



# **Adding modular HSxPA cellular broadband connectivity to laptop computers and portable consumer equipment**

*White Paper*

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## 1 Introduction

Manufacturers of laptop computers, mobile telephones, PDAs and other consumer items, such as media players and game consoles, are experiencing an increasing demand for data connectivity in their products. For example, almost 90% of all new laptop computers now feature built-in WLAN (wireless local area networking, such as 802.11 “WiFi”) <sup>[1]</sup>.

However, WLAN offers data connectivity only when the user is stationary within an area of “hotspot” network coverage. True “mobile” high-speed data connectivity, sometimes referred to as WWAN (wireless wide area networking), can only be delivered by cellular data services. Cellular data services can seamlessly manage the connectivity of users as they move locally (perhaps at speed within a car) and roam nationally and internationally. Consumers’ expectations of data performance are based on their home or work broadband connections; their mobility and billing expectations are based on the ease and simplicity of cellular voice roaming.

HSxPA (high speed packet access, an evolution of the UMTS standard defined by the 3GPP organisation) stands out as the cellular broadband data technology of choice because of its high performance and widespread service availability. HSxPA consists of two closely related technologies – HSDPA (high speed downlink packet access), which improves download performance, and HSUPA (high speed uplink packet access), which improves the upload performance. As well as offering higher peak transfer speeds, both technologies also improve the responsiveness of data connections, significantly enhancing the mobile data experience.

The first HSxPA-enabled laptop computers, PDAs and smartphones became available in 2006. These first-generation devices featured only lower-speed HSDPA (up to 1.8 Mbps). The laptop market was initially served with after-market HSxPA plug-in cards. From 2007 to 2011, the market for HSxPA solutions is forecast to grow at an annual rate of 38% <sup>[1]</sup>. During this period the market will be dominated by more capable products that feature HSUPA and offer higher-speed HSDPA (3.6 Mbps and 7.2Mbps). The proportion of products that “embed” HSxPA functionality, rather than relying on an external plug-in card, will also increase as the market matures.

The following sections discuss the choices available to manufacturers who wish to benefit from this growth market by incorporating HSxPA functionality in a “target” product.

## 2 Options for adding HSxPA cellular broadband connectivity

### 2.1 Basic requirements

The integration of HSxPA connectivity to a device requires the addition of a suitable antenna (or antennae) and an HSxPA modem. The modem typically exchanges data with the main processor in the target system using the system bus (e.g. PCI Express).

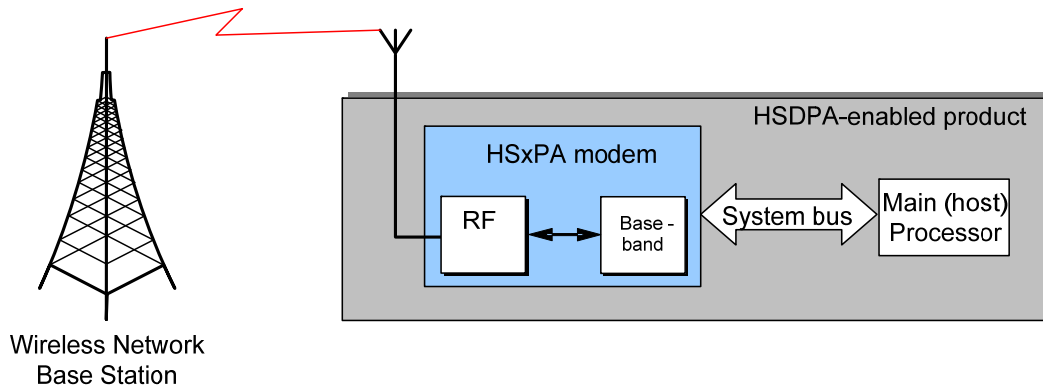


Figure 1: Basic architecture of HSxPA-enabled product

The HSxPA modem itself contains the following sub-systems:

- ❖ RF section: The radio frequency (RF) front-end converts and amplifies the high frequency radio signals that are carried over the air to/from the antenna. The RF section converts signals between the radio frequency (e.g. 2 GHz, although varies by region – see section 2.2.3) and the lower “baseband” frequency used elsewhere in the modem.
- ❖ Baseband modem: The baseband modem processes the incoming and outgoing data to ensure optimal radio reception and transmission. In the transmit path, the baseband modem encodes and modulates the data sent from the host processor, in strict accordance with the 3GPP radio standards. In the receive path, the baseband may use a variety of processing techniques to recover the original data from the distorted received signal.

