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SECOND COLLEGE ON MICROPROCESSORS: TECHNOLOGY AND APPLICATIONS IN PHYSICS

(18 April - 13 May 1983)

CONTROL OF EXPERIMENTS

Part 2

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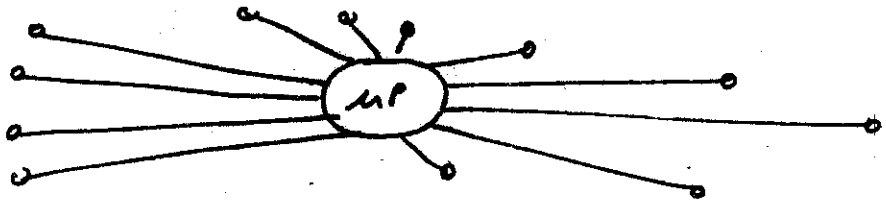
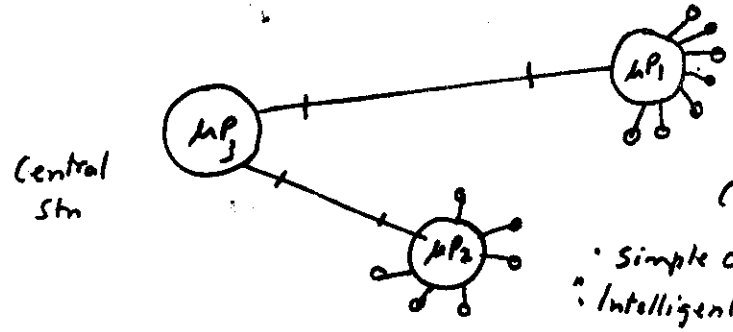
These are preliminary lecture notes, intended only for distribution to participants.

Distributed processing / computing

Multi microprocessor control

- Single μP cannot perform the required fn.
  e.g. number of signals may be too large
  wide variety of processing needs
- Expt. / Processing physically distributed over wide area. Hence significant data transmission required.
- Remote data transmission / telemetry

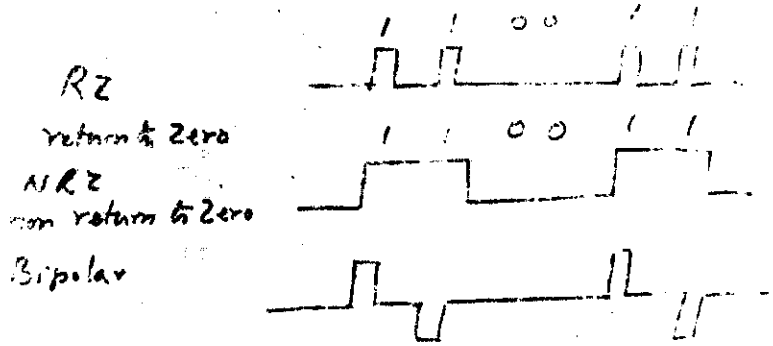




Concentrators

- Simple concentration
- "Intelligent" " with processing

Data Transmission



Data lines:
- Flat cables
- Twisted pairs
- Coax cables
- optical fibres
- Radio, VHF, μwave, etc.
- Telephone lines (PLT)

Base band trans.
- Pulse transmitted directly
  - problems with long lines (changing d.c. component)
  - use bipolar coding
  - several megabits per second on twisted pair
  - error detection by checking bipolarity violation.

More generally :

MODULATION

eg : [illegible]

For telephone lines : 300 Hz – [illegible] kHz

(DC – low freq. are cut)

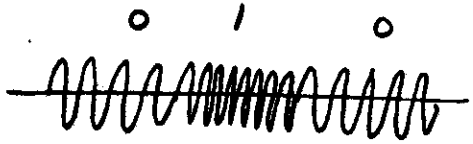
Tone modulation

Rate	Mean Carrier freq. Hz	Upper freq. Hz	lower freq. Hz
600 bps	1500	1700	1300
1200 bps	1700	2100	1300

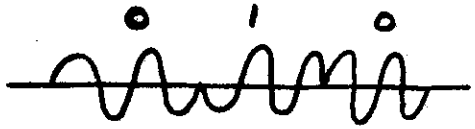
Mean at 1600 Hz , Min distortion, delay, etc.

