DPD - The strongest method to reduce SDRAM Power Consumption

Application Notes(Oct.' 02)

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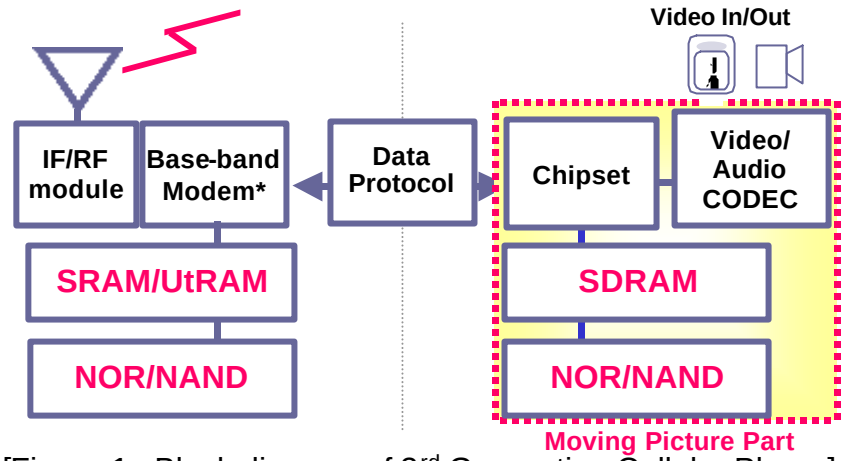
Introduction

Mobile market is booming and booming and its growth rate is bigger than any computer market. The mobile applications will be DSC(Digital Still Camera), Cellular Phone, PDA(Personal Digital Assistant) and etc. The important characteristics of mobile application is on mobile personality and the battery usage for power source.

Mobile application size specially like cellular phone is getting smaller and smaller to reduce its weight, to carry it conveniently without increasing battery size. On the contrary, the functions are getting stronger and stronger to support multimedia service. But, the penalty for supporting multimedia with a cellular phone is a little critical due to its large power consumption; to support color display, to run a movie, to communicate with seeing caller's face and etc. The important point to keep in mind is that system makers' competitiveness depends on their ability to manage power consumption of the cellular phone even though many additional devices are included to support multimedia service.

What is DPD ?

SDRAM has been adopted in the cellular phone market to meet higher bandwidth requirement for multimedia service[See Figure1]. The cellular phone makers can provide multimedia service due to SDRAM's high speed ability, the penalty is SDRAM's power consumption. Even though the interface voltage for the SDRAM has been moving from 3.3V to 1.8V to save its power, there is still remaining power consumption due to its refresh current. SDRAM cell consists of one transistor and one capacitance which stores its datum



[Figure 1.- Block diagram of 3rd Generation Cellular Phone]

with electronic charge. Due to its capacitance, SDRAM needs refresh time because the capacitance discharge as time goes by. In other words, SDRAM needs refresh current regardless of its usage status to save the data if the system power is on and this is big penalty in power consumption point.

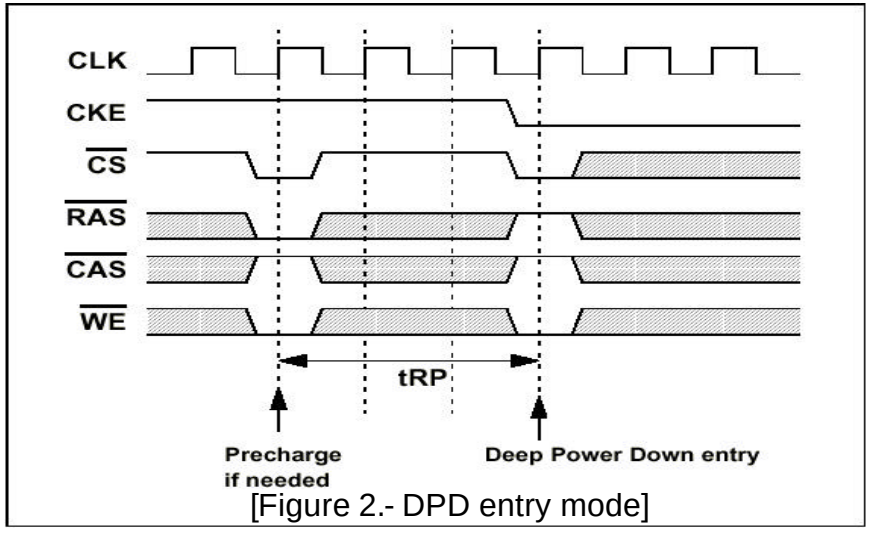
JEDEC members have tried to find a solution to minimize SDRAM's power consumption without turning off its power and defined mobile features with three functions; PASR(Partial Array Self Refresh), TCSR(Temperature Compensate Self Refresh), DPD(Deep Power Down). PASR and TCSR are related with reducing SDRAM's self refresh current, on the contrary, DPD is for minimizing SDRAM's power consumption.

