ROYAL OBSERVATORY, HONG KONG

Technical Note No. 85

An Updated Version of the Real-time RAINFALL DATA ACQUISITION SYSTEM of the Royal Observatory

by

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1. INTRODUCTION

Based on microprocessor, the first version of the Royal Observatory's Rainfall Data Acquisition System (RDAS) was installed in 1983. It consisted of a central station and 20 field stations. Each field station was equipped with a tipping-bucket raingauge and was connected to the central station via dedicated telephone wires.

Because of obsolescence of some electronic spare parts, it was necessary to replace RDAS with a new version, RDAS II, in 1991. In planning the RDAS II, reference was made to the Observatory's previous designs as documented in Lam and Li (1979), Lee (1984), Yeung et al. (1989).

In essence, the RDAS II made use of : a) an IBM-compatible personal computer as the central station to minimise reliance on specialised electronic parts; and b) packet-switching circuits which are available commercially in Hong Kong at a relative low cost.

This report provides technical details for the design and construction of the RDAS II.

The design of RDAS II aims at the following objectives :

(a) Each tip of the raingauge bucket is converted into an electrical signal with contact bouncing elimination.

(b) Processed data from each field station are sent to the central station every five minutes.

(c) The central station has to be capable of handling the following tasks :

  i. to process the rainfall information from all field stations, print the results on a line printer and drive a remote display,

  ii. to archive the raw data on magnetic disk,

  iii. to forward the rainfall information , real-time or backlog, to a minicomputer (MV20000).

(d) The System should be equipped with power back-up, both at central and field stations to ensure smooth operation during domestic power fluctuations or interruptions.

(e) Problems arising from electrical interferences like lightning surges are to be reduced to a minimum.

3. THE DESIGN

(a) System configuration

RDAS II consists of a central station and a number of field stations. A system block diagram is shown in Fig. 1 . Data and control between all field stations and the central station are passed via "Minilink" circuits in a serial asynchronous format.

"Minilink" is a digital data exchange network service offered by Hong Kong Telecom (HKT, 1988). The network ends at each user node with a Network Terminating Unit (NTU) which is essentially a modem. Each node is assigned a dedicated Network User Address (NUA). The central station can communicate with the field station one at a time by addressing the respective NUA.

Each field station (Plate 1) has a field unit, an NTU, a tipping bucket raingauge and a 250VA Uninterruptible Power Supply (UPS). The field unit is an electronic package that accumulates the electrical signals from the raingauge every 5 minutes and passes the latest three 5-minute totals to the central station on request. The NTU and field unit are powered from the UPS which is charged by domestic power. The UPS can back up the station for about 12 hours during domestic power failure. The Field Unit contains a micro-controller based printed circuit board (PCB) as shown in Plate 2, which provides all the functional capabilities for the field station. A detailed discussion of the circuit for the field unit can be found in Appendix 1.

The central station (Plate 3) consists of a standard microcomputer. It polls all field stations every five minutes to get the latest three 5-minute rainfall values. Rainfall amount over longer periods can then be computed as required. The 5-minute rainfall figures of all field stations are sent to a remote mini-computer MV20000 for off-line processing and data archive. The console display is reproduced in the Central Forecasting Office (CFO) so that pressing a pushbutton at CFO will enable selection of data pages to be displayed. For details of operation, please refer to the "Keyboard Monitor" section in Page 9.

The Central Unit of the central station is an AST Premium 386SX/16 running on MS-DOS 3.3 with a VGA monitor, a green monitor and a parallel printer. An NTU with outgoing capabilit-lity and an 1KVA UPS are also installed. The UPS can back up the station for 6 hours during domestic power failures.

The micro-computer is equipped with the following hardware :-

(1) 3MB system memory;
(2) one 5" 1.2M floppy disk drive;
(3) one 3.5" 1.4M floppy disk drive;
(4) one 40 MB hard disk drive;
(5) one printer port;
(6) two serial ports;
(7) one VGA and one CGA card.

The hard disk (drive C) stores the disk operation system, powering up auto-booting routine, and the data acquisition software. The 3.5" floppy disk (drive B) currently acts as data archival. The 5.0" floppy disk (drive A) is mainly for file transfer.

The primary video adaptor VGA drives a VGA monitor. The add-in CGA provides a composite video for a green monitor and a remote multi-channel display. Text output goes through the parallel printer port. A communication port (COM2) is connected to the NTU and then to a "Minilink" circuit at 2400 bps, asynchronous, full duplex. Polling of field stations is done through this port. Another communication port (COM1) is linked to the minicomputer MV20000. See Appendix 2 for details of data protocol and format.

(b) Tipping bucket raingauge

The tipping bucket raingauge (Plate 1) is manufactured by Casella London Ltd, with model number W5724. It is a 400 cm^2-orifice tipping bucket raingauge with a 0.5 mm sensitivity.

