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RADIO FREQUENCY AND ANALOG/MIXED-SIGNAL (RF AND AMS) TECHNOLOGIES FOR WIRELESS COMMUNICATIONS

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SCOPE

The demands to bring new and advanced features in various wireless and mobile communication products continue to drive the revenue growth of semiconductor ICs used for wireless and mobile communications [1-4]. The RF and AMS devices in these products depend on many materials systems, some of which are compatible with complementary metal oxide semiconductor (CMOS) processing, such as SiGe and others of which are not compatible with CMOS processing such as those compound semiconductors composed of elements from group III and V in the periodic table. As shown in Figure 1, wireless and mobile communications cover a very wide spectrum of applications including radio and TV broadcasting, cellular phones (GSM, GPRS, EDGE, CDMA, 3GPP), wireless cables and wireless local area networks (Bluetooth, Wi-Fi, ZigBee), broadband wireless access (UWB, WiMAX), global position system (GPS), phased array RF systems, RFID and smart handheld devices. The impact of wireless and mobile communications on our daily lives has been significant as they empower us to communicate voice, data, image and video to anywhere at anytime. In future years, it is expected that the frequency axis in Figure 2 will lose its significance in defining the boundaries among technologies for some of the applications listed therein.

RF and AMS ICs are the critical and enabling elements in these wireless and mobile communication applications. The drivers for wireless communications systems are cost, power consumption, functionality, size of mobile units, production volume, and standards and protocols. Also, RF technologies often require additional headroom with respect to performance because several conflicting or competing requirements have to be met simultaneously. These include power added efficiency (PAE), high output power, low current, and low voltage. Increased RF performance for silicon is usually achieved by geometrical scaling. Increased RF performance for III-V compound semiconductors is achieved by optimizing carrier transport properties through materials and bandgap engineering. During the last two decades, technologies based on III-V compounds have established new business opportunities for wireless communications systems. When high volumes of product are expected, silicon and more recently silicon-germanium replace the III-Vs in those markets for which these group IVs can deliver appropriate performance at low cost. The wireless communication circuits considered as application drivers for this roadmap may be classified into AMS circuits (including analog-to digital and digital-to analog converters), RF transceiver circuits (including low noise amplifiers (LNAs), frequency synthesizers, voltage controlled oscillators (VCO), driver amplifiers and filters) and PAs.

Figure 2 shows the circuit functions of a typical mobile communication system with operating or carrier frequencies of the wireless systems between 0.8 GHz and 10 GHz. The four basic circuit functions shown therein are power management (PM), power amplifier (PA) , RF transceiver and, AMS, which interfaces with the digital signal processor (DSP). The RF and AMS 2008 ITRS Update considers the latter three circuit functions that drive RF and analog technology needs. The roadmap is subdivided into technologies for applications below 10GHz (CMOS, Bipolar, Passives and power amplifier) and those above (mm-wave roadmap).

In 2007, the wireless roadmap was expanded to include a new section on “More than Moore” that includes discussions on solutions to realize multi-band, mutli-mode portable applications. RMMEMS and Embedded passives requirements are added which are considered essential technologies to realize the switching filtering network and added handheld user interface.

WHAT IS NEW IN THE 2008 ITRS UPDATE OF TECHNICAL REQUIREMENTS TABLES FOR RADIO FREQUENCY AND ANALOG/MIXED-SIGNAL TECHNOLOGIES FOR WIRELESS COMMUNICATIONS?

RF and AMS CMOS - The technology requirements tables are linked with PIDS. The Performance RF/Analog table is linked to low stand-by power (LSTP) CMOS with a 1 year lag and the mm-wave CMOS is linked to high performance CMOS with a 2 year lag. The RF analog parameters now reflect the ORTC update of gate length scaling with year. The mm-wave noise figure scaling now matches published data and requirements for 94 GHz are added.

RF and AMS Bipolar Devices - Minor adjustments made in the tables to align PA bipolar requirements with recently published data.

ON CHIP AND EMBEDDED PASSIVES FOR RF AND ANAlog **-** MIM and MOM capacity density, varactor Q and inductor Q all updated to be consistent with new published data. The capacitor density was lowered to reflect new forecasts on the actual requirements for this application

POWER AMPLIFIERS (0.8 GHZ–10 GHZ) - Due to the technical challenges associated with battery advances, the end of life battery voltage remains at 2.4 V to 2020 instead of at 1.6 V as stated in the 2007 Chapter.

MEMS - The table maintains the four device choices of bulk acoustic wave (BAW), resonator, switch with capacitive contacts, and switch with metal contact. Each of these devices will be treated with more details in the 2009 RF and AM Chapter. Specific performance and cost driver applications will be added. And design tool requirements will be clarified..

Millimeter Wave (10 GHz–100 GHz) - The geometry scaling for most III-V technologies is delayed by 1 to 2 years to be consistent with trends in industry. In general, the mm-wave tables reflect the migration from GaAs PHEMT to alternate III-V technologies.

2009 RF AND AMS CHALLENGES

Some portions of the RF and AMS technology roadmap reflect prototype capabilities rather than volume production as in most of the other ITRS Chapters. Production requires markets. But in certain emerging applications, such as mm-wave connectivity and imaging applications, markets currently lag technology capabilities as predicted by the roadmap.

In 2009, we plan to add discussions on whether the entries in the technical requirements tables correspond to technologies that are prototype-capable versus in-production. We also hope to create a matrix of applications and corresponding technologies. Other specific technology challenge including; the need of alternate high gain and high voltage CMOS device especially since digital CMOS scaling greatly degrade gain and voltage handling performance, impact of fully depleted/double gate devices and other emerging research devices on RF and AMS performance, and expanding MEMS device list to cover microphones, accelerometers and gyroscopes which have increasing influence in mobile device user interface.. Integrated MEMS device will add challenge in the area of design tools and packaging. In addition to handling EM and thermal simulation, added mechanical simulation need to be considered. Unique reliable packaging requirements needed for MEMS need to be address while maintaining overall low cost product.

