

# The Place of Analog in A Digital World

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Analog Semiconductor Leaders' Forum  
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# Analog 101: Why Analog is Different

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- Analog and Digital are NOT mutually exclusive
- The legacy of Moore's Law
  - Digital Transistors switch ON-OFF at very high clock rates. All they need to do is register ON-OFF states
  - Shrinking CMOS geometries makes them switch faster
  - They remain noisy and imprecise, and they leak
  - What you can do with a billion transistors per chip?
- Getting analog transistors to behave differently
  - Need to Control Rise and Fall Times
  - But...analog does not scale (no mad rush to 22nm)
- Digital Electronics Grows Analog Business

# Our Key Issues

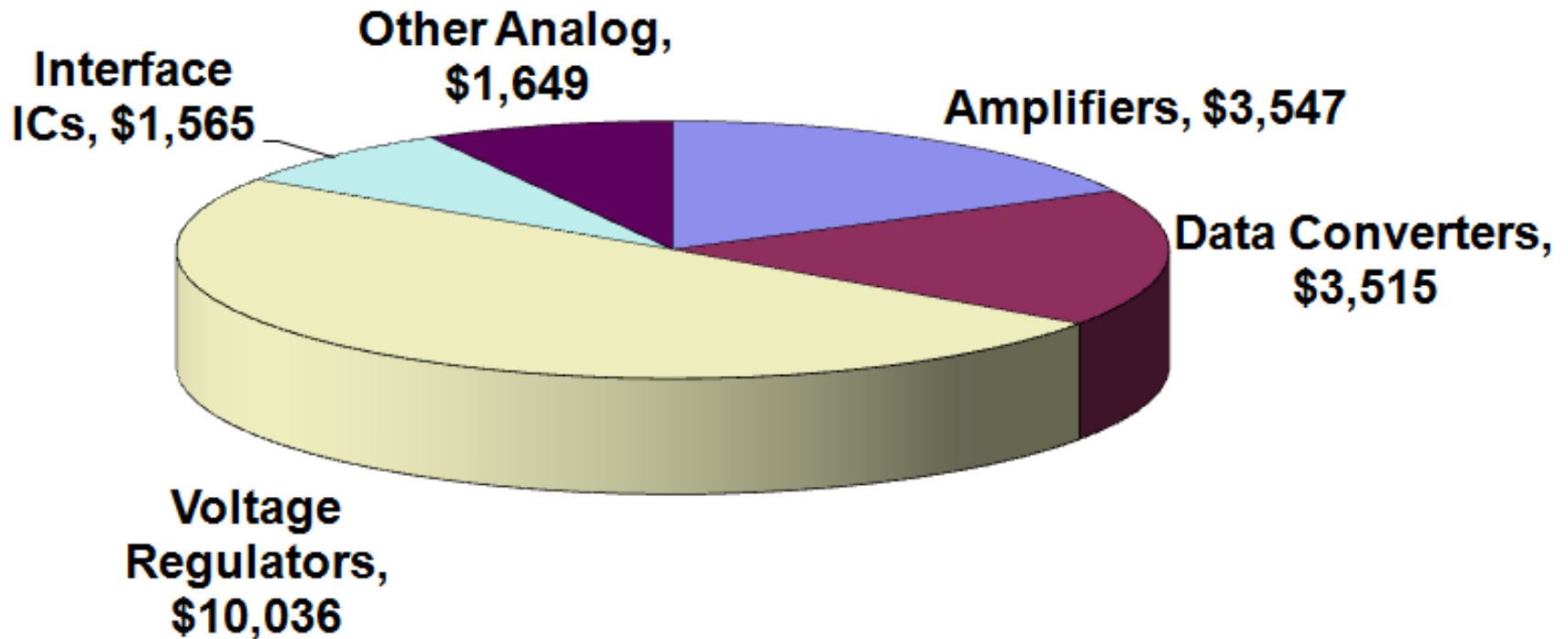
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- What do we know about the analog parts market ?
  - Standard analog: Increasing Concentration on Power Management
  - Application-Specific Analog: Growth for Smartphone PMICs
- How do we support analog manufacturing?
  - New Process Variables: BiCMOS and BCD
  - High Voltage
- Why is the Semiconductor Industry in Transition?

# The Analog Parts Market

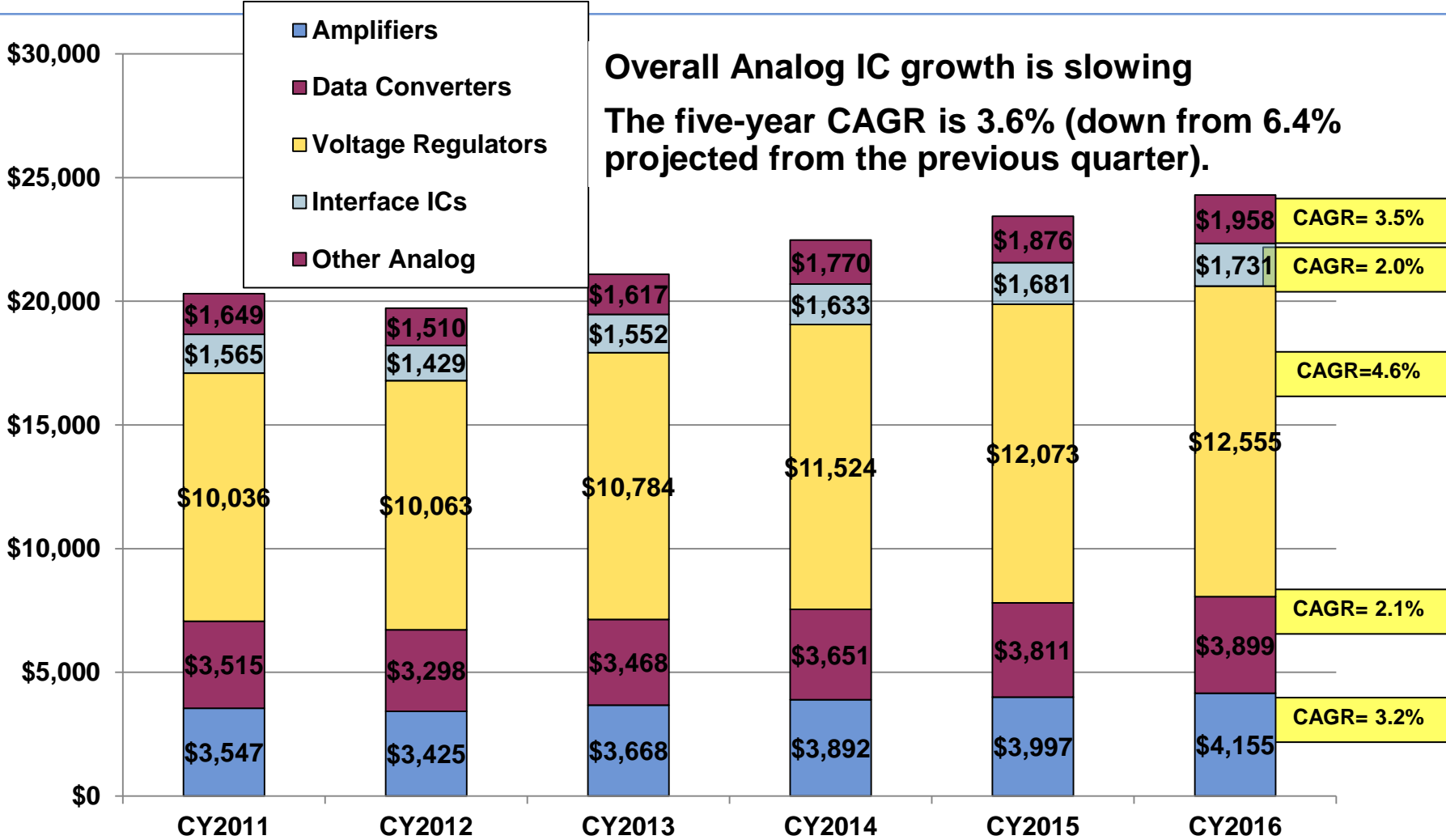
What drives revenue growth?

