BCM1101
Ethernet Enterprise IP Phone /
Gateway Platform

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Enterprise IP Telephony Topology
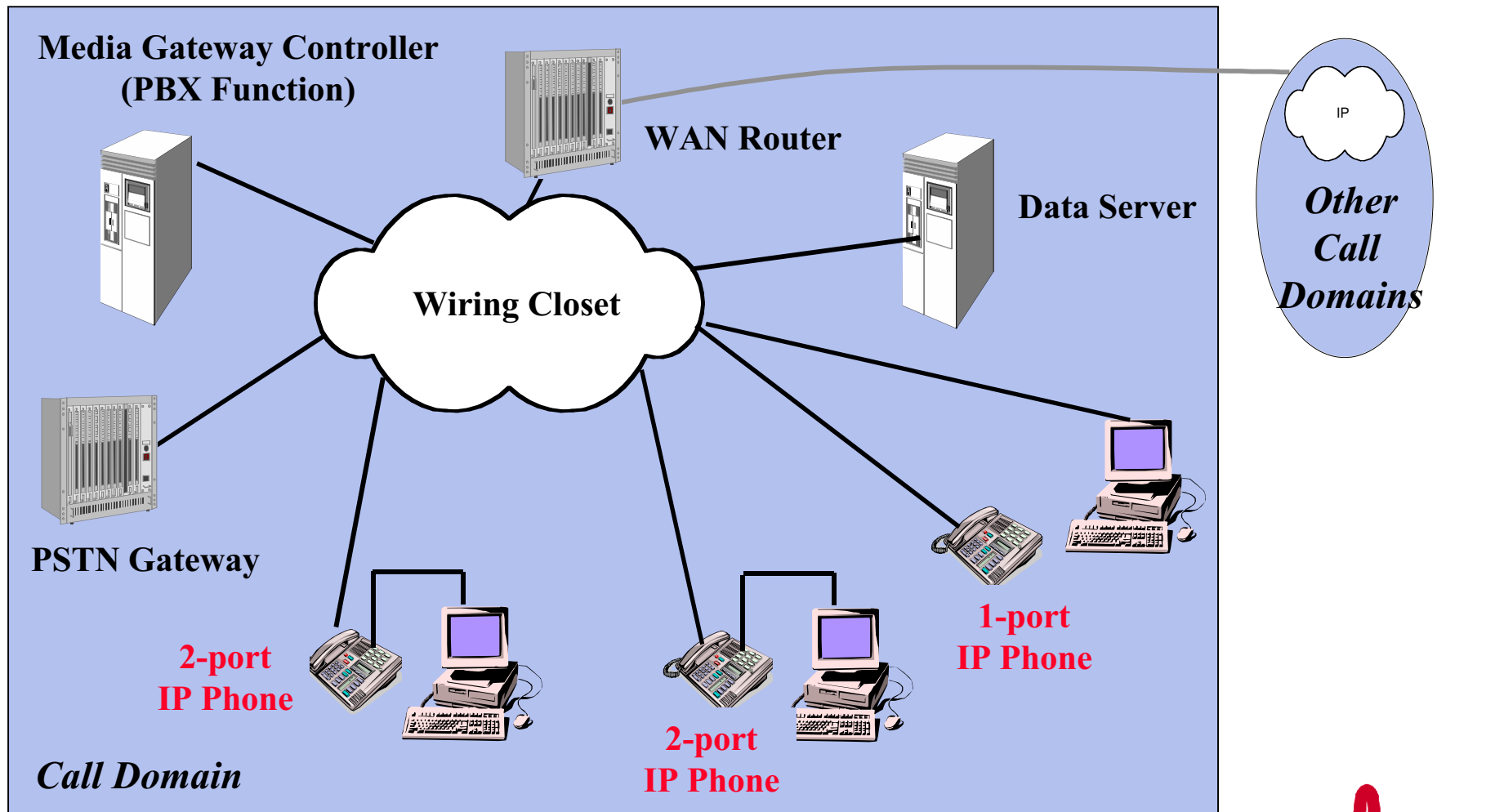
IP Phone Chip Requirements

- **Single Chip Solution**

  – Integrate all key blocks for IP Telephony

- **Low cost**

- **Two External 10/100BASE-T Ethernet Ports**

  – One port to network, one port to PC

- **3 port 10/100BaseT Ethernet Switch**

  – Switch isolates IP Phone CPU core from PC<->network traffic
  – Hub solution floods CPU with PC<->network traffic, resulting in poor voice quality