This instrument employs a light weight plastic injection moulded 'tipping bucket' and support assembly. The bucket mechanism, containing stainless steel pivot pin, rests upon stainless steel pins locating in the support assembly.

The use of pins allows a rolling rather than a pivoting motion to occur with each bucket tip, thus reducing the likelihood of friction occurring. At each tip of the bucket a magnet, contained within the bucket moulding, closes a reed switch mounted in the support assembly. The product of the raingauge sensitivity (0.5 mm) and the number of tips made within a certain time interval will give the accumulative rainfall amount over that period.

(c) Transmission of Rainfall Data at the field station

The closure of the reed switch of the raingauge triggers an electronic counter in the field unit. The field unit maintains 4 counting buffers A, B, C and D. On each tip of the raingauge, the content of buffer A is increased by one. Buffers B through D hold the latest whole 5-minute tip counts so that at the end of a 5-minute interval, the content of buffer C is moved to buffer D, that of buffer B to buffer C and that of buffer A to buffer B.

Each field unit is polled by the central station at regular 5-minute intervals. When polled the contents of buffer B to D are formatted and transmitted to the central station via the NTU and Minilink network. See Appendix 2 for details of data protocol and format. See Appendix 5 for a thorough circuit description of the field unit.

(d) Reception and Processing of Rainfall Data at the central station

Development

The same micro-computer was used for the development and testing of RDAS II software. All source codes were written in 8086 assemble language. The operating version includes an executable file RDAS2.EXE and an overlay file RDASOVR.R2. RDAS2.EXE controls the sequence of task from initialization to processing cycles. The overlay specifies the archive disk drive and particulars of raingauge sites.

System Start up

Fig. 4 shows a flow chart for the central station. The program first reads in the overlay "RDASOVR.R2". Then it checks the archive drive for the amount of remaining free space. The screen clock and status field appears. Further program execution stays in the main loop.

The main loop is responsible for all the scheduled tasks. When not polling raingauges, it checks and sends any pending data messages to MV20000 and the archive disk. Then it updates the screen clock and status field, checks the time if a new raingauge poll is to be started and monitors the keyboard for any user input.

Reception of rainfall data

Raingauge polling follows the order of the field station list in the overlay file (Appendix 3). It starts when the minute of time is a multiple of 5, making a total of 288 polls per day.

The field station NUA is fetched from the list and sent to Minilink via the local NTU. Once connected it forwards the enquiry character <ENQ> (05H) and waits for the site to reply with a rainfall data message. When the message is received all right, it acknowledges with <ACK> (06H), or else it just frees the linkage. Missing data can be supplemented from the next poll. Please see Appendix 2 for details. Such procedures are repeated with the next field station. 5-minute rainfall counts are extracted to a raw buffer for later processing.

Processing of data

The Central Unit maintains a raw buffer for holding counts from all field stations and eight processing buffers for keeping account of the total amount of rain fallen for the following different periods:

(1) previous 15-minute interval;
(2) previous 60-minute interval;
(3) previous 4-hour interval;
(4) previous 24-hour interval;
(5) quarter-hourly, reset when the minute is 00,15,30,45;
(6) hourly, reset when the minute is 00;
(7) mid-night daily, reset when the time is 00:00;
(8) 3 p.m. daily, reset when the time is 15:00.

Fresh data in the raw buffer are used to compute the content of each processing buffers. The results are used to format the various products required: accumulated and running totals over different periods for the screen and line printer. 5-minute data are also sent to archive disks and the MV20000.

Screen Display

Samples of screen display can be found in Fig. 7. The screen display is partitioned with a horizontal dash line into 2 parts The upper one shows tabulated rainfall totals and field status in five pages. The lower one shows the system status such as total number of fields, NUA of central NTU, NUA of field NTU with any error prompts during polling and free space left in archival disk. The five pages on the screen to be shown in the upper part are described below.

Page 1, 2, 3 and 5 on the screen show rainfall data. Page 4 shows field station status. The column headed by "STN" is common to all pages. It denotes the station mnemonics in the order as they appear in the overlay file. All rainfall values shown have a range of 0 to 999.5 mm. Overflow is denoted by "OVRFW". Data not available is denoted by " /// ". Values exceeding preset threshold levels will be shown preceded by the character '*' or '"'.

* when the value has just exceeded the threshold in the latest 5-minute interval but not the preceding one.

" when the value exceeded the threshold in the last two 5-minute intervals.

