Lower Voltage Technology Cards and Terminals

1. Introduction

In March 1998, Europay International's, MasterCard International's, and Visa International's representatives presented to the ISO SC17 WG4 a contribution that explored possible techniques for the introduction of lower voltage integrated circuit cards (ICCs) into the EMV ICC Specifications (WG4 N1355). This contribution favoured a card driven migration strategy. This migration strategy called for the migration of all cards to 'Class A and B' (i.e., Class A = 5 V, Class B = 3V), thereby allowing terminals to be Class A or Class B, as required by a particular implementation. Initially, ISO 7816-3 (1997) included specifications for Class A and B. Soon after publication, however, a request was raised to include even lower voltages (i.e., Class C = 1.8V). Recently, component manufacturers, who indicated the technical feasibility of multi-class 'A and B and C' cards, confirmed its viability.

EMVCo, LLC (herein "EMVCo"), a Delaware limited liability company, supports a card-driven migration strategy over that of a terminal-driven migration strategy for the following reasons:

- Lesser affect on existing business and implementations and is faster.
- Where the card is multi-class, this offers a clear migration path with minimal acceptance issues, and no requirements for upgrading existing terminals.
- Facilitates scenarios where the card can "roam" between different card accepting environments (e.g., payment, loyalty, GSM (i.e., plastic roaming)).

This document details the possible card-driven migration scenarios (including multi-voltage terminals) and their advantages and disadvantages.

Note:
The classes are broadly categorised by operating voltage where Class A is 5V, Class B is 3V, and Class C is 1.8V. However, other operating conditions are also defined as part of the class' operating conditions such as current drawn from the supply voltage (VCC), maximum clock frequency, etc.
Within this document, cards or terminals may be referred to herein as Class ABC. This means that they support all the operating conditions applicable to classes A, B, and C, and so forth for other combinations of classes.

The operable combinations of cards and interface devices (IFDs) are shown in Table 1.

IFD class / ICC class	A	B	C
A	Yes	No	No
A and B	Yes	Yes	No
B	No	Yes	No
B and C	No	Yes	Yes
C	No	No	Yes
A and B and C	Yes	Yes	Yes

Table 1 – Compatibility of Cards and Terminals of Differing Operating Classes

2. Terminal-Driven Migration (Multi-voltage terminals)

The terminal-driven migration strategy utilises the technique of voltage selection made by the terminal, as described in ISO 7816-3. This strategy has a major disadvantage in that it can not guarantee acceptance of payment sector cards, or cards from other sectors conforming to ISO until all current terminals are replaced (estimated around year 2012).

The migration timing is shown in Figure 1.