References

[1] *Worldwide WiMAX Semiconductor 2006-2010 Forecast and Analysis*, IDC, February, 2006.

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[3] *Worldwide WLAN Semiconductor 2005-2009 Forecast*, IDC, April 2005.

[4] *Forecast: Mobile Phone Production and Semiconductor Market, Worldwide, 2003-2010, 1Q06 Update*, Gartner, March 2006.

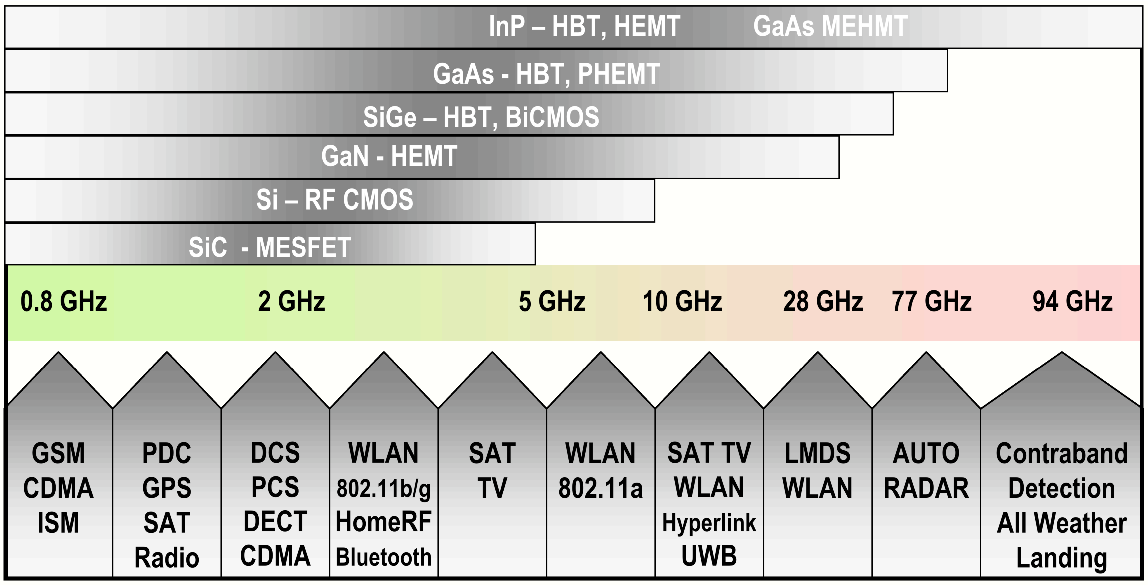

Figure 1: Applications Spectrum

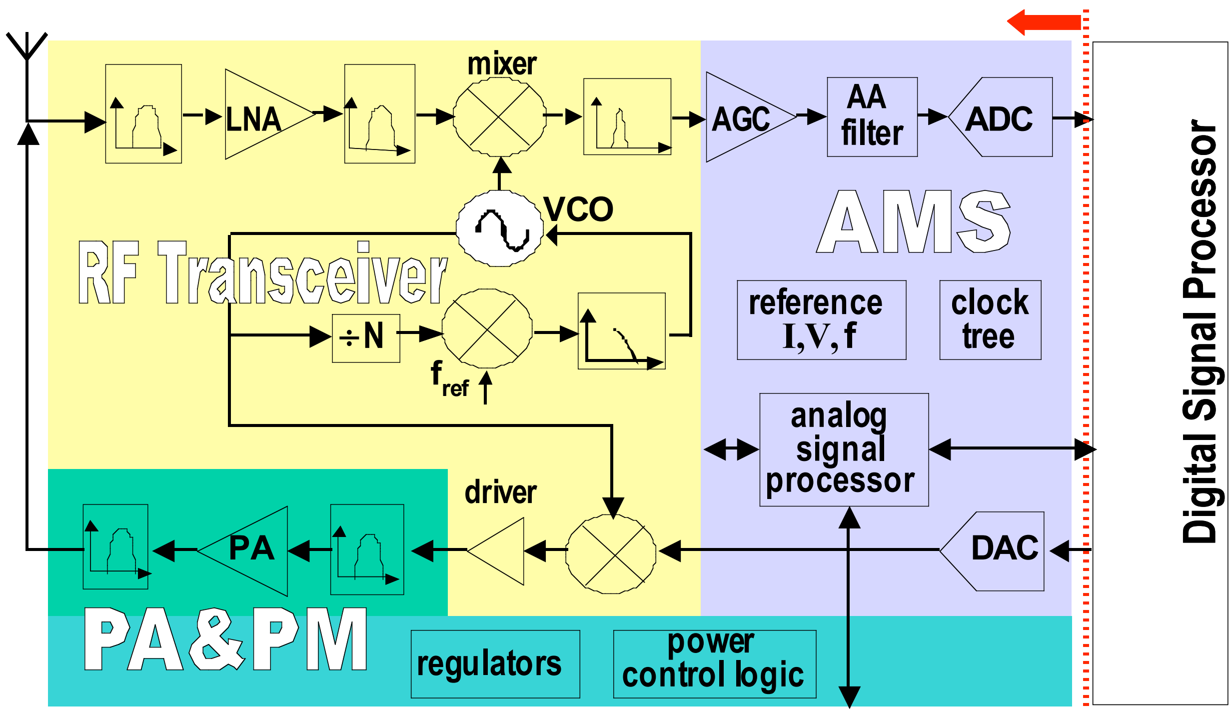

Figure 2: Circuit Functions