***Because of the range of possible baseband processing techniques, the baseband modem is a key differentiator in the overall wireless performance of the product.***

Since the HSxPA modem functionality can be clearly separated from the other functionality of the product (by the antenna on one side and by the system bus on the other), a product designer has several integration options. HSxPA could be included:

- ❖ as a tightly-integrated part of the basic product design, or;
- ❖ as a modular component in the product design, or;
- ❖ only as an after-market solution (by supporting “plug-in” functionality).

The choice is influenced by design, manufacturing and commercial factors. It is quite possible for a device designer to buy individual off-the-shelf components to build their own modem functionality. However, because HSxPA is a cellular wireless technology that is reliant on commercial mobile network operators to provide the cellular wireless infrastructure, the target product will need to be compliance tested before the necessary network certification can be achieved.

Operator compliance testing can be a complex process. A network operator may also have considerable influence over the selection and promotion of devices attached to their network, requiring careful consideration of the implementation of the HSxPA modem. Operators are increasingly aware that users with higher-performance baseband modems significantly improve the operating profitability of their networks<sup>[11]</sup>.

***The use of a module that has been sourced from a third party, or closely based on a reference design provided by a third party, can greatly simplify the design, manufacture and certification of a high-quality, high-performance, HSxPA-enabled product. The majority of the compliance testing can be handled by the modem module designer/manufacture, leaving only the final “in system” testing to the end-product manufacturer.***

## 2.2 Selection criteria for modular HSxPA modems

The following criteria should be considered when evaluating sources of modular HSxPA modems.

### 2.2.1 Modem performance

#### 2.2.1.1 Basic 3GPP modem categorisation

An HSxPA modem has a separate categorisation, defined by the 3GPP organisation, for its HSDPA and for its HSUPA performance, as shown in Table 1:

HSDPA modem category	Maximum Data Rate	HSUPA modem category	Maximum Data Rate
1, 2	1.2 Mbps	1	0.73 Mbps
3, 4	1.8 Mbps	2, 3	1.46 Mbps
5, 6	3.6 Mbps	4	2.0 / 2.92 Mbps <sup>(1)</sup>
7, 8	7.2 Mbps	5	2.0 Mbps
9	10.2 Mbps	6	2.0 / 5.76 Mbps <sup>(1)</sup>
10	14.4 Mbps		
11 <sup>(2)</sup>	0.9 Mbps		
12 <sup>(2)</sup>	1.8 Mbps		

Table 1: HSDPA and HSUPA modem categorisation

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<sup>1</sup> Some HSUPA categories have different operation modes, resulting in different maximum data rates.

<sup>2</sup> Although allocated higher numbers, Category 11 and 12 are actually very basic HSDPA devices.

Thus, as an example, an HSxPA modem might be described as “HSDPA Category 6, HSUPA Category 2”.

### 2.2.1.2 Differentiated performance - advanced receivers

The 3GPP modem categories define an upper bound on the performance that can be achieved by a given HSxPA modem. However, different modems from the same category can have significantly different performance in the field. This is particularly noticeable for HSDPA, where the modem must recover high-speed data from a signal that may have been heavily distorted in transit from the base-station by: reflections from buildings and other objects (“multi-path interference”); the influence of radio noise, and; the Doppler effect of the user’s motion.

Two techniques, “receive diversity” and “equalisation”, have been shown to significantly enhance the ability of a modem to compensate for this distortion, considerably improving the achieved data rate [III]. From Release 6 of the 3GPP standard, a modem that supports both techniques is referred to as a “type 3 advanced receiver”. Receive diversity requires two (or more) antennae, a suitable RF section and a baseband modem that can simultaneously decode the signals received from each antenna. This improves the ability of the modem to distinguish the original signal from the noise. Equalisation further improves performance by reducing the effect of multi-path interference, which commonly occurs in urban environments.

As shown in Figure 2, an optimised “type 3 advanced receiver” Category 6 modem provides up to 140% better performance than a traditional “rake-based” Category 6 HSDPA modem, over a wide range of RF signal conditions. These results are obtained from an advanced receiver modem developed by Icera that uses Adaptive Wireless™ techniques to continuously optimise the receiver configuration for the prevailing radio conditions [III, IV, V].

Advanced receiver functionality is therefore essential for consistently high performance HSxPA connectivity.