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IP Phone Chip Requirements

- **Excellent Voice Quality**

  – Wideband codecs

  – QOS

  – Low delay

  – Adaptive jitter buffer

- **Support wide selection of vocoders:**

  – Narrowband: G.711, G.726, G729A/AB/E, G.723.1/A, G.728, BroadVoice^{TM}

  – Wideband: G.711, G.722, BroadVoice^{TM}

- **Power over Ethernet**

  – Built in support

  – Low power consumption

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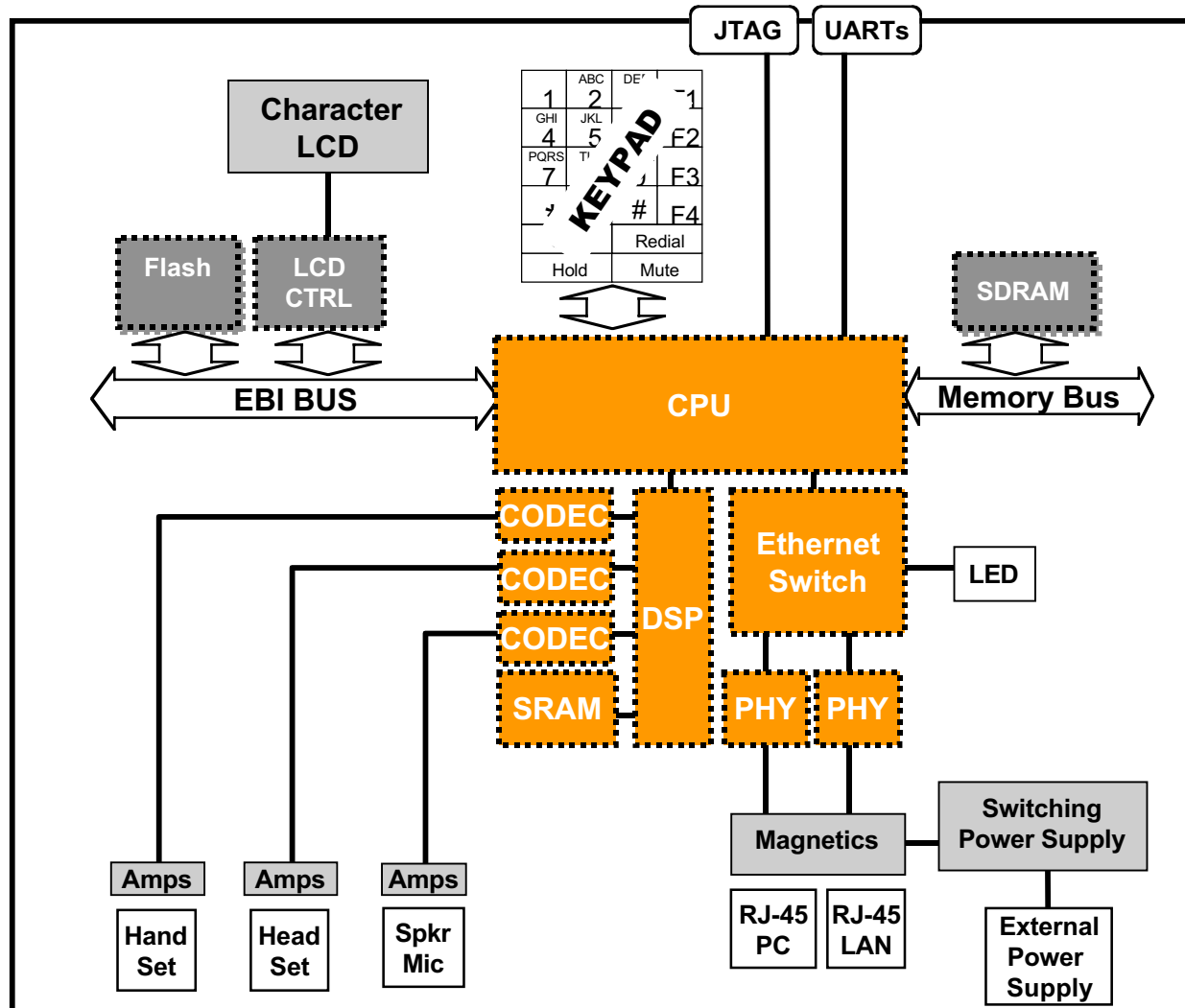# IP Phone Chip Requirements

- ## Phone Application

  - 3 wideband capable codecs (handset / handsfree / headset)