Current threshold values are:

(1)	1/4HR	15-minute running total	15 mm
(2)	1 HR	1-hour running total	30 mm
(3)	4 HR	4-hour running total	50 mm
(4)	24 HR	daily running total	100 mm
(5)	Q	15-minute accumulated total	15 mm
(6)	H	1-hour accumulated total	30 mm
(7)	D	daily accumulated total	100 mm
(8)	15:00	daily since 15:00	100 mm

(1) Screen Page 1 : running totals

The columns headed by "1/4HR", "1 HR", and "4 HR" are running totals for the following intervals:

1/4HR = previous 15-minute interval;
1 HR = previous 60-minute interval;
4 HR = previous 4-hour interval.

(2) Screen Page 2 : accumulated totals

The column headed by "Q", "H" and "D" are accumulated totals since last data buffer reset:

Q = quarter-hourly, reset when minute is 00,15,30,45;
H = hourly, reset when minute is 00;
D = daily, reset when the time is 00:00.

(3) Screen Page 3 : daily totals

Column "LOCTN" is abbreviated field locations. "D" is the same as in page 2. "24 HR" is the running total for the previous 24-hour interval.

(4) Screen Page 4 : site status

"LOCTN" is the same as in page 3. "Call No" is the field NUA. "TIP" is the rain data in tip count for normal data. Sometimes it shows "<L>", "<R>" and "<N>" for local (or central) NTU error, remote (or field) NTU error and no data respectively. "RXC" increments by one each time a correct data message is received from the raingauge site, up to 288.

(5) Screen Page 5 : daily since 15:00

The column headed by "15:00" lists the accumulated totals since last reset at 15:00 the previous day, coinciding with the practice of manual observation in the conventional raingauge network.

Line printing

Page 2 accumulated rainfall total is printed when the minute of the poll time is 00, 15, 30, 45. Page 5 is printed when the time is 15:00. The format and content is the same as the screen display.

Keyboard monitor

The page displayed can be selected with "1" to "5" or the space bar. When CTL-B is pressed the last line of status field prompts a line for further command:

"Suspend /Abort to Dos /Force RG scan /Dump MV ---> (S/A/F/D) ?"

(1) S = Suspend to DOS

Suspend the program and exit to disk operation system (DOS) temporarily. Type "exit" to resume the program.

(2) A = Abort to DOS

Terminate the execution of the program.

(3) F = Force RG scan

Force a raingauge polling irrespective of the current time.

(4) D = Dump MV

Dump the previous 36 sets of data to MV20000. The data pending count for MV20000 in the status field becomes 36 at once.

4. MAINTENANCE

There is little need of routine maintenance work for the system. It simply includes cleaning of floppy disk magnetic head for the central station. Since the central station is just a common microcomputer, most of the spare parts can be readily obtained. To ensure proper operation of the raingauges which are inevitably exposed to weather and subject to environmental influences, regular visits to field stations are required. Replacements of the batteries inside the UPS might be necessary once every two years.

5. DISCUSSIONS

Apart from some minor adjustments in software and hardware during the installation period, RDAS II has been operating satisfactorily. The usual problem was the tripping of NTU or field units in remote rural areas where domestic power was interrupted frequently. However the additon of a rechargeable 6V battery as an internal power backup for the field unit in March 1992 tremendously reduced the tripping rate. This modification was subsequently generalized to all field stations and included in the field station circuit diagram.

A flat battery in the UPS will prevent it from providing normal a.c. supply to the RDAS II even upon the restoration of the domestic mains. Therefore, UPSs of greater capacities should be employed in places where frequent and prolonged power outages are expected.

Operation of the RDAS II is simple. Only replacement of the archive floppy disk is needed, about once every four weeks.

Apart from NTU or leased line break-down, data and control between fields stations and the central station is generally reliable. The protocol and communication format ensure that no false information is received.

6. ACKNOWLEDGEMENT

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The efforts and contributions offered by Mr. L. H. Lit, Mr. M. C. Chiu and Mr. Y.W. Ng during the implementation and installation stages are gratefully acknowledged.