# Standard Analog ICs represented a \$20-Billion market (worldwide) in 2011



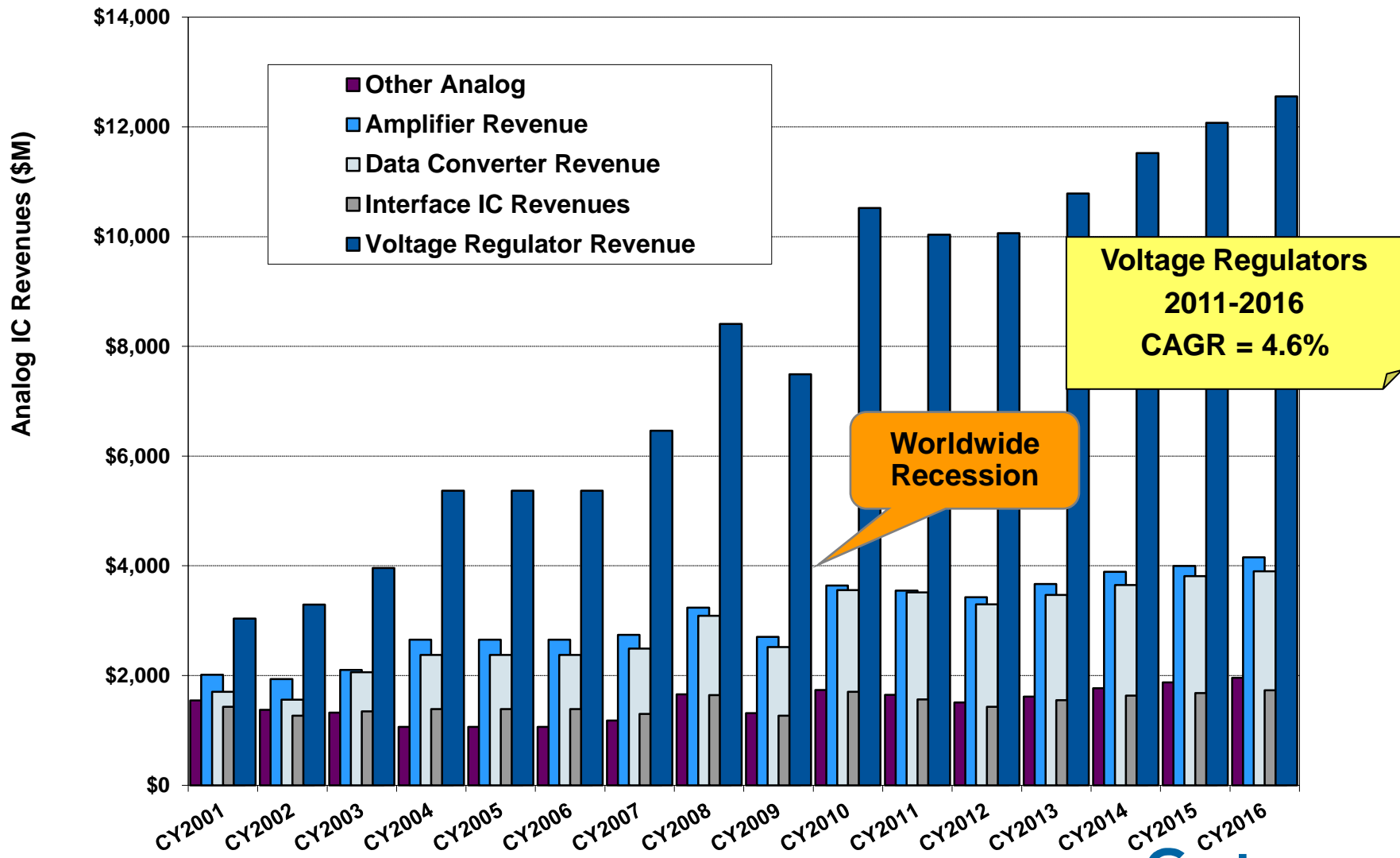
Voltage regulators — Power Management ICs — were largest part: 50% of the Standard Analog Market

# Standard Analog IC Revenue Growth follows Semiconductor Industry Patterns

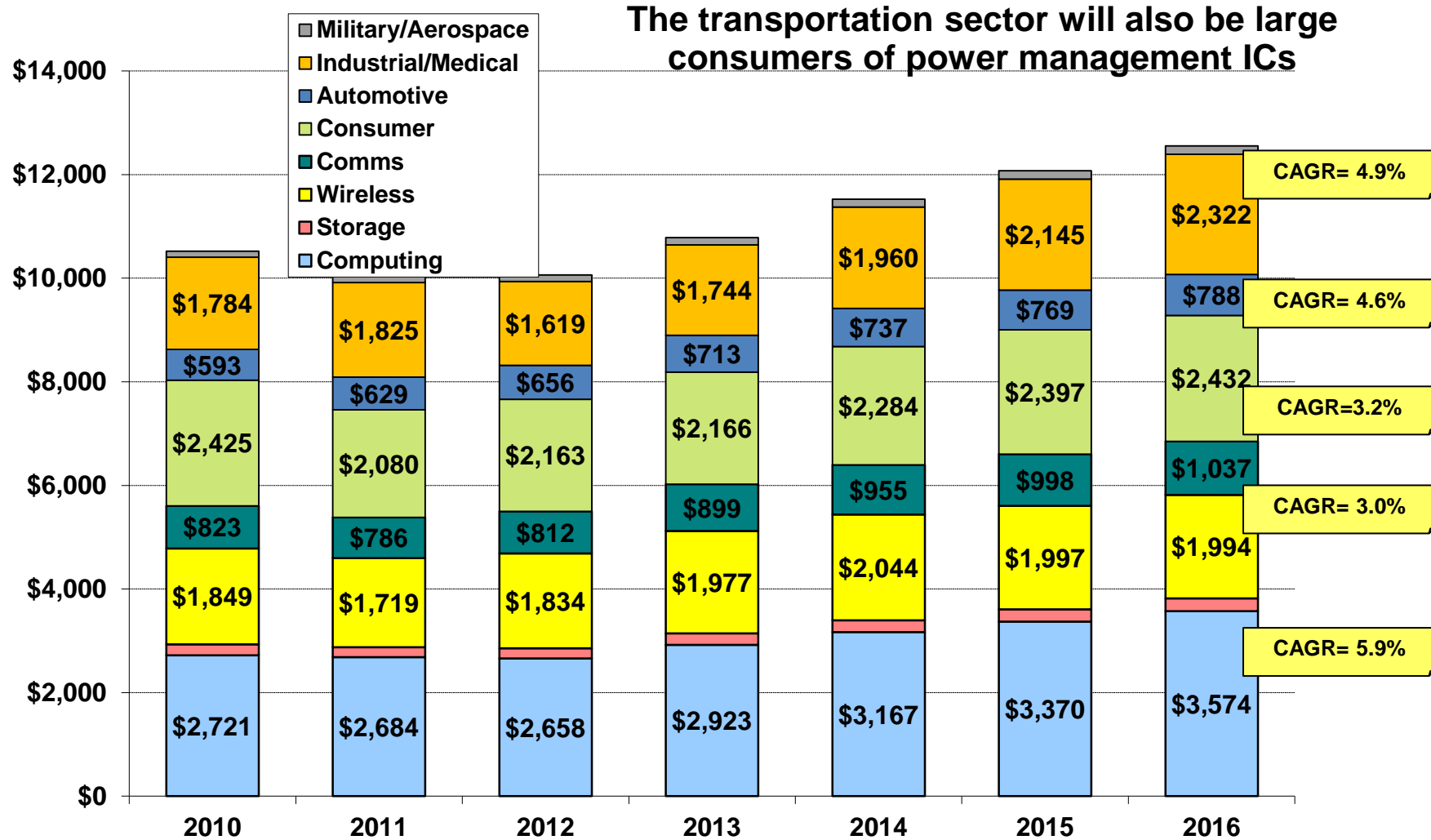


Source: Gartner (October 2012)

# Voltage regulators continue to show the strongest growth (in spite of recession)



# Computing and Industrial Applications Drive Power Management IC Growth



Source: Gartner (October 2012)

