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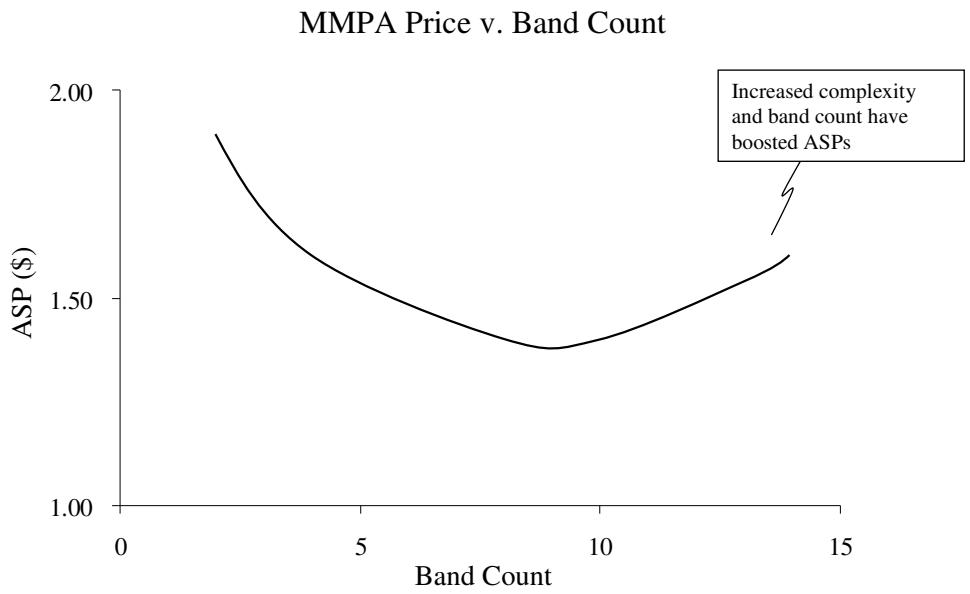
The Ten Most Common Fallacies about the RF TAM

(Bigger than it seems)

#1: MMPAs

Multi band amplifiers will accelerate price erosion and destroy the market.

The arrival of multi mode amplifiers (MMPA) in 2010 did drive down pricing, but only on a per-band basis, and then only in high-band count devices; they had no impact on ASPs[1] for PAMs[2], PADs[3], FEMIDs[4] or filters. Like Costco, lower per unit cost could only be obtained through bulk purchases, but single serving prices remained unchanged. MMPAs offered more for less, but they weren't supported by most baseband vendors, so there wasn't much of an impact in 2011. Today virtually all smartphones use MMPAs, yet ASPs have not plummeted because the number of bands has risen faster than pricing has declined[5]. In fact, after an initial drop, ASPs have started to rebound as the current crop of products must clear a higher performance hurdle and include many more bands.

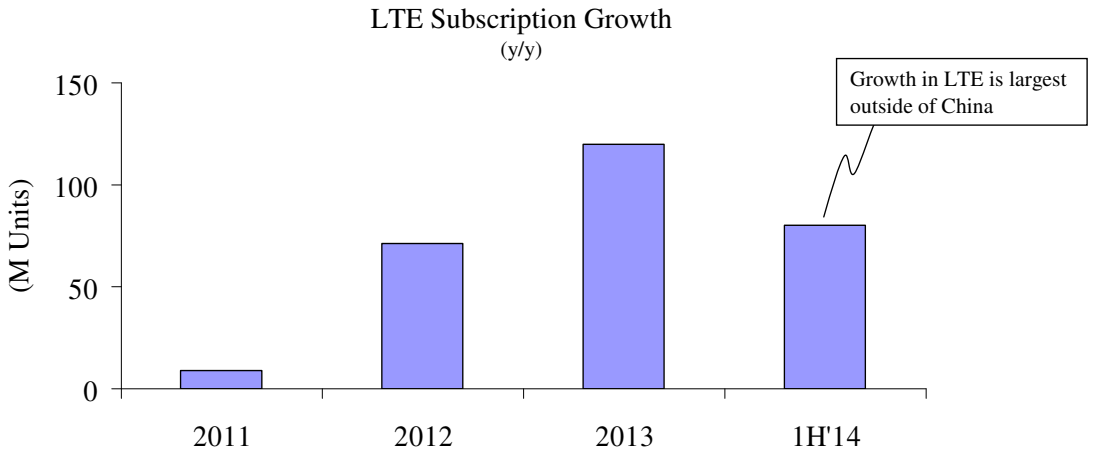


Indeed, instead of the four GSM and six WCDMA channels required for most 3G phones, high-end 4G handsets have to support 15 to 20 for the 28 LTE bands deployed throughout the world. This is beyond even the most advanced technology, which is why MMPAs are being augmented with satellite PAs[6], and although the current crop of MMPAs do support more bands, they can't cover the full spectrum, and they're not inexpensive. The higher performance required by LTE and the fact that the wideband amplifiers used in these devices must be coupled to an SOI switch[7], add complexity and cost to what was originally a very simple, multi-die device. Had the world stopped in 2010 and 3G been the last standard, the MMPA price-erosion thesis may have proved true. As it was, 4G followed so closely on the heels of 3G that ASPs for MMPAs have started to rise even as per band pricing continues to decline. Front-ends are now so complex that OEMs are pushing more of the RF design to the GaAs semiconductor manufacturers, which are moving beyond MMPAs to more sophisticated, higher-content solutions like all-in-ones (SkyOne, RF Fusion, Global One) and PADIDs.

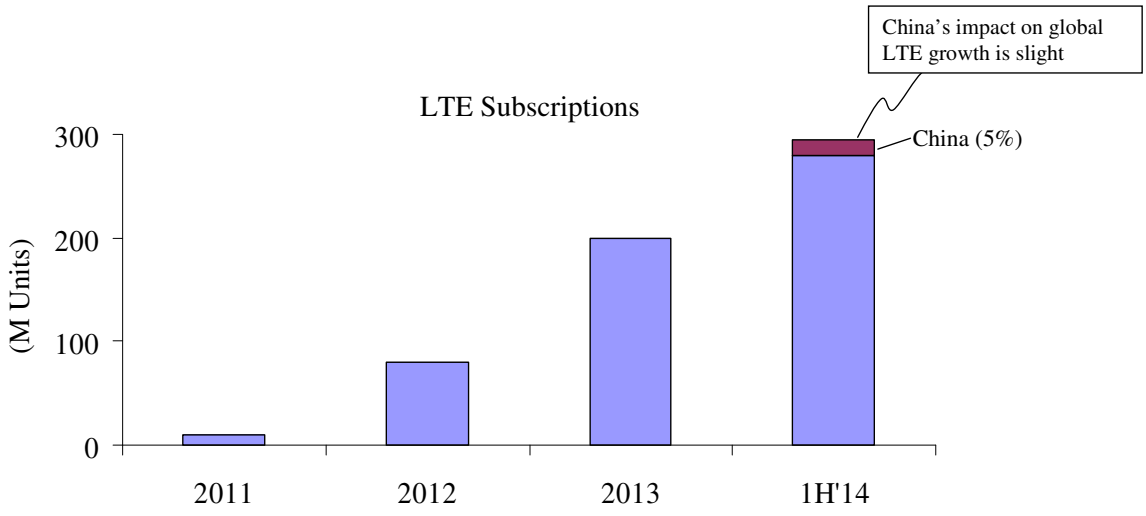
#2: CHINA

Double ordering by Chinese OEMs is causing an inventory glut in 4G that will mute or reverse TAM growth next year.

