1.2.2 *PayPass* – Reference PICC

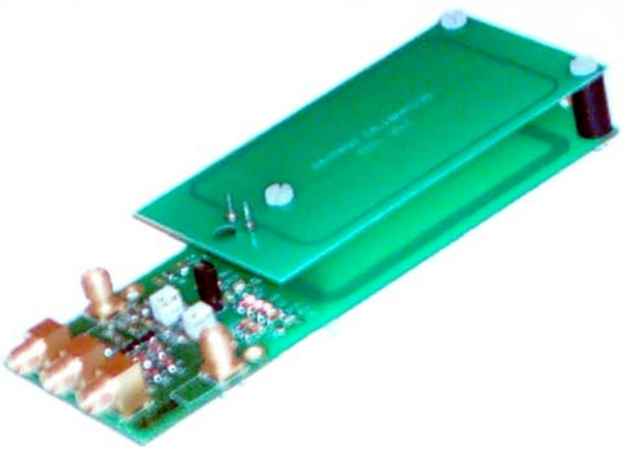
The *PayPass* – Reference PICC has an antenna as can be found in ID-1 cards. As *PayPass* is designed to work with one card in the field, the *PayPass* – Reference PCD is tuned at 16.1 MHz. This is a compromise between power consumption, detuning and communication capability.

The *PayPass* – Reference PICC allows analyzing the signal as sent out by a PCD. For analyzing the frequency content of these signals, the *PayPass* – Reference PICC is equipped with a Calibration Coil, which is an integral part of the *PayPass* – Reference PICC. The Calibration Coil is mounted 15mm above the PICC PCB as a single assembly as show in Figure 1.3.

The *PayPass* – Reference PICC can also send information back to a PCD, using different levels of load modulation. When sending back data, the Calibration Coil can be used to induce noise to test the receiver quality of the PCD.

The *PayPass* – Reference PICC has a variable load, self-adapting itself to the magnetic field strength. The (variable) load parameters of the *PayPass* – Reference PICC are set based on the maximum power consumption in current *PayPass* cards. The maximum power consumption represents a worst case scenario for a PCD. It is the expectation that a PICC requires less power than the *PayPass* – Reference PICC and that this will even be more the case for future versions of PICCs, as technology evolves. If a PCD works with the *PayPass* – Reference PICC, it will work with current PICCs as well as with future PICCs.

Figure 1.3—*PayPass* – Reference PICC



Note **There is no requirement to create *PayPass* devices using the architecture, antenna layout and resonance frequencies used for the *PayPass* – Reference PCD or *PayPass* – Reference PICC. The *PayPass* reference equipment is put in place to specify an externally observable behavior. A PCD or PICC with a complete different design, that creates a similar observable behavior, will pass the testing as described in Chapter 2.**