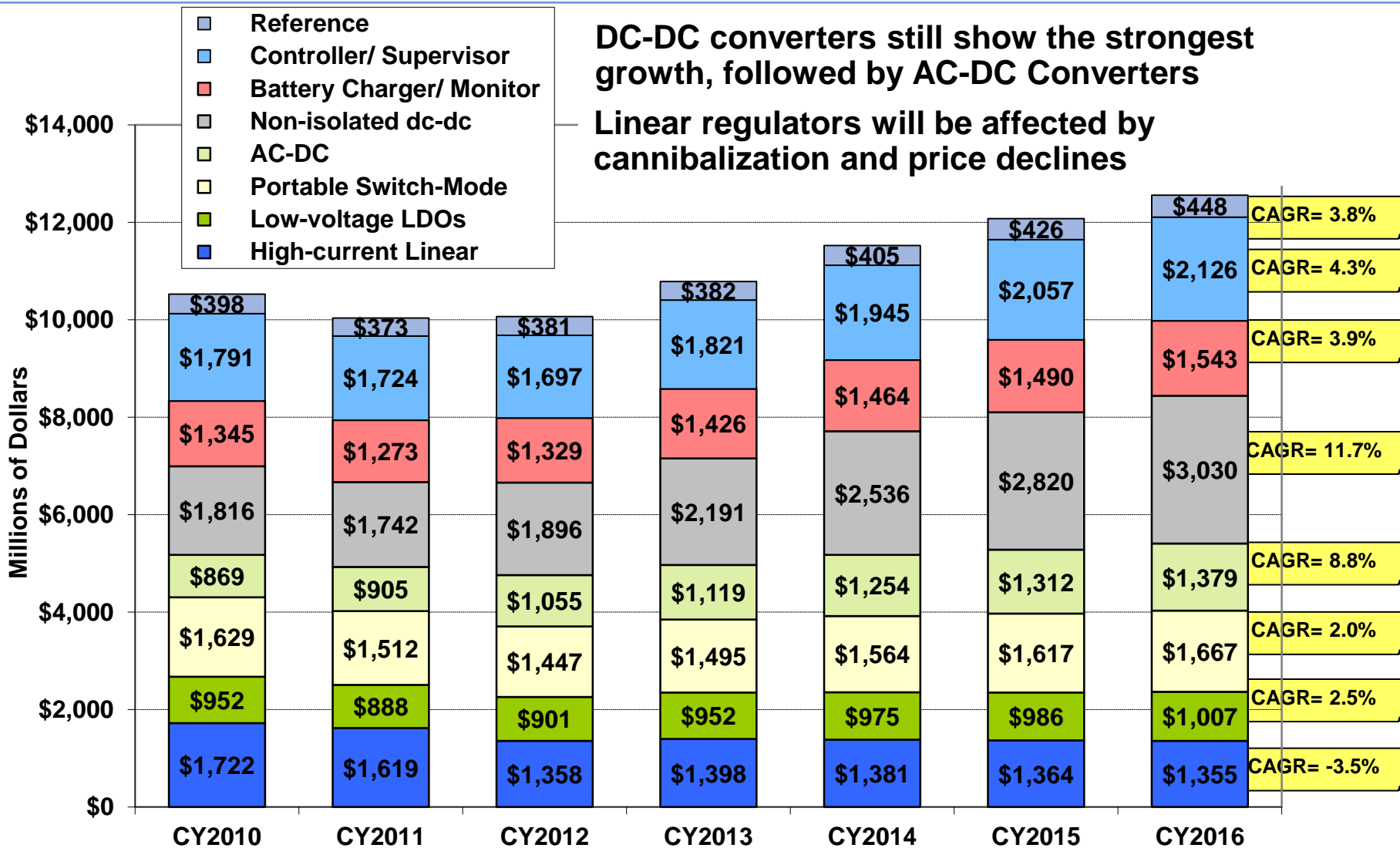


# Computers and communications servers demand energy-efficient ICs



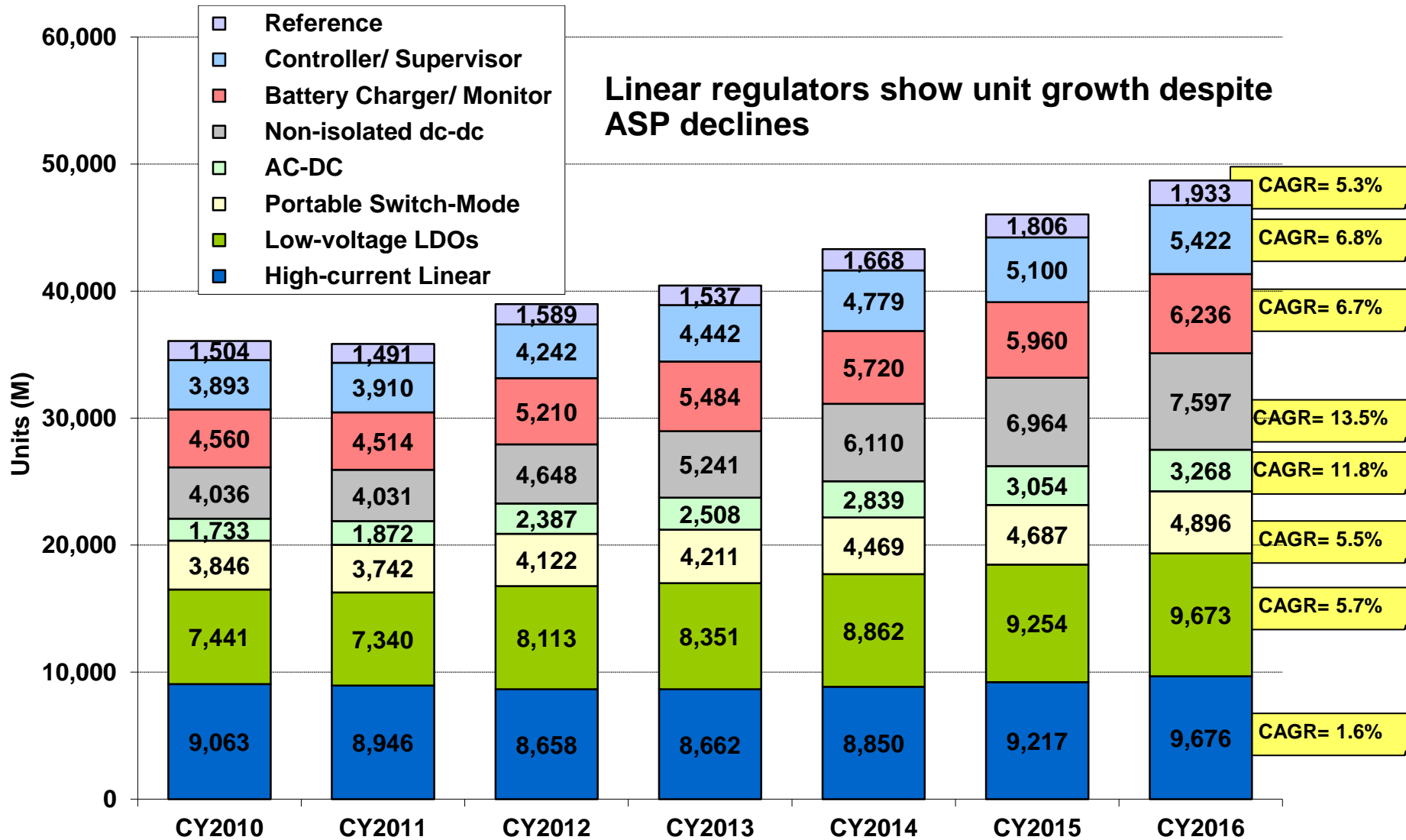
- Communications and computer system vendors already have large investments power supply efficiency
- DC-DC converters minimize heat dissipation, cooling and air conditioning costs
- Increasing clout of energy-efficiency standards (Energy Star, 80 Plus, California Energy Commission)
- Semiconductor companies benefiting: Power Management IC and Power Transistor makers

# The world revenue forecast for voltage regulators by device type (in dollars M)



Source: Gartner (October 2012)

# The forecast for voltage regulators by device type shows high growth (units M)



Source: Gartner (October 2012)

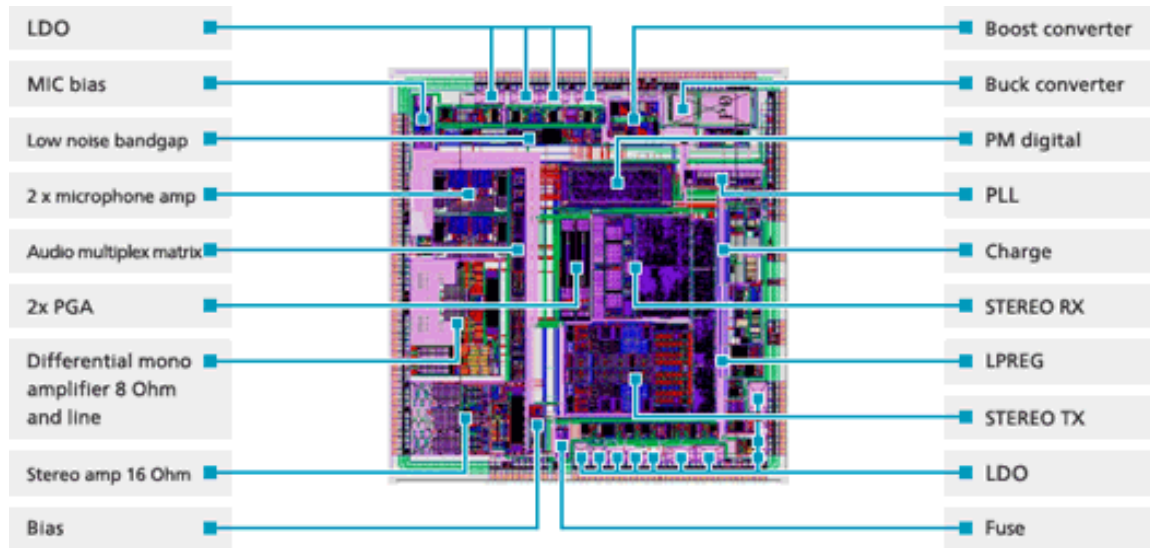
# The Leaders in Standard Analog IC Sales also Lead in Power Management ICs