SDRAM has been used and will be used for providing multimedia function and is controlled by the chipset in moving picture part. From cellular phone makers' research results,

the status of the cellular phone is standby mode more than 50%, the chipset and SDRAM don't need to work in this mode. In this mode, chipset enters sleep mode and can issue DPD command to SDRAM to consume its minimum power.

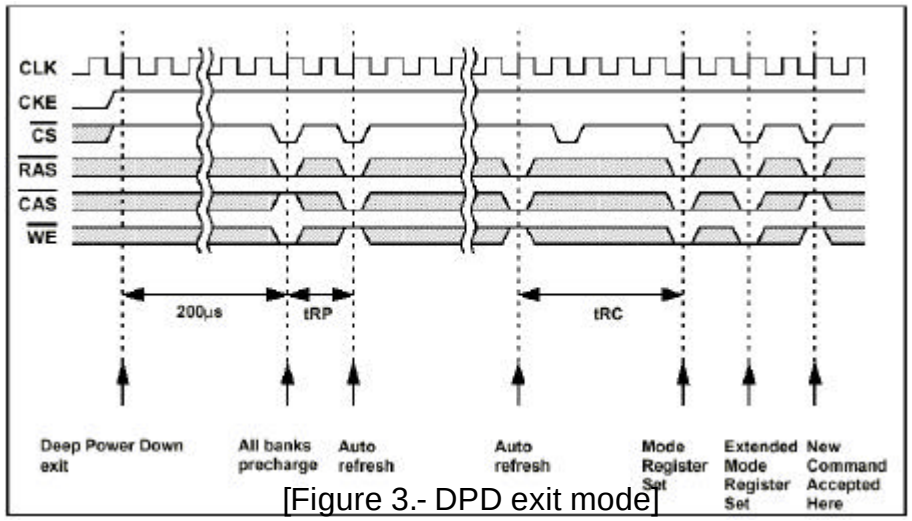
How to use DPD ?

JEDEC defined DPD entry and exit mode with a special timing. [See Figure 2]. DPD entry mode requires to make CKE,/CS,/WE pin low and /RAS,/CAS pin high in any time because DPD mode will discard SDRAM's data. But previous state is a little bit important because the time to reach the target DC value of DPD mode can be different according to internal SDRAM's charge level difference.



[Figure 2.- DPD entry mode]

Make CKE pin high to exit DPD mode and follow power up sequence one more to start normal operation[See Figure 3].



[Figure 3.- DPD exit mode]

The effects of DPD.

Mobile SDRAM uses many IVC(Internal Voltage Converter) circuits to save DC current. Even though SDRAM manages many IVC circuits effectively with distinction of Active mode and Standby mode, every IVC circuit consumes DC. Minimum DC value due to IVC circuits is defined in DC specification with ICC2P[See Figure 4]. ICC2P is power down mode which doesn't save the data. From power down point of view, there is no difference between DPD and ICC2P and those mode don't save the data. To save the data, SDRAM needs refresh current and it is large compared with ICC2P and DPD.