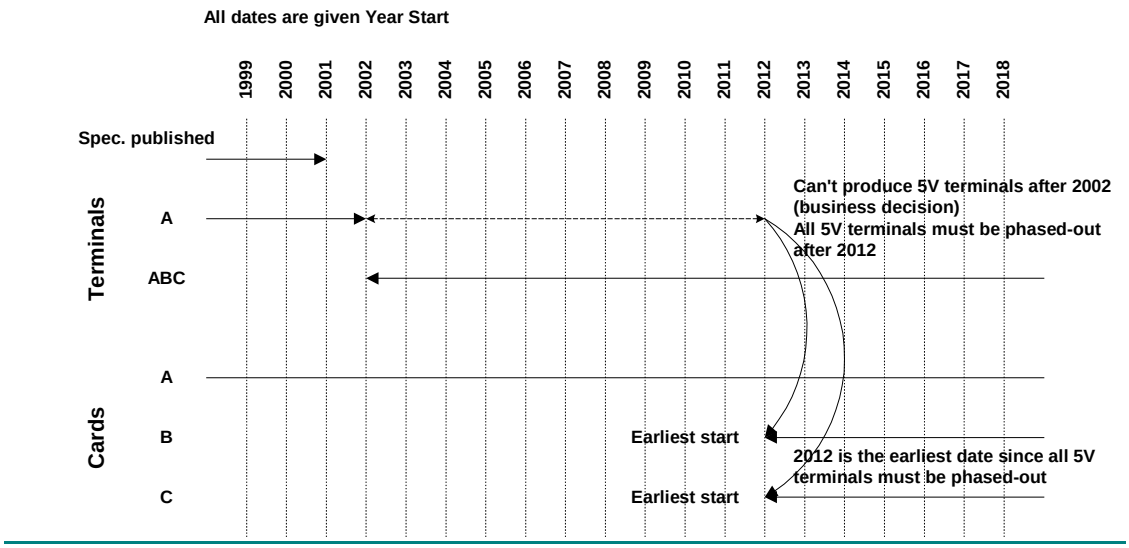

Figure 1 – Time Line for Terminal-Driven Migration

3. Card-Driven Migration (Multi Voltage Cards)

A general overview of potential migration time lines is shown in Figure 2. From Figure 2, the strategy employed for moving towards lower voltages must be carefully considered since each migration step to a lower class or classes takes many years. A multiple step approach may prove to be unacceptably long and/or expensive.

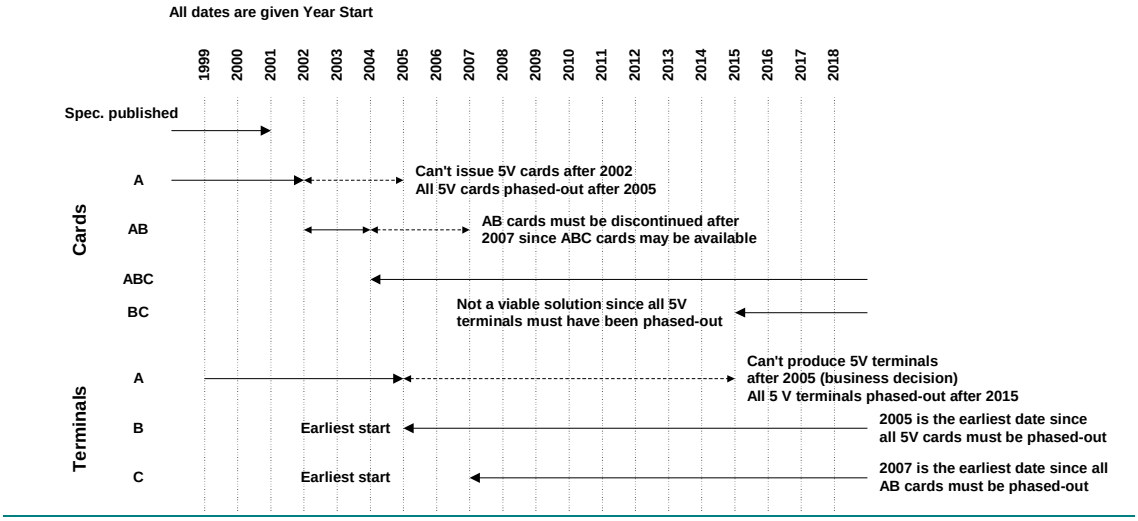

Figure 2 - General Overview of Potential Migration

Therefore, several migration strategies are possible. These migration strategies are to migrate to:

- Class AB only
- Class AB and then later to class ABC
- Class AB and then later to class BC
- Class BC only
- Class ABC only

This document explores these options along with their advantages and disadvantages in greater detail.

3.1 Migration to Class AB only

The migration timing to Class AB only is shown in Figure 3.