1.3 Landing Plane

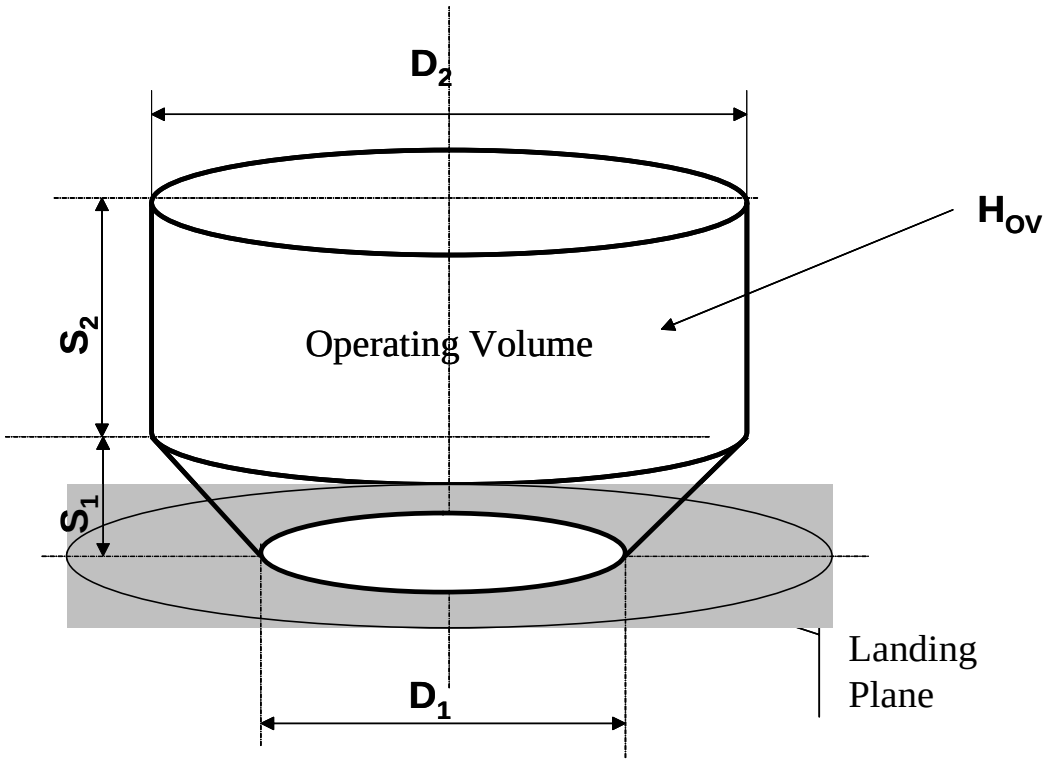
The Landing Plane is defined as that surface on the PCD on which the cardholder must tap their *PayPass* Card. It is used as the base of the Operating Volume defined in section 1.4. The "*PayPass*" logo must be put on the Landing Plane to indicate to the cardholder where to tap their card.

1.4 Operating Volume

The Operating Volume of a PCD is the 3-dimensional space in which the PCD can communicate with a PICC by means of a magnetic field H_{OV} (the Operating Field). The geometry of the Operating Volume is indicated in Figure 1.4. The Operating Volume is measured from the center of the Landing Plane, along an axis perpendicular to the Landing Plane. Requirements on this geometry suppose that the PCD is stationary and that the card moves slowly through the Operating Volume. The position of a PICC within the Operating Volume is represented by the quadruplet (r,φ,z,θ) as described in Annex C. The values of the symbols used in Figure 1.4 are defined in Annex A.

In order to provide the required power to the PICC, the PCD shall create a magnetic field strength of a minimum level. The maximum field strength that a PCD can create shall be limited to prevent excess dissipation in the PICC.[1]

Figure 1.4—Operating Volume



[1] The maximum field strength must also comply with all international and national legal and regulatory requirements.

2.2 RF Power

This section specifies the requirements for the power transfer from PCD to PICC through the electromagnetic field created by the PCD.

2.2.1 PCD Requirements for Power Transfer PCD to PICC

This section specifies the PCD requirement for the power transfer from PCD to PICC. The PCD creates an energizing RF field (the Operating Field) that enables the PICC to power up. Table 2.2 describes the measurement procedure for the power transfer from PCD to PICC.

Table 2.2—Measurement of Power Transfer PCD to PICC (PCD Transmission)

Step #	Action
Step 1	Regulate the PCD in such a way that it emits the carrier without any modulation. Regulation of the PCD is performed by means of the SDK as described in *[TTA]*.
Step 2	Calibrate the *PayPass* – Reference PICC for power and data reception as specified in annex B.6.1.
Step 3	Place the *PayPass* – Reference PICC in the Operating Volume of the PCD. The modulator input (J2) of the *PayPass* – Reference PICC must be disconnected.
Step 4	Measure the voltage V_{ov} (DC) at J1 of the *PayPass* – Reference PICC.