  - Half and full duplex speakerphone

  - 3 channel conferencing
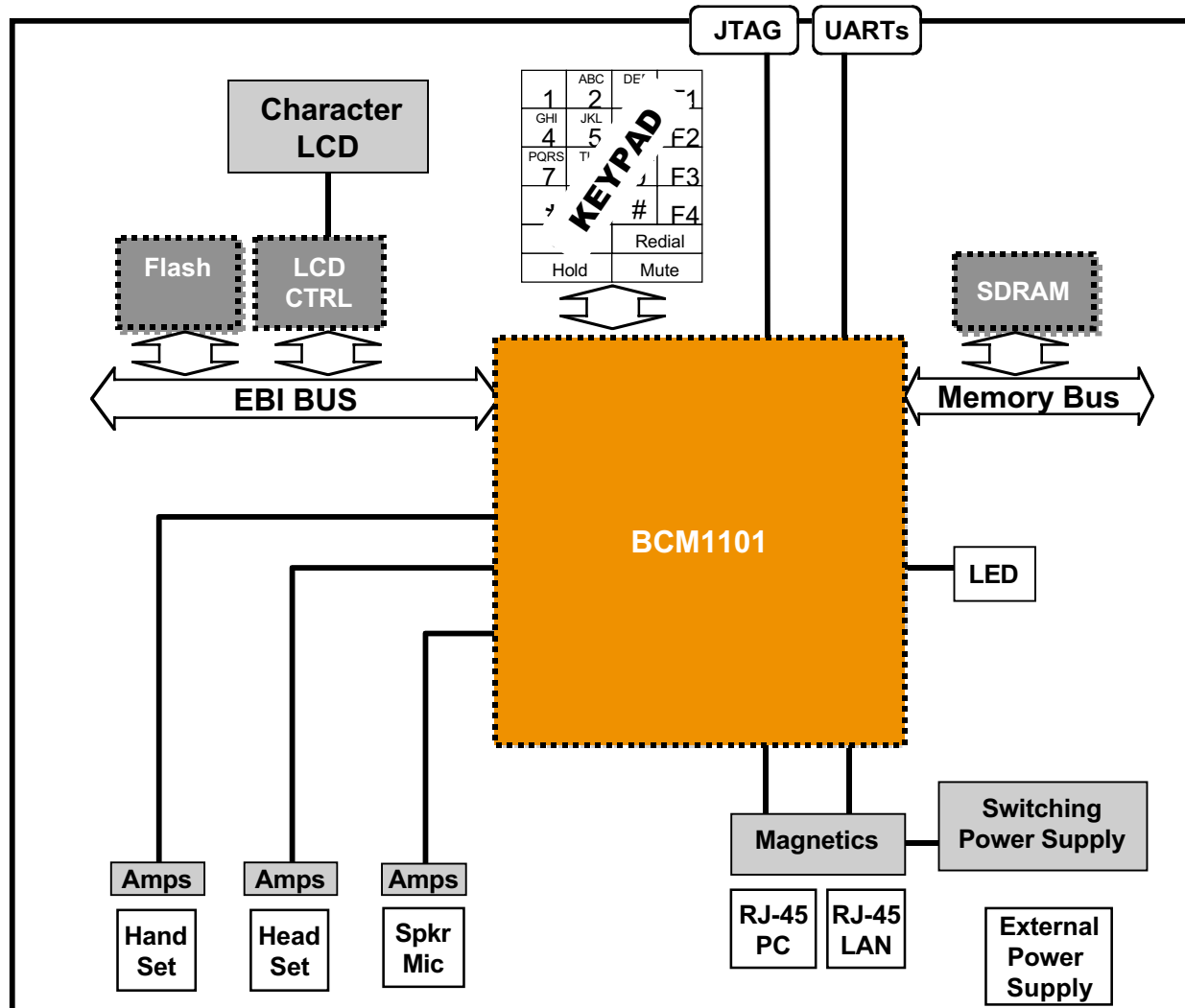
- ## Gateway Application

  - Glueless interface to external SLICs

  - 2 wideband capable codecs (line 1 / line 2)