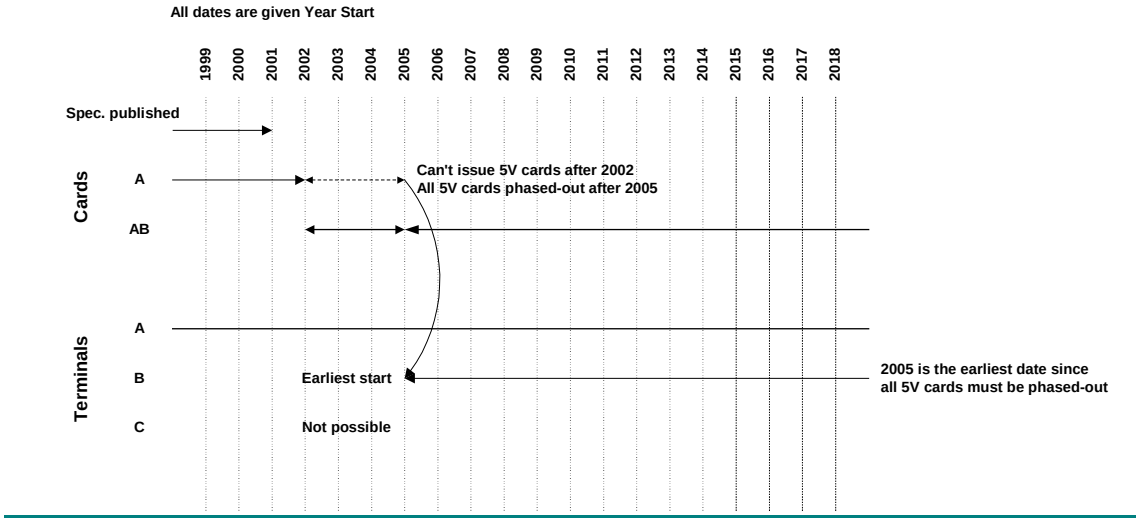

Figure 3 – Time Line for Migration Class AB Only

The advantages and disadvantages of the class AB only approach are summarised in Table 2.

Advantages	***Disadvantages***
• Known ready availability of components	• No price/ performance benefit as no change to chip geometry
• Minimal price increase	• No support for 1.8V terminals
• Supports 3V terminals (as well as 5V)	
• Possible that existing cards already work (determined by certification)	

Table 2 – Advantages and Disadvantages of the Class AB Only Approach

While the Class AB only approach allows a quick, one step, low cost migration to support 3V terminals, it does not offer any other advantages nor does it allow for participation in markets employing 1.8V terminals. The Class AB only approach does not provide a long-term solution coupled with a further migration step has its disadvantages (see section 3.2).

3.2 Migration to Class AB and then later to Class ABC

The migration timing to Class AB and then later to Class ABC is shown in Figure 4.

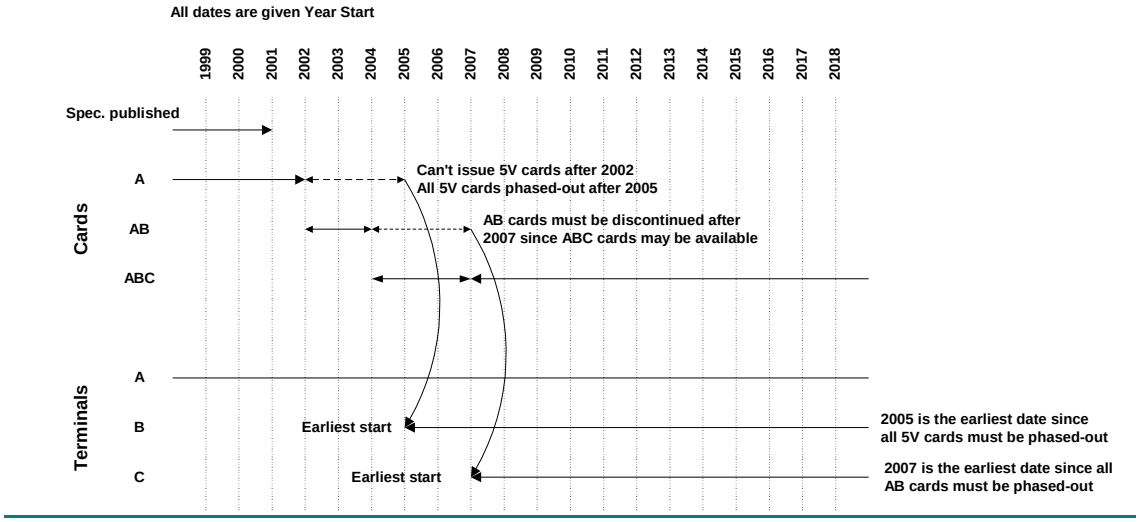

Figure 4 – Time Line for Migration to Class AB and then later to Class ABC

The advantages and disadvantages of the Class AB and then later to Class ABC approach are summarised in Table 3.