Top 10 Companies Revenue from Shipments of Voltage Regulator/Reference - All Applications (Millions of \$US)

2010 Rank	2011 Rank	Company Name	2010 Revenue	2011 Revenue	Percentage Change	2011 Share (%)
1	1	Texas Instruments	1,631	1,700	4%	17%
2	2	Maxim Integrated Products	946	998	5%	10%
4	3	Linear Technology	769	724	-6%	7%
5	4	ON Semiconductor	453	515	14%	5%
6	5	STMicroelectronics	442	426	-4%	4%
8	6	Sanken	393	412	5%	4%
3	7	National Semiconductor	810	393	-51%	4%
7	8	Intersil	436	360	-17%	4%
9	9	Power Integrations	300	296	-1%	3%
10	10	Richtek Technology	275	283	3%	3%
		Others	4,069	3,929	-3%	39%
		Total Market	10,524	10,036	-5%	100%

Source: Gartner's Annual Market Share Compilation<sup>1</sup>(March, 2012)

# Custom Power Management ICs (PMICs) Demand Higher Levels of Integration

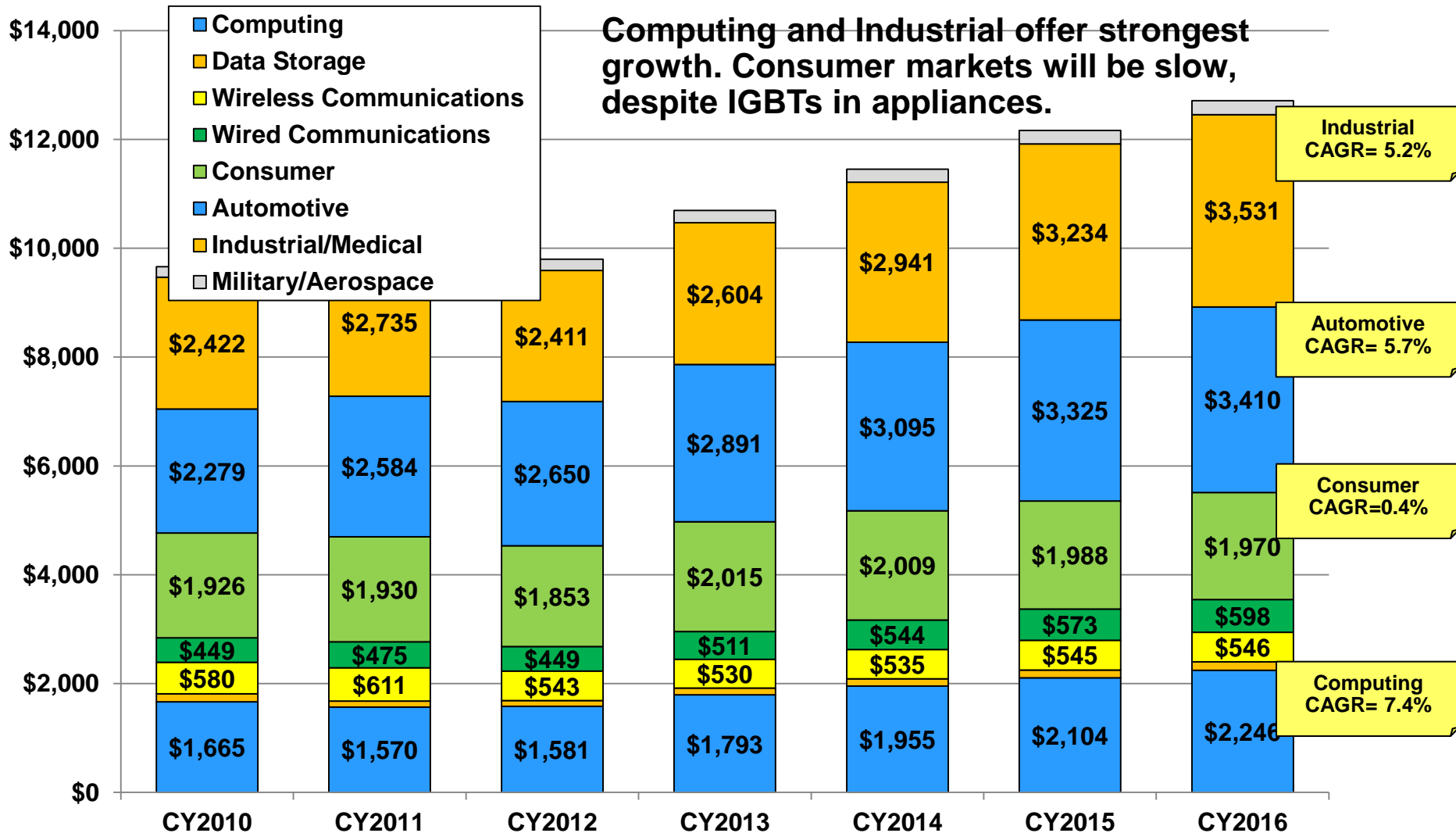


- As many as three separate switch-mode regulators, 22 LDOs, two LED backlight drivers and USB interface are on one chip
- A number of vendors have integrated stereo audio codecs with headphone and speaker drivers on the PMIC
- Audio hub controllers which allow handsets to control home media centers can become a \$1-billion business
- Devices are increasingly architected in 0.18-micron BiCMOS.

# The Carry-Over for Power Transistor Makers

**MOSFETs, IGBTs, and Wide Bandgap Devices**

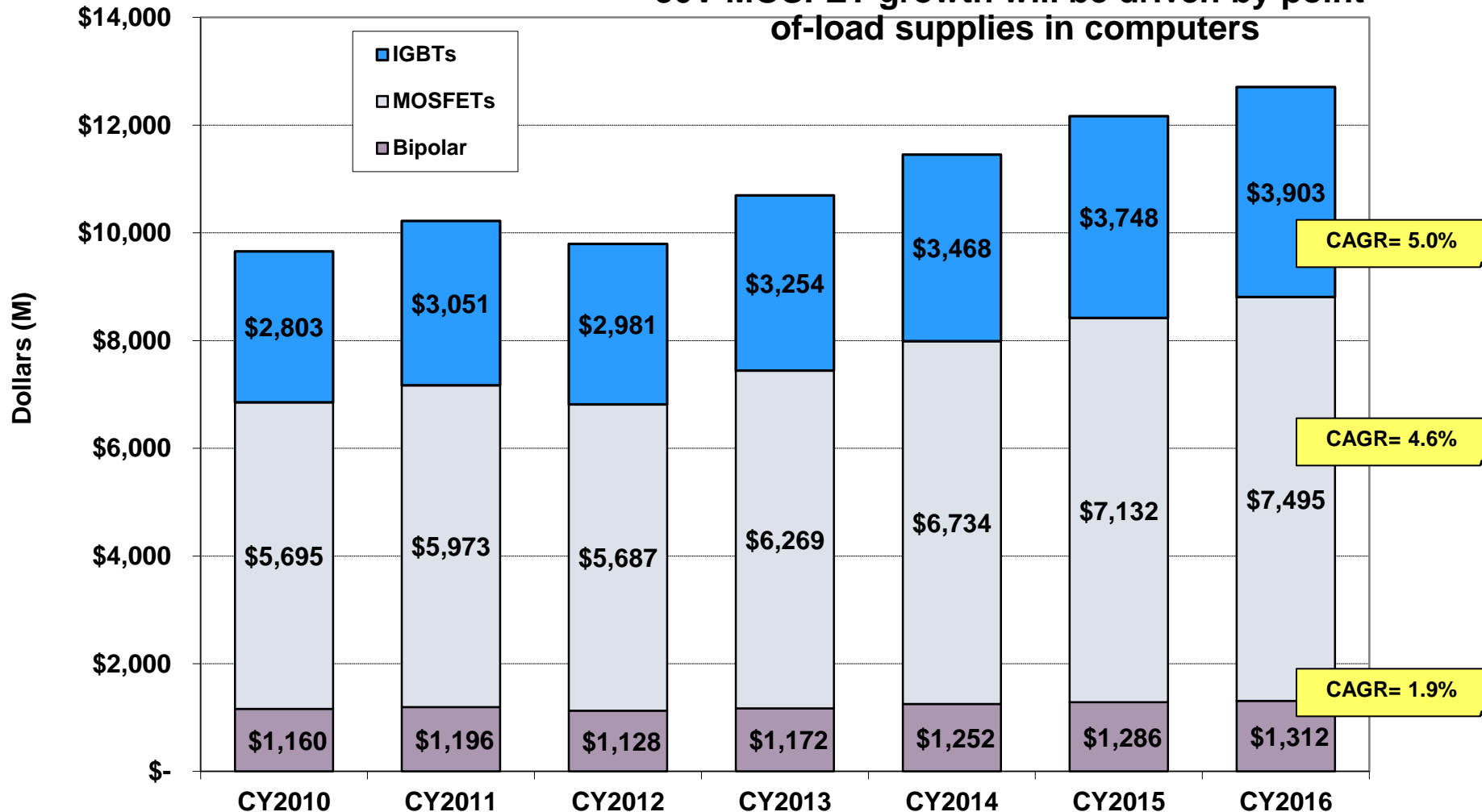
# Computing/Industrial applications offer sustained growth for power transistors