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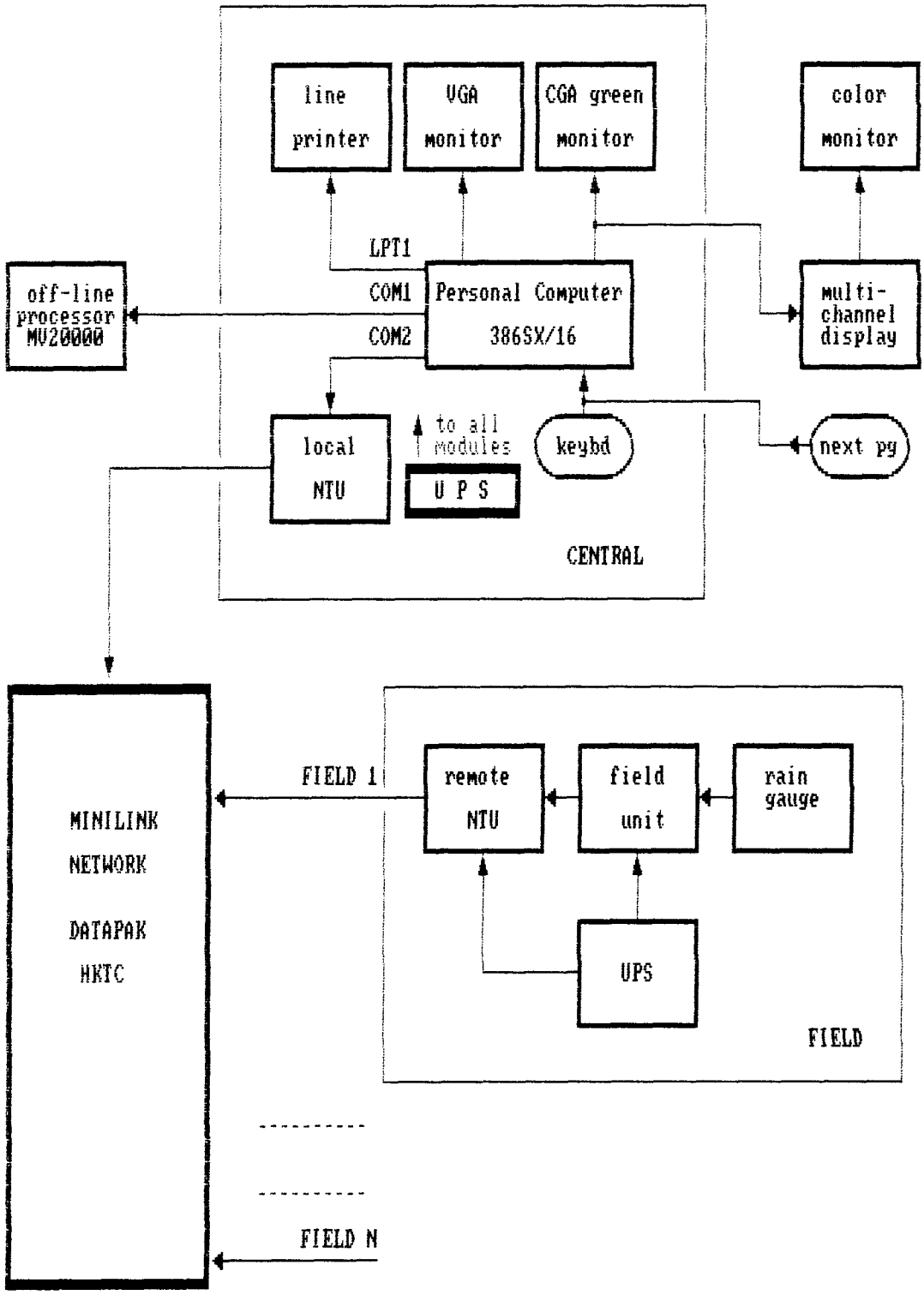