Precharge Standby Current in power-down mode	I_{CC2P}	CKE ≤ V_{IL}(max), t_{CC} = 10ns	0.3	mA	
	I_{CC2PS}	CKE & CLK ≤ V_{IL}(max), t_{CC} = ∞	0.3		

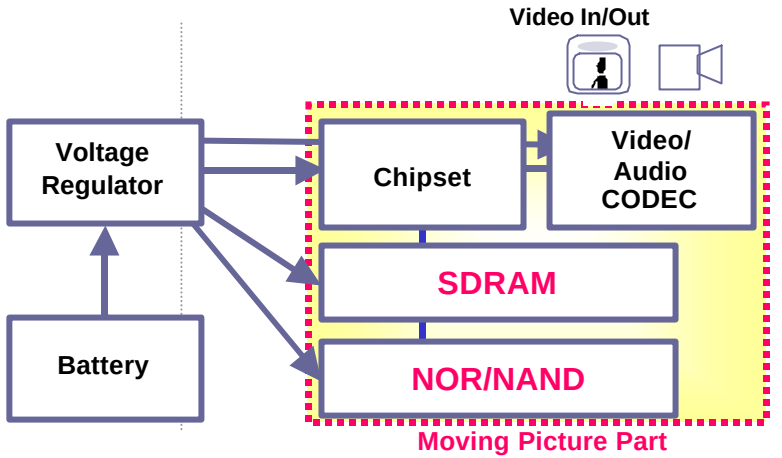
[Figure 4.- 128Mb MSDRAM 1.8V]

The DC of ICC2P is large compared with DPD because DPD turns off all IVC circuits with having an External VCC only. Its value will be different from vendor by vendor and may be different from process by process and device by device even in the same vendor because it is related with transistors' size adjacent to EVCC, but the value due to process and device difference is almost same in the same vendor. The DC value of DPD mode can' t be zero due to transistor' s leakage current; a reverse PN diode leakage current which is called ' Junction leakage current' and a punch-through leakage current. Junction leakage current is a dominant factor to explain the leakage current of a transistor if the transistor is turned off. Junction leakage current can be calculated with a complicated equation.

$Io = Is(e^{qV/kT} - 1)$ ---------- [Equation 1]

Is : Reverse saturation current, V : Diode voltage,
q : electronic charge, k : Boltzmann' s constant,
T : Temperature.

There is a misunderstanding point about the effects of DPD in the power saving point. Someone can think if the chipset can stop supplying VCC to the SDRAM, the power saving effect will be better than DPD mode; may be zero. Why does JEDEC define DPD mode for mobile feature instead of using power off ? Normally, the cellular phone uses the voltage regulator to supply VCC to each device[See Figure 5]. If the chipset can have an internal voltage regulator, it can reduce SDRAM power with turning off VCC to the SDRAM, but in that case, there may be a control issue and the chip size penalty of the chipset. And also, the time to reach the target VCC from 0V is a little bit long, noise control and etc. The DC gain from



[Figure 5.- Power Block diagram of a cellular phone]

controlling the power supply to the SDRAM will be less than 20uA and this is not effective to the chipset because the chipset can use DPD mode easily.

Conclusion

The main concerns of the cellular phone market is on power consumption from its adoption of multiple devices to provide many services, from voice to data, even to multimedia. SDRAM has adopted in this market due to its high speed ability, but due to its refresh current, the cellular phone makers have requested to minimize SDRAM' s power consumption with the special mode which is called DPD. DPD can be used by the chipset with the special timing which has already been defined by JEDEC when application chipset, which is for providing additional features like multimedia, goes down sleep mode and the phone doesn' t need SDRAM' s operation in this mode. DPD mode is only for minimizing SDRAM' s power

consumption with supplying an external VCC only, but the SDRAM loses data in this mode and this mode requires another power up sequence after exiting this mode. DPD mode is very useful for the cellular phone because the application is normally in standby mode more than 50% and it doesn't need working the SDRAM to save its power.

Before introducing DPD mode by JEDEC and being supported by SDRAM vendors, SDRAM vendors have focused on reducing SDRAM's self refresh current and should try to reduce power consumption in DPD mode as much as possible.

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