All criteria for double-ordering are present in the LTE phone ramp in China[8], but it isn't clear how much excess inventory has accumulated, or if there's any at all. A highly fragmented supplier base, and the enthusiasm with which it is pursuing China Mobile's goal of the 100M LTE phones, increase the likelihood that production will exceed demand, especially given China Mobile's relatively modest growth in 4G subscribers. Shortages in filters and switches will almost certainly lead to double ordering of these components, which acts as a multiplier, amplifying excess phone production in the backlogs of the RF semiconductor manufacturers. But the scale of the LTE build-out in China relative to the rest of the world, and component demand from the 2G to 3G and LTE to advanced LTE migrations will mute the impact of order cancellations this year and probably next.



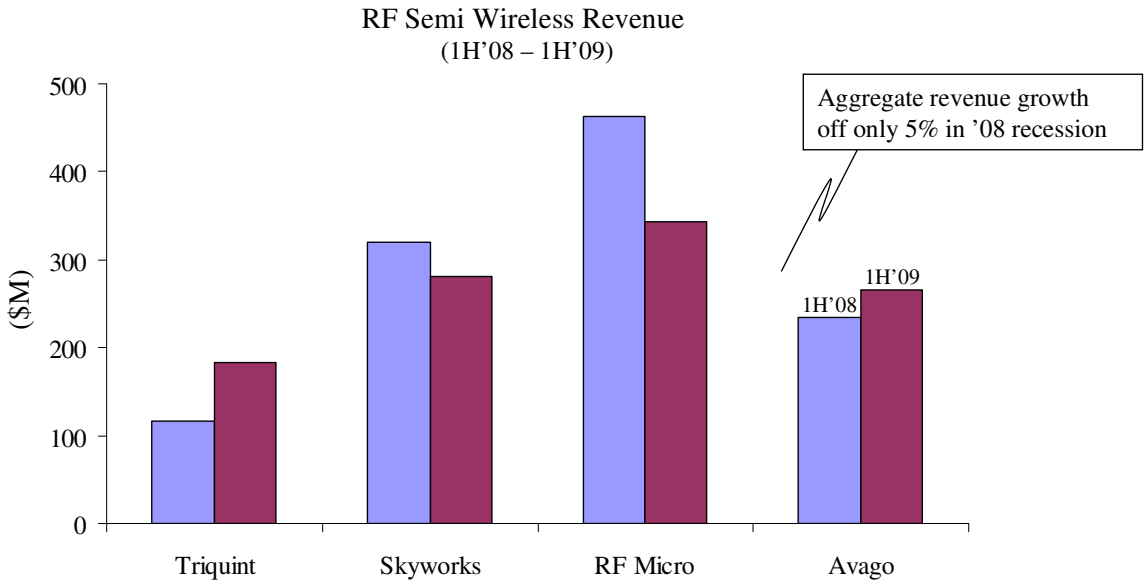
From 2011 to 2013, LTE subscriber growth exceeded 100% per year and total users topped 200M prior to China entering the 4G market in 2014. After two quarters, the country accounts for only 5% of the world total. That will increase, but given the rate of growth in Europe and the U.S., it will be some time before China reaches parity in 4G, certainly not before the end of this year.



The small footprint of 4G in China relative to the rest of the world, and the fact that the OEMs most prone to double ordering are local suppliers that don't ship to international carriers, minimize the impact of over-production on RF semiconductor manufacturers. The preponderance of revenue in mobile phone components for all of these suppliers is outside Chinese white label OEMs. In fact, Apple and Samsung account for the majority of handset component revenue for every one of the largest RF component suppliers, and with both of these OEMs using inventory hubs, the chances of building large amounts of excess inventory are minimal.

To guard against overproduction, all of the RF semiconductor manufacturers are monitoring Chinese 4G subscriber growth relative to orders and adjusting shipments accordingly. Part allocations, higher ASPs and expedite fees are used to filter true demand from buffer stock. And unlike in 2001, when the recession revealed a glut of double-ordering that left the industry with six months of excess inventory, today, all major OEMs are on inventory hubs, which limits how far supply can outstrip demand.

The supply base has also moved to a different production model. In 2001, only Skyworks (then Alpha Industries) used the flexible manufacturing model, where an internal fab was kept heavily loaded by outsourcing excess and turns business to foundries. All other manufacturers were devoted to large internal fabs, which where prone to over-production to minimize utilization charges. Today, all of the RF GaAs component manufacturers use the outsource model except for Triquint, which once merged with RF Micro Devices will have it as well. This increases flexibility and reduces response time to excess production. Perhaps the best example of this was the 2008 recession, where a steep decline in demand in 3Q08 was met with an even more rapid reduction in capacity, so that by mid-2009, component shortages were stretching out lead times and pushing up ASPs. So while excess inventory could be accumulating in China, it is unlikely to be anywhere near as severe as the 5% decline in demand seen in 1H08. Additionally, by 1Q15 there will only be three major RF handset component suppliers, where there were six[9] in 2008.



Finally, the prospect of double ordering has pervaded investors' conversations for the last two quarters, making it increasingly unlikely that anyone will be surprised if it occurs at all. Additionally, unless the impact is large relative to TAM growth this year (an unlikely prospect given the size of 4G in China), excess 4G component inventory in China could end up being a non-event.

#3: SLOWING PHONE SALES

Slowing demand for smartphones, especially at Apple and Samsung, will undercut TAM growth, given the high concentration of content in the best selling handsets.

The growth rate for high-end phone sales is slowing, partly because of the law of large numbers, and partly because demand in developed countries is saturating. But while growth is off, unit sales are still increasing, and are expected to accelerate this year now that Apple has retail stores in China. Even if units were flat, however, the RF TAM would still increase, given the migration of phones to more advanced standards (2G to 3G, 3G to 4G), and transition of many 4G bands to more difficult filtering standards.

The average RF content in a 2G phone is about $0.85 while for 3G it's around $3.00, which means the move from 2G to 3G nearly quadruples RF content. Multiplied across 4.2B[10] 2G subscribers, the 2G-to-3G migration represents a $9B increase in the RF TAM. A similar, albeit smaller impact is seen with the 3G to 4G transition, where content increases 80% - 200%. Not all of the 2.0B[11] 3G subscribers will move to 4G in the next two years, but that base of users represents another $5B to $10B increase in the TAM. Eventually, many of the subscribers that moved from 2G to 3G will make the leap to 4G, which could add ten billion dollars more to the RF TAM.

