

## **AR7VWi – A Highly-Integrated Broadband Residential Gateway Platform**

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### **Introduction**

Advancements in silicon and systems integration have led to the development of a new generation of broadband residential gateway platforms that also support voice. This new generation of platforms not only eases the deployment of DSL-based residential gateways but also provides new opportunities for the service provider to derive additional value from the already deployed copper infrastructure.

While many analysts do not foresee the residential gateway market gaining more than 30 percent of the broadband market share until 2007, and this market share does not include voice, there are several indicators that voice-enabled gateways could grow more rapidly than analysts predict. Some of these indicators include: 1.) the success of voice-enabled broadband services in the far east, particularly Japan; 2.) the increased number of RFPs for voice-enabled broadband services throughout the world; 3.) the recent success of broadband voice service providers including Vonage; and 4.) the accelerating rate of customer loss by telcos is forcing them to offer enhanced broadband services via the telephone twisted pair.

Setting a new precedent in this evolving market, Texas Instruments' AR7VWi is a highly-integrated, voice-enabled residential gateway platform that is positioned to enhance the user's broadband experience. Encompassing three core competencies of the Texas Instruments Broadband Communications Group, AR7VWi is the first product of its kind to integrate DSL, 802.11b/g WLAN and VoIP on a single motherboard for a cost-effective and highly-differentiated product.

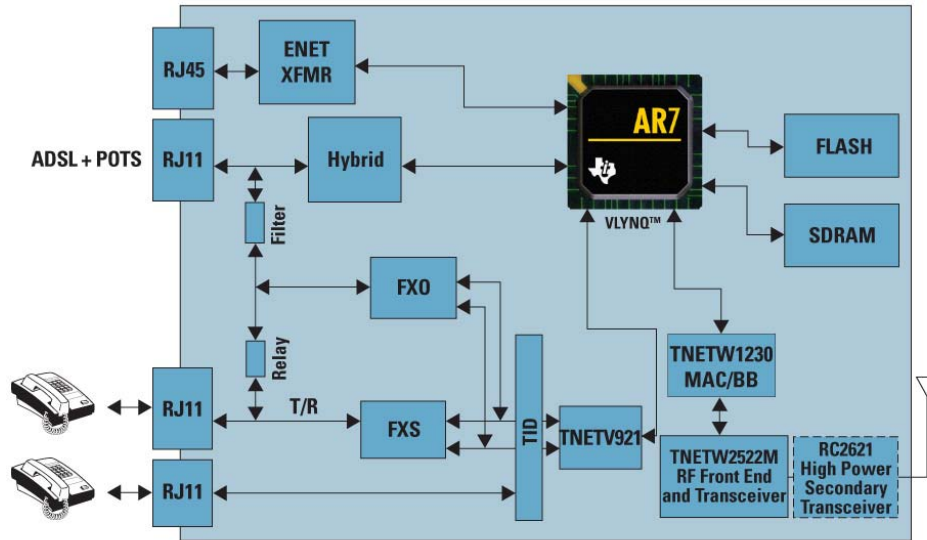


Figure 1 – AR7VWi Block Diagram

The fundamental components of the AR7VWi platform include:

- **TNETD7300A (AR7)** – The single-chip DSL PHY/router. The TNETD7300A supports the following DSL standards: ADSL1, ADSL2, ADSL2+, Annex A and Annex B. The TNETD7300A also contains a MIPS32™ 4KEc™ 32-Bit RISC processor, a hardware ATM SAR, an internal Ethernet PHY with Auto-MDIX, and an internal power management module.
- **SDRAM/FLASH memory subsystem** – The memory subsystem is configurable depending upon the specific application requirements.
- **TNETV901** – The TNETV901 Voice Digital Signal Processor contains a TMS320C55x™ DSP core and embedded memory for performing voice and fax processing over IP.
- **FXS/FXO telephony interface subsystem** – The FXS telephony interfaces directly support one or multiple standard telephone devices that can be used for VoIP over the packet network or traditional circuit switch voice calls over the PSTN via the FXO interface.
- **FXS to FXO bridging** – The failover relay provides lifeline emergency telephone service to the PSTN in the event of power failure.
- **Filter** – The built-in inline filter eliminates interference of the POTS FXO circuit into the DSL.
- **TNETW1230** – The TNETW1230 is the WLAN baseband digital processor.
- **TNETW2522M** – The TNETW2522M is a single-chip 802.11b/g radio with an integrated power amplifier.
- **RC2621** – The RC2621 is an optional second-stage power amplifier with an integrated receiver sensitivity gain section that increases the overall output power to 1 Watt (as measured at the transmit/receive switch).
- **On-board 802.11b/g antenna** – The design supports an on-board 802.11b/g antenna, an external whip antenna, or both, providing antenna diversity for 802.11b.