  - Line echo canceller

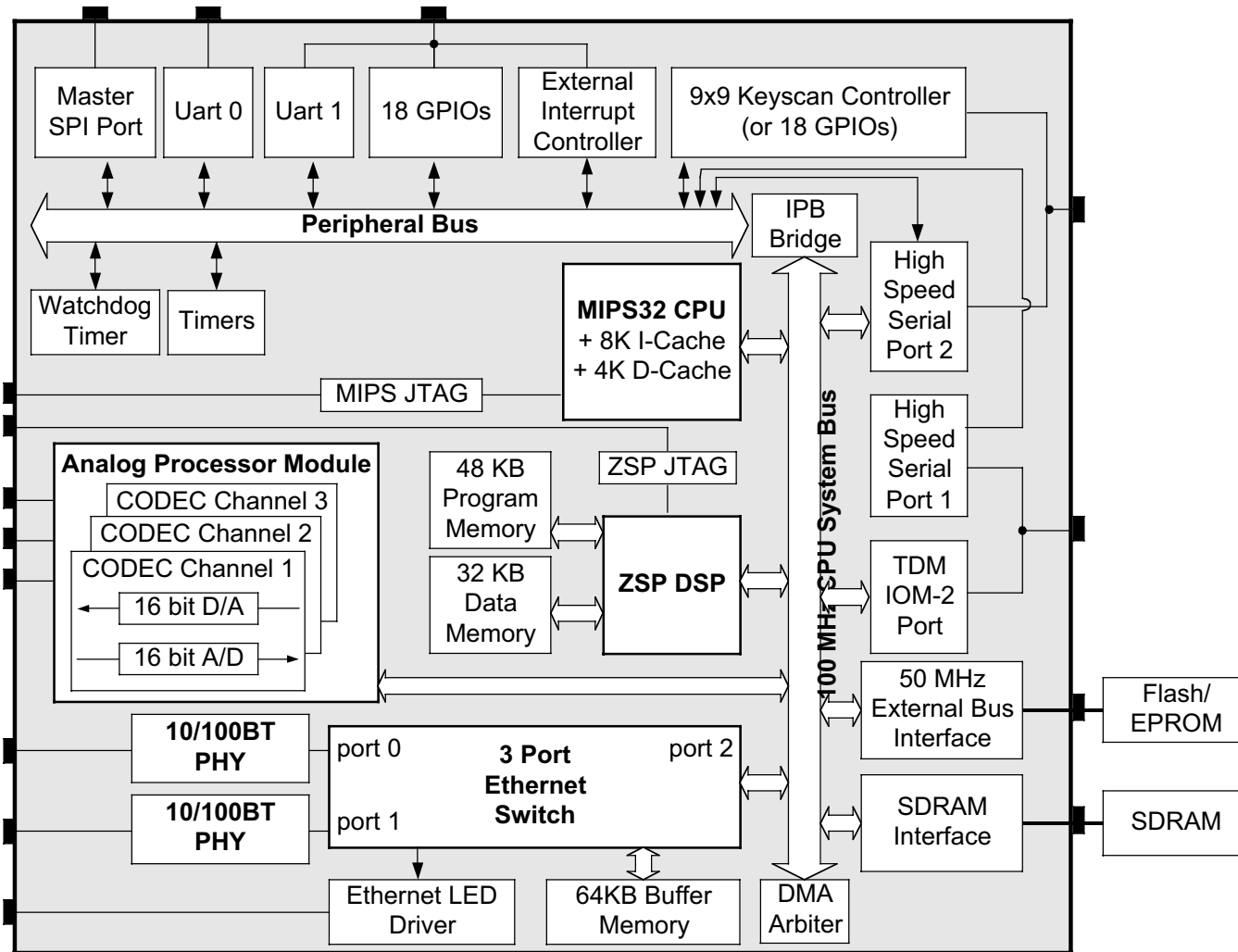 - Fax relay / Voice band data

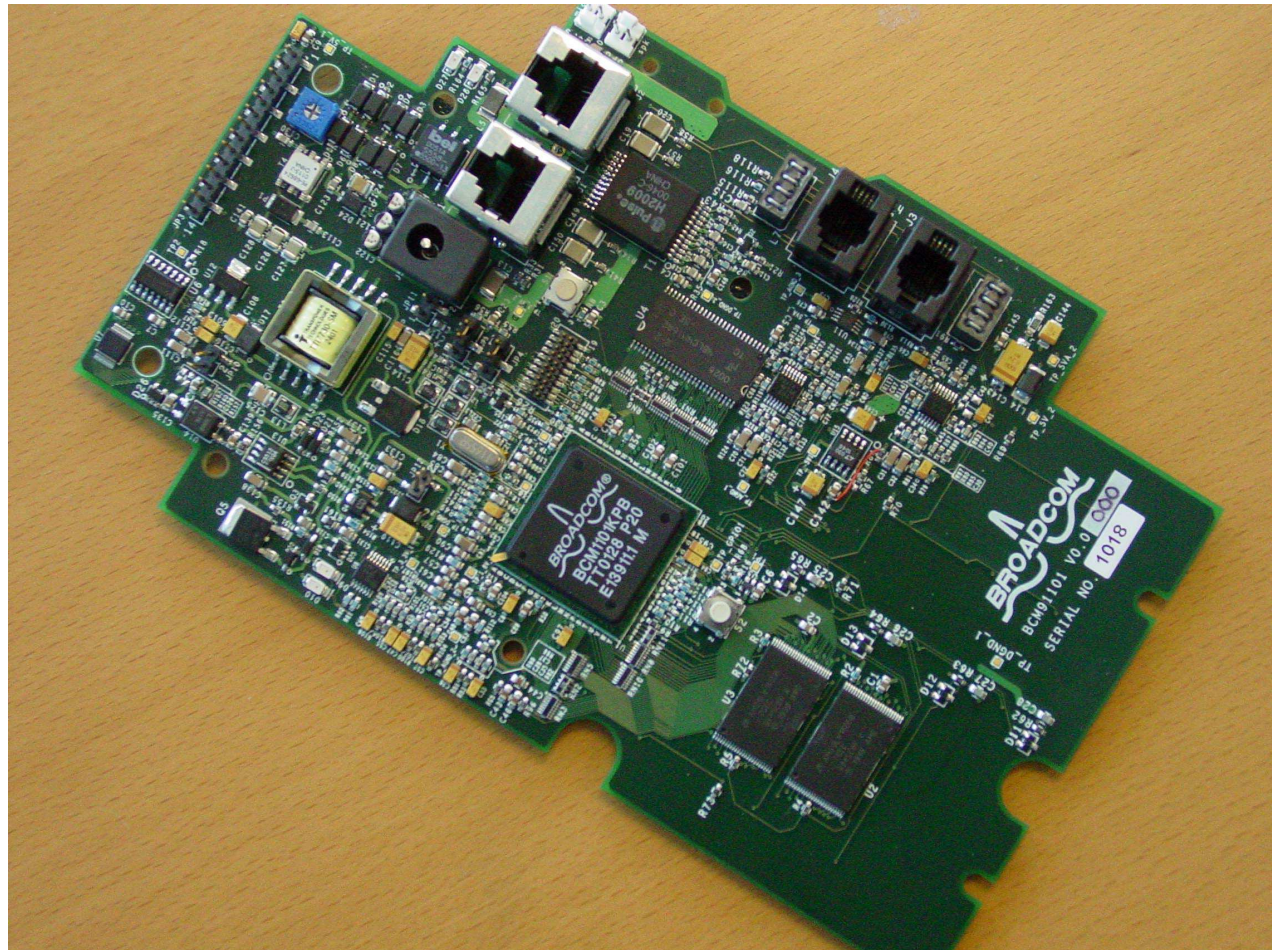 - 3 channel conferencing

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First Generation IP Phone

BCM1101 IP Phone

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BCM91101 IP Phone Platform

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BCM1101 Chip Features

- **MIPS32 CPU (150 MHz / 165 DMIPS; 8kB I-cache, 4kB D-cache)**

  – IP, RTP, UDP, VoIP protocol stacks (H.323, H.248/Megaco, MGCP, SIP)

  – Realtime OS

- **ZSP DSP (140 MHz / 280 MIPS; 48kB Prog RAM, 32kB Data RAM)**

  – Vocoders (G.711, G.726, G.723.1/A, G.729A/AB/E, G.728, BroadVoice™, G.722.1)

  – 3 channel conference

  – Half & Full Duplex Speakerphone

  – Telephony algorithms: DTMF, Call Progress Tone Generation, etc.

  – Adaptive Jitter Buffer, Packet Loss Concealment

  – Framework (DSP 'RTOS')

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BCM1101 Chip Features

- **Three CODECS for simultaneous handset/headset/speakerphone**

  – 16-bit, 8 kHz and 16 kHz (wideband) sampling

- **Non-Blocking Managed Switch**

  – 64 kB buffer enables Wire-Speed Non-Blocking - no dropped packets
  – 802.1p Prioritization ensures voice quality
  – 802.1Q VLAN tagging support for communications security
  – Switch solution is more robust than a repeater hub

- **Two 10/100BASE-T Ethernet transceivers**

  – Power Over Ethernet support (MLP method)
  – Auto MDIX support simplifies network installation
  – LED port for Ethernet status

