ_{Seg}	54	58

The PICC shall be able to receive a PSK modulation with parameter ΦSeg within the limits specified by Table13

PSK order M	Parameter	Min	Max
4	Φ_{Seg}	56	64
8	Φ_{Seg}	52	60

Table 13 — PCD reception: IQ segment parameters

11.1.2 ISI parameters

The effect of bandwidth limitations, for example originating from the PCD antenna, is to introduce inter-symbol interference (ISI), resulting in ISI clouds around each constellation point. See also Annex B.

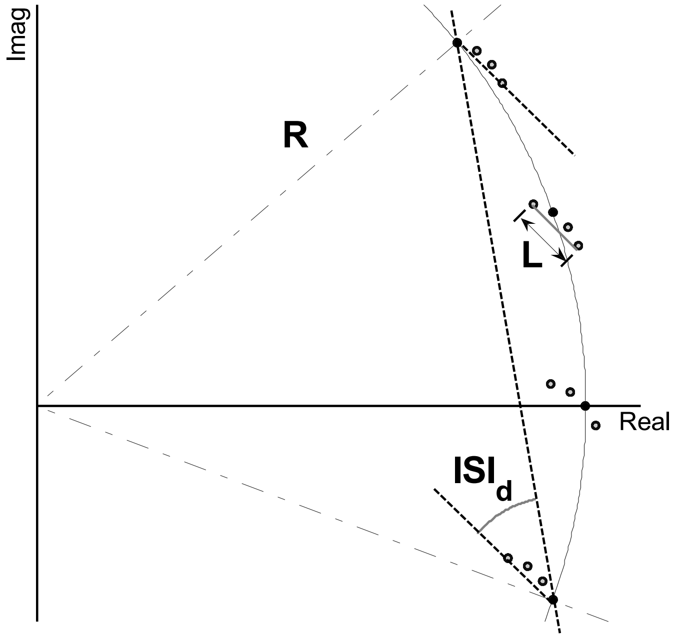


Figure 21 — ISI parameters illustration

NOTE Black circles correspond to the nominal positions

Such inter-symbol interference is defined by the following two parameters:

ISI_m: the ISI magnitude normalized to the symbol interval Φ_{SI}.

ISI_d: the ISI rotation.

Instead of observing ISI_m directly, one can measure distance L between the two outermost points of an ISI cloud

and then calculate the corresponding ISI_m as:

$$ISI_m = arcsin(L/R)/\Phi_{SI}$$

where R is the amplitude of the original constellation points as shown in Figure 21.

The ISI magnitude ISI_m generated by the PCD shall be as specified in Table 14 Parameter $ISI_{d,lim}$ is used in the condition field.

Table 14 — PCD transmission: ISI parameters

Parameter	Condition	Min	Max
ISI_m	abs(ISI_d) > 20°	0	0,50
	abs(ISI_d) ≤ 20°	0	1,8

The PICC shall be able to receive an amount of ISI as specified in Table 15.

Table 15 — PICC reception ISI parameters

Parameter	Condition	Min	Max
ISI_m	$abs(ISI_d) > 21°$	0	0,52
	$abs(ISI_d) \leq 21°$	0	1,9

11.1.3 Phase noise

Any physical signal will in practice be contaminated by noise. In the case of a PSK modulated signal, it is the noise in the phase component of the signal (also known as the phase noise) that could affect reliable data recovery and should therefore be within limits. Similar to ISI, such phase noise would be visible in a constellation diagram as clouds around the wanted constellation points. It is possible to distinguish the two due to the fact that ISI can be modelled by a linear filter response of the transmitted signal, whereas noise, of course, cannot.