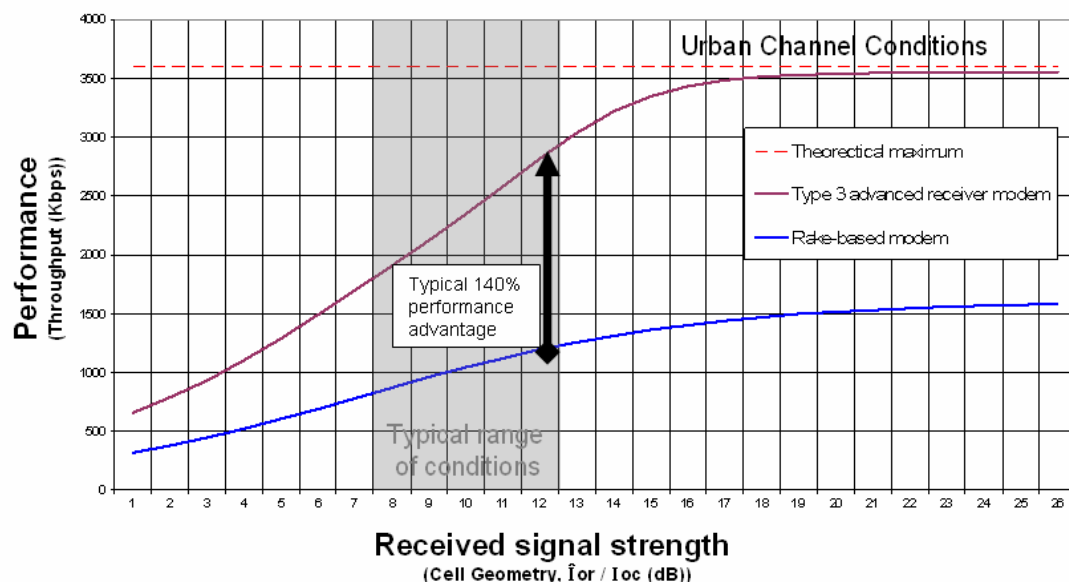


Figure 2: The relative Category 6 HSDPA performance of a type 3 advanced receiver compared to a rake-based modem

***The 3GPP categorisation alone does not determine the performance of an HSxPA modem. It is therefore important that a product designer, looking to create competitive differentiation through the inclusion of a high performance modular third-party HSxPA modem, should confirm that the module supports type 3 advanced receiver functionality (receive diversity and equalisation).***

## 2.2.2 Form factors

### 2.2.2.1 After-market plug-in cards

The initial demand for HSxPA connectivity was met with after-market plug-in cards. These typically used the PC Card (PCMCIA) format for the mainstream laptop market and the CompactFlash (CF+) format for ultra-compact laptops and PDAs.

The PC Card slot remains widespread in legacy laptops and is often still included in new laptop designs. However, the PC Card format has been superseded by the ExpressCard format (either in 34mm or 54mm width), which is increasingly found in both laptop and desktop computers. The ExpressCard standard allows the use of either PCI Express (PCIe) or USB 2.0 electrical signals across a common mechanical interface.

In addition to CompactFlash, PDAs and smartphones may also use the SDIO form factor. Figure 3 shows the relative form factors commonly used for after-market plug-in cards:

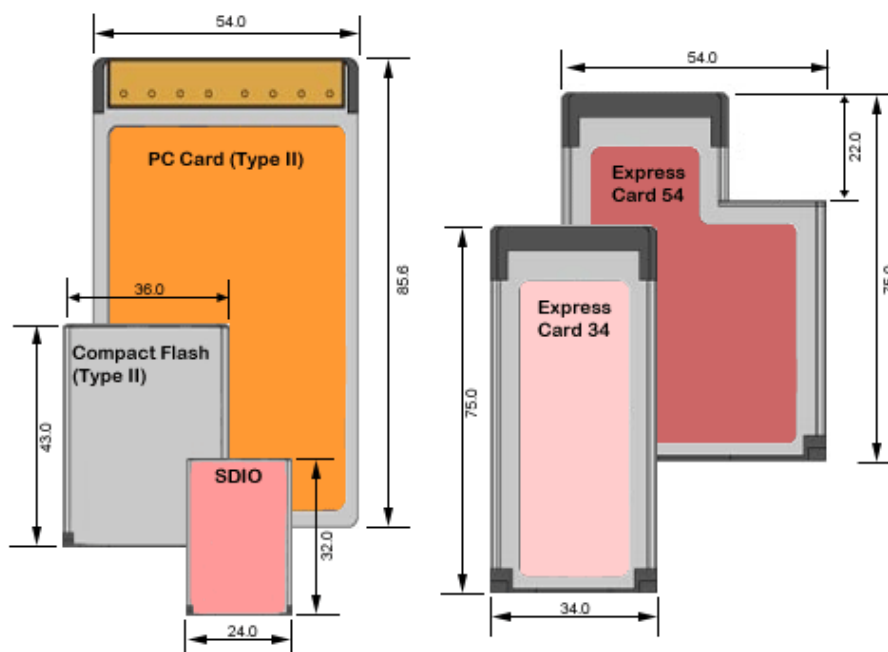


Figure 3: Common form factors for after-market plug-in modules

Aftermarket cards may also attach to an external USB interface (“USB dongles”).

After-market plug-in card designs represent an ongoing source of HSxPA modules for both laptop computers and other embedded applications. The card may be integrated directly within the target product or a new modular design may be developed, using the card as a reference. For example, ExpressCard and USB dongle designs may be very similar due to the common use of a USB electrical interface (albeit with a different connector).

#### 2.2.2.2 “Pass-through” data connectivity from another device

After-market plug-in HSxPA solutions can also include separate HSxPA-enabled products, such as Smartphones, that connect to the target device via USB or Bluetooth to provide “pass-through” connectivity (although Bluetooth does not have the capacity to transfer full-speed HSxPA data). No further consideration will be given to “pass-through” solutions as they do not offer the level of integration and control to device developers looking to embed HSxPA functionality directly into their own product.

#### 2.2.2.3 Embedded modules

Embedded HSxPA modules offer a solution for designers looking to integrate HSxPA connectivity within a laptop computer or consumer electronic product. There are a variety of industry standard form factors in use, with the further possibility of proprietary designs. However, the merchant market supply of HSxPA modules uses the mini-PCI format (supporting the legacy PCI system bus) and the PCI Express mini-card/half-mini-card form factors, as shown in Figure 4.

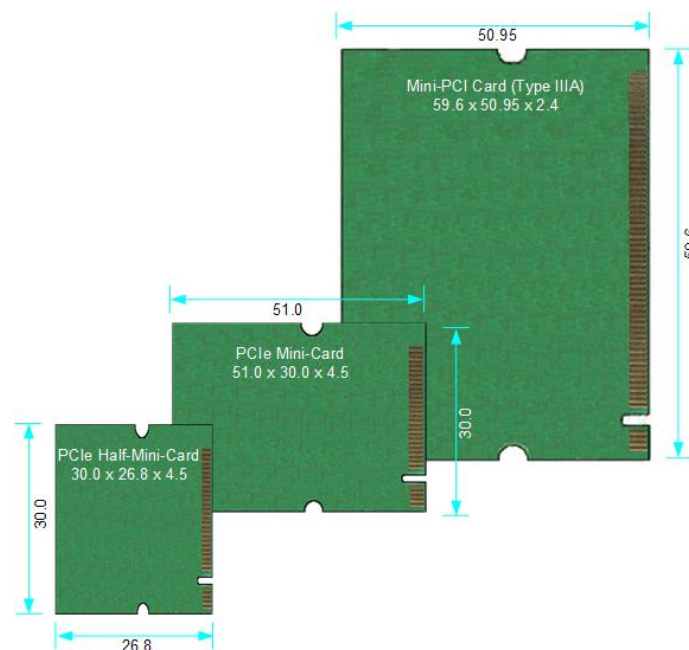


Figure 4: Common form factors for embedded HSxPA modem modules

### 2.2.3 Radio Frequency bands and multi-standard support

HSxPA is an enhancement to the UMTS standard, so uses the same internationally-agreed transmission frequencies, as shown in Table 2.