Requirements 2.1—Power Transfer PCD to PICC (PCD Transmission)

PCD	
2.2.1.1	Within the Operating Volume, the PCD shall generate a DC voltage V_{ov} at J1 of the *PayPass* – Reference PICC. Refer to Annex A for the value of V_{ov}.

2.2.2 PICC Requirements for Power Transfer PCD to PICC

This section specifies the PICC requirement for the power transfer from PCD to PICC. Table 2.3 describes the measurement procedure to verify if the PICC functions properly with the *PayPass* – Reference PCD creating an Operating Field with field strength H_{OV}.

Table 2.3—Measurement of Power Transfer PCD to PICC (PICC Reception)

Step #	Action
Step 1	Calibrate the *PayPass* – Reference PCD for power transmission as specified in annex B.5.1.
Step 2	Place the *PayPass* – Reference PICC in position (r=0, φ=0, z=4, θ=0) of the Operating Volume of the *PayPass* – Reference PCD. The modulator input (J2) of the *PayPass* – Reference PICC must be disconnected.
Step 3	Regulate the signal generator V of the *PayPass* – Reference PCD in such a way that it generates a voltage of $V_{OV,MIN}$ at the output J1 of the *PayPass* – Reference PICC (refer to Annex A.2 and use for $V_{OV,MIN}$ the minimum value of $\mathbf{V_{ov}}$ for the PICC). Remove the *PayPass* – Reference PICC from the Operating Volume of the *PayPass* – Reference PCD.
Step 4	Calibrate the *PayPass* – Reference PCD for data transmission as specified in annex B.5.2 using the modulation characteristics MOD A1 (for Type A) or MOD B1 (for Type B).
Step 5	Place the PICC in the Operating Volume of the *PayPass* – Reference PCD and send a valid command to the PICC. If the PICC responds, then the PICC functions properly at minimum power level. Remove the PICC from the Operating Volume of the *PayPass* – Reference PCD.
Step 6	Place the *PayPass* – Reference PICC in position (r=0, φ=0, z=0, θ=0) of the Operating Volume of the *PayPass* – Reference PCD. The modulator input (J2) of the *PayPass* – Reference PICC must be disconnected.
Step 7	Regulate the signal generator V of the *PayPass* – Reference PCD in such a way that it generates a voltage of $V_{OV,MAX}$ (refer to section A.2 and use for $V_{OV,MAX}$ the maximum value of $\mathbf{V_{ov}}$ for the PICC) at the output J1 of the *PayPass* – Reference PICC. Remove the *PayPass* – Reference PICC from the Operating Volume of the *PayPass* – Reference PCD.
Step 8	Calibrate the *PayPass* – Reference PCD for data transmission as specified in annex B.5.2 using the modulation characteristics MOD A1 (for Type A) or MOD B1 (for Type B).
Step 9	Place the PICC in the Operating Volume of the *PayPass* – Reference PCD and send a valid command to the PICC. If the PICC responds, then the PICC functions properly at maximum power level.

Requirements 2.2—Power Transfer PCD to PICC (PICC Reception)

PICC	
2.2.2.1	A PICC shall function properly within the Operating Volume when placed in the position where the *PayPass* – Reference PICC shows a DC voltage $\mathbf{V_{ov}}$ at J1. Refer to Annex A for the value of $\mathbf{V_{ov}}$.

2.2.3 Influence of the PICC on the Operating Field

Due to the electromagnetic coupling (i.e. mutual inductance) between the PICC and PCD antennas, the PICC changes the Operating Field created by the PCD when brought into the Operating Volume. The magnetic field strength within the Operating Volume will decrease due to the extra load caused by the PICC. This section lists the PICC requirement limiting the maximum load a PICC is allowed to have.

The load of a PICC is measured by the voltage drop ΔV_{OV} (= $V_{OV,FREE\ AIR} - V_{OV,PICC}$) at J2 of the *PayPass* – Reference PCD caused by the presence of the PICC in the Operating Volume as described in Table 2.4.