Source: Gartner (October 2012)

# ...making MOSFETs the fastest growing power transistor revenue segment (\$M)

30V MOSFET growth will be driven by point-of-load supplies in computers



Source: Gartner (October 2012)



# The Leaders in Power Transistors

Top 10 Companies Revenue from Shipments of Power Transistor - All Applications (Millions of \$US)

2010 Rank	2011 Rank	Company Name	2010 Revenue	2011 Revenue	Percentage Change	2011 Share (%)
1	1	Infineon Technologies	995	1,151	16%	11%
2	2	Mitsubishi	889	959	8%	9%
4	3	Toshiba	859	882	3%	9%
3	4	Fairchild Semiconductor	878	874	0%	9%
5	5	Renesas Electronics	819	820	0%	8%
7	6	Fuji Electric	642	759	18%	7%
6	7	International Rectifier	653	713	9%	7%
8	8	STMicroelectronics	605	629	4%	6%
10	9	ON Semiconductor	357	605	69%	6%
9	10	Vishay	504	415	-18%	4%
		Others	2,457	2,413	-2%	24%
		Total Market	9,658	10,220	6%	100%

# Power Transistor Forecast for selected devices by Voltage (units M)

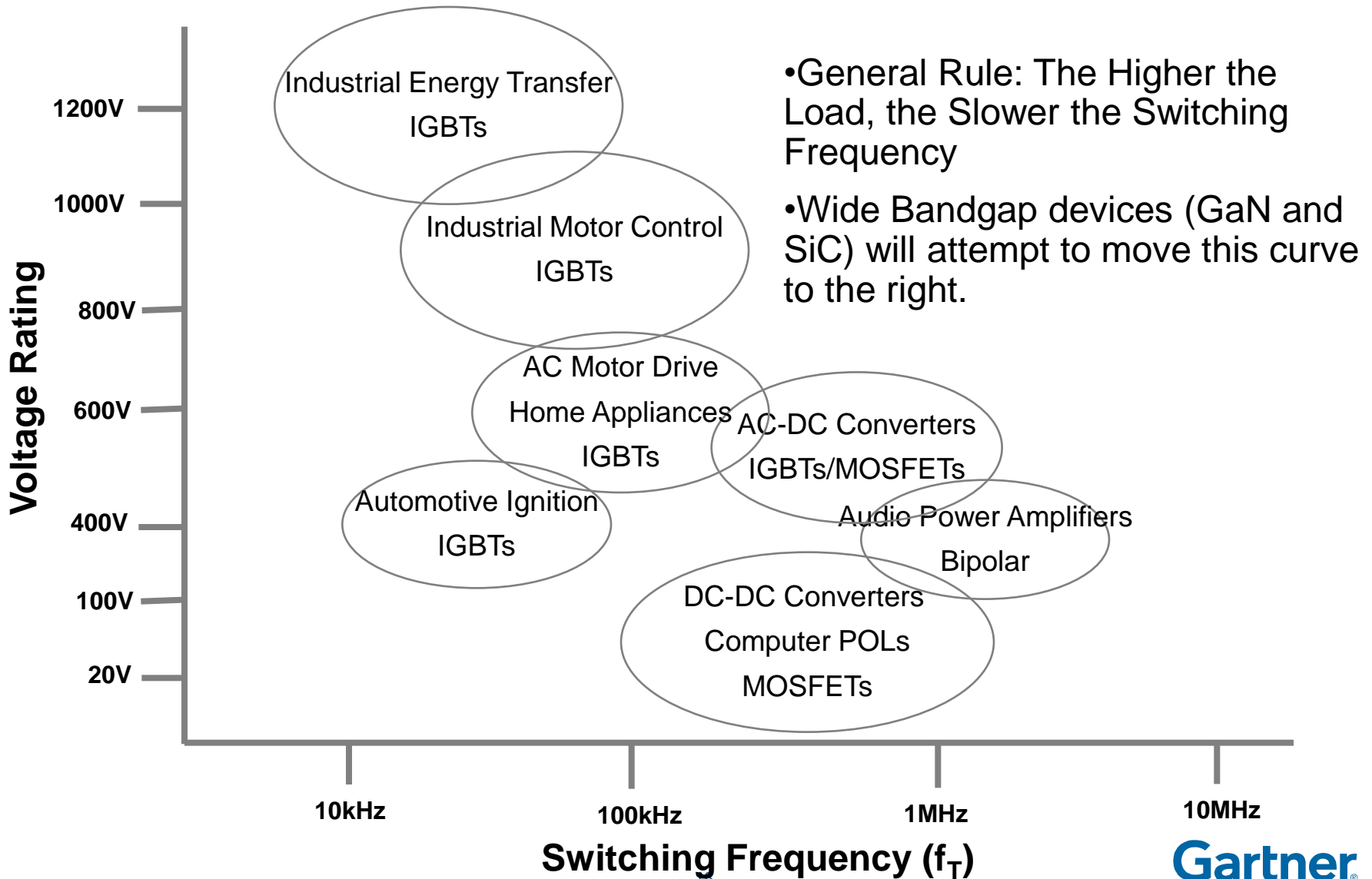
**30V-MOSFETs will lead unit growth**

Primary Application	Product Type	CY2010	CY2011	CY2012	CY2013	CY2014	CY2015	CY2016	5-year CAGR
Point-of-Load (POLs)	30V MOSFET	11,416	12,244	12,628	14,193	16,341	18,646	21,139	11.5%
Audio Amplifier	80V Bipolar	3,253	3,370	3,311	3,529	3,677	3,750	3,846	2.7%
Auto Ignition	400V IGBT	1,958	2,121	2,180	2,228	2,370	2,517	2,636	4.4%
Lighting Ballast	1000V Bipolar	4,001	4,638	4,570	4,841	5,642	6,454	7,333	9.6%
AC-DC Primary	600V MOSFET	6,505	7,251	10,022	10,824	12,838	14,425	15,520	16.4%
AC Motor Drive (washing machine)	600V IGBT	383	749	842	940	1,035	1,117	1,224	10.3%
Power Line Inverters	1200V IGBT	587	679	664	697	839	989	1,155	11.2%

**HV suppliers look to GaN and SiC**

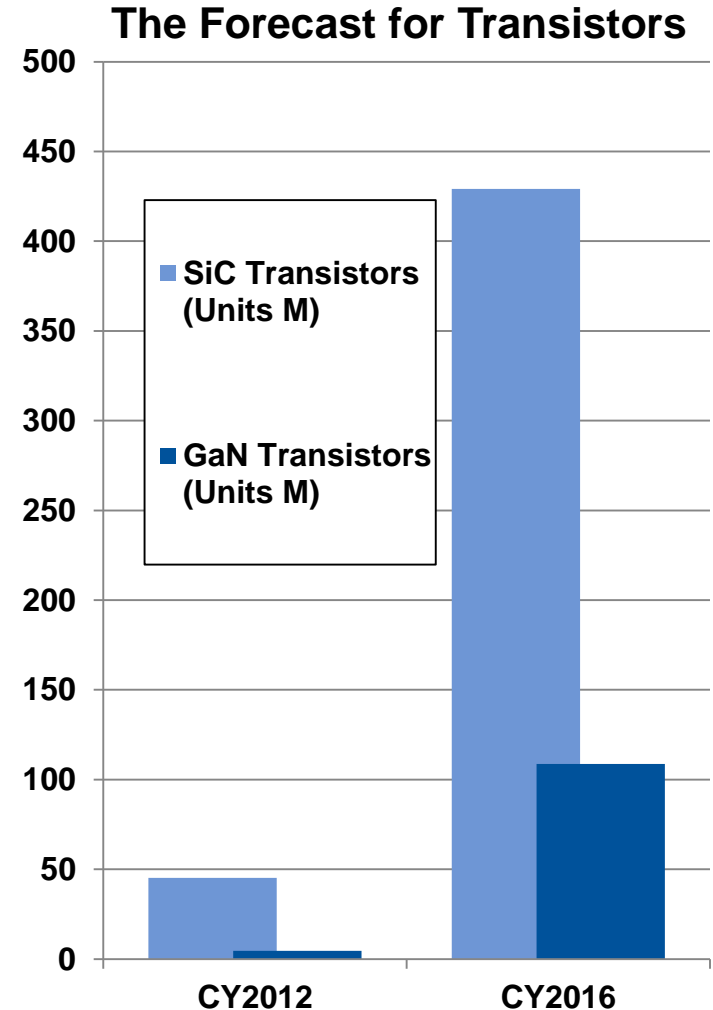
Source: Gartner Estimates (October 2012)