(TP 75 bps 0 – 150 Hz
TTY 110 bps
direct on telephone channels will not be possible)

Frequency Shift Keying FSK



Phase Shift Keying PSK



Quaternary Phase Shift Keying QPSK — Four phases

Other methods with different phases and amplitudes

More bits/hz but with poor S/N ratio

Simple MODEM in IC form for (modulators/demodulators) 0 – 600 bps

Simplex-mode ([redacted] better quality)

Duplex mode ([redacted] dep.
(simultaneous 2way) (limited rates) [redacted]

TRANSMISSION OF DIGITAL DATA

Rate: BAUD Bits per second

Imperfections / errors in transmission measured as BIT ERROR RATE (BER)

$A \times 10^{B}$ eg. 5×10^{6}

Improvements by:

- Better medium (lower attenuation, better f, ϕ, charac.)
- Higher trans. power
- Better receiver sensitivity
- Special coding (error control) techniques

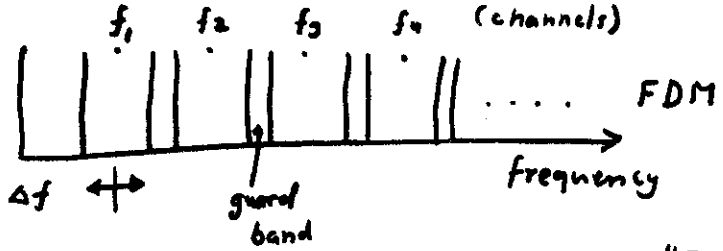
More sensitive to imperfections in medium than analog data transmission

e.g. equalizers are required for transmission of data on telephone channels

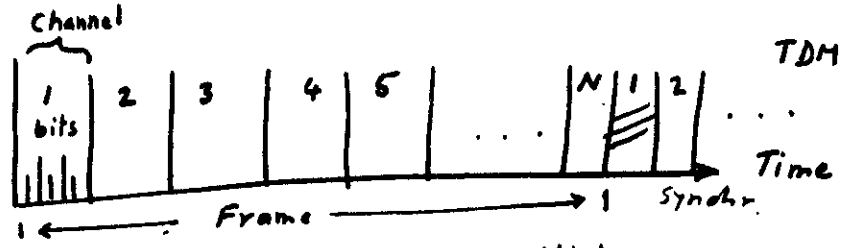
Methods of increasing transmission capacity:

MULTIPLEXING

- Frequency Division Multiplexing - FDM
- Time Division Multiplexing TDM



used in large μware systems with digital carriers.



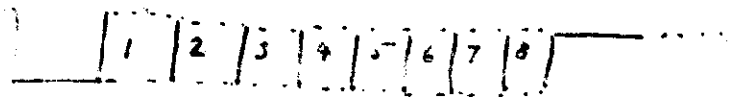
- Easy to multiplex and demultiplex
- Adaptable to digital technology

e.g. PCM, satellite comm^{n} etc. etc.

SERIAL and PARALLEL Transmission

... and Synchronous Trans.

...RONOUS : Character oriented
(start - stop)

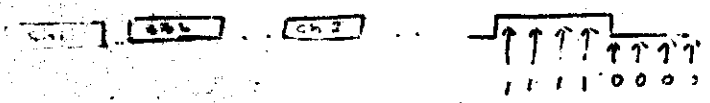


Start
1 bit

(Data + parity)

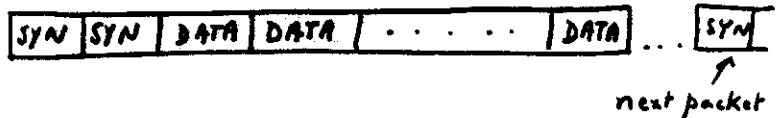
Stop
1, 1.5, 2 bits

- Data transmitted in units of characters
(10, 11 bits)
- No separate clock. Regeneration / synchronization on character basis
- Data regenerated at receiver by sampling
$f_x = 16 f$



SYNCHRONOUS TRANSMISSION

Data transmitted in blocks / packets
of fixed or variable length (~1000 bits)



INDICATORS : SYNC, HEADERS, CONTROL CHARACTERS
END OF PACKET, END OF TRANS.