Table 2.4—Measurement of the Influence of the PICC on the Operating Field

Step #	Action
Step 1	Calibrate the *PayPass* – Reference PCD for power transmission as specified in annex B.5.1.
Step 2	Measure $V_{OV,FREE\ AIR}$ (peak to peak) at J2 of the *PayPass* – Reference PCD.
Step 3	Place the PICC in the Operating Volume of the *PayPass* – Reference PCD and measure $V_{OV,PICC}$ (peak to peak) at J2 of the *PayPass* – Reference PCD. ΔV_{OV} is defined as $V_{OV,FREE\ AIR} - V_{OV,PICC}$.

Requirements 2.3—Influence of the PICC on the Operating Field

PICC	
2.2.3.1	When placed in the Operating Volume of the *PayPass* – Reference PCD, a PICC shall cause a voltage drop ΔV at J2 of the *PayPass* – Reference PCD not greater than $\mathbf{\Delta V_{OV,MAX}}$. ΔV_{OV} is defined as $V_{OV,FREE\ AIR} - V_{OV,PICC}$. $V_{OV,FREE\ AIR}$ is the voltage (peak to peak) measured at J2 when there is no PICC in the Operating Volume. $V_{OV,PICC}$ is the voltage (peak to peak) measured at J2 after bringing the PICC in the Operating Volume of the *PayPass* – Reference PCD. Refer to Annex A for the value of $\mathbf{\Delta V_{OV,MAX}}$.

2.2.4 PCD Requirements for the Carrier Frequency f_c

This section specifies the PCD requirement for the frequency of the Operating Field (i.e. the carrier frequency $\mathbf{f_c}$) created by the PCD. Table 2.5 describes how to measure $\mathbf{f_c}$.

Table 2.5—Measurement of Carrier Frequency f_c (PCD Transmission)

Step #	Action
Step 1	Calibrate the *PayPass* – Reference PICC for power and data reception as specified in annex B.6.1.
Step 2	Regulate the PCD in such a way that it emits the carrier without any modulation. Regulation of the PCD is performed by means of the SDK as described in *[TTA]*.
Step 3	Place the *PayPass* – Reference PICC in the Operating Volume of the PCD. The modulator input (J2) of the *PayPass* – Reference PICC must be disconnected.

Step #	Action
Step 4	Capture the signal at the output of the Calibration Coil of the *PayPass* – Reference PICC. Perform a frequency spectrum analysis of the signal and verify if the frequency of the carrier falls within $\mathbf{f_c \pm \Delta f_c}$.

Requirements 2.4—Carrier Frequency f_c (PCD Transmission)

PCD	
2.2.4.1	The frequency of the Operating Field (carrier frequency) provided by the PCD shall be $\mathbf{f_c \pm \Delta f_c}$. Refer to Annex A for the values of $\mathbf{f_c}$ and $\mathbf{\Delta f_c}$.

2.2.5 PICC Requirements for the Carrier Frequency f_c

The section specifies the requirement that the PICC must function properly with a carrier frequency $\mathbf{f_c \pm \Delta f_c}$. Table 2.6 describes how to verify if a PICC functions properly with a carrier frequency $\mathbf{f_c \pm \Delta f_c}$.

Table 2.6—Measurement of Carrier Frequency f_c (PICC Reception)

Step #	Action
Step 1	Calibrate the *PayPass* – Reference PCD for power transmission as specified in annex B.5.1, but adjust the carrier frequency of the *PayPass* – Reference PCD to $\mathbf{f_c - \Delta f_c}$.
Step 2	Calibrate the *PayPass* – Reference PCD for data transmission as specified in annex B.5.2 using the modulation characteristics MOD A1 (for Type A) or MOD B1 (for Type B).
Step 3	Place the PICC in the Operating Volume of the *PayPass* – Reference PCD and send a valid command. If the PICC returns a response, then the PICC functions properly.
Step 4	Repeat Step 1, Step 2 and Step 3 but adjust the carrier frequency of the *PayPass* – Reference PCD to $\mathbf{f_c + \Delta f_c}$.