# Power Transistor Applications by Voltage and Switching Frequency



# The outlook for Wide Bandgap Devices: GaN and SiC will be slow in coming

- Silicon Carbide (SiC) Transistors are starting to appear with 1200V ratings
  - Cree and Semisouth are primary sources
  - Infineon Announced a 1200V transistor... but is currently selling diodes
- A growing number of developers (product and process) report momentum is building for GaN (e.g. International Rectifier, Transphorm, EPC, Fairchild, NXP)
- But skepticism remains (“Science Fair Projects”)
- Consensus that GaN on silicon offers practical results, but concerns with materials remain:
  - Uneven deposition of GaN layer
  - Graininess
  - Mismatched modulus of expansion
- Unresolved: Wafer size and Die Costs

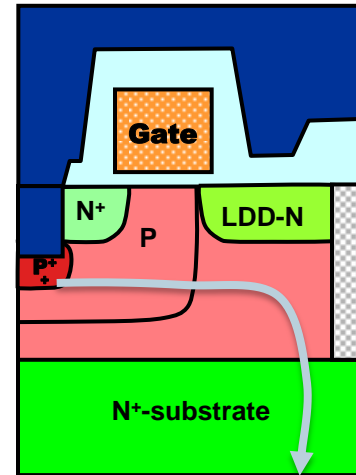


# What are the implications for foundry service vendors?

**The Importance of BCD and High Voltage Capabilities.**

# What are the implications for Foundry Service Vendors?

- Analog ICs shift toward 0.18-micron CMOS
- Greater emphasis on BiCMOS and BCD
  - Implanted power transistors
  - Switching speed vs.  $R_{\text{DS(on)}}$
  - Need for Horizontal Conduction
- More High-Voltage Processes
  - 40V for LED lighting strings
  - 600V for off-line power supplies, appliances
- Manufacturing with 300mm Wafers



Texas Instruments' NexFET

# Dongbu HiTek Example

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- The BD180LV process offers 0.18-micron BCD, with 30V LDMOS power FETs (and low  $R_{\text{DSON}}$ )
- Also promoted: A 700V BCD process with LDMOS power transistors on 0.35-micron CMOS. The process supports
  - Off-line AC-DC converters
  - LED lighting
  - Appliance controls
- The catalog includes well-characterized 5V analog CMOS, bipolar transistors, and passives.

# Texas Instruments' 300mm example: Overcapacity or Market Dominance?

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- TI's RFAB was the first manufacturer to utilize 300mm wafers for analog IC fabrication
- TI is using a BCD process to fabricate power management devices with implanted power transistors
- Gartner estimates that TI could, be itself, supply 10% of the world's DC-DC converters.
- Additional 200mm analog capacity exists in Aizu, Japan and Chengdu, China. TI quantifies its new capacity at \$4.5 billion.
- But if demand declines...



# Semiconductor Industry Outlook

**What is the outlook for the semiconductor industry? What influence will SIGMA ecosystems wield?**

# Industry Outlook Has Clearly Weakened

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- Despite recent inventory correction, chip inventory is still relatively high
- Q2 semiconductor revenue growth was weaker than expected, and Q3 quarter outlook is below seasonal.
- Economic forecasts have been ratcheted down in recent months
- Semiconductor ASPs are weakening overall
- Success in electronic equipment markets is clearly uneven, impacting the fortunes of key semiconductor suppliers

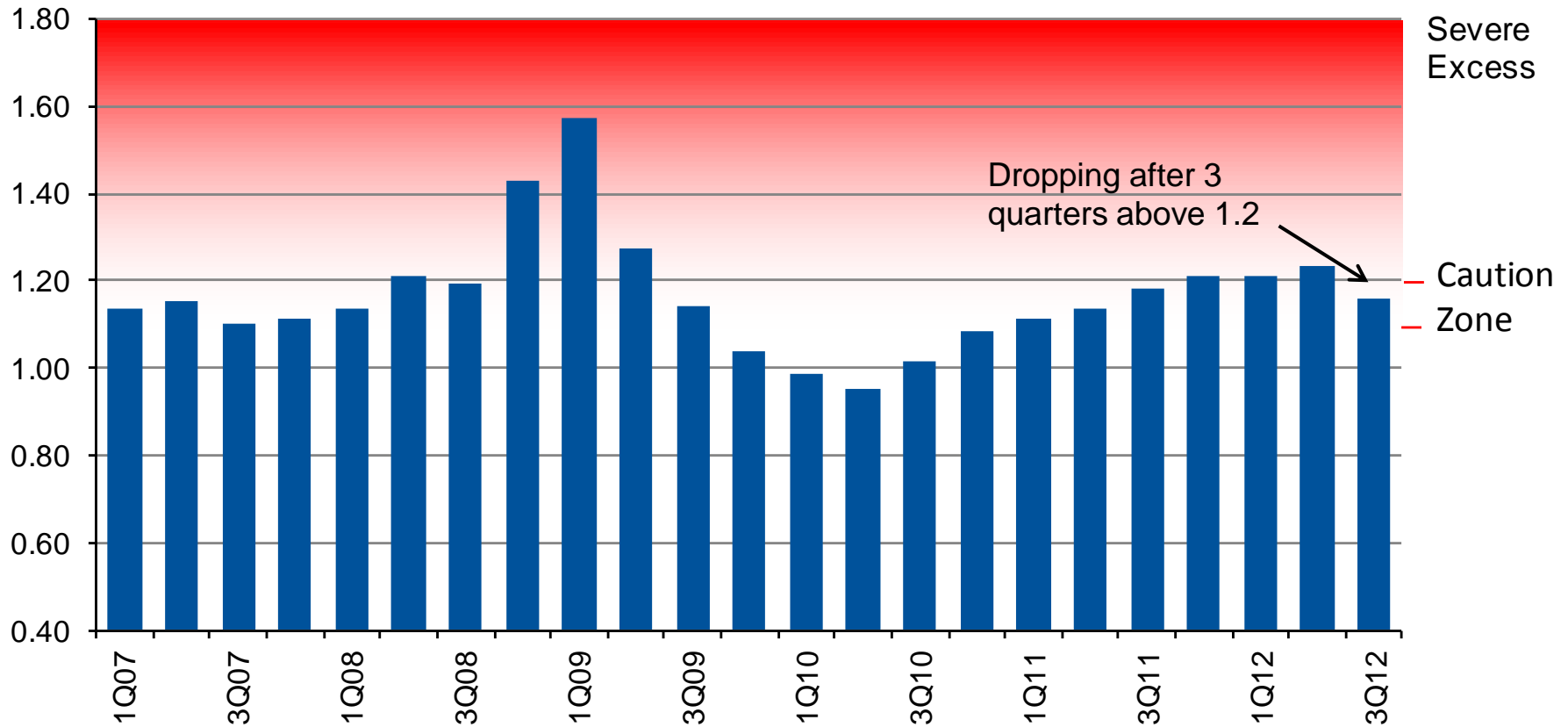
# Global Economic Summary

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- Global GDP growth now expected to register 2.6% in 2012, 2.7% in 2013 and 3.6% in 2014
- Data over the past month confirm economic growth in all the key economies of the world have slowed down, almost simultaneously
- With few exceptions, consumer and business pessimism has become more pervasive and more pronounced
- Central bank concerns about the economic outlook have also increased considerably—and many are easing policies further
- The distribution of growth remains largely the same:
  - recession in much of Europe
  - lacklustre growth in the United States and Japan
  - slower growth in much of the emerging world, albeit still faster than in the developed world