### Features of the AR7VWi Platform

The AR7VWi is implemented as a single-sided, four-layer printed circuit board.

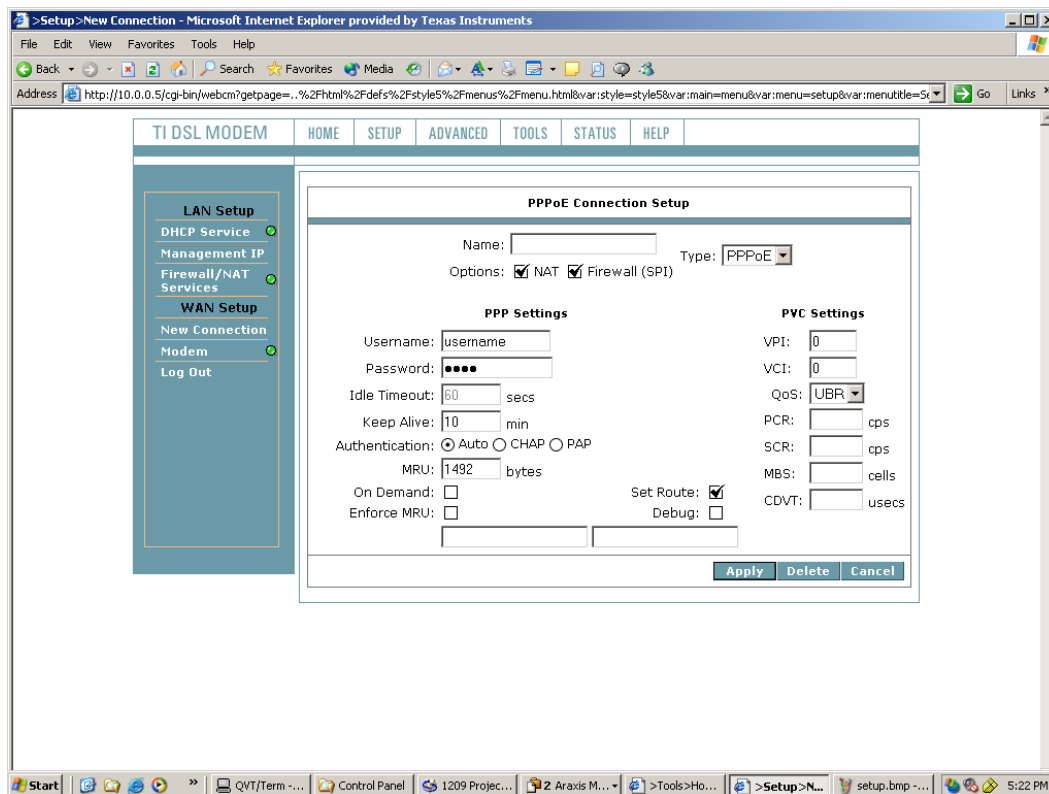
The overall bill of materials of the AR7VWi platform is minimized through integration of many discrete components into the above listed silicon devices. The smallest achievable form factor of the AR7VWi is only constrained by the mixture of connectors and indicators.