RF Content in LTE Phones

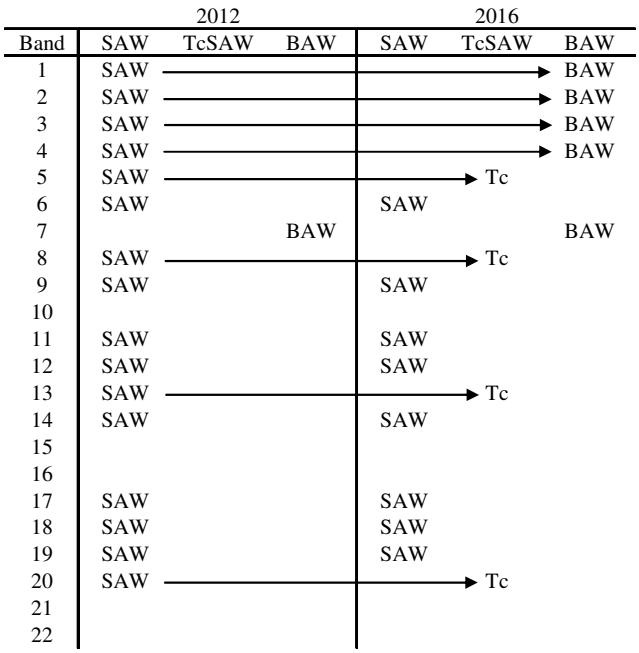
RF content rockets with migration to advance standards

	Typical 3G	Regional LTE	Global Roaming LTE
SAW filters	$1.25	$2.00	$2.25
TC-SAW filters	$0.00	$0.50	$1.50
BAW filters	$0.00	$1.50	$3.50
Total filter content	**$1.25**	**$4.00**	**$7.25**
Amplifiers / switches / other	$2.50	$3.50	$5.50
Total RF content	**$3.75**	**$7.25**	**$12.75 +**

Source: TriQuint

Even if there were no migration to more advanced standards, RF spending would still increase, because many existing easy-to-filter bands are transitioning to more difficult standards[12]. Some of this is the result of carriers deploying LTE on bands previously used for 3G, and some is the extension of LTE bands to include other operators.

Changes in Filter Technology

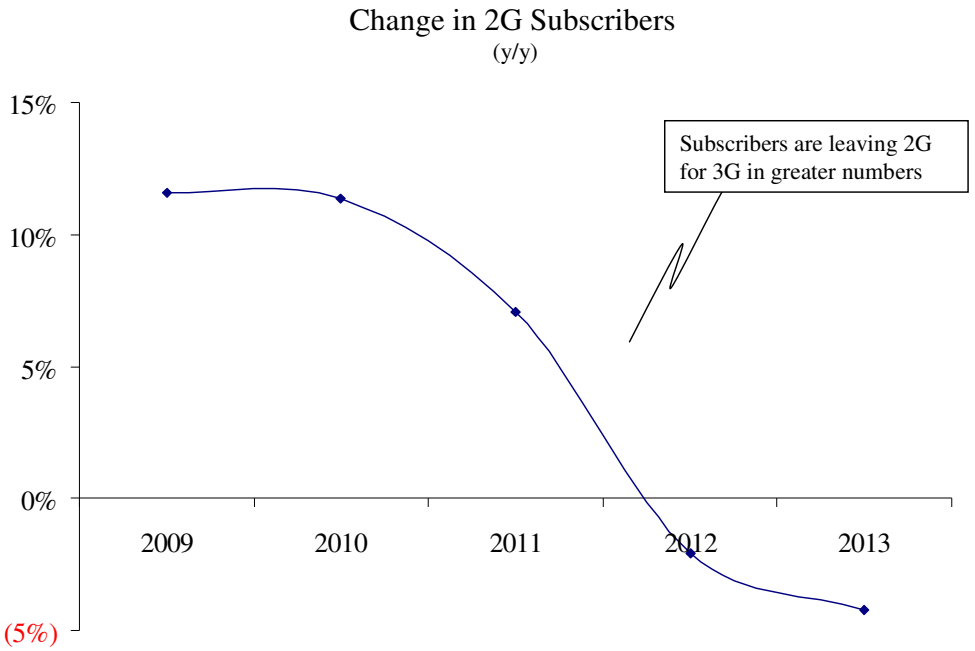


In either case, the net impact is an increase in the cost of filters for eight widely deployed bands. This means that if Apple were to re-release the iPhone 5S with the same bands it used in 2012, it would still spend more for higher performance filters and switches. The TAM for RF components will increase even if unit volumes are flat or down slightly.

#4: MIX SHIFT (SLOWING PHONE SALES + CHINA)

As demand for high-end smartphones slow, more of the incremental growth will come from mid and low-tier Chinese handsets, which have much lower RF content.

A variant of the 'slowing smartphone' theme, the concern that a mix shift to lower content phones in China will reduce the TAM for RF components ignores subscriber growth rates and the migration to more advanced standards. The fact that well over half of all Chinese subscribers are using 2G phones, and that low-cost 3G modems are outselling all other standards at MediaTek, suggests that the 2G to 3G conversion is hitting its stride.



And as we highlighted in #2 above, the 2G-to-3G migration results in three to four times more RF content per phone, which could translate to more than $1B in additional spending in 2015. This would be well above the $600M - $900M yearly increase seen over the last four years. So the fact that China is thick with low-content 2G handsets is a virtue, not a drawback.

#5: DECLING HIGH-END (SLOWING PHONE SALES + CHINA + APPLE)

Apple and the Chinese 4G build-out account for so much of the RF TAM, that a slowing demand for iPhone and double ordering by LTE OEMs in China will crush the TAM.

This is essentially the same argument as #4 with a more specific focus on Apple as the culprit for slower smartphone sales. As we outlined in #2 above, double ordering in the 4G build-out in China isn't likely to have much of an impact on overall demand for RF components in 2014 and will probably be minor relative to overall demand in China in 2015.

Adding a slowdown at Apple isn't going to change much, given there is virtually no chance that unit demand can decline enough to shrink TAM growth in 2015. For that to occur, Apple would have to see greater than 30% y/y decline in demand, given the RF content in iPhone 6 is 30% higher than it is in iPhone 5S/C, a highly unlikely scenario in any case.

#6: APPLE SEGMENTING PHONE BY REGION

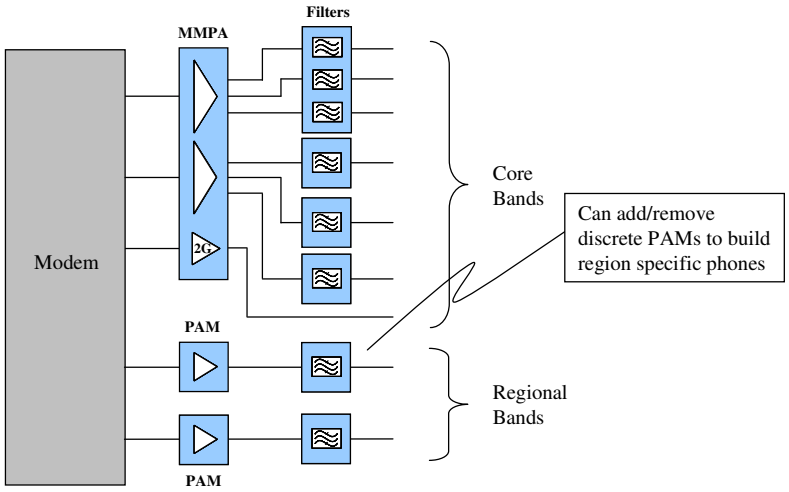
Once Apple begins segmenting its phones by region, the total dollars it spends on RF content will decline, crushing the RF TAM.

The RF roadmap Apple has pursued is the polar opposite of Samsung's, and while it optimizes performance and reduces size, it prevents the company from segment phones by region.