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BCM1101 Chip Features

- ## Peripherals

  - 9x9 key-scan supports standard and feature-phone keys

  - 2 UARTs and 2 High Speed Serial ports

  - 18 GPIO pins

  - TDM bus with IOM-2® support

- ## Physical Features

  - 0.18u process, 1.8/3.3V operation

  - 1.1W Peak, 0.3-0.8W Standby Modes

  - 256 pin PBGA package

    - Pin assignments designed to enable low cost, 4-layer PCB design

IOM-2 is a registered trademark of Infineon Technologies AG

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DSP Memory Requirements

- **Rich DSP functionality requires >200kB RAM**

  – Jitter buffer

  – G.711, G.726, G.723.1/A, G.729A/AB/E, G.728, BroadVoice™, G.722.1

  – Tone generation / detection

  – echo cancellation (for handset / headset / line echo cancellation)

  – Full duplex speakerphone

  – Wideband audio

- **Additional DSP memory needed for future expansion**

  – ie. new codecs, speech recognition, MP3 player

- **Internal SRAM is expensive**

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BCM1101 DSP Memory Reduction

- ## Distributed DSP Operating System

  – Portion of DSP Operating System runs on MIPS

  – Software developer can move non time critical tasks to MIPS (ie. superpacketization, fax relay)

- ## Program Paging

  – DMA program and data tables from external SDRAM to DSP memory

  – Software development tools make paging transparent to programmer.

  – Programmer simply list functions to be paged

  – Function is stubbed out with code that sets up the DMA descriptor, pages function, transfer control to page

- ## Instance Memory Paging

  – DMA instance memory on demand from external SDRAM

  – Once processing is complete, instance memory DMA'ed back to SDRAM

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BCM1101 DSP Memory Reduction

- ## BCM1101 has 80kB Internal DSP RAM

  - Traditional architecture requires >200kB
  - 48K Program Memory
  - 32K Data Memory

- ## Novel software and hardware architecture

  - Internal DMA controller is managed by software to page memory on demand
  - Minimizes memory footprint while supporting extensive DSP feature set
  - DSP feature set can be expanded without adding memory
  - No external expensive SRAM required for DSP core
  - Memory pages stored in SDRAM which is shared with MIPS core => no additional external memory needed for DSP

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Ethernet Switch Voice Enhancements
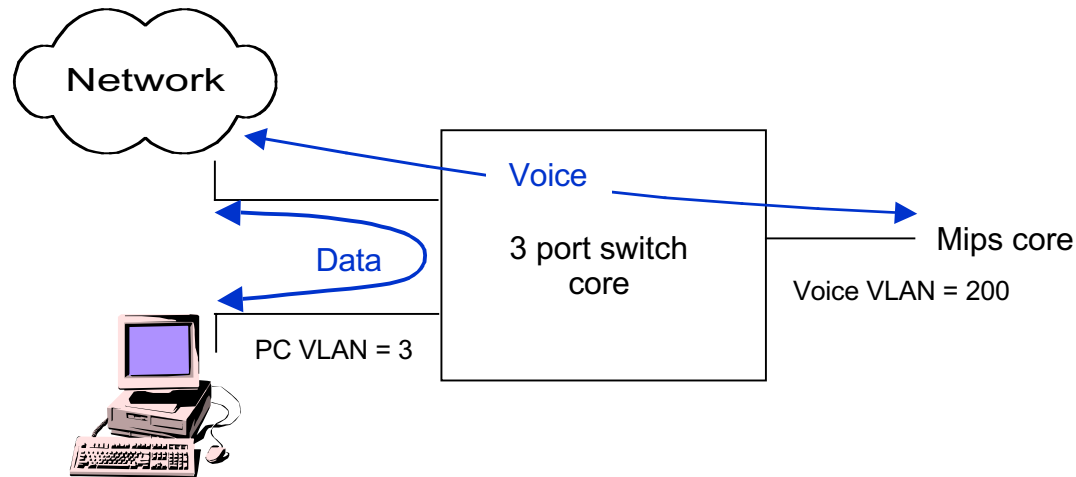