Advantages	*Disadvantages*
• Mitigates the risks over the uncertainty over date of availability of Class ABC cards	• Slow introduction of support for other industry sectors
• Can support 3V and 1.8V terminals (as well as 5V) when all cards are migrated to Class ABC	• Potential price/performance benefit offset by need for on-chip voltage regulator (Class ABC)
• Improves DPA immunity (voltage regulator) when all cards are migrated to Class ABC	• Concerns over reliability of 1.8V interface from electrical noise standpoint; especially 'traditional' POS/ATM. This is a terminal constraint, not a card constraint. By having the card operational over Class ABC, this "difficult" acceptance environment would be kept at 5V only.
• Potential price/performance benefit from reduced geometry (see disadvantages)	• Need for costly repetition of card security analyses

Table 3 – Advantages and Disadvantages of the Class AB and then Later to Class ABC Approach

While the Class AB and then later to Class ABC approach mitigates the availability and price risks associated with an immediate migration to class ABC only, its timescales are extended. Furthermore, a two step approach may lead to costs associated with the repetition of security evaluations.

3.3 Migration to Class AB and then later to Class BC

The migration timing to Class AB and then later to Class BC is shown in Figure 5.

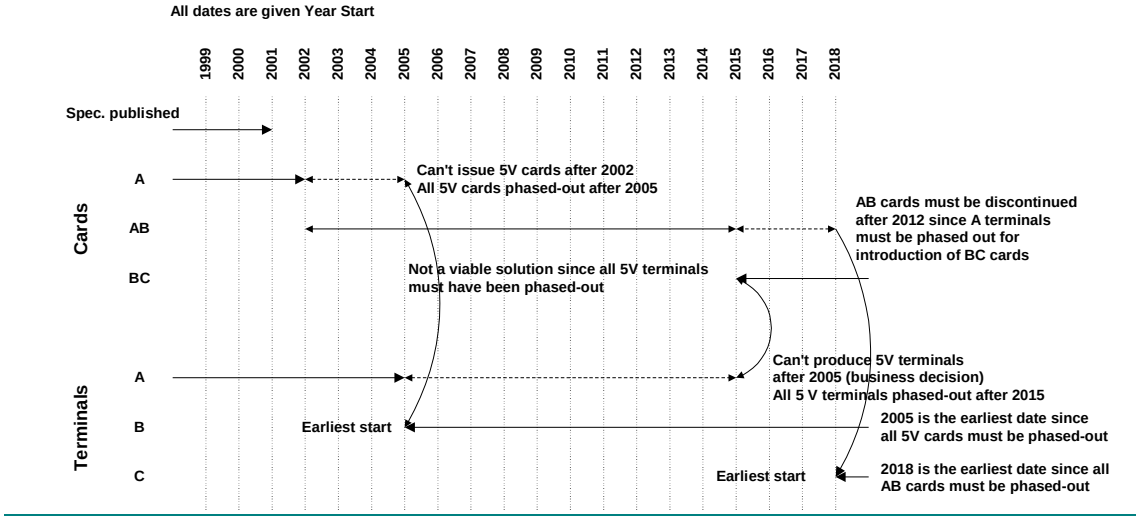

Figure 5 – Time Line for Migration to Class AB and then Later to Class BC

Due to the very long migration timescales, this migration strategy to Class AB and then later to Class BC is viewed as infeasible.

3.4 Migration to Class BC only

The migration timing to Class BC only is shown in Figure 6.