The amount of noise added to the PSK signal (on top of the ISI) is defined by the following parameter:

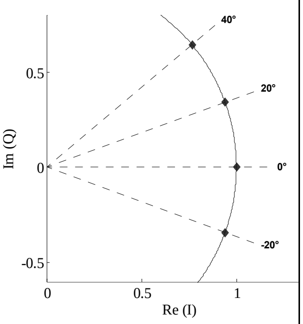
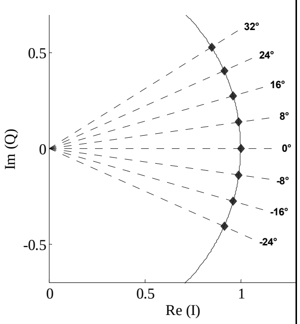
PN_{RMS}: The root-mean-square phase component of the noise present in the PSK signal, normalized to a symbol interval Φ_{SI}.

Normalizing to the symbol interval means that when the measured RMS phase noise is expressed in degrees, this number has to be divided by the symbol interval Φ_{SI} (also expressed in degrees) to yield PN_{RMS}.

The amount of phase noise by which the PCD signal is contaminated shall be lower than 0,030 time Φ_{SI}.

The PICC shall be able to receive an amount of phase noise lower than 0,032 time Φ_{SI}.

Table 16 — PSK mode symbols

Modulation	4PSK	8PSK
Symbols in the IQ plane		

NOTE on the 8PSK modulation. The IQ segment for this data rate is 56 °

11.2 Bit representing and coding

For very high bit rates of 3*fc*/4 and fc the complete information chain is as shown in Figure 22.

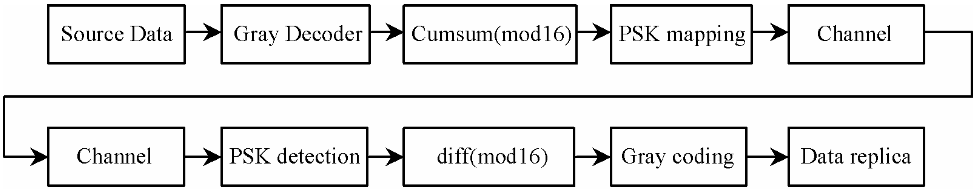


Figure 22 — Complete information chain for VHBR

Data is transmitted in symbols. Every bit rate is related to an individual symbol alphabet.

For 4PSK binary information is encoded in 4 symbols allowing an information content of 2 bits per symbol.

For 8PSK binary information is encoded in 8 symbols allowing an information content of 3 bits per symbol.

The following subclauses define the complete information chain for every bit rate.

11.2.1 Bit representation and Coding for 4PSK

Step 1, the source data to Gray decoding process is described in table 22.

Table 22 — Source data to Gray decoding

Source data	Gray decoder out
00	00
01	01
10	11
11	10

NOTE coding is define by MSB first

Step 2, the cumsum operation is described according to:

out(n) = (out(n-1) + in(n))mod4

Step 3, mapping to 4PSK is described in table 23.

Table 23 — Phase states for the symbols, represented by binary information content

.Cumsum out	Phase state
00	$\phi_0 + 40$ °
01	$\phi_0 + 20$ °
10	ϕ_0
11	$\phi_0 - 20$ °

NOTE coding is define by MSB first

These phase states are transmitted by the PCD over the channel, and received by the PICC.

Step 4, PSK detection by the PICC and mapping to binary information is done according to table 23.

Step 5, the diff operation is defined as out(n) = (in(n) – in(n-1)) mod4

Step 6, a replica of the source data is restored by Gray coding according to table 24.

Table 24 — Data replica by Gray coding.

Diff out	Data replica
00	00
01	01
10	11
11	10

NOTE coding is define by MSB first

11.2.2 Bit representation and Coding for 8PSK

Step 1, the source data to Gray decoding process is described in table 25.

Table 25 — Source data to Gray decoding.

Source data	Gray decoder out
000	000
001	001
010	011
011	010
100	111
101	110
110	100
111	101

NOTE coding is define by MSB first

Step 2, the cumsum operation is described according to: out(n) = (out(n-1) + in(n))mod8

Step 3, mapping to 8PSK is described in table 26.

Table 26 — Phase states for the symbols, represented by binary information content.

