BRADLEY UNIVERSITY

MARTIN ENGINEERING

Modular Rapid Monitoring System

Timothy Kritzler and Joseph Mintun

Sponsor: Martin Engineering, Illinois

Advisors: Dr. Malinowski and Dr. Ahn

Bradley University Electrical and Computer Engineering

April 21, 2016

Agenda

- Problem Background
- Design Approach
- Division of Labor
- Solution
  - Gateway Interface System
  - Sensor Interface System
- Project Cost
- Future Work

Problem Background

- Sponsored by Martin Engineering
- Modular Rapid Monitoring System
  - Logs analog and digital signals.
  - Ability to easily add additional inputs.
  - Low cost design.
- Past project progress
  - Team in class of 2015 worked on same project.
  - Goal: Continue development to make a “proof-of-concept” system for sponsor.

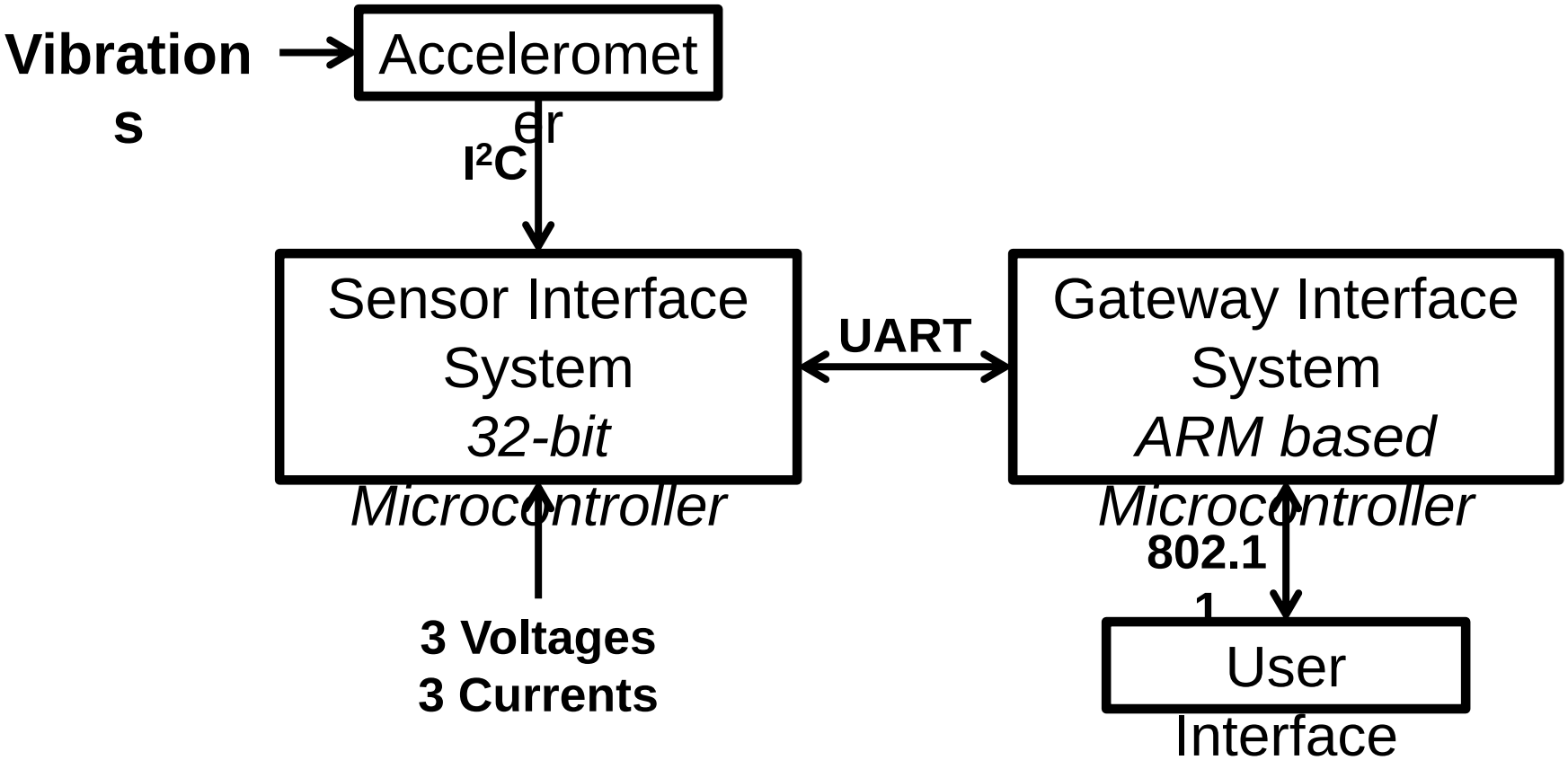
Problem Background

- System logging data within 50 ms after boot.
- Accelerometer and ADC sampling at 600 Hz.
- Permanently store the first five minutes of incoming data.
- Permanently store the five minutes of data after power down.
- Keep cost under $300.

Design: Approach

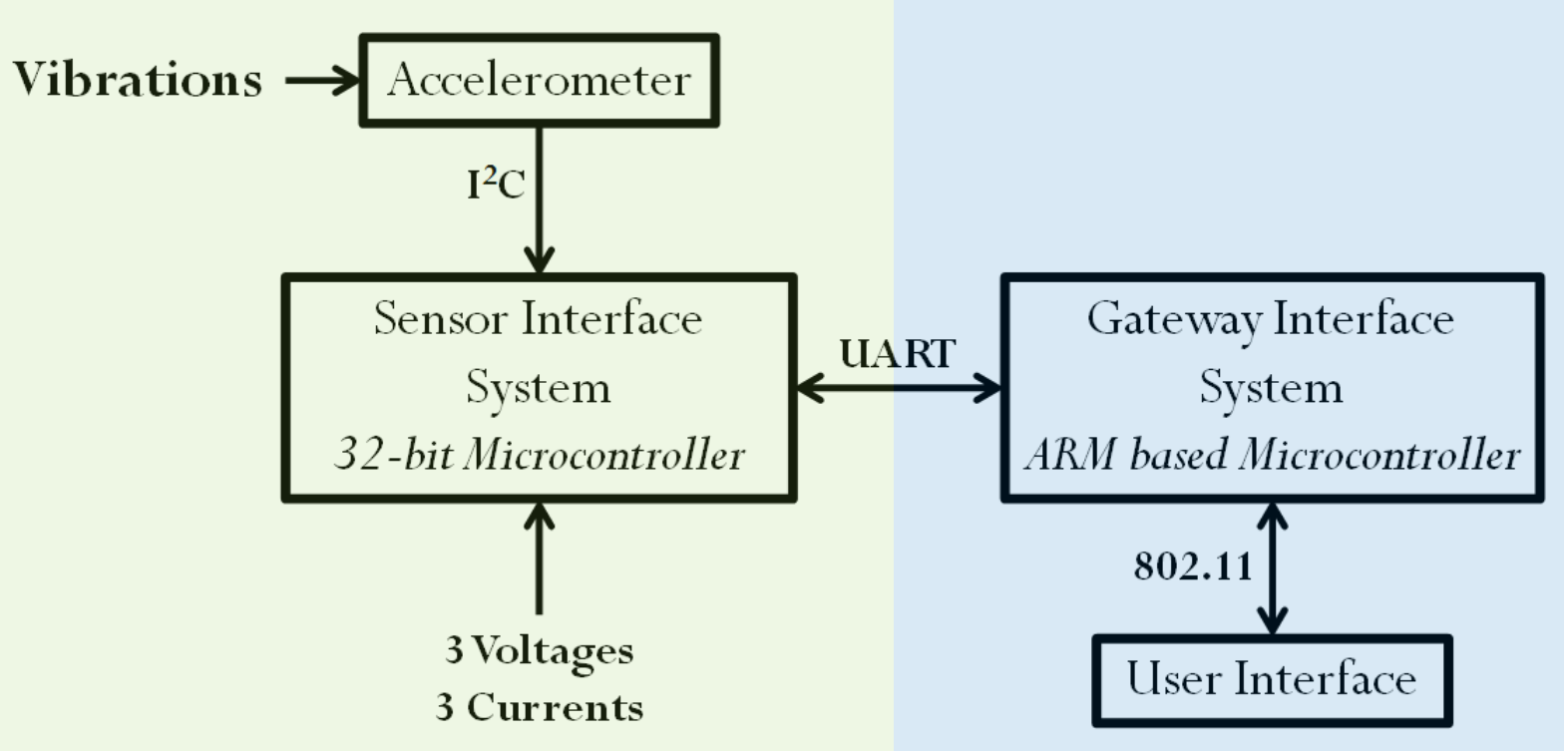
- Two subsystems
  - Sensor Interface System (SIS)
    - Acquires data from ADC and accelerometer.
    - Stores in rotary buffer.
    - Sends data via serial.
  - Gateway Interface System (GIS)
    - Receives and stores data from SIS.
    - Hosts web server that displays data to user.
    - Wireless network to access server.