Like Motorola in 1998 and again in 2004, Apple has taken a one-size-fits-all approach to phones. This simplifies manufacturing and inventory management, but increases BOM costs and limits what the company can do on handset pricing to remain competitive. The approach works well for hugely popular handsets like StarTAC, RAZR and iPhone, but leads to trouble once high flying models begin to lose their luster. It seems only reasonable then that Apple would move to regional segmentation, given y/y unit growth fell below 20% last year. That hasn't happened and it probably won't, if for no other reason than that the RF architecture required to regionalize the phone is the polar opposite of the one the company is currently using, and it's moving further away from that possibility every year.

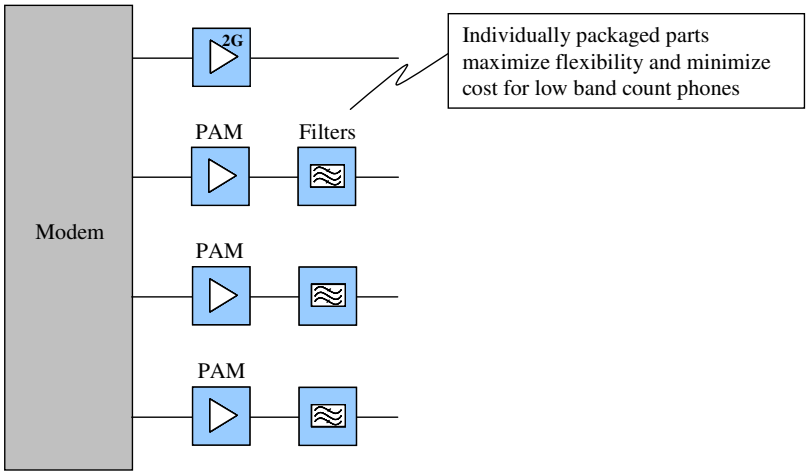
Apple's devotion to minimizing SKUs requires it to increase the number of bands in each new model to ensure it can ship to any carrier in any region. There are a couple of ways to do this and still be able to regionalize the handset. The most common approach in smartphones is to use an integrated amplifier (MMPA) to support the world bands and discrete power amplifiers (PAs) to pick up the regional bands. In such an architecture, regional filters are in separate packages or combined with an antenna switch in a FEMID. Qualcomm supports this approach and it's employed by many OEMs, including Samsung.

MMPA + Satellite Architecture
(Qualcomm Reference Design Smartphones)



The second method is the discrete architecture, where all amplifiers and filters are individually packaged parts instead of an MMPA. It is less expensive, but consumes more board area and requires the OEM to lay out every band individually, so it is only used in phones with few bands.

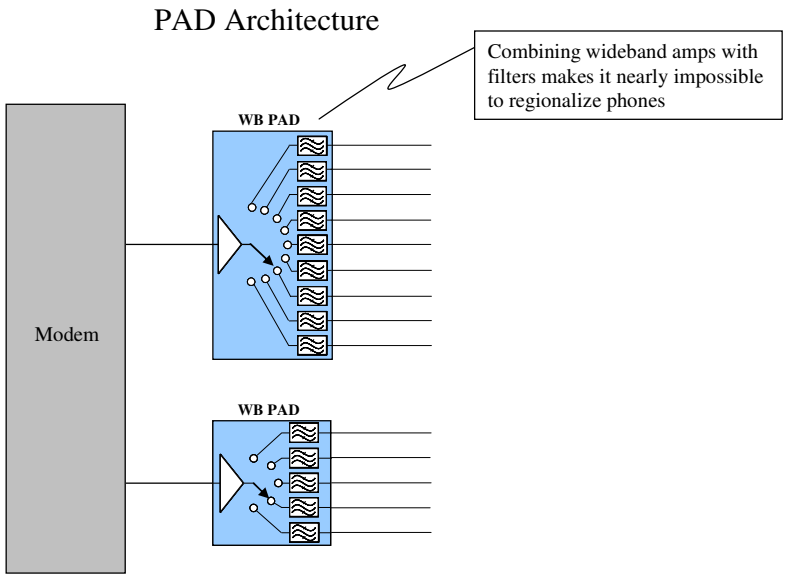
Discrete Architecture
(2G, Low Band 3G)



Because it is fully discrete, it only includes bands being used in the region in which the phone will operate, making it ideal for low-cost phones that don't require roaming, such as 2G and low-end 3G handsets.

Apple doesn't use either of these layouts, and instead has chosen a more highly integrated PAD[13] architecture that combines amplifiers and filters in the same package. This improves performance and reduces size, but sacrifices flexibility. It is the only OEM to employ this approach, and has devoted considerable resources to its development.

PAD Architecture

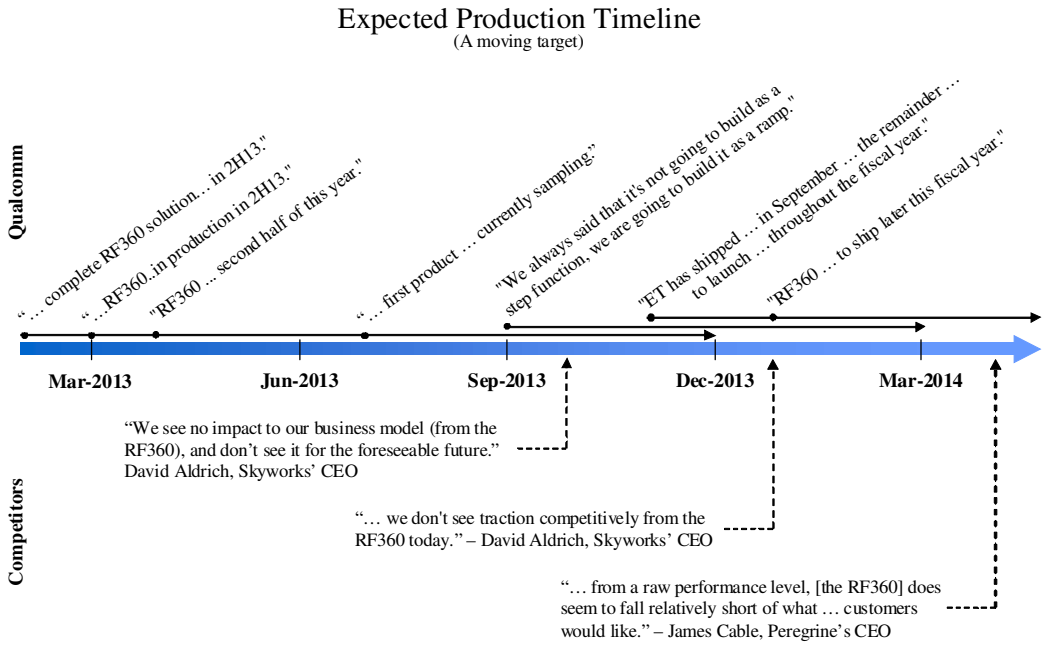


The progression of this architecture from single band PADs ('08 – '11) to dual band ('12 – '13), and now wideband ('14), has steadily moved Apple away from regionalization. And every step towards higher density packaging further reduces the likelihood of segmentation by removing the ability to pick and choose which bands are removed, and which stay. The move to wideband PADs with six filters was a big step in that direction this year, and we expect it to be followed by a nine band part in 2015. As long as Apple uses this approach, it can't segment and will, in fact, increase RF content with every new model.

#7: QUALCOMM'S RF360

Qualcomm's control of the reference design for the majority of mid and high-end phones will make RF360 unstoppable, even if it isn't the best performing solution.