Requirements 2.5—Carrier Frequency f_c (PICC Reception)

PICC	
2.2.5.1	When placed in the Operating Volume of the *PayPass* – Reference PCD, a PICC shall function properly at a carrier frequency $\mathbf{f_c \pm \Delta f_c}$.

2.3 Signal Interface PCD to PICC

This section specifies the modulation methods used by Type A and Type B for the communication PCD to PICC. It deals with:

- The data transmission characteristics of the PCD
- The reception capabilities of the PICC to interpret the data transmission of the PCD.

2.3.1 Introduction

The ISO/IEC 14443 standard defines two possible modulation types, called Type A and Type B. For communication from PCD to PICC, both Type A and Type B use Amplitude Shift Keying (ASK). The amplitude of the carrier is switched between H_1 and H_2, creating a "lower level" when the field is at value H_2. The requirements of the "lower level" as well as of the envelope of the carrier for the two modulation types of ISO/IEC 14443 are defined below.

2.3.2 PCD Requirements for Modulation PCD to PICC – Type A

Type A communication from PCD to PICC uses the modulation principle of ASK 100%. The carrier is turned on and off, creating a "lower level" when turned off. In practice, it will result in a modulation index of 95% or higher. The "lower level" for Type A modulation is referred to as "pause" by *[ISO/IEC 14443-2]*. Table 2.7 describes how to measure the Type A modulation characteristics of a PCD.

Table 2.7—Measurement of Modulation PCD to PICC – Type A (PCD Transmission)

Step #	Action
Step 1	Calibrate the *PayPass* – Reference PICC for power and data reception as specified in annex B.6.1.
Step 2	Place the *PayPass* – Reference PICC in the Operating Volume of the PCD. The modulator input (J2) of the *PayPass* – Reference PICC must be disconnected.
Step 3	Request the PCD to send a WUPA command. Regulation of the PCD is performed by means of the SDK as described in *[TTA]*.
Step 4	Capture the WUPA signal sent by the PCD at the output of the Calibration Coil of the *PayPass* – Reference PICC and analyze the modulation characteristics.

For this section, V represents the envelope of the signal measured at the output of the Calibration Coil of the *PayPass* – Reference PICC, placed in the Operating Volume of the PCD. V_1 is the initial value measured immediately before any modulation is applied by the PCD. V_2, V_3 and V_4 are defined as follows:

$V_2 = \mathbf{p}_{m,A} V_1$ (Refer to Annex A for the value of $\mathbf{p}_{m,A}$)