# Inventory Days Will Drop in Q3, But Remain Relatively High

Semiconductor Inventory Index



Source: Gartner (September 2012)

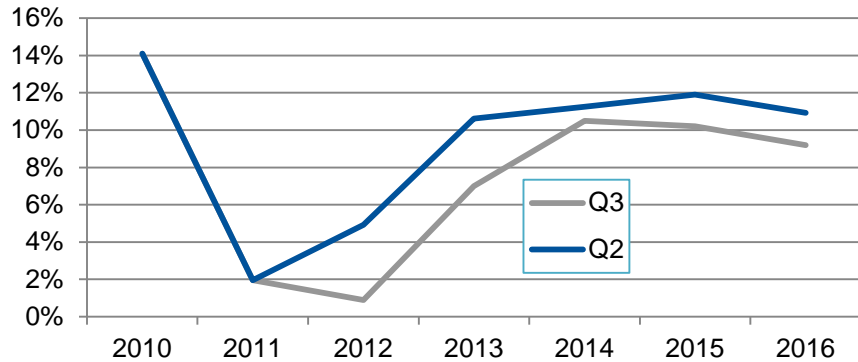
# Key 3Q12 Semiconductor Assumptions

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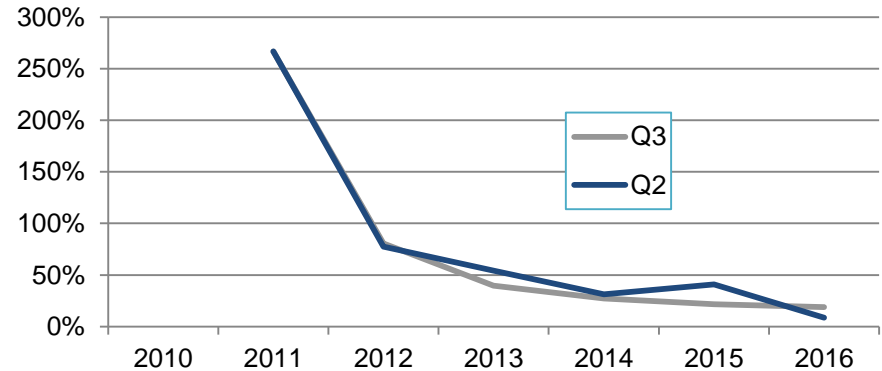
- Near-term forecast assumes weak but stable economy, with inventory overhang entering 2013.
- 2012 PC unit production growth was decreased significantly from 4.9% to 0.9%.
- 2012 Mobile phone unit production growth decreased slightly from 6.5% to 4.4%.
- Media tablet production forecast increased slightly to 121.5M units in 2012, growing 80% over 2011.
- DRAM recovery cut short; 3Q12 will remain in oversupply and 4Q12 will now only see a mild undersupply
- 2012 NAND forecast reduced after extremely weak Q2; strong 2013 revenue growth as ASPs firm

# Major Application Unit Growth Rates

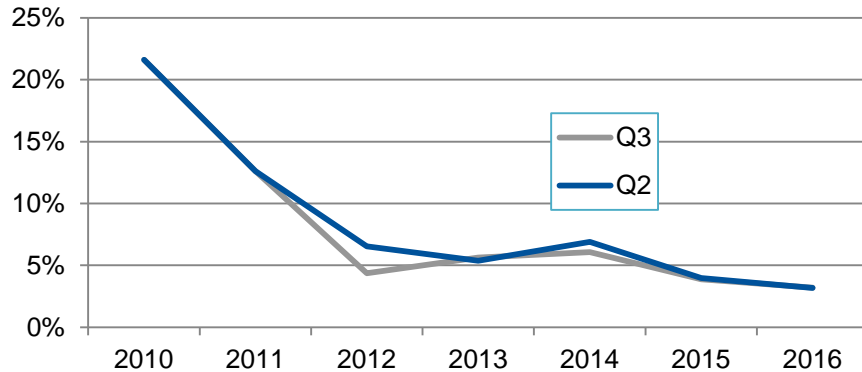
## PC



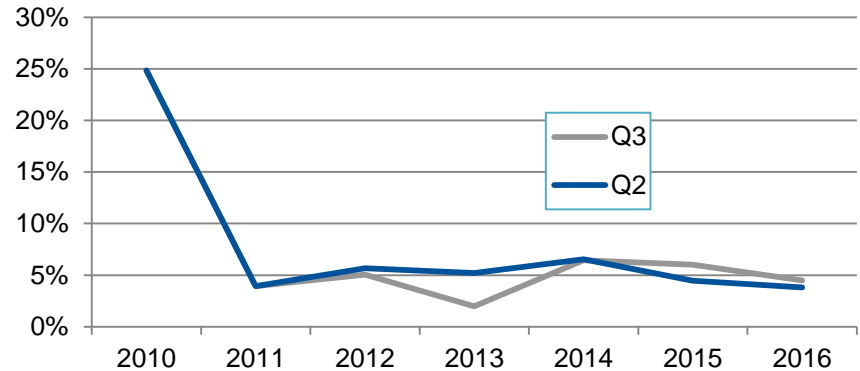
## Media Tablet



## Mobile Phone



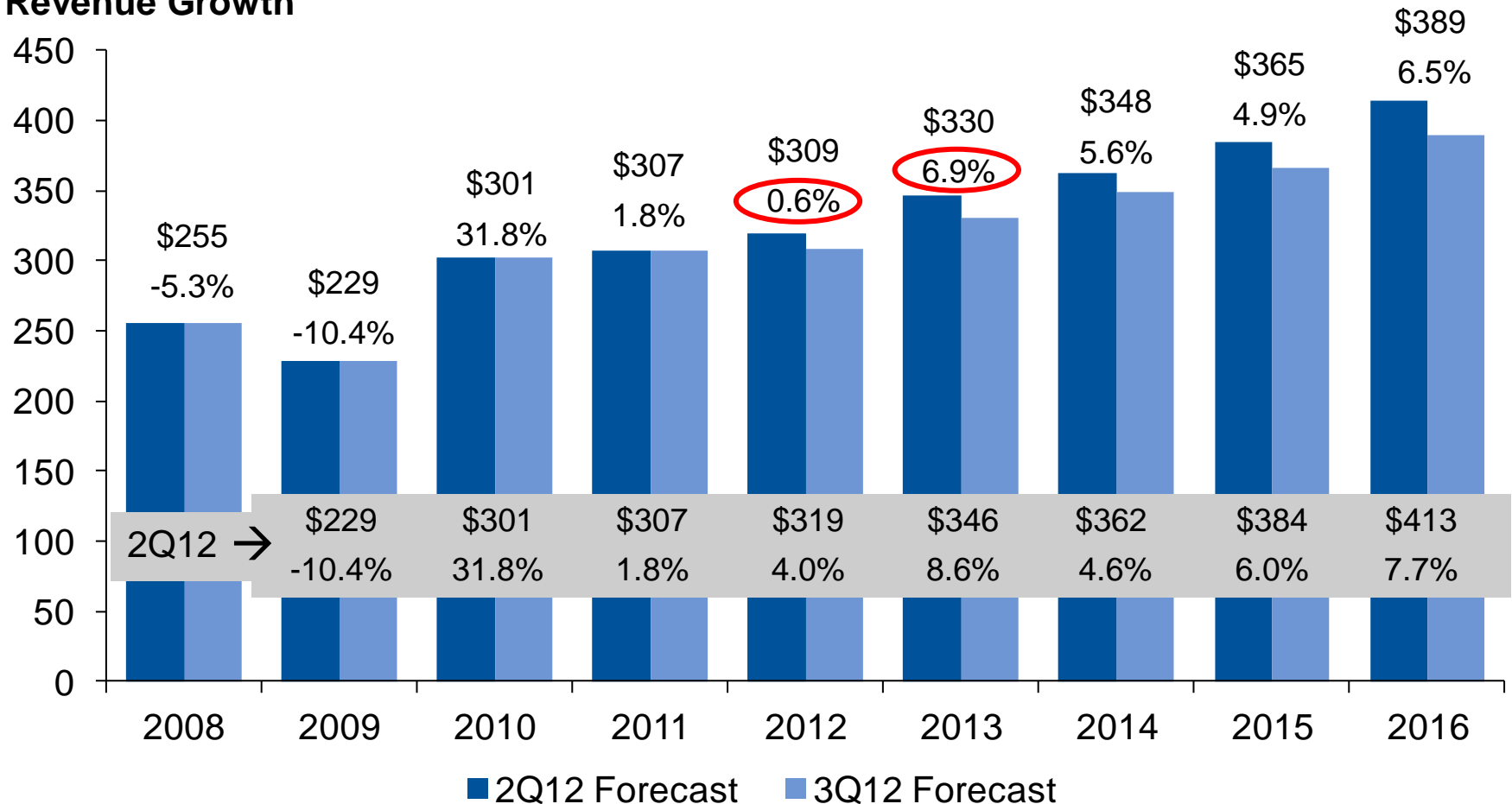
## Automotive Light Vehicles



Source: Gartner (September 2012)