Some options available on the AR7VWi platform include:

- Four-port Ethernet switch
- Additional FXS ports (more than two simultaneous FXS operations may require additional TNETV901s)
- Drivers for several common FXS/FXO device suppliers
- DSL dying gasp stuffing option

### Advanced AR7VWi Applications

The capabilities of the AR7VWi broadband residential gateway platform allow for some highly-advanced applications beyond just typical DSL, WLAN access points or VoIP. Benefiting from the fact the AR7VWi platform also connects to a PSTN line by nature of the DSL connection, some of these applications can provide a competitive advantage over equivalent cable modem services. Also, given the inclusion of a powerful MIPS-based RISC processor and a WLAN connection, these services can be managed from virtually anywhere in the home through an easy to use web-GUI management interface.



**Figure 2 – AR7VWi Web-based GUI Interface** (Figure 2 shows an example of the Web-based GUI interface that is provided with AR7VWi.)

The following paragraphs elaborate on some of these applications and services that are possible with the AR7VWi platform:

- **Single-port voice gateway with VoIP call forwarding** – Given the AR7VWi can support both VoIP and connection to the PSTN via the FXO interface, AR7VWi can operate as a single-port voice gateway with VoIP call forwarding capability. For example, when properly configured, the AR7VWi platform can forward VoIP calls to a cell phone or any other number the user selects essentially creating a VoIP “follow me” service. Of course, when providing any type of call forwarding capability, it is always necessary to guard against the possibilities of fraud, which could be largely avoided by only allowing call forwarding to a single or short list of numbers.
- **Home PBX** – By taking advantage of the software capabilities of a resident MIPS RISC processor, an underlying Linux®-based operating system and an extensible memory system, many PBX features could be made available in the home at little additional cost. Some of the capabilities might include detailed call reports, most cost-effective call routing via VoIP or the PSTN, call screening, direct inward dialing to the desired extension,

distinctive ringing based upon number dialed or ANI, VoIP/PSTN call waiting and many more. These services are easily managed with Web-UI via any Ethernet or Wireless connection.

- **Network-based voice messaging** – Lending to the fact that AR7VWi is connected to a broadband interface, either PSTN or VoIP originated voice messages can be stored and forwarded to a broadband network, making them retrievable anywhere in the network. This same capability can also be enhanced to provide a remote message indicator through the network when there is a message available.
- **VoIP to PSTN multi-party conferencing system** – By taking advantage of simultaneous connections to both the PSTN and VoIP, it is possible to provide multi-party conferencing between both networks. In addition, via in-band or out-of-band signaling using a DTMF keypad or keyboard, the user could control an individual's volume or muting.
- **Work-at-home distributed call center with broadband data access** – Using the PSTN to receive calls forwarded from a call center, the call agent can talk to customers while obtaining customer data via the broadband connection. In addition, the call center can simultaneously track the agent's activity via messaging over the broadband connection. Statistics can be maintained on each agent and the agent can "busy out" when breaks are needed all through the network. Finally, using a single-direction VoIP call, a supervisor may choose to listen in on an agent's activity without the agent knowing, or calls can be recorded and immediately forwarded to the network through the network-based voice messaging discussed above.
- **Multi-line home network with life-line failover** – Probably one of the most beneficial features of the AR7VWi platform is the ability to effectively support multi-line capabilities over a single twisted pair. The multiple voice lines would actually be carried over VoIP to the central office. Of course, this may require termination of the VoIP calls at the central office. In the event of a power failure, the relay would disengage and directly connect the FXS lines to the PSTN.

**Voice Features**

The voice features of the AR7VWi are built upon the industry-leading Telogy Software® voice technology platform. The Telogy voice technology platform is based upon years of VoIP experience that provides the industry’s highest quality and most fully-featured VoIP capabilities. The following table lists the fundamental features of the Telogy voice technology platform.