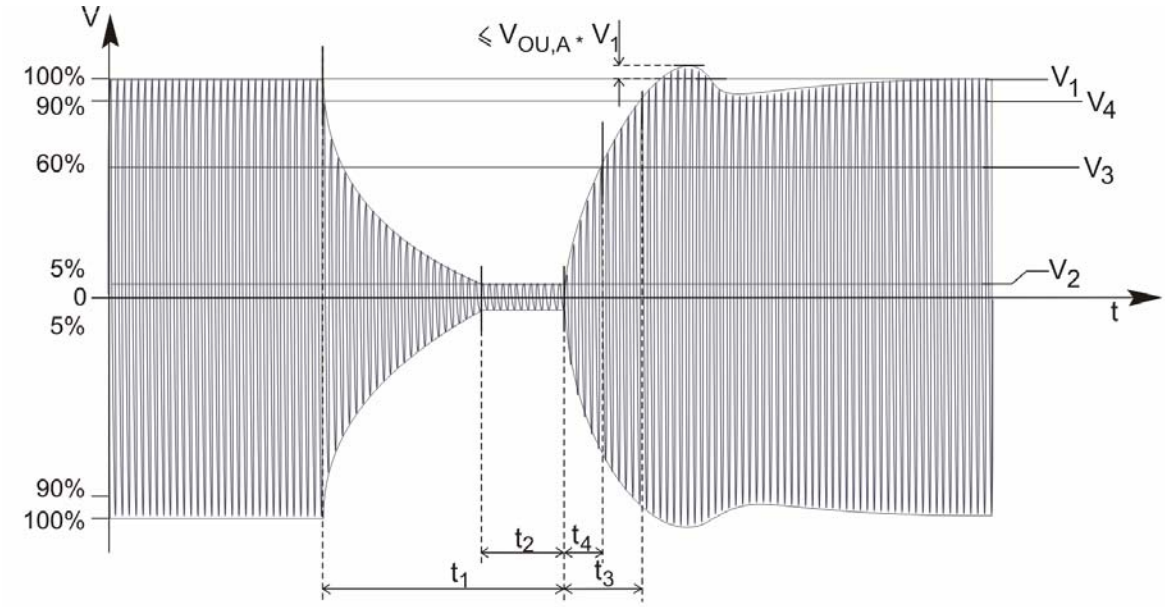
$V_3 = 0.6 V_1$

$V_4 = 0.9 V_1$

Requirements 2.6—Modulation PCD to PICC – Type A (PCD Transmission)

PCD	
2.3.2.1	The PCD shall modulate the Operating Field in the Operating Volume in such a way that the signal measured at the output of the Calibration Coil of the *PayPass* – Reference PICC has the following characteristics (see also Figure 2.1): • V shall decrease from V_1 to less than V_2 in a time $\mathbf{t_1 - t_2}$. • If V does not decrease monotonically, the time between a local maximum and the time of passing the same value before the local maximum shall be $\mathbf{t_5}$. This shall only apply if the local maximum is greater than V_2. • V shall remain less than V_2 for a time $\mathbf{t_2}$. • V shall increase monotonically to V_3 in a time $\mathbf{t_4}$. • V shall increase monotonically to V_4 or more in a time $\mathbf{t_3}$. • Overshoots immediately following the rising edge shall remain within $(1\pm\mathbf{V_{OU,A}})V_1$ Refer to Annex A for the values of $\mathbf{t_1}$, $\mathbf{t_2}$, $\mathbf{t_3}$, $\mathbf{t_4}$, $\mathbf{t_5}$ and $\mathbf{V_{OU,A}}$.

Figure 2.1—Lower Level – Type A



2.3.3 PICC Requirements for Modulation PCD to PICC – Type A

This section lists the requirements for the reception capabilities of a PICC of Type A. Table 2.8 describes how to verify if a PICC functions properly with the *PayPass* – Reference PCD applying Type A modulation characteristics at the border of the tolerance interval.

Table 2.8—Measurement of Modulation PCD to PICC – Type A (PICC Reception)

Step #	Action
Step 1	Calibrate the *PayPass* – Reference PCD for power transmission as specified in annex B.5.1.
Step 2	Calibrate the *PayPass* – Reference PCD for data transmission as specified in annex B.5.2 using the modulation characteristics MOD A1.
Step 3	Place the PICC in the Operating Volume of the *PayPass* – Reference PCD and send a valid command to the PICC. If the PICC returns a response, then the PICC functions properly.
Step 4	Repeat Step 2 and Step 3 for each set of modulation characteristics defined in Table B.11.

Requirements 2.7—Modulation PCD to PICC – Type A (PICC Reception)

PICC	
2.3.3.1	When placed in the Operating Volume of the *PayPass* – Reference PCD, a PICC of Type A shall function properly provided the *PayPass* – Reference PCD applies valid modulation characteristics.