FIG 1 SYSTEM BLOCK DIAGRAM

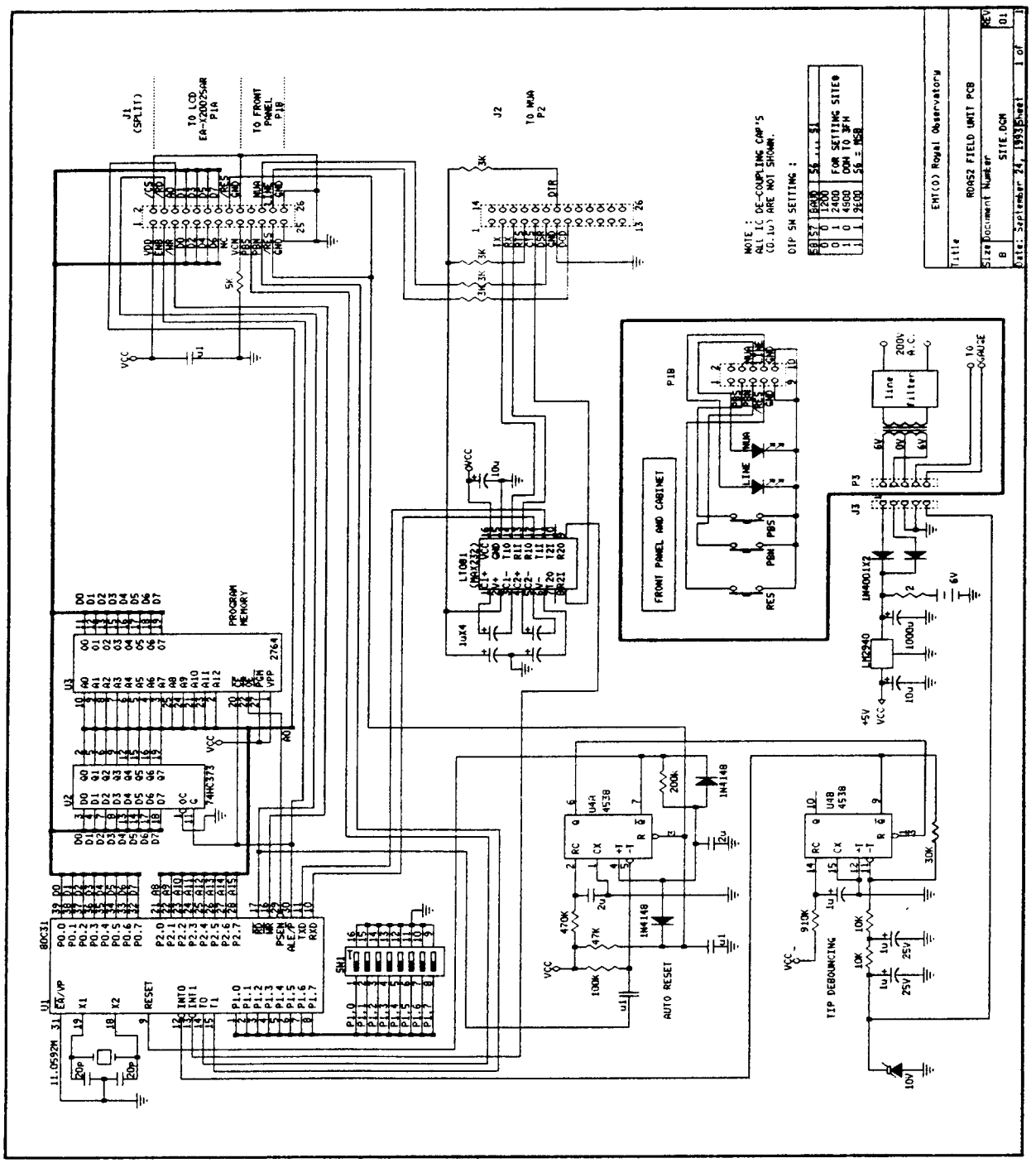


FIG 2 FIELD UNIT CIRCUIT DIAGRAM

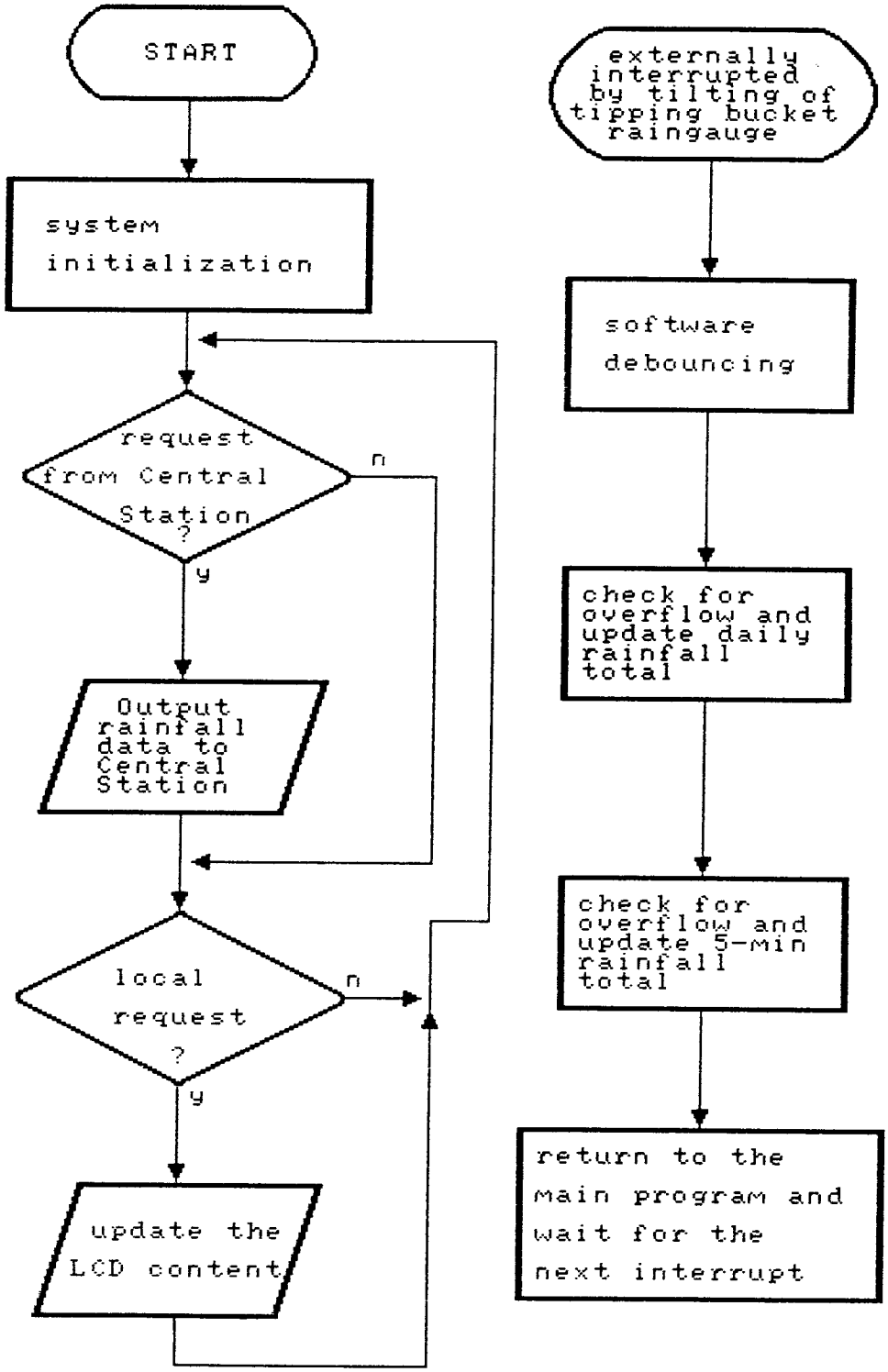


FIG 3 FIELD STATION FLOW CHART

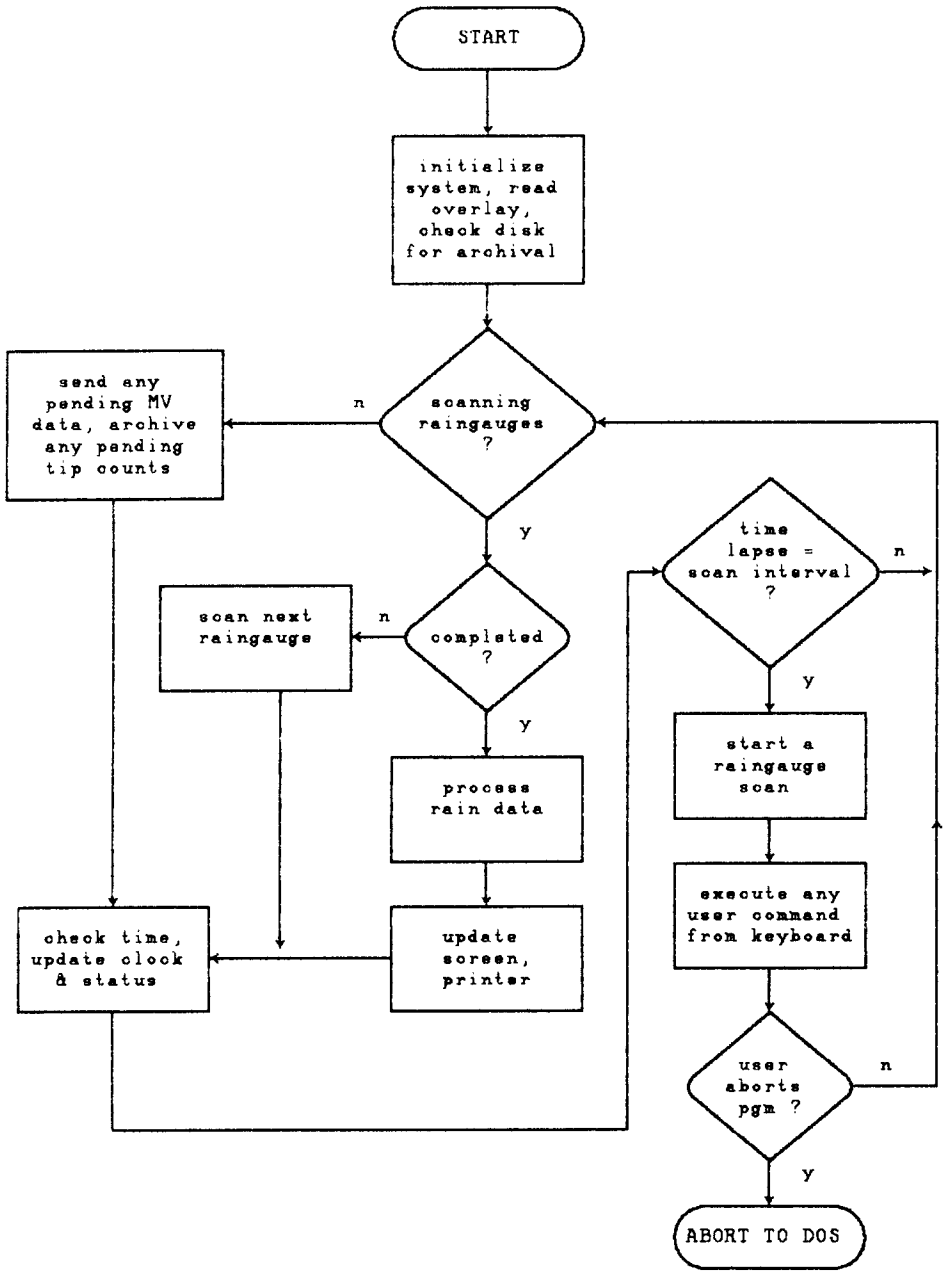