Cumsum out	Phase state
000	ϕ_0 + 32 °
001	ϕ_0 + 24°
010	ϕ_0 + 16 °
011	ϕ_0 + 8 °
100	ϕ_0
101	ϕ_0 - 8 °
110	ϕ_0 - 16 °
111	ϕ_0 - 24 °

NOTE coding is define by MSB first

NOTE These phase states are transmitted by the PCD over the channel, and received by the PICC.

Step 4, PSK detection by the PICC and mapping to binary information is done according to table 26.

Step 5, the diff operation is defined as out(n) = (in(n) – in(n-1)) mod8

Step 6, a replica of the source data is restored by Gray coding according to table 27.

Table 27 — Source data to Gray decoding.

Diff out	Data replica
000	000
001	001
010	011
011	010
100	110
101	111
110	101
111	100

NOTE coding is define by MSB first

11.2.3 SOC

For very high bit rates, the standard frame contains a start of communication (SOC) field and an end of frame (EOF) field. The frame size of the SOC depends on the PSK order and the etu duration. For 4PSK and 8PSK the SOC consists of 76 etu.

The SOC consists of

— calibration sequence CAL (44 etu),

— synchronization sequence SYNC (4 etu),

— a training sequence TSC.

CAL	SYNC	TSC
44 etu	4 etu	92 etu

The constitution of the calibration sequence and the synchronization sequence is generic; the same principle is applied to all PSK modes.

The calibration sequence consists of 2 symbols of the IQ segment, depending on the PSK order. A portion of 2 equal symbols is alternating with a portion of 2 other equal symbols. This sequence is transmitted 8 times, resulting in 32 etu in total.

For 4PSK the sequence starts with 2 symbols of 20° followed by 2 symbols of – 20°.

For 8PSK the sequence starts with 2 symbols of 24° followed by 2 symbols of – 24°.

The synchronization sequence consists of the same 2 symbols as the calibration sequence. The sequence starts with the symbol of positive phase. One symbol alternating with the other symbol is transmitted 2 times. This results in 4 etu in total.

The training sequence is specific for every PSK order.

For the 1st frame transmitted, the training sequence consists of 92 etu, for all following frames the training sequence consists of 28 etu. The concept is a pseudo-random sequence; a definition for every data rate is given in Tables 31 to 33.

Table 31 — Phase states of the training sequence for the 1st frame of 4PSK.

etu No	Phase state	etu No	Phase state	etu No	Phase state	Etu No	Phase state
1	40 °	24	20 °	47	-20 °	70	20 °
2	40 °	25	20°	48	40 °	71	0 °
3	-20 °	26	-20 °	49	-20 °	72	40 °
4	20 °	27	40 °	50	40 °	73	-20 °
5	-20 °	28	40 °	51	0 °	74	40 °
6	20 °	29	0 °	52	40 °	75	-20 °
7	-20 °	30	0 °	53	0 °	76	40 °
8	0 °	31	20 °	54	20 °	77	-20 °
9	40 °	32	0 °	55	-20 °	78	20 °
10	0 °	33	-20 °	56	20 °	79	40 °
11	0 °	34	20 °	57	20°	80	20 °
12	0 °	35	40 °	58	-20 °	81	0 °
13	20 °	36	40 °	59	-20 °	82	20 °
14	0 °	37	-20 °	60	-20 °	83	20°
15	0 °	38	20 °	61	0 °	84	-20 °
16	40 °	39	-20 °	62	20 °	85	40 °
17	20 °	40	40 °	63	-20 °	86	-20 °
18	40 °	41	20 °	64	0 °	87	20 °
19	20 °	42	-20 °	65	20 °	88	-20 °
20	0 °	43	40 °	66	0 °	89	-20 °
21	20 °	44	-20 °	67	-20 °	90	-20 °
22	0 °	45	0°	68	20 °	91	40 °
23	40 °	46	0 °	69	20 °	92	20 °

Table 32 — Phase states of the training sequence for the 1st frame of 8PSK.