Design: Approach

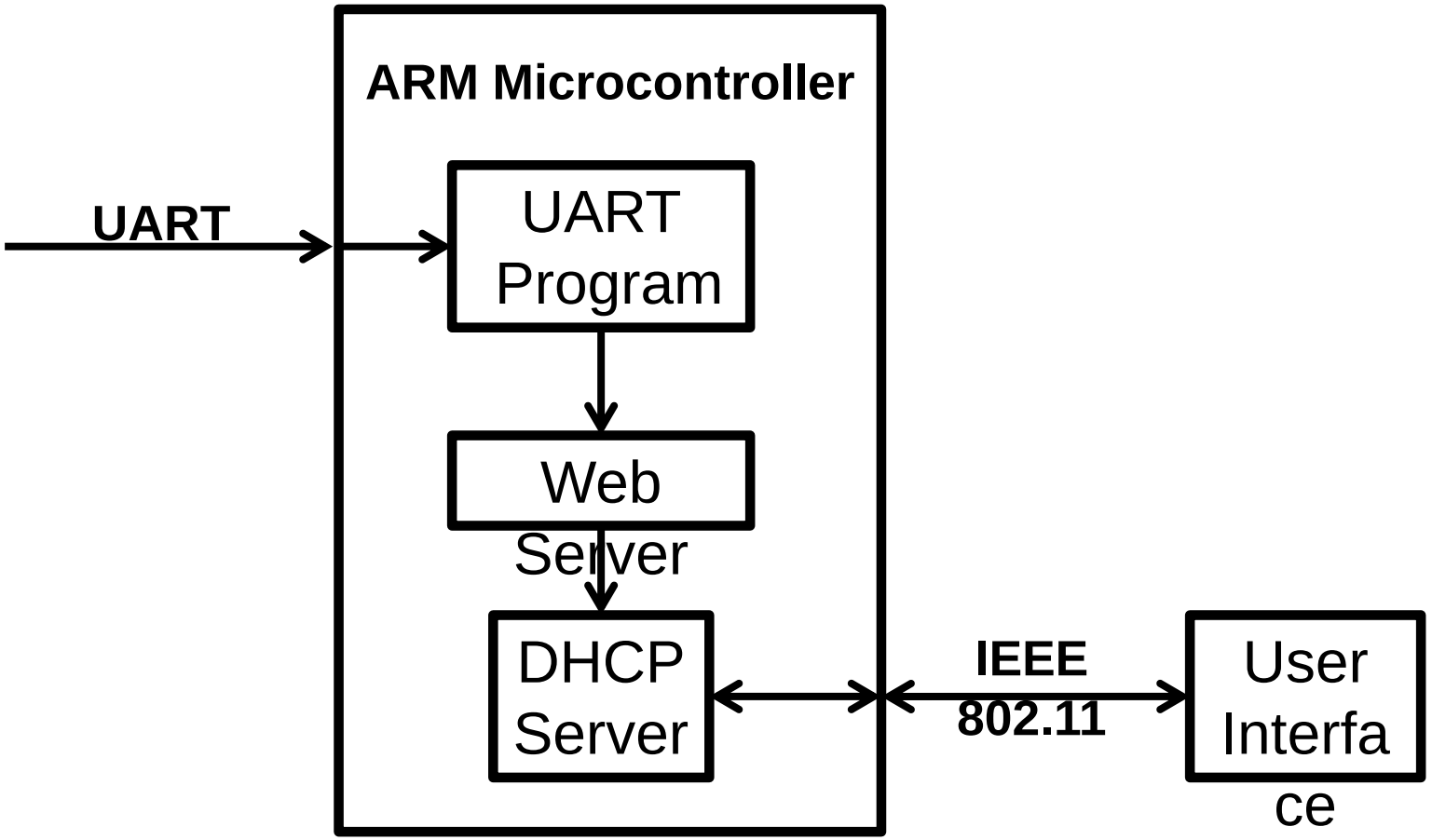


Division of Labor

- Sensor Interface System
  - Joseph Mintun
- Gateway Interface System
  - Timothy Kritzler



Solution: Gateway Interface System



Solution: Gateway Interface System

- Hardware
  - Raspberry Pi
  - RT5370 USB Wi-Fi dongle
- Software
  - Tiny Core Linux for Raspberry Pi
    - Also known as piCore

Solution: Gateway Interface System

- Software (cont.)
  - UART Communication to Sensor Interface System
    - 115200 Baud Rate, 8 Data Bits, 2 Stop Bits, No Parity
  - Web Server
    - lighttpd Web server package
      - Very lightweight and fast
    - Display basic web page
      - Links to download data files stored in local memory
  - Wi-Fi Network
    - RT5370 Wi-Fi dongle configured as Access Point with DHCP

Solution: Gateway Interface System

- Tiny Core Linux
  - Unusual boot sequence
    - OS is located in compressed file
      - Stored in the original state
      - Loaded to RAM every boot
    - Extra packages stored in another compressed file
      - Reinstalled every boot.
    - Files must be backed up before shutdown
      - Pre-written script

Solution: Gateway Interface System

- Tiny Core Linux (cont.)
  - Benefits
    - Speed
      - Lightweight with no extra software
      - Quick boot time
    - Reliable
      - Restores original configuration every boot
        - Issues can be resolved with a reboot
      - Running from RAM prevents MicroSD burnout

Solution: Gateway Interface System

- Benefits (cont.)
  - Vast online developer community
    - Regular software updates
    - Support for new hardware
    - Troubleshooting techniques easily available