FIG 4 CENTRAL STATION FLOW CHART

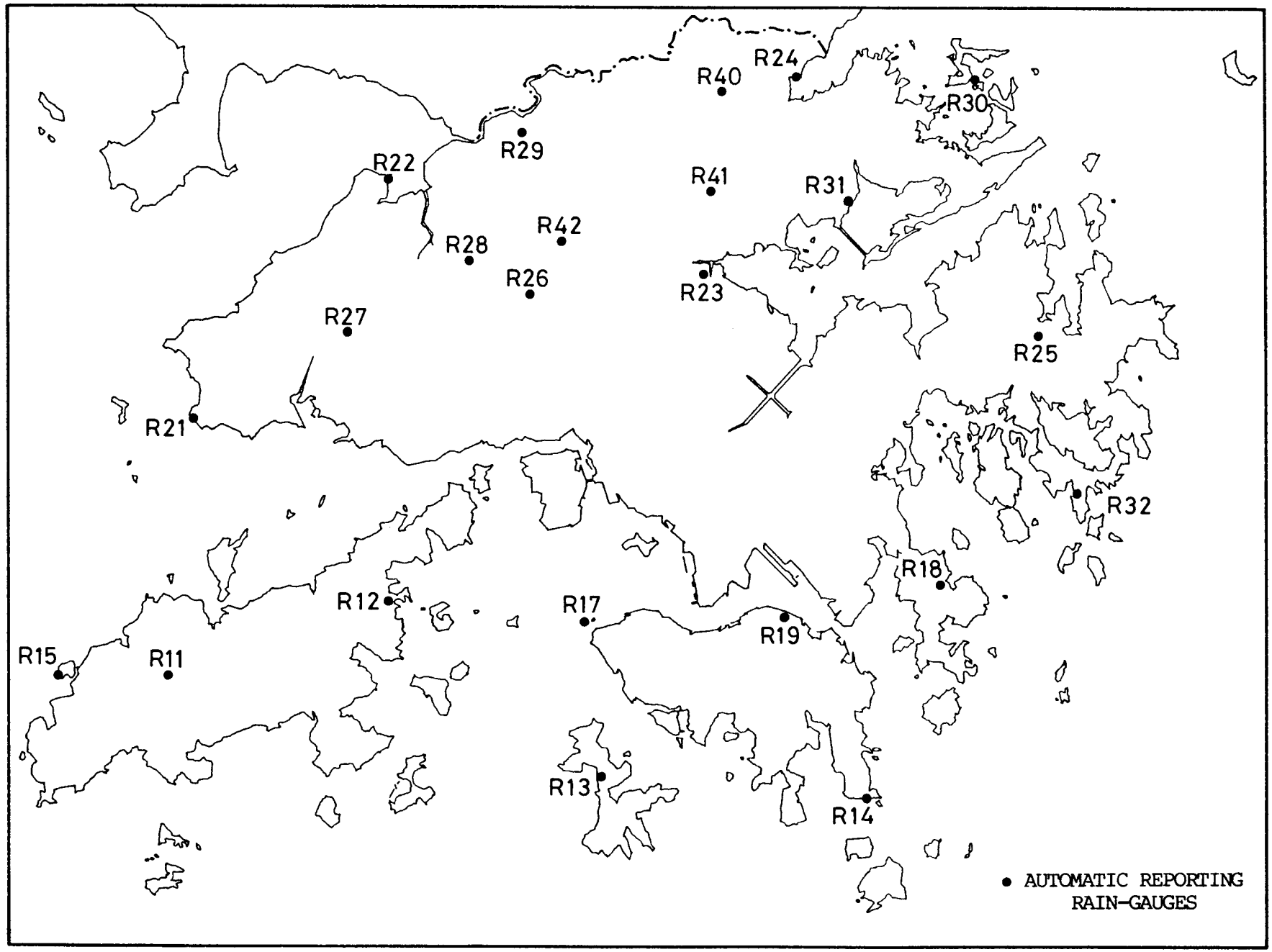


FIG 5 MAP SHOWING FIELD STATION LOCATIONS

Page #	Page Content
	0 5 10 15 20 |....|....|....|....|
0	HH:MM:SSH DD-MM-YY xxx.x xxx.x xxx.x mm
1	Daily since 00:00H xxx.x xxx.x xxx.x mm
2	5-minute tip counts xxH xxH xxH xxH
3	1 = data sent & ack 00000000 00000000 0
4	Site number = xxH Baud 2400:8DN1 CTS=0
5	Tip test ... Tip count = xxH