- ERROR CONTROL : CRC check
ARQ : Automatic Repeat Request

- Bit synchronization
- Frame synchronization

Data exchanged through a PROTOCOL
well standardized. Hardware and software
Recommended for new systems

CIRCUIT SWITCHING, MESSAGE SWITCHING AND PACKET SWITCHING

• CIRCUIT SWITCHING

- end to end 2 way (duplex) connection
  negl. delay, quick interaction possible
  Examples: Telephone, Telex.

• MESSAGE SWITCHING

- Full messages are stored at a node (switch) forwarded when free path available ("store and forward")
- Error Control. Messages regenerated at each node
- Better reliability
- Delay, depending upon network
  No interaction possible (No end to end physical connection)
- Good utilization of resources
  Example: Telegram service

• PACKET SWITCHING

("Advantages" of circuit and message switching)

- Messages split into packets, (recomposed at terminal "switch")
- Small size of packets, reduce delay
- Error control
- Tolerable delay, interaction possible
  - "logical" end to end connection or "virtual"

  Example: Airline reservation system

Recommended for all new networks

SYSTEM IMPLEMENTATION

putting it all together

- Exact spec for hardware and software
- Spec. for each module incl. input/output
- Spec. for test of each module

- Power supply (tolerances, etc)

- Special conditions
- Detailed documents • operation
  - maintenance/repair
    (details of signals to be applied and waveforms to be observed)
    or an automated test
  - Technical details · any critical components
    · any spl. tuning, trimming required.
- The user and the Designer may not be the same person
- Work should be transferable

FAULT DIAGNOSIS AND TEST

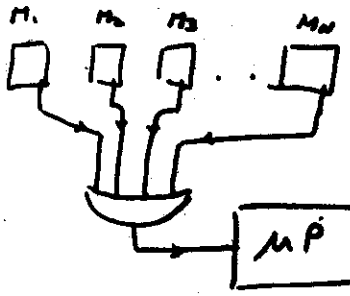
Types of faults: fixed or intermittent (transient)

Stuck at 1
Stuck at 0

- Testing combinational circuits is more easy than testing sequential circuits
- Memories and similar circuits with "regular" structure are easy to test
- Some ckts. are pattern sensitive

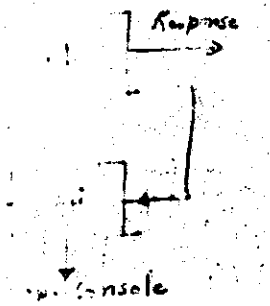
Typical tests for diagnosis of faults

Passive Diagnosis:



- Absence of voltages
- Absence of clocks or other repetitive signals (use mono shots)
- Use processor time slice to fire a monoshot regularly
- Parity
- Absence of any spl. signal

... that cannot be checked by ... feeding an input signal and ... response.



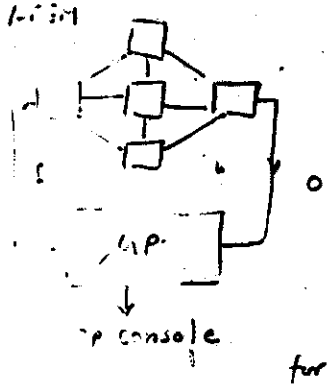
... Detection of any irregular ... will automatically schedule a routine ... will generate and feed a test signal pattern to the selected ... Check the response.

All this is to be incorporated at the design stage only

Nominal extra hardware 5 - 10 %

... DIAGNOSIS

... requires simulation of more complex input conditions and checking the overall system behaviour to be done periodically.