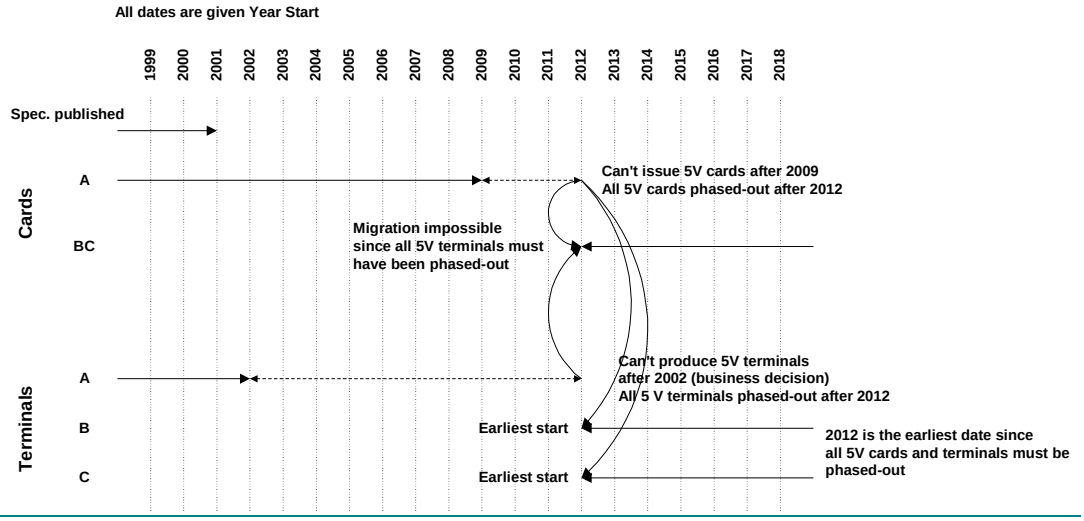

Figure 6 – Time Line for Migration to Class BC only

It is estimated that Class A cards shall run until 2012. The terminal park will dwindle between the years 2002 and 2012, and cards between the years 2009 and 2012. Since the Class BC only approach does not allow support for 'legacy' 5V terminals, this migration strategy is viewed as infeasible.

3.5 Migration to Class ABC only

The migration timing to Class ABC only is shown in Figure 7.

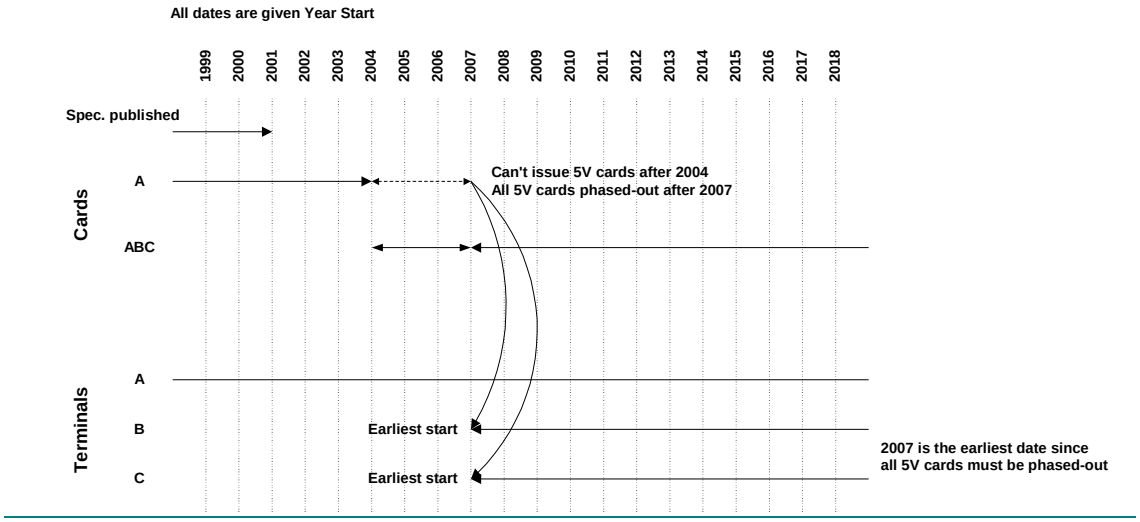

Figure 7 – Time Line for Migration to Class ABC Only

The advantages and disadvantages of the Class ABC only approach are summarised in Table 4.

Advantages	*Disadvantages*
• Avoid the costs involved in migrating to 3-5V, and then to 1.8-5V.	• Uncertainty over the date of availability for Class ABC cards
• Provides potentially better inter sector compatibility	• Potential price/performance benefit offset by need for on-chip voltage regulator
• Can support 3 V and 1.8V terminals (as well as 5V) as soon as all cards are migrated to Class ABC.	• Concerns over reliability of 1.8V interface from electrical noise standpoint; especially 'traditional' POS/ATM. This is a terminal constraint, not a card constraint. By having the card operational over Class ABC, this "difficult" acceptance environment at 5V only can be maintained.
• Minimises migration risks (one time migration)	
• Improves DPA immunity (voltage regulator)	
• Potential price/performance benefit from reduced geometry (see disadvantages)	

Table 4 – Advantages and Disadvantages of the Class ABC Only Approach

The advantages of the Class ABC only approach are it is a single step migration and offers the fastest route to interoperability with other industry sectors already using lower voltage terminals. These advantages, however, are offset to some extent by concerns over the price and card availability.