**Table 1 - Telogy Software® VoIP Features in AR7VWi**

<b>DSP type:</b>	vDSP
<b>Frame sizes:</b>	5/5.5/10/20/30 ms
<b>Build type:</b>	Voice/fax
<b>Channels:</b>	2 LBRC + 1 PCM
<b>Codec(s):</b>	G.711, Appendix 1, 2 G.726 G.729AB G.723.1A
<b>Telephony signaling:</b>	MGCP, SIP, H.323
<b>Caller ID generate/detect:</b>	Bellcore, ETSI, UK, Chinese
<b>Fax relay:</b>	RFC-2833
<b>Fax modem:</b>	v.21, v.27ter, v.29, v.17
<b>Fax protocol:</b>	T.38U
<b>Miscellaneous features:</b>	Conferencing support Call waiting Call transfer Voice mail indication Gain control Codec switchover Asymmetric codecs (Rx/Tx) Configuration provisioning
<b>Echo cancellation:</b>	32 ms G.168 NLP Double talk detection
<b>Voice activity detection:</b>	Noise level matching Adaptive level SID support Pink CNG
<b>Tone generation/detection:</b>	G.711 Appendix 2 DTMF v.21 fax v.25 modem/fax Call progress tone v.18A CNG, fax calling tone 1100 Hz
<b>Tone relay:</b>	DTMF/MF relay DTMF RTP relay (RFC-2833)
<b>Packet loss concealment:</b>	G.711 Appendix 1
<b>Peer-to-peer:</b>	RFC-2833, AAL2 (UUI)
<b>PCM hardware interface:</b>	μ-Law a-Law Linear

## DSL Features

AR7 has been designed to achieve the lowest possible bill of materials while still supporting all ADSL standards at the highest possible performance. AR7 can be used in applications from simple, integrated bridge/routers, as shown in Figure 3, all the way up to advanced voice enabled gateways. Some of the key performance features are discussed in more detail in other white papers and technical briefs. The following is a list of key features of AR7:

- Future proof ADSL - all standards on one chip
  - Annex A, B, I, J, L, M
  - ADSL2/ADSL2+/READSL
- VxWorks® PSP and complete Linux NSP software solution
- Proven industry leading interoperability and performance
  - Worldwide interoperability footprint
  - Dynamic Adaptive Equalization™ (DAE) enhances performance and improves interoperability
    - Switchable hybrid
    - Programmable transmit and receive filters
    - Echo cancellation
    - Configurable equalization structures
- Integrated line driver
- Integrated power management
- Lowest BOM cost of any ADSL solution
- Integrated Ethernet 10/100BaseT PHY

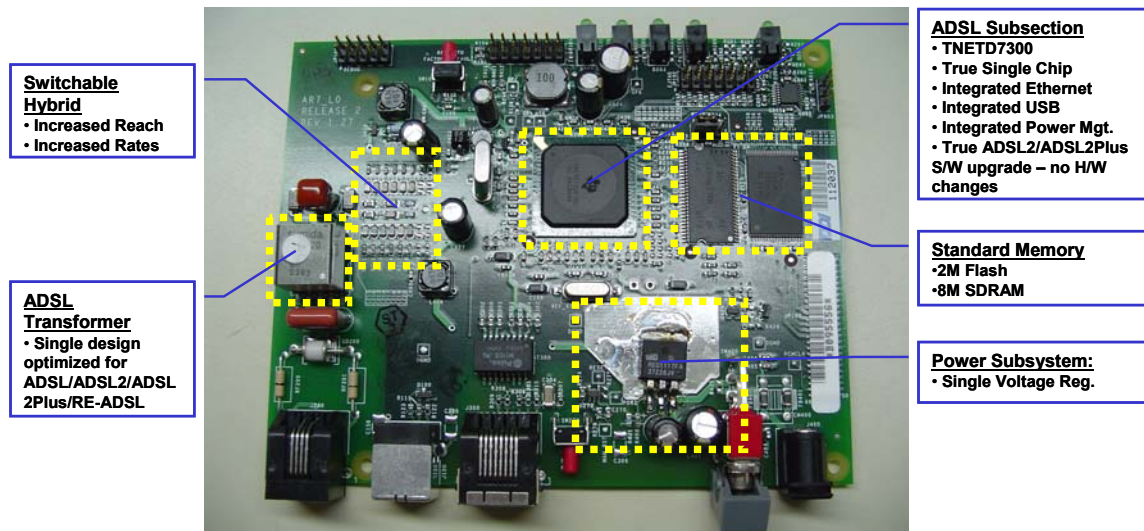


Figure 3 – Basic Bridge/Router based on AR7

DAE is a key feature of AR7 and is largely responsible for AR7 setting new ADSL performance standards, including meeting the new DSL Forum WT-085 performance bar. Because of the improved performance of AR7, it is actually being leveraged by service providers to increase the range and coverage area served.