Qualcomm's grip on the high-end 3G modem market and nearly all of LTE provides a large channel through which to enter the RF sector. Most of the OEMs in these markets follow the company's reference design to the letter, including Samsung, for a large number of phones. But while the reference design requires the use of Qualcomm's modem and transceiver, it gives the OEM the option of several other vendors for the RF components. Listing RF360 as one of these options could spur adoption, but only to the extent it is less expensive and/or performs better than competing solutions. If it's only at parity, most OEMs will opt for third party devices to reduce their exposure to Qualcomm. If RF360's performance falls below that of other solutions, Qualcomm won't be able to give it away, and instead will have to lock it's modem/transceiver designs to RF360; first by listing it as the only option on the reference design, and then by reverting to a proprietary control bus to preclude OEMs from designing around the part. And that's precisely what has occurred. RF360 has underperformed expectations so badly, both in timing and performance, that no OEM was willing to adopt the full suite of components that comprise RF360. Management's guidance[14] since the product's debut in February 2013 reflects the slide in expectations, while comments from competitors in RF semiconductors reveal the lack of impact on the industry.



The solution, which started off as four components, is now comprised of three[15], and those only showed up in two ZTE phones, 15 months after the product was announced.

Although the initial goals of the RF360 were to facilitate expansion of LTE and grow the company's content in handsets[16], recent comments from management suggest that content growth has been deemphasized. That leaves the proliferation of LTE as the primary driver, which means that once Chinese 4G deployment is in full swing, the motivation to continue with the product will probably ebb. We expect that would be the preferred outcome, given the cost of just the CMOS amplifier/switch would be highly dilutive to margins[17], and the backlash of trying to force OEMs to adopt the part appears to have cost Qualcomm modem sales at Samsung[18]. The first signs that management may be reconsidering RF360 have already occurred, with the company canceling SOI wafers and reversing its decision to lock the latest reference design to the RF360. In any case, the solution has had no material impact on market shares in the RF section or TAM expansion.

#8: MURATA + PEREGRINE

Murata's purchase of Peregrine and its willingness to suffer lower margins give it an insurmountable advantage at Apple.

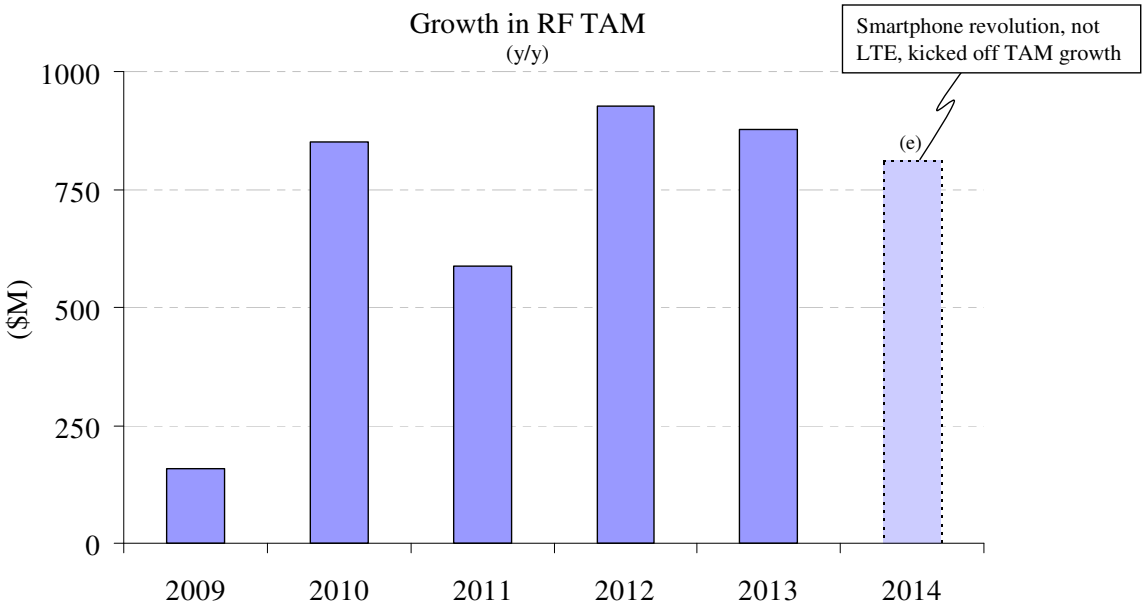
Murata has long supplied Apple with WiFi modules that combine its high performance LTCC[19] substrate with PAs from Skyworks and Triquint. More recently, it landed the antenna switch module using SOS switches from Peregrine. That win was short lived, ending last year when RF Micro Devices took the slot using its own SOI switches on an externally foundered LTCC substrate. RF Micro Devices not only held onto the ASM in the iPhone 6, it also expanded its share of switch content by taking the diversity switch. This is perhaps the best evidence that Murata's performance using Peregrine components isn't competitive.

It's widely known throughout the industry that price comes second to performance at Apple. Without the best performing part, price concessions are useless, so the thesis that Murata's willingness to suffer lower margins will displace RF Micro Devices, or any other vendor at Apple, is untrue. If it were, the Murata/Peregrine partnership would have never lost the ASM the first time. As it is, the cost and performance advantages of SOI both at RF Micro Devices and Skyworks has pushed Peregrine almost completely out of the commercial switch market, and forced the company to sell itself to Murata. We don't believe Murata's capabilities after acquiring Peregrine will be materially better then when they were separate companies working together. Costs may be lower but that will carry little sway with Apple if it can't win on performance.

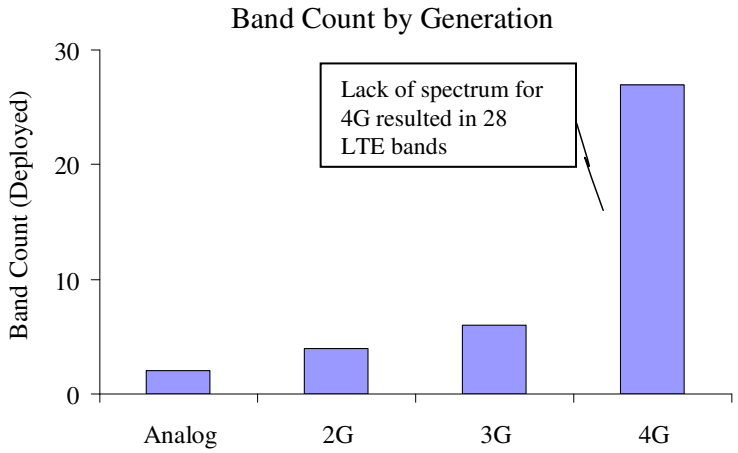
#9: UNSUSTAINABILITY

A glut of demand on the initial roll-out of LTE has generated growth and margins that cannot be sustained.