SIS Block Diagram

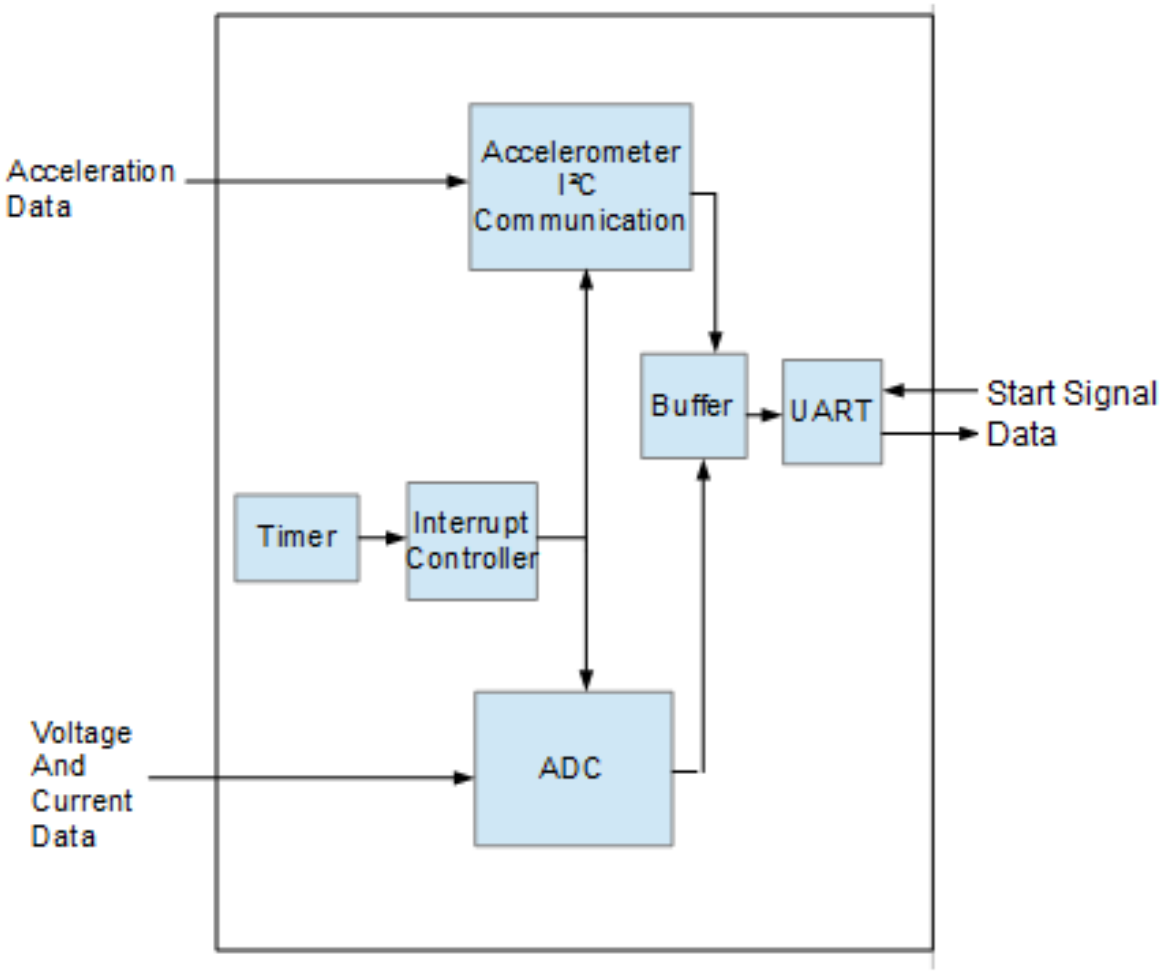


Fig. 1 SIS System Block Diagram

Main Loop

- Running at 12 MHz
- Enable ADC
- Enable timer
- Initialize interrupt

Interrupt Setup

- 600 Hz sampling
- Tested using on board LED toggling
- Verified using oscilloscope

Analog to Digital Converter

- 6 channels
- Begin first reading upon 600 Hz interrupt
- Subsequent readings triggered by cascading interrupt until all are read
- Results stored in rotary buffer
- 6 potentiometers used for testing
- Compared scoped readings to ADC readings

Rotary Buffer

- Needed enough memory to ensure no data loss during GIS boot
- Time stamp + 6 byte ADC data = 7 bytes
- Memory Needed = 7 bytes * 600 Hz * 6 sec

UART Communication

- Send data from rotary buffer
- Wait for ready signal
- Baud Rate

Accelerometer

ADC Time

Start-Stop

$$(5\ bytes * 6) + 6\ bytes + 9\ bytes + 11\ bits$$
$$= 506\ bits$$

$$\frac{363\ bits}{sample} * \frac{506\ samples}{second} = \frac{303{,}600\ bits}{second}$$

Project Cost

Part	Cost	Store
Raspberry Pi Model B+	$45.63	Digi-Key
Atmel UC3-A3 Xplained	$31.25	Digi-Key
ADXL335 Accelerometer Evaluation Board	$14.95	Sparkfun
Generic 2A Micro USB Power Adapter (2x)	$7.99	Amazon
RT5370 USB Wi-Fi Dongle	$4.81	Amazon
Total:	$112.62	