One of the key performance features of AR7 related to DAE is a “switchable hybrid” that matches the impedance of the hybrid to the line. This feature greatly enhances the performance in the presence of bridge taps or unruly house wiring.

For a complete description of all the DAE features, please read the Dynamic Adaptive Equalization Technical Brief.

As mentioned above, the AR7 software packages includes support for both Linux and VxWorks. While the features for VxWorks are individually licensed from WindRiver, the Linux features are supported directly through Texas Instruments via a standard Monta-Vista license distribution.

The Linux-based Networking Support Package (NSP) for AR7VWi provides the following features:

- Bridging
- Routing (RIP v1/2, IGMP proxy, IP forwarding, MAC encapsulation)
- WAN protocols (PPPoA, PPPoE, RFC 1577)
- Address translation and security
  - NAT/NATP
  - UPnP Internet Gateway Device (IGD)
  - ALGs
  - Stateful inspection firewall
  - Denial of service
  - Filtering
- Gateway services
  - DHCP client/server/relay
  - DNS relay/proxy
  - Syslog
- Network management
  - Customer extendible configuration manager
  - Web server and reference Web pages
  - SNMP SETs and traps for four groups in MIB-II only
  - Command Line Interface (CLI) for NSP & WLAN. Will keep VoP CLI.
  - Telnet, FTP



- Other
  - WLAN user isolation for added security in hot-spot and multi-family dwelling installations
  - VLAN tagging per PVC
  - SNTP with DHCP options
  - New memory-saving Web UI
  - Firewall support for voice signaling and media streams
  - Voice & IP QoS integration
  - Extended bridge filtering with per-port rules
  
- Diagnostics and test capabilities

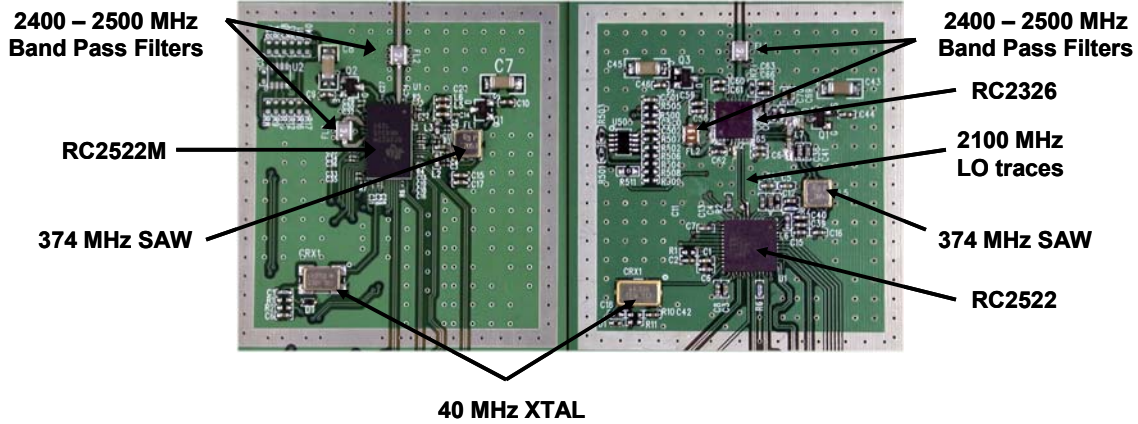
### WLAN Features and Applications

Tests of Texas Instruments' latest WLAN products show a clear lead in rate and reach over other current suppliers. Texas Instruments designs WLAN products knowing that better range means more awards and fewer support calls from customers and a better end-experience for customers.