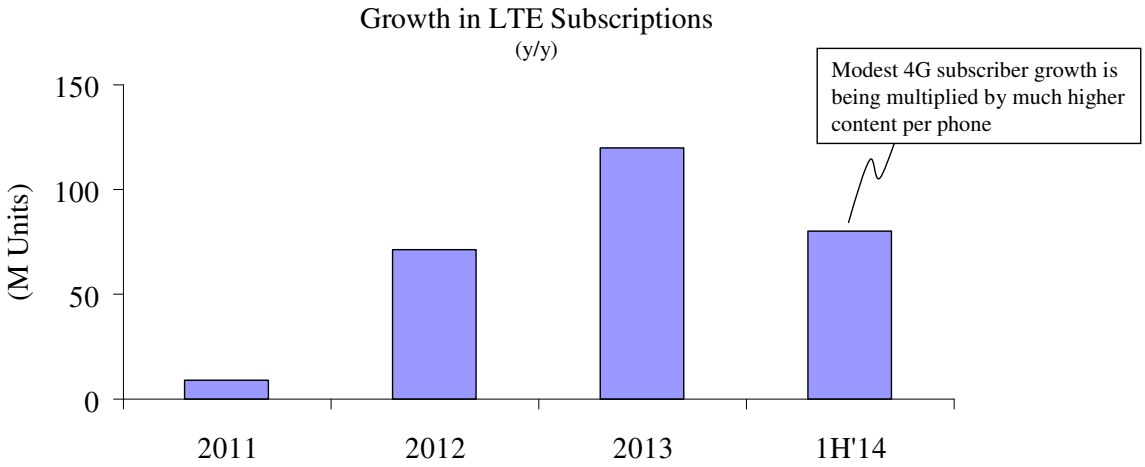
Acceleration in the growth in the TAM for RF components began in 2010 with arrival of the iPhone 4, a 3G only phone that predated the roll-out of LTE by at least two years. A 50% increase in RF content, combined with a 150% y/y increase in unit sales, made the iPhone 4 a goldmine for RF component suppliers. It was largely responsible for the $850M (23%) y/y increase in the TAM in 2010 and, combined with Samsung's push into high-end smartphones, has driven double digit year-over-year increases ever since.



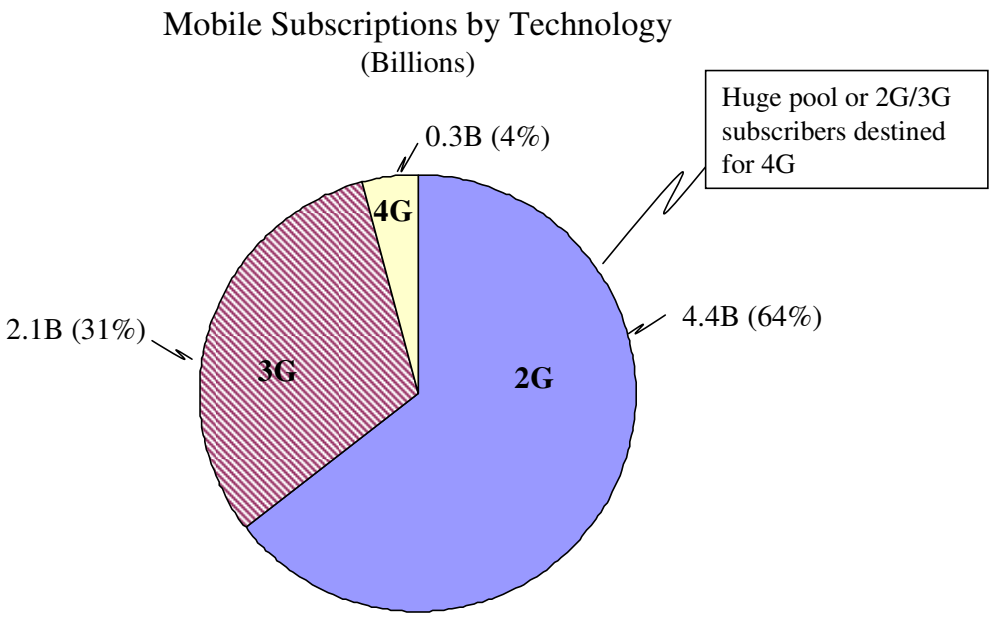
Subscriptions to 4G service didn't make a material contribution to the TAM until 2012, just as smartphone content was ebbing. The situation is now reversed, instead of unit growth being the primary driver, it is the higher content per phone needed to support a fragmented LTE spectrum. Indeed, 4G subscriptions have barely got off the ground, yet the TAM continues to increase at double digit rates, even though in absolute terms it is already more than twice what it was in 2010.



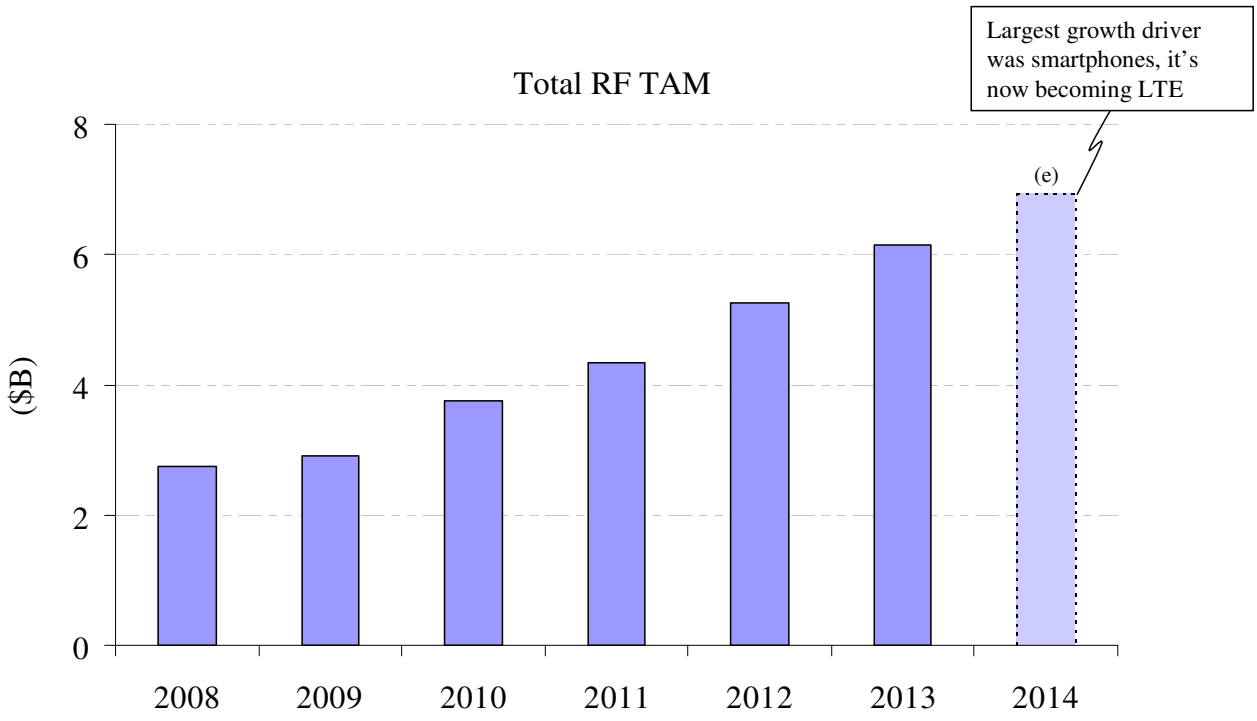
Higher RF content is primarily the result of higher band counts which is a larger multiplier of unit growth, much larger than we saw with 3G. This is how a relatively meager 120M unit increase in LTE subscribers resulted in a $900M increase in the RF TAM in 2013. Clearly, it is not a glut in demand for LTE that is driving RF revenue growth so much as a glut of spending per phone, which isn't likely to change, given band fragmentation and that performance requirements are not getting any less arduous.