etu No	Phase state	etu No	Phase state	etu No	Phase state	Etu No	Phase state
1	32 °	24	32 °	47	-24 °	70	24 °
2	32 °	25	-24 °	48	32 °	71	16 °
3	-24 °	26	16 °	49	-8 °	72	-16 °
4	8 °	27	8 °	50	-24 °	73	-24 °
5	-16 °	28	8 °	51	8 °	74	32 °
6	24 °	29	-24 °	52	-24 °	75	-24 °
7	-8 °	30	-16 °	53	8 °	76	32 °
8	8 °	31	0 °	54	32 °	77	-24 °
9	-16 °	32	-8 °	55	8 °	78	8 °
10	16 °	33	-16 °	56	-16 °	79	24 °
11	16 °	34	24 °	57	-16 °	80	16 °
12	16 °	35	-16 °	58	24 °	81	0 °
13	-24 °	36	-8 °	59	24 °	82	16 °
14	24 °	37	16 °	60	32 °	83	24 °
15	32 °	38	-16 °	61	-16 °	84	-8 °
16	8 °	39	24 °	62	0 °	85	-24 °
17	-8 °	40	8 °	63	32 °	86	0 °
18	16 °	41	0 °	64	-16 °	87	32 °
19	8 °	42	32 °	65	8 °	88	8 °
20	-8 °	43	16 °	66	-8 °	89	8 °
21	16 °	44	32 °	67	-16 °	90	16 °
22	8 °	45	-16 °	68	24 °	91	8 °
23	-16 °	46	-16 °	69	24 °	92	0 °

Table 33 — Phase states of the training sequences for all following frames for PSK modes 4PSK and 8PSK

etu No	4PSK	8PSK
1	20 °	8 °
2	-20 °	-16 °
3	20 °	24 °
4	-20 °	-24 °
5	40 °	32 °
6	-20 °	-24 °
7	40 °	32 °
8	-20 °	-24 °
9	40 °	32 °
10	-20 °	-24 °
11	40 °	32 °
12	-20 °	-24 °
13	20 °	16 °
14	0 °	0 °
15	20 °	24 °
16	0 °	16 °
17	-20 °	0 °
18	0 °	24 °
19	-20 °	16 °
20	20 °	-8 °
21	0 °	-24 °
22	0 °	-16 °
23	40 °	24 °
24	20 °	16 °
25	20 °	16 °
26	-20 °	-16 °
27	-20 °	-8 °
28	0 °	8 °

11.2.4 EOC

The EOC consists of 8 etu containing phase states outside of the IQ segment for the data rate. These phase states are ϕ_0 - 180 ° in the IQ plane.

Annex A
(INFORMATIVE)

Complex envelope and constellation diagram

In carrier-based transmission systems, it is convenient to represent the information-carrying component of the symbol $x(t)$ by the so-called complex envelope v:

$$x(\mathrm{t}) = \mathrm{v}(t)\cdot\exp(j\cdot 2\cdot\pi\cdot f_c\cdot t) + \mathrm{v}^*(t)\cdot \exp(-j\cdot 2\cdot\pi\cdot f_c\cdot t)$$

with $v(t)$ the complex envelope and $v^*(t)$ the complex conjugate of v, j is the imaginary unit and f_c the carrier frequency. For a purely ASK modulated signal, the argument (angle) of v would be constant over time and the information is coded in the magnitude of v. For a purely PSK modulated signal, the magnitude of v would be constant over time and the information is coded in the argument of v. Note that passing the signal $x(t)$ through a band-limited channel would affect the complex envelope of v. In some cases, a purely amplitude modulated signal might exhibit a varying phase component after the channel. Similarly, a purely phase-modulated signal generally exhibits some amplitude variations after passing though a band limited channel.

The complex envelope signal v is often conveniently plotted in the complex plane at the symbol sampling instants only, in what is called a constellation diagram. So, the complex values of $v(\mathrm{k}\cdot T_{\mathrm{symb}})$ are plotted (imaginary component versus real component), where k is a set of integer numbers and T_{symb} is the symbol time. All samples are plotted in the same diagram, without explicit time information. An example of such a diagram is found in Annex B.