AR7VWi has incorporated several new WLAN features that are not present in previous designs. These features include:

- 802.11b/g integrated right on the motherboard
- Use of the TNETW2522M (RC2522M) to simplify and cost reduce the radio design
- Future stuffing option for the RC2621 second-stage power amplifier that effectively doubles the range of 802.11b/g
- Motherboard layout includes an on-board antenna as well as connection to an optional external antenna

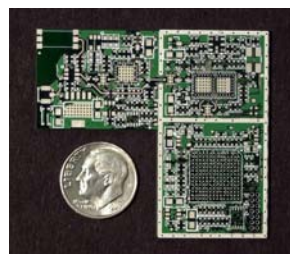
Figure 4 shows the comparison of the radio design between the previous generation and the AR7VWi version using the TNETW2522M (RC2522M). Use of the TNETW2522M eliminates RF interconnects sensitive to layout and PCB, thereby significantly reducing customer layout issues. In addition, use of the TNETW2522M reduces the number of components to less than 35 components in the radio subsystem. The TNETW2522M uses a 6 mm x 10 mm QFN-like package.



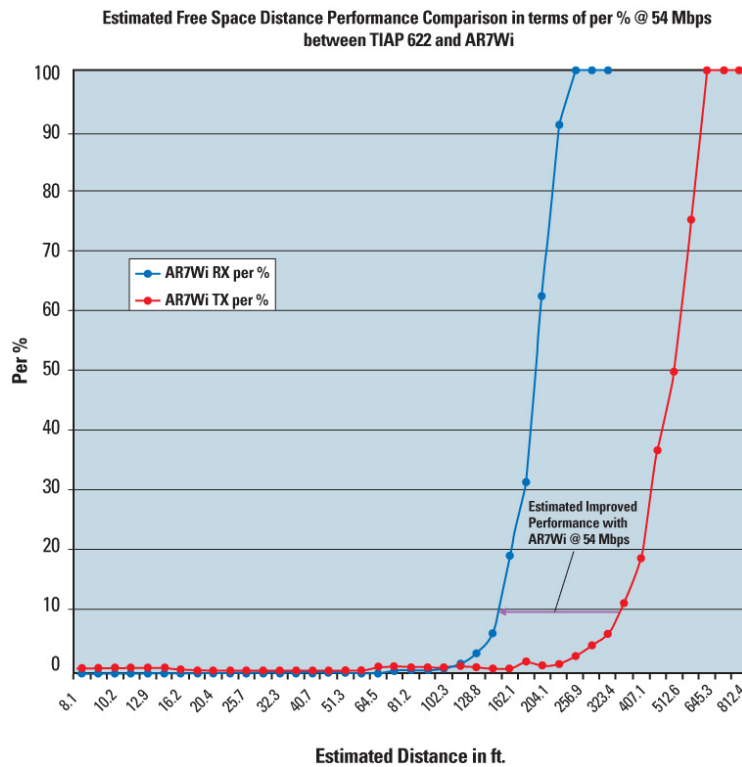
**Figure 4 – Comparison of 802.11 radio design using the TNETW2522M**

The entire 802.11b/g design consumes less than three square inches on the AR7VWi motherboard. Figure 5 shows a photo of this layout. The bottom right corner of this layout includes an on-board antenna that can be used as the only antenna required for 802.11b/g or, for greater performance, an external antenna may be used. In addition, both the on-board antenna and the external antenna can be used simultaneously for 802.11b antenna diversity.

The layout also shows the location of the RC2621 power amplifier in the bottom right. The addition of the RC2621 can boost the power up to 1 Watt, thereby overcoming issues with deployment in difficult homes or multi-family dwellings. Figure 6 on the next page shows the relative performance of 802.11g at 54 Mbps with the RC2621.



**Figure 5 - 802.11b/g layout for AR7VWi**



**Figure 6 – Performance Improvements of 802.11g with the RC2621**

**Summary**

In summary, the AR7VWi design offers many unique opportunities to offer advanced applications never before realized in a single, integrated platform. In addition, there are many key features that aid in easing the deployment of both DSL and WLAN. These features extend the customer service area for DSL and ease the deployment of 802.11 in difficult homes. These characteristics provide a powerful combination that should be appealing to both the service provider and end user. The end result could potentially change the analyst’s view of voice-enabled residential gateways to an earlier and more rapid market growth.

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