Budget: $300

Future Work

- Overall
  - Further develop UART protocol
    - Include handshake
    - Compress and send in binary (currently ASCII)
      - Above 115,200 baud rate unstable
      - To send all data in ACII requires 300+ kbps
- Gateway Interface System
  - Include data plotting on Web server
  - Add service to check for shutdown signal
  - Compress OS with packages installed to allow faster boot

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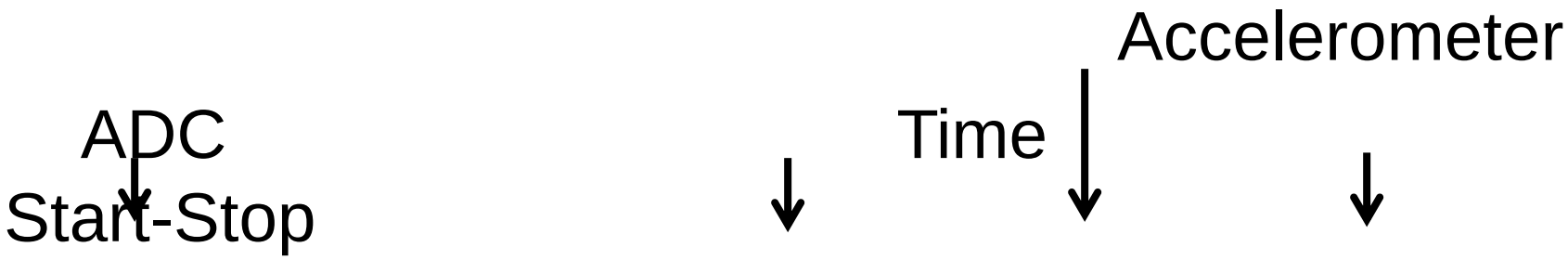
Modular Rapid Monitoring System

- UART ASCII Baud Calculation

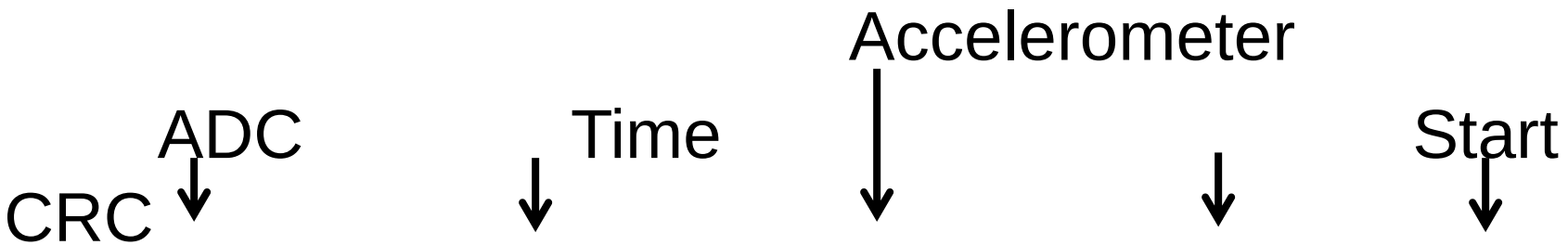


$$5\ bytes\ * 6\ channels + 6\ bytes + 9\ bytes + 11\ bits = 506\ bits$$

$$\frac{363\ bits}{sample} * \frac{506\ samples}{second} = \frac{303{,}600\ bits}{second}$$

Modular Rapid Monitoring System

- UART Binary Baud Calculation



$$(6 * 1\ byte) + 4\ bytes + (3 * 1\ byte) + 1\ byte + 1\ byte = 14\ bytes$$

$$\frac{14\ \cancel{bytes}}{\cancel{sample}} * \frac{11\ bits}{\cancel{byte}} * \frac{600\ \cancel{samples}}{second} = \frac{92{,}400\ bits}{second}$$