Network

Voice

3 port switch core

Mips core
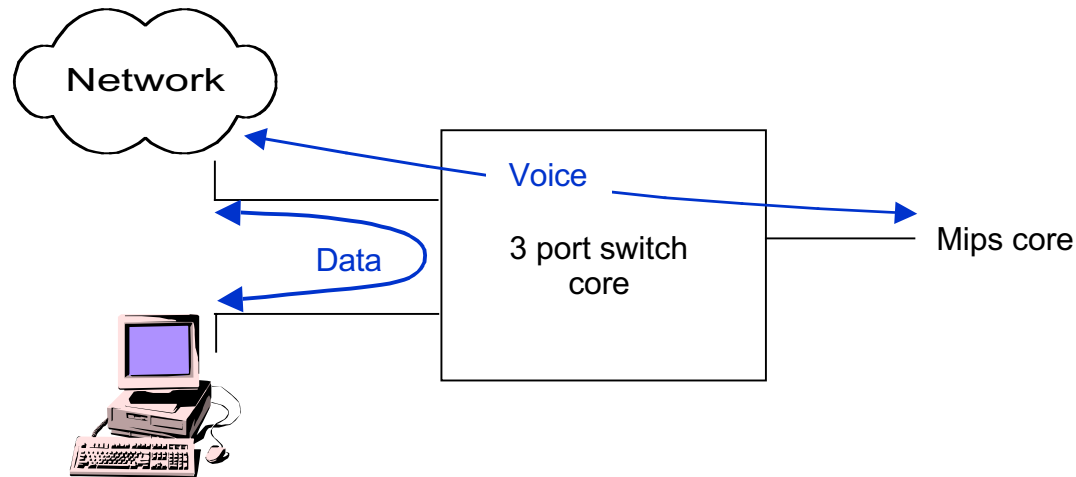
Data

• 802.1p Priority

– Voice traffic receives priority treatment over data => reduce latency

– 3 bit 802.1p QOS field in Ethernet header

– Switch examines 802.1p field and queues packet into either high or low priority queue

– 2 priority queues per port

– Override mode retags 802.1p field from PC or Network port

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Ethernet Switch Voice Enhancements

Network

Voice

3 port switch core

Mips core

Voice VLAN = 200

Data

PC VLAN = 3

- **802.1Q VLAN**
  - Allows network segmentation to increase security and decrease broadcast/multicast traffic
  - 12 bit 802.1Q VLAN ID in Ethernet header
  - Programmable VLAN ID on each of 3 ports
  - Packets only forwarded to port with matching VLAN ID
  - Optional VLAN ID removal on outgoing frames
  - Optional VLAN ID insertion/retagging on incoming frames

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Power Over Ethernet (POE)

- **BCM1101 supports MLP (Modified Link Pulse) method**

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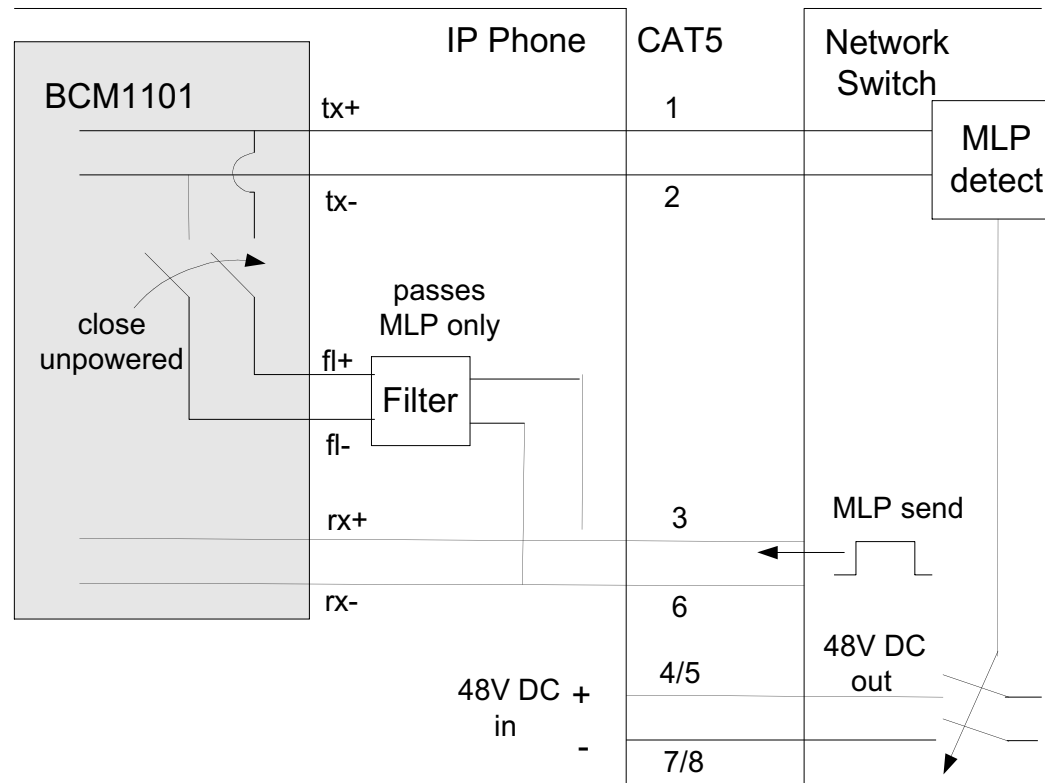
Power Over Ethernet