In that sense, the biggest expansion in the TAM has yet to begin. Of the 6.8B subscribers in the world, at the end of 2Q14, only 4% (280M) were 4G, while 31% were 3G and 64% were still in 2G. LTE isn't even the fastest growing standard, that title is still owned by 3G. It seems a bit premature then, to predict lower spending on a slowdown in LTE growth, when only 4% of total subscriptions are in 4G networks.



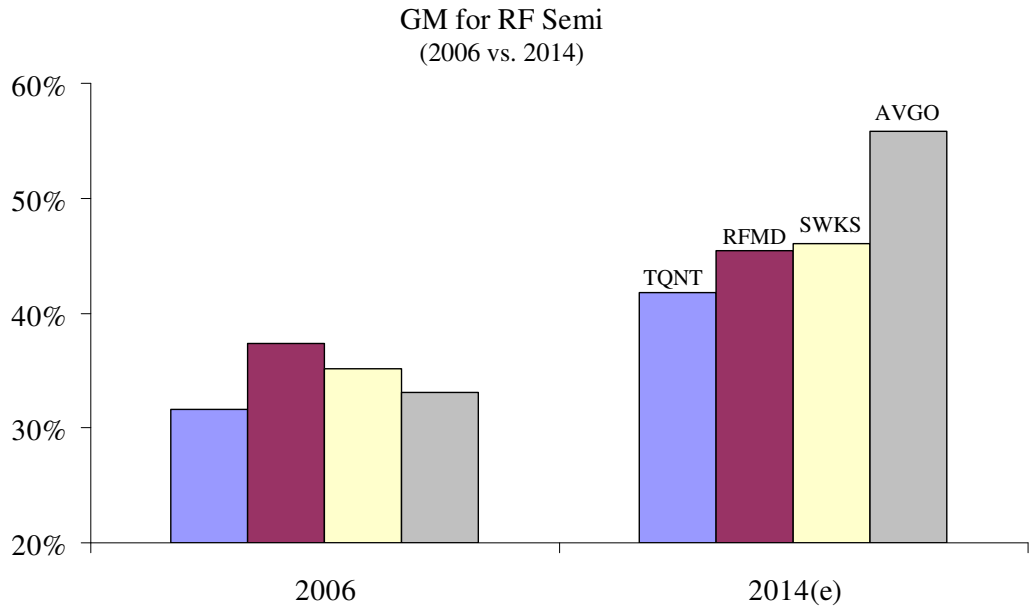
Source: Ericsson Mobility Report (August 2014), Charter Estimates:
3G includes W-CDMA/HSPA, TD-SCDMA and CDMA2000/EV-DO
4G includes LTE and WiMax



#10: COMMODITY PARTS IN A CUT-THROAT INDUSTRY

RF parts are commodity products and the industry is plagued by excess capacity, which always leads to cut-throat pricing.

This argument is a throwback to the mid-2000s, before the smartphone revolution or the arrival of LTE, when GaAs amplifiers were the core, and in many cases, sole product of most suppliers. In 2006, success or failure in mobile phones had little to do with RF technology, and all vendors offered similar, if not pin-for-pin compatible components, so pricing was weak and substitution was common. That era ended in 2008, and even a cursory review of income statements for any of the major component suppliers will betray the idea that RF components are commodity products.



Apple changed the face of the smartphone industry, driving the old leaders, Nokia and Blackberry to despondency, and forcing any would-be challengers to follow suit in increasing content and performance. The popularity of these phones caused a rapid expansion in the types and quantity of components used in handsets, and once again tied differentiation in phones to performance in RF. The supply chain reacted by ramping production, but also by fragmenting to focus on different types of devices. Unlike in 2005 when there were fewer products and more competitors, today there are more products and fewer competitors. Indeed, many product categories are dominated by duopolies. TriQuint and Avago are a duopoly in high-performance BAW, TriQuint and Skyworks in TC-SAW, RF Micro Devices and Skyworks in SOI, 3G GaAs and 2G CMOS amplifiers, and Avago and Skyworks in GaAs MMPAs.

Leaders in…	AVGO	SWKS	RFMD	TQNT
BAW				
SAW				
TC-SAW				
SOI Switches				
3G GaAs				
2G CMOS				
GaAs MMPAs				

It was this specialization that led to the RF Micro Devices/Triquint merger, to Skyworks joint-venture/purchase of Panasonic's filter division, and to Avago's purchase of Javelin Semiconductor (SOI switches); all of which were unthinkable in 2005. Consolidation and the migration of phones to more advanced standards have narrowed the supply base, expanded demand and have converted a lethargic industry into a high growth, high profit segment.

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End Notes

[1] ASP: Average Selling Price.
[2] PAM: Power Amplifier Module. A GaAs amplifier die mounted on a small substrate with discrete matching components.
[3] PAD: Power Amplifier Duplexer. A power amplifier die and a duplex filter die mounted on the same substrate with matching. The entire device is called a module because the amplifier is matched to the filter and the inputs and outputs are matched to 50 ohms. The module is encapsulated in plastic and sold as a packaged part.
[4] FEMID: Front End Module Integrated Duplexer. Several filters in a single package combined with an antenna switch.
[5] ASP curves for MMPAs reflect this reality with initial devices (RFMD's PowerSmart) priced at about $1.90 for four bands, followed by $1.80 for five, and eventually $1.50 for ten. Tne current crop of MMPAs support 15 to 18 bands and sell for $1.55 to $1.65 in volume.
[6] This is beyond what can be included in even the most advanced MMPA, which is why LTE phones use "satellite" PAs. These are discrete PAMs or PADs used to handle LTE bands that are too high in frequency, difficult or expensive to implement in the MMPA.
[7] High band count amplifiers require routing switches to connect the correct duplex filter to the amplifier for the band being transmitted. The technology employed must meet the more difficult performance standard for LTE, which in practical terms means they have to be SOI (Silicon on Insulator) devices. This is why SOI switches are used throughout LTE phones, are more expensive, and have almost completely displaced GaAs pHEMT devices.
[8] The three criteria for double-ordering to be likely are:

1) A big, well established carrot. China Mobile's goal of shipping 100M LTE phones in CY2013 is well known throughout the food-chain, with nearly all of the white label OEMs chasing the same product at the same customer.
2) A highly fragmented supplier base. A large number of uncoordinated suppliers all striving for 15% market share at the same customer makes it more likely that total production will exceed demand. A highly fragmented supplier base makes it difficult for OEMs or analysts to track production and channel inventory, increasing the chances of excess finished goods, even if demand meets expectations. Supply chains with only two large vendors, such as Samsung and Apple in high-end smartphones, are more transparent and less likely to overshoot production by very much or for very long.
3) Component shortages. A tight supply chain, especially in critical components like BAW filters and SOI switches, will drive manufacturers to overstate their needs in hope of getting enough to meet production goals. Component suppliers try to estimate actual demand by monitoring subscriber growth and sell-through, but with dozens of independent OEMs, it's difficult to track excess inventory. The multiplicative effect of double-ordering at factories that are over-building finished goods ripples back through the food chain in the form of large order cancelations after several periods of OEMs underselling production.