# Worldwide Semiconductor Revenue Forecast: Reduction in Overall CAGR

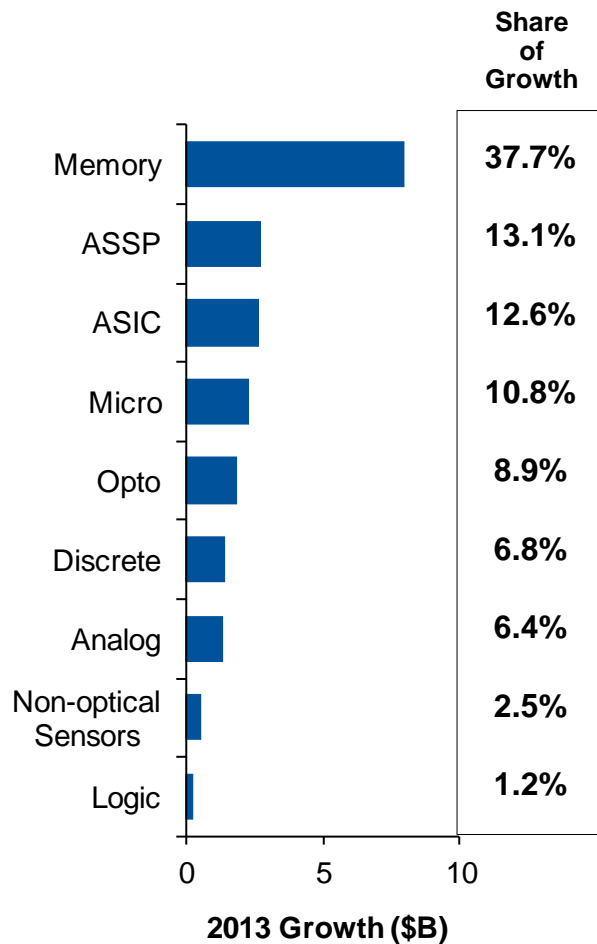
Billions of Dollars and Revenue Growth



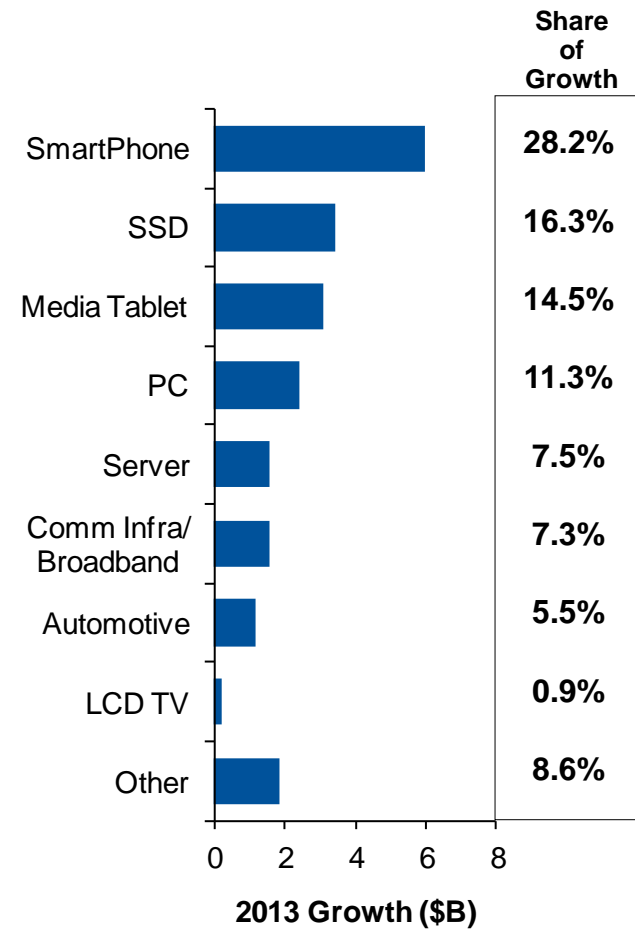
Source: Gartner (September 2012)

# Contribution to 2013 Growth

## Contribution by Device Type



## Contribution by Electronic Application



Source: Gartner (September 2012)



# Semiconductor Revenue, 3Q12 Update: Device Revenue and Annual Growth

Revenue (\$B)	2011	2012	2013	2014	2015	2016	CAGR
Memory	61.1	58.9	66.8	68.7	70.6	79.8	5.5
Microcomponents	62.0	61.9	64.2	67.6	71.1	74.6	3.8
Logic	12.2	12.2	12.4	13.0	13.6	14.2	3.1
Analog	20.3	19.7	21.1	22.5	23.4	24.3	3.6
Discrete	20.4	19.5	20.9	22.1	23.1	23.8	3.1
Optoelectronics	23.5	25.6	27.5	30.5	33.5	37.0	9.5
ASIC	21.8	22.5	25.2	27.3	29.4	30.9	7.2
ASSP	80.6	82.8	85.5	89.8	93.4	96.6	3.7
Non-Optical Sensors	4.9	5.6	6.1	6.8	7.4	8.0	10.2
<b>Total Semiconductor</b>	<b>306.8</b>	<b>308.6</b>	<b>329.8</b>	<b>348.2</b>	<b>365.4</b>	<b>389.2</b>	<b>4.9</b>
Annual Growth (%)							
Memory	-10.0%	-3.7%	13.6%	2.8%	2.7%	13.0%	
Microcomponents	10.4%	-0.2%	3.7%	5.4%	5.2%	5.0%	
Logic	1.3%	0.0%	2.0%	4.4%	4.8%	4.3%	
Analog	-4.0%	-2.9%	6.9%	6.5%	4.3%	3.7%	
Discrete	4.2%	-4.7%	7.4%	5.8%	4.4%	3.2%	
Optoelectronics	7.4%	9.1%	7.4%	10.8%	9.7%	10.5%	
ASIC	0.8%	3.0%	11.9%	8.5%	7.6%	5.4%	
ASSP	5.0%	2.7%	3.3%	5.0%	4.0%	3.4%	
Non-Optical Sensors	14.3%	13.4%	9.5%	11.4%	9.0%	7.7%	
<b>Total Semiconductor</b>	<b>1.8%</b>	<b>0.6%</b>	<b>6.9%</b>	<b>5.6%</b>	<b>4.9%</b>	<b>6.5%</b>	
<b>Non-Memory</b>	<b>5.2%</b>	<b>1.6%</b>	<b>5.3%</b>	<b>6.3%</b>	<b>5.5%</b>	<b>4.9%</b>	

Source: Gartner (September 2012)

# SIGMA: These 5 companies set the trends for the entire electronics industry

Company	Influence
Samsung	It is the largest CE company. It is vertically integrated: it makes chips, displays on the component side and PC, phones, tablets, TVs & white goods. It is acquiring key IP blocks for smartphone/tablet semiconductors. It is a mega-user of other's ecosystems & it is a mega-supplier to them, particularly by setting memory markets.
Intel	It sets the main enterprise ecosystem for the PC and server markets by defining their architectural standards– but are less relevant in the rest of electronics. It may be developing the next generation of SOCs for CE and is investing heavily in phones & ultrabooks.
Google	It provides the open OS for electronics, and is leading the design of internet infrastructure. Android enables the smartphone market – but its only strong in phones, tablets and TVs are still trying to become relevant.
Microsoft	It sets the main OS ecosystem for the PC market, and has a portfolio of SW for it. It is leading a gaming revolution via its XBOX and Kinect ecosystems They are working on Win 8 for phones and tablets
Apple	Apple is currently the style and trend setter for CE, and owns the main ecosystem. Sets trends in industry – still. All its devices have leading edge UI and you can control TV from the tablet/phone. Apple TV is a dongle – also its OS and ecosystem is best developed

# Conclusions and Recommendations

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- Analog ICs manufacturers should steer design, development and production of DC-DC and AC-DC converters
- ODMs and foundry service providers must perfect their skills in mixed technologies which implant power transistors on CMOS substrates
- With increasing digital content of analog control circuits, analog CMOS providers should anticipate a shift toward 0.18- and 0.13-microns
- All semiconductor makers should anticipate slower revenue growth, and acknowledge the influence of SIGMA.

**We welcome your questions...**