2.3.4 PCD Requirements for Modulation PCD to PICC – Type B

Type B communication from PCD to PICC uses the modulation principle of ASK 10%. The amplitude of the carrier is reduced to create a "lower level" with a modulation index m_i. The requirements on the "lower level" as well as on the envelope of the carrier are defined below. Table 2.9 describes how to measure the Type B modulation characteristics of a PCD.

Table 2.9—Measurement of Modulation PCD to PICC – Type B (PCD Transmission)

Step #	Action
Step 1	Calibrate the *PayPass* – Reference PICC for power and data reception as specified in annex B.6.1.
Step 2	Place the *PayPass* – Reference PICC in the Operating Volume of the PCD. The modulator input (J2) of the *PayPass* – Reference PICC must be disconnected.
Step 3	Request the PCD to send a WUPB command. Regulation of the PCD is performed by means of the SDK as described in *[TTA]*.
Step 4	Capture the WUPB signal sent by the PCD at the output of the Calibration Coil of the *PayPass* – Reference PICC and analyze the modulation characteristics.

For this section, V represents the envelope of the signal measured at the output of the Calibration Coil of the *PayPass* – Reference PICC, placed in the Operating Volume of the PCD. V_1 is the initial value measured immediately before any modulation is applied by the PCD. V_2 is the lower level. The modulation index (m_i), V_3 and V_4 are defined as follows:

$$m_i = \frac{V_1 - V_2}{V_1 + V_2}$$

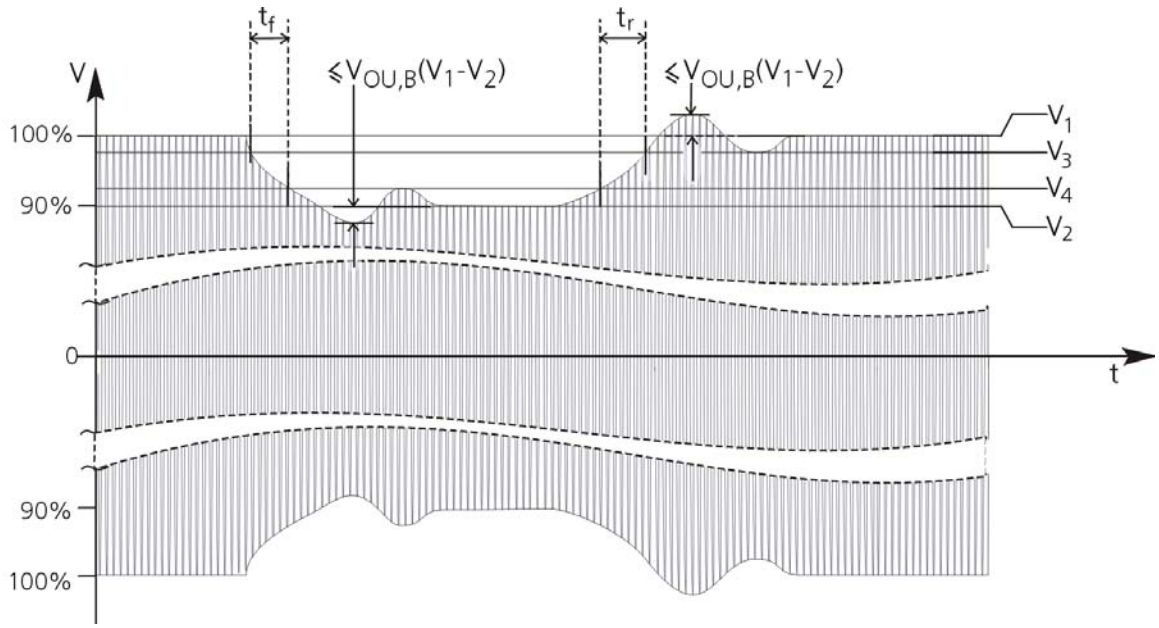
$$V_3 = V_1 - 0.1(V_1 - V_2)$$

$$V_4 = V_2 + 0.1(V_1 - V_2)$$

Requirements 2.8—Modulation PCD to PICC – Type B (PCD Transmission)