- ## Network switch supports POE

  - Phone is unpowered => BCM1101 relay closed
  - Network switch does not detect link, transmits link pulses (NLP, FLP, MLP)
  - MLP passes through filter
  - Network switch detected returned MLP, stops MLP tx
  - Network switch supplies power
  - BCM1101 relay opened

- ## Network switch does not support POE

  - Phone is unpowered => BCM1101 relay closed
  - Network switch transmits NLP (Normal Link Pulse) or FLP (Fast Link Pulse)
  - Filter blocks NLP and FLP => not looped back to switch
 - Network switch operates as normal

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BroadVoice™ Vocoder

- ## Wideband Telephony

  - Conventional speech
    - 8 kHz (300 to 3400 Hz - dash curve)
  - Wideband speech
    - 16 kHz (50 to 7000 Hz solid curve)
    - Flat response and added bass and treble
    - More natural-sounding and intelligible
    - But higher bit rate required
    - Distinguishing feature for VoIP

- ## BroadVoice™ was developed with the following goals

  - Wideband and Narrowband modes
  - Low Complexity / Low Delay / Very High Quality
  - Free of third party IPR

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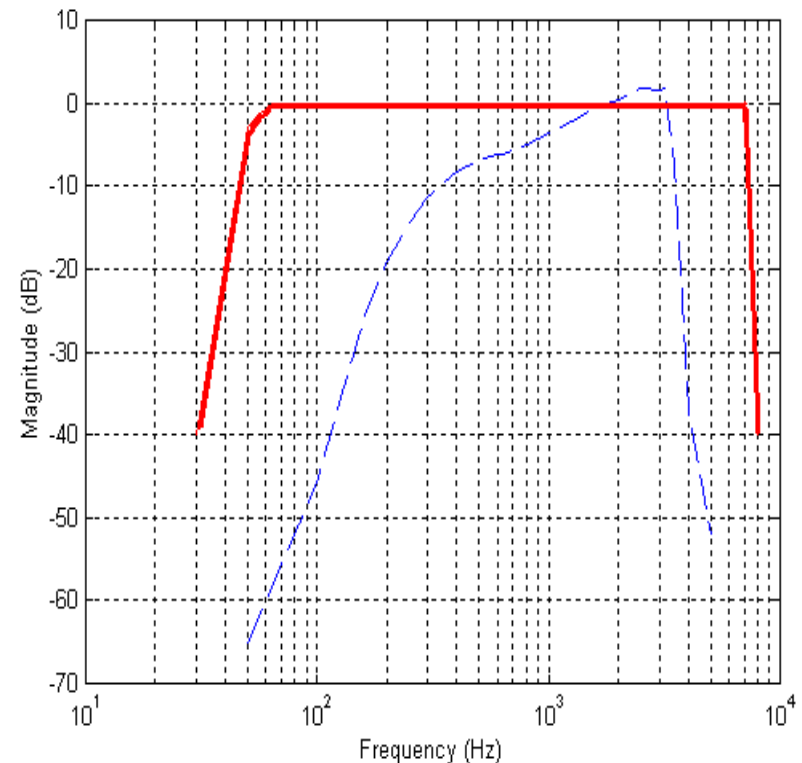
BroadVoice™ Features

- ## Very high quality

  - Narrowband BroadVoice16 better than G.723.1, G.728, G.729, and G.729A
  - Wideband BroadVoice32 better than G.722 at 64 kb/s

- ## Very low coding delay

  - only 5 ms, versus 15 ms for G.729 and 37.5 ms for G.723.1

- ## Low codec complexity

  - 13 MIPS for narrowband BroadVoice16 codec
  - 19 MIPS for wideband BroadVoice32 codec
  - Low memory foot print

- ## Free of third-party's intellectual property rights (Broadcom owns all IPR)

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Summary

- ## Highly integrated single chip IP phone solution

  – MIPS32 CPU, ZSP DSP, DSP memory, ethernet switch / phy, 3 codecs

- ## Hardware/software designed to reduce DSP memory

  – DMA architecture for program and instance memory paging

  – Distribute DSP operating system allows tasks to run on MIPS

  – Paging allows rich DSP feature set on small memory footprint

  – No external SRAM required for DSP

- ## Features for IP Telephony

  – Wideband codecs

  – 802.1p / 802.1Q Priority support

  – Integrated power over Ethernet support

  – BroadVoice support

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