A system checkout program ... tests the most significant aspects of the system is also required for a quick check and operator confidence

No separate programs are needed to be developed for diagnosis. Small routines for testing separate modules during hardware development are to be adapted and integrated into one system

ONLINE DIAGNOSIS
↓
... smallest replaceable module resident in the system)

OFFLINE DIAGNOSIS
(very detailed)
↓
testing modules and isolate faulty component

Interconnection and Packaging

Interconnection between

- Racks
- Modules
- Cards
- Ics on the same card

Minimize the effect of impedance mismatch

Minimize effect of noise

Imp matching important for very high speed ckts
(rise times are comparable to delay times)

Noise tolerance achieved by shield cables twisted pairs and differential drivers and receivers
(from card to card)

- Types of families : TTL LSTTL CMOS
  problems when mixed, due to mismatch in input output characteristics

Noise immunity of device is also important
TTLs generate noise and hence decoupling required invariably

Spl. components. Opto isolators
Transformer coupled bus

Power supplies. Protection against failure
battery backup for atleast limited section
eg. CMOS Mem.

Reliability

- Inherent to the design
- Slower components
- Lower power components
- Minimize mechanical contacts (fewer socket pins)
- Minimize soldered connections (wire wrap better)
- Minimize the no. of ICs
- Good cooling
- Fault Tolerant Design
- Duplication or N+1 redundancy of critical modules

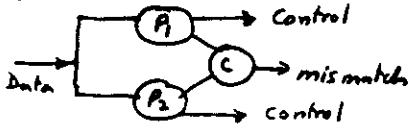
Duplication of control. (μP)

- Load sharing (same work shared by 2 or more μP_s)
- Cold stand by (spare μP switched in when needed)
- Hot stand by 2 μP process same data, one controls expt. outputs are compared

mismatch → fault → Diagnostic routine for both → Isolate fault free μP

→ work continues with fault free processor → Repair / replace faulty μP

bring replaced μP in synchronism with the other μP

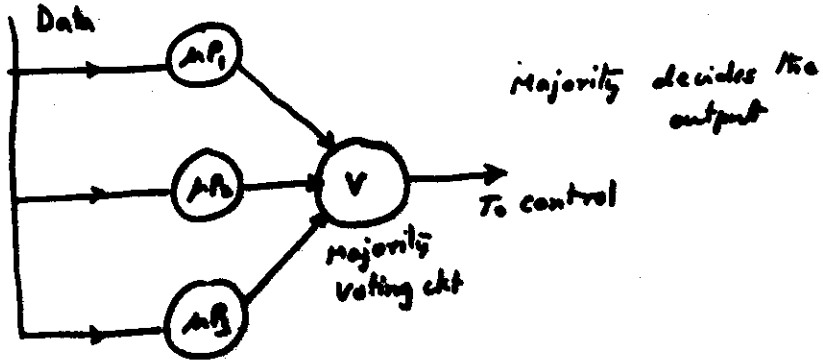


Problems specific to µP systems.
(Hot standby)

- Diagnostic routine may take too much time
  delay not acceptable
- Hardware and software overhead too high

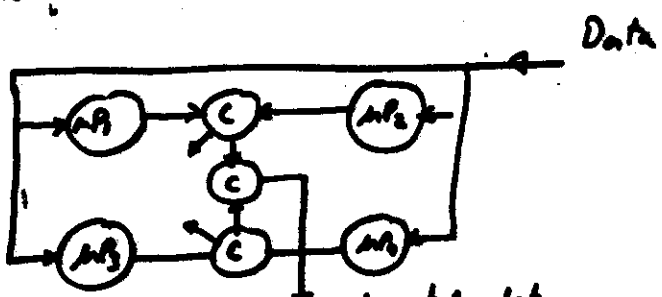
Other possibility :

Triplicated Control



More popular with µP

Duplicated Doublets



Advantages :
- Immediate detection and isolation of the faulty doublet
- Simple hardware and software for implementation