PCD	
2.3.4.1	The PCD shall modulate the Operating Field in the Operating Volume in such a way that the signal measured at the output of the Calibration Coil of the *PayPass* – Reference PICC has the following characteristics (see also Figure 2.2): • The modulation index (m_i) of the signal shall be **mod_i**. • V shall decrease monotonically from V_3 to V_4 in a time **t_f**. • V shall increase monotonically from V_4 to V_3 in a time **t_r**. • The rising and falling edges of the modulation shall be monotonic. • Overshoots and undershoots immediately following the falling and rising edge shall be less than **$V_{OU,B}$**(V_1-V_2). Refer to Annex A for the values of **mod_i**, **t_f**, **t_r** and **$V_{OU,B}$**.

Figure 2.2— Modulation PCD to PICC – Type B



2.3.5 PICC Requirements for Modulation PCD to PICC – Type B

This section lists the requirements for the reception capabilities of a PICC of Type B. Table 2.10 describes how to verify if a PICC functions properly when the *PayPass* – Reference PCD applies Type B modulation characteristics at the border of the tolerance interval.

Table 2.10—Measurement of PCD to PICC Modulation – Type B (PICC Reception)

Step #	Action
Step 1	Calibrate the *PayPass* – Reference PCD for power transmission as specified in annex B.5.1.
Step 2	Calibrate the *PayPass* – Reference PCD for data transmission as specified in annex B.5.2 using the modulation characteristics MOD B1.
Step 3	Place the PICC in the Operating Volume of the *PayPass* – Reference PCD and send a valid command to the PICC. If the PICC returns a response, then the PICC functions properly.
Step 4	Repeat Step 2 and Step 3 for each set of modulation characteristics defined in Table B.12.

Requirements 2.9—Modulation PCD to PICC – Type B (PICC Reception)

PICC	
2.3.5.1	When placed in the Operating Volume of the *PayPass* – Reference PCD, a PICC of Type B shall function properly, provided the *PayPass* – Reference PCD applies valid modulation characteristics.

A.1 Introduction

Topic	Parameter	PCD Min	Nom.	Max	PICC Min	Nom	Max	Units
Operating Volume	D_1	3						cm
	D_2	5						cm
	S_1	1		1				cm
	S_2	2						cm
	S_2	2						cm

A.2 RF Power and Signal Interface

Topic	Parameter	PCD Min	Nom.	Max	PICC Min	Nom	Max	Units
Power Transfer PCD→PICC	V_{OV}	3 – α z		8.5	2.8 – α z		8.7	V
	α	0.35			0.35			V/cm
	$\Delta V_{OV,MAX}$					0.8		V
Carrier Frequency	f_c		13.56					MHz
	Δf_c	0		7	0		10	kHz
Modulation PCD→PICC (Type A)	$p_{m,A}$	0		5	0		10	%
	t_1	2.0		3.0	1.9		3.1	µs
	t_2 ($t_1 > 2.5\mu s$)	0.5		t_1	0.48		t_1	µs
	t_2 ($t_1 \leq 2.5\mu s$)	0.7		t_1	0.68		t_1	µs
	t_3	0		1.5	0		1.55	µs
	t_4	0		0.4	0		0.42	µs
	t_5	0		0.5	0		0.52	µs
	$V_{OU,A}$			0.1			0.11	-
Modulation PCD→PICC (Type B)	mod_i	8		18 - β z	7		20 - β z	%
	β			1.25			1.5	%/cm
	t_f	0		2	0		2.1	µs
	t_r	0		2	0		2.1	µs
	$V_{OU,B}$	0		0.1	0		0.11	-
Load Modulation	$V_{pp,A}$	5		90	7		80	mV
	$V_{pp,B}$	3		-	5		-	mV