4. Feedback from IC Fabricators

Feedback received from recent discussions with IC fabricators confirms that Class AB and Class ABC cards are technically feasible, but that certain design constraints need to be taken into consideration. Most currently used cards will operate at Class AB, but are not fully tested or categorised at this class. Also, they may contain certain security features that would need to be modified to allow proper functioning. This means that while currently used cards could potentially be used at Class AB, they may need to undergo security re-evaluations before they can be used. Therefore, Class AB cards could be readily available. The timescales for availability of Class ABC cards, however, is less certain, since there are no plans to produce such components unless a clear requirement emerges from the payment sector.

A further consideration for Class ABC cards is that a voltage regulator must be built in order to protect the component against damage and to allow it to operate at 5V. The reason for this is that the reduced chip geometry used to allow operation at 1.8V could not sustain 5V; the IC operates internally at its lowest voltage. The silicon overhead needed for this regulator will to some extent offset the benefits of increased fabrication density offered by the reduced chip geometry. This may make simple single application cards more expensive. However, it is envisaged that most cards will be multi-application (i.e., having a 16K or 32K memory) and therefore some price and performance benefits should be realised.

A ‘fringe benefit’ of the usage of a voltage regulator on the card may be enhanced protection against DPA attacks since the internal and external operating voltages are to some degree isolated from each other.

5. Conclusion

It is proposed to introduce a multi-voltage card while keeping the terminal at a single voltage. The four practical possibilities for lower voltage card-driven migration are summarised in Table 5. They are:

- Stay with 5 volt cards;
- One step migration to class AB* only;
- Two step migration, class AB now followed by a further migration to class ABC later;
- One step migration to class ABC now.

***Note:**
Class A = 5V, Class B = 3V, Class C = 1.8V

Class A	Class AB now	Class AB now followed by class ABC later	Class ABC now
Existing situation – Remain status quo	This is the simplest lowest cost/risk solution, but offers modest benefit (i.e., 3V terminals can be used) and is not future proofed (i.e., introduction of any other voltage class is cumbersome)	This offers a simple low cost/risk starting point solution, allowing a further migration to class ABC when the availability, cost and reliability concerns have been clarified. However, it offers little benefit short term, involves additional costs if a later migration to class ABC is undertaken, and the timescales to support other industry sectors is lengthened.	This is the most elegant way to migrate to a multi-voltage environment. It offers potentially the fastest solution for introducing multi-voltage support with the simplicity and cost benefits of a single step migration. However, the availability, cost and reliability (of the 1.8V electrical interface) are not well understood. A price premium is likely for single application cards

Table 5 – Possibilities for Lower Voltage Migration

If financial institution certified multi-application platform cards (e.g., MULTOS and Java Open Platform) are used across other industry sectors, the classes of operation used by those other industries (i.e., Classes

A, B and C) need to be supported. To avoid fragmentation of IC production between and among the financial services industry, telecommunications industry and other industries (e.g., health, loyalty, government, etc.), a global approach that benefits all industries must be promoted. A component serving the needs of all market sectors will prove a benefit by leveraging card volumes to achieve price reductions and ensure card availability.

6. Questions

EMVCo is requesting general feedback on this paper and specifically responses to the following questions. This paper will serve as the basis for whether the support for lower voltage cards to be included in the EMV 2000specification.

A. General

- What is your experience of electrical performance of the card-to-terminal interface when using 1.8V components, especially in the open POS environment?
- Are there any special contact requirements as a result of using reduced voltages?

B. Component/Card Manufacturers

- What is the feasibility and availability of Class AB and Class ABC components/cards?
- What are the development plans for such components/cards? How would an open requirement statement from the payment sector affect the cost/availability of such components/cards?
- What is the likely price or savings for Class AB and Class ABC cards versus card complexity?
- How is chip performance affected by reduced operating voltage; especially with respect to cryptographic processing speed, etc.?

C. Terminal Manufacturers

- What are the inter-sector trends for utilisation of low voltage terminals by market (e.g., 3V / 1.8V mobile handsets)?
- What are the implementation timescales for such terminals?

D. Financial Sector

- What classes of cards are required and in what timeframes in order to support planned inter-sector business collaboration?
- What price would be acceptable (or savings expected) for cards versus card complexity (i.e., from simple single application cards through to multi-application large memory cards)?