[9] In 2008, there were six major RF handset component suppliers: Avago, Anadigics, RF Micro Devices, Renesas, Skyworks and Triquint. By January 2015, only Avago, NewCo (RF Micro Devices + Triquint) and Skyworks will be competitive at all of the major handset OEMs.
[10] Ericsson Mobility Report, June 2014 puts mobiles subscribers for GSM/EDGE-only service at 4.2B, WCDMA/HSPA at 1.6B and LTE at 200M as of year end 2013.
[11] Ericsson Mobility Report, June 2014 puts broadband subscribers (3G/4G) at 2.2B and LTE (4G) at 200M.
[12] **Band 1** is moving to AWS3 in the transition to LTE, which will likely require OEMs to use BAW instead of SAW filters. **Band 2** in Verizon's network used to be the most difficult band to filter and required the highest performance BAW. Specifications were relaxed in 2011, allowing many OEMs to switch to SAW. The FCC then added a 5 MHZ extension (the G-block) to band 2 to create band 25, which Sprint would use for LTE service. This pushed the filtering requirements beyond SAW and led to the development of TC-SAW. To keep from having to field carrier specific handsets, OEMs use band 25 for band 2, and just live with the extra cost of TC-SAW. It's still cheaper than fielding two SKUs, one using band 2 for Verizon and the other band 25 for Sprint. **Band 3** is now being used for LTE, which requires that signals use the entire band, making it unsuitable for SAW. Most suppliers will use BAW, but Murata may attempt it with TC-SAW. **Band 4** is moving to AWS3, where the receive and transmit channels are spaced so far apart that the rejection of the transmit filter begins to tail off in the receive band. And since a large part of the duplex filter's performance derives from transmit filter attenuation in the RX band, the wide spacing is a problem. This will probably force OEMs to use BAW filters rather than SAW. **Band 5** is being subsumed by band 26 in the move to LTE. The new band will be wider and more difficult to filter, requiring TC-SAW where band 5 used SAW. **Band 8**, like band 3 is being used for LTE by some carriers, which means it can no longer be filtered by SAW and instead must use TC-SAW. **Band 13**: National Safety (NS-07) requirements will make this one of the most difficult bands to filter. Between the public safety radios in the middle of the band and its low frequency of operation, band 13 presents a complex filtering problem that can only be address cost effectively by TC-SAW. **Band 20**: Moving to LTE requires full use of the bandwidth , so probably SAW to TC-SAW.
[13] PAD: Power Amplifier Duplexer

14

Qualcomm Management Quotes on RF360

Date	Event	Quote
February 2013	RF360 Press Release	"OEM Products featuring the complete RF360 solution are antipated to be launched in 2H2013."
March 2013	RF360 Conference Call	"We anticipate that our OEM partners will be able to use these products in some form in the second half of this year." "As for the RF360, we expect it to be in production in phones in 2H2013."
April 2013	2Q13 Earnings Conference Call	"On RF360, ... you should see in the second half of this year."
July 2013	3Q13 Earnings Conference Call	"The first product in this family of product is on-track and currently sampling to a major Tier 1 OEM."
September 2013	Deutsche Bank Tech Conf.	"You will see it [RF360] on the Tier-1 later this year. It's going pretty much the way that we said." "We always said that it's not going to build as a step function, we are going to build it as a ramp."
November 2013	4Q13 Earnings Conference Call	"The envelope tracker has shipped commercially in handsets in September and the remainder of the solutions are scheduled to launch as expected throughout the fiscal year."
November 2013	Analyst Meeting	"RF360, is really four components, they come out in a series of different releases over the 2014 period, we've already have some traction at the end of '13, with envelope trackers already in a number of designs, and you'll start to see the PA and the RF POP coming out in '14 as well" "If you look at our current pipeline we have about 50 different designs across 15 OEMs that use one or several of the components and we think that will build, we've always talked about this will be something that builds overtime and its going, it's on track."
January 2014	1Q14 Earnings Conference Call	"RF360 products are on track to ship later this fiscal year as expected." "Our RF360 family of products also continues to progress well. Our envelope tracking solution has been shipping for a number of months." "Our dynamic antenna tuner recently launched in flagship Lumia 1520 and the remaining RF360 products are on track to ship later this fiscal year as expected."
February 2014	MWC 2014	"RF360, it's a series of products ... and you're seeing the design traction"
April 2014	2Q14 Earnings Conference Call	"We are making excellent progress with our RF360 solutions, particularly the envelope tracker."

[15] RF360 was originally comprised of an Envelope Power Tracker (QFE11xx), a CMOS Integrated PA/Antenna Switch (QFE23xx), a Dynamic Antenna Matching tuner (QFE15xx) and a double-decker packaging system to reduce footprint, called the RF POP (QFE27xx). RF POP is now a packaging option. The only component that has seen any real deployment is the envelope tracking PMIC (QFE1100), primarily because it's the only part supported on Qualcomm's reference design. It does provide a material boost in efficiency, but we believe it generates noise that interferes with the handset's receiver, which increases the dropped call rates in phones that use it. This has not gone over well with OEMs or carriers. Problems with this part were evident well before the February 2013 announcement, and we highlighted and predicted the problems that they would have in phones in our analysis published at the time.

> "**The ET solution isn't working in production and will probably never achieve the performance of rival products.** Qualcomm's QFE1100 (QPOET) uses a design that requires complicated digital pre-distortion (DPD), as well as a rather noisy switcher. This makes it complicated and delicate to tune, yielding, in our opinion, performance that puts it behind several competing solutions. We've visited, measured and tracked the progress of nearly every viable ET solution since 2010, and do not believe Qualcomm's (part) can reach parity with the high-efficiency, GaAs amplifiers on the market today, much less those amps coupled with leading ET controllers. Moreover, we believe QPOET suffers from noise problems that desensitizes the receiver and requires more expensive duplex filters. We believe problems with the QFE1100 have prevented Qualcomm from enabling the ET function in early samples of its 8974 platform, of which it is a key component. **QCOM's plunge into the RF front-end isn't what it seems, February 21, 2013."**

[16] "…In order to proliferate LTE… That was the main motivation to doing this (RF360)." – Jim Tran, Vice President of Product Management, RF360 Conference Call, March 6, 2013
"So we look at that (Front End integration) as an opportunity to grow our content of the device." – Steve Mollenkopf, President & COO of Qualcomm, Deutsch Bank Tech Conference, September 10, 2013
[17] The die size of Qualcomm's SOI CMOS integrated amplifier/switch (QFE23XX) is more than seven times larger than competing solutions and consume so much area that the prospect of selling the part has required Qualcomm reserve enormous quantities of SOI wafers.
[18] RF360 has not met expectations for performance or uptake, leading Qualcomm to spur adoption by bundling and tying support for new products to the use of RF360. It appears the company has also customized its new 3925 transceiver to only work with components of RF360, as an attempt to force OEMs to its RF solution. These tactics don't appear to by yielding the intended results; on the contrary, we believe Samsung has used Intel's 7260 baseband for all non-CDMA versions of the Note 4 platform instead of Qualcomm's solution in order to avoid being forced into RF360. We also believe LG will drop its support for the one component (QFE1100) of RF360 it was using in the Nexus 5 in favor of previous generation parts that don't involve Qualcomm's RF parts. So while bundling price discounts and technical locks will probably land a few low volume sockets at tier 2 and tier 3 manufacturers, poor performance and excessive pressure to adopt RF360 will likely cost Qualcomm more in modem share at the larger OEMs than it gains in RF semiconductors at small ones.
[19] LTCC: Low Temperature Co-fired Ceramic.