Annex B
(INFORMATIVE)

Inter-Symbol Interference

The bandpass characteristic of the PCD antenna resonator (inductive loop plus tuned matching network) affects the complex envelope of the transmitted signal and, thus, gives rise to inter-symbol interference (ISI). The effect of such ISI can be seen when observing the constellation diagram of the transmitted signal: the ISI spreads every constellation point into an *ISI cloud*, which has the same shape as the original constellation, a *size* depending on the channel bandwidth, and a *rotation* depending on the PCD tuning. These effects are depicted in Figure B.1 and B.2.

Figure B.1 shows intervals of ISI around the nominal (transmitted) phase values. Such intervals are a simplified view of the actual interference patterns which are visible two-dimensionally in Figure B.2 (the constellation diagram). The rotation of these clouds is caused by detuning of the PCD. In such detuned case, the line joining the extremes of these clouds form an angle ISId with respect to the line joining P1 and P4 (which correspond to the original transmitted constellation points before channel filtering).

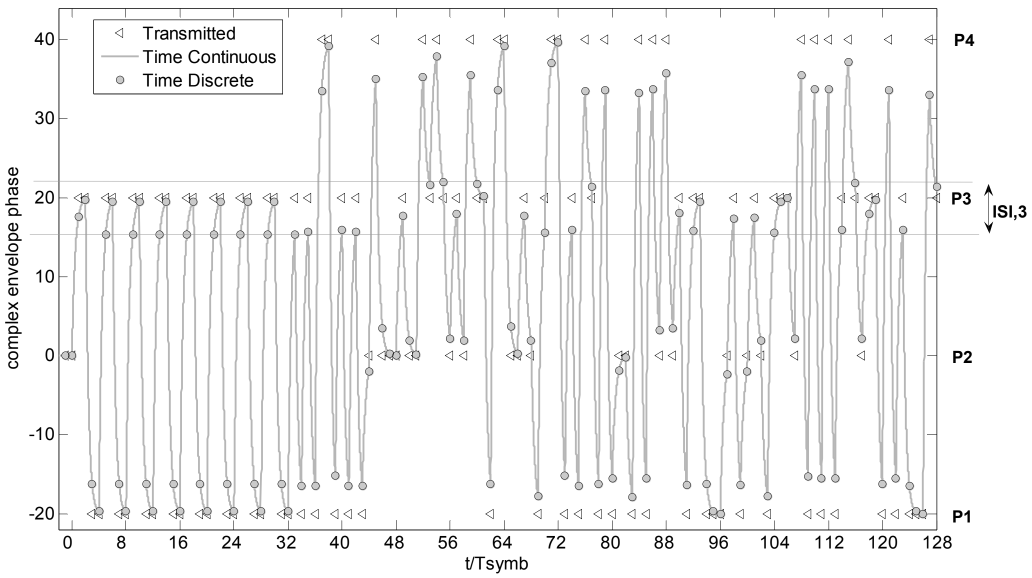


Figure B.1 — Example of inter-symbol interference due to a band-limited channel as a function of time.

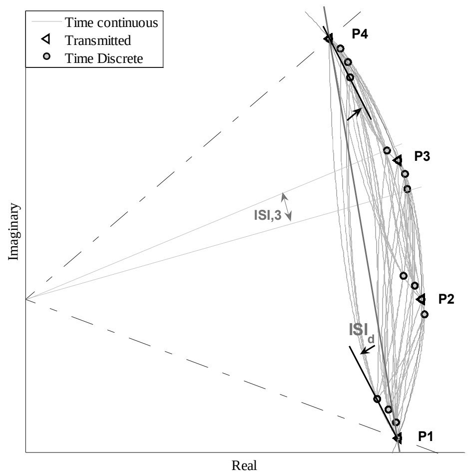


Figure B.2 — Example of inter-symbol interference due to a band-limited channel the corresponding constellation diagram showing both amplitude and phase of the modulated carrier, in continuous time.