Table 2: HSxPA (UMTS) frequencies from 3GPP TS 25.101

Operating Band	Uplink Frequencies UE transmit, Node B receive	Downlink frequencies UE receive, Node B transmit
I	1920 – 1980 MHz	2110 –2170 MHz
II	1850 –1910 MHz	1930 –1990 MHz
III	1710-1785 MHz	1805-1880 MHz
IV	1710-1755 MHz	2110-2155 MHz
V	824 – 849 MHz	869-894 MHz
VI	830-840 MHz	875-885 MHz
VII	2500-2570 MHz	2620-2690 MHz
VIII	880 – 915 MHz	925 – 960 MHz
IX	1749.9-1784.9 MHz	1844.9-1879.9 MHz

***Currently the most commonly used bands are Band I (international); Band II and V (US). The modem module should be selected and configured for the appropriate frequency band(s) used in the target market.***

#### 2.2.4 Multi-standard support

Many operators with existing UMTS networks are managing their CAPEX (capital expenditure) by incrementally upgrading individual base-stations to HSxPA. All HSxPA modems should support basic-rate (384kbps) data over these legacy UMTS networks, providing data coverage during the transitional period. Further support for 2G/2.5G cellular wireless data standards can allow a modem to deliver greater data coverage, especially when used in rural areas or during international roaming.

***Products that are to be used in developing HSxPA regions should support a variety of legacy data standards, such as E-GPRS (GSM, GPRS and EDGE).***

#### 2.2.5 Software drivers

The host processor in the target product typically executes an Operating System such as Windows XP (in a PC) or RTOS (real-time operating system) (in an embedded product), for which a modem driver is required. Standard Windows XP modem drivers cannot support the very high speeds offered by HSxPA.

***An HSxPA modem should be accompanied by verified, high-speed, drivers for the target operating system to simplify product development.***

#### 2.2.6 Upgrade path

The 3GPP standards define HSDPA performance up to 14.4Mbps and HSUPA performance to 5.76Mbps. However, first generation HSxPA base-stations do not support HSUPA and typically only support 7.2Mbps HSDPA. Existing back-haul links often further limit achievable network speeds to 3.6Mbps. HSxPA-enabled devices should therefore support, and ideally take advantage of, the various improvements that are being made by the operators as they upgrade their networks.

Modems targeting the 2007-2008 market should support 3.6 Mbps HSDPA (Category 6), using a type 3 advanced receiver to maximise performance, with an upgrade path to 7.2 Mbps HSDPA (Category 8), HSUPA and a range of international operating bands.

Form factors for embedded modem modules are shrinking, reducing the board space and thermal budget available for modem components. The baseband chipset, as a key component of the HSxPA modem, should therefore provide all of the necessary functionality, using the minimum amount of power in the minimum package size, whilst providing the capability for future upgrades.

Modems that can be upgraded in software, rather than requiring hardware changes, deliver higher return on platform investment, requiring the minimum amount of additional development resource for product upgrades and allowing rapid response to changing market demands.

***A designer contemplating the selection, or development, of an HSxPA modem module should therefore pay careful attention to the current capabilities and upgrade path for the baseband chipset.***

### 3 About Icera's PC200 modular HSxPA reference design

Icera develops modular HSxPA reference designs, based upon its Livanto<sup>®</sup> wireless soft modem that it licenses to ODMs and OEMs for modem manufacture or product integration.

The Icera PC200 reference design delivers type 3 advanced receiver HSDPA performance in a PCIe mini-card form factor. This reference design is suitable for adoption as the basis of a manufactured mini-card module or can be readily adapted to a variety of other plug-in card and embedded module formats such as ExpressCard, CompactFlash and USB dongle.

The Livanto<sup>®</sup> wireless soft modem is unburdened by media and applications processing tasks and is therefore ideally suited to module designs due to its high performance, small form factor and low power requirements. The Adaptive Wireless<sup>®</sup> software running on the Livanto<sup>®</sup> modem continuously fine-tunes the modem in response to the prevailing radio conditions to deliver optimal performance.

The Livanto<sup>®</sup> modem and Adaptive Wireless<sup>®</sup> software have been successfully deployed in modular HSxPA modems that have been tested with a wide variety of HSxPA infrastructure equipment and have received operator approval for use on commercial networks.

The PC200 reference design offers:

- ❖ **PCI Express mini-card form factor**
  - **Flexibility allows other form factors**
- ❖ **Immediate support for Type 3 advanced receiver Category 6 HSDPA (3.6 Mbps)**
  - **Ready for software upgrade to Category 8 HSDPA (7.2 Mbps)**
  - **Ready for software upgrade to Category 2, 3, 5 HSUPA**
- ❖ **Tri-band operation in Band I, V, II/IX**
- ❖ **Tri-band diversity**
- ❖ **Quad-band E-GPRS**
- ❖ **Low power consumption**
- ❖ **High performance, Windows XP reference drivers**
- ❖ **Connectivity Manager PC management software**

## 4 Contact Details

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