FIG. 6 -- FIELD UNIT LCD CONTENTS

R.O. RAIN DATA PG.1 - RUNNING TOTALS 13:35 03-APR-92

STN	1/4HR	1 HR	4 HR	STN	1/4HR	1 HR	4 HR	STN	1/4HR	1 HR	4 HR
R11	0	0	0	R19	0	0	0	R27	2.0	3.0	5.5
R12	1.0	2.0	3.5	R21	///	///	///	R28	0	0	0
R13	0	0	0	R22	///	///	///	R29	0	0	0
R14	0	0	0.5	R23	0	0	0	R30	0	0.5	1.0
R15	0	0	0	R24	1.0	1.5	2.0	R31	0	0	0
R16	0	0	0.5	R25	0	0	0.5	R32	1.0	3.0	4.5
R17	0.5	0.5	1.5	R26	0	0.5	3.0	R42	0	0	0
R18	0	0	0								

Gauge:22 Datapak: 5321 786 13:35:58 03-APR-92
Data pending: MV - 001 Archives - 001
Drive B: 01324KB free (030) day

Fig.7 (a) Sample screen display -- page 1.

R.O. RAIN DATA PG.2 - ACCUMULATED TOTALS 13:35 03-APR-92

STN	Q	H	D	STN	Q	H	D	STN	Q	H	D
R11	0	0	0	R19	0	0	0	R27	1.0	1.5	10.0
R12	0.5	1.5	5.0	R21	///	///	///	R28	0	0	0
R13	0	0	0	R22	///	///	///	R29	0	0	0
R14	0	0	2.0	R23	0	0	0	R30	0	0.5	1.5
R15	0	0	0	R24	0.5	1.0	4.0	R31	0	0	0
R16	0	0	0.5	R25	0	0	1.0	R32	0.5	1.5	6.0
R17	0	0	1.5	R26	0	0.5	3.5	R42	0.5	1.5	6.0
R18	0	0	0								

Gauge:22 Datapak: 5321 786 13:35:58 03-APR-92
Data pending: MV - 001 Archives - 001
Drive B: 01324KB free (030 day)

Fig.7 (b) Sample screen display -- page 2.

```
R.O. RAIN DATA PG.3 - DAILY ACCD & RUNG                    13:35  03-APR-92

STN LOCTN     D      24HR | STN LOCTN     D      24HR | STN LOCTN     D      24HR
---+-----+------+------ | ---+-----+------+------ | ---+-----+------+------
R11 Ngong     0       0   | R19 QUARY     0       0   | R27 YLong    10.0    12.0
R12 Discv     5.0     5.0 | R21 TSKok    ///     ///  | R28 AuTau     0       0
R13 Lamma     0       0.5 | R22 T B T    ///     ///  | R29 LokMa     0       0.5
R14 CapeD     2.0     3.0 | R23 Taipo     0       0   | R30 Kat O     1.5     1.5
R15 Tai O     0       0   | R24 S T K     4.0     4.0 | R31 TMTuk     0       0
R16 CChau     0.5     4.5 | R25 PT Au     1.0     2.5 | R32 Hi Is     6.0     7.0
R17 Green     1.5     1.5 | R26 SKong     3.5     3.5 | R42 YLFSD     6.0     7.0
R18 LHWan     0       0


Gauge:22 Datapak: 5321 786                                 13:35:58 03-APR-92
Data pending:  MV - 001  Archives - 001
Drive B: 01324KB free (030 day)
```

Fig.7 (c) Sample screen display -- page 3.

```
R.O. RAIN DATA PG.4 - SITE STATUS                          13:35  03-APR-92

STN LOCTN CALL No TIP RXC |STN LOCTN CALL No TIP RXC |STN LOCTN CALL No TIP RXC
---+-----+-------+---+--- |---+-----+-------+---+--- |---+-----+-------+---+---
R11 Ngong 5511661 000 288 |R19 QUARY 5571367 000 288 |R27 YLong 5391330 002 288
R12 Discv 5511502 001 288 |R21 TSKok 5321821 <R> 000 |R28 AuTau 5371523 000 288
R13 Lamma 5513204 000 288 |R22 T B T 5321732 <R> 000 |R29 LokMa 5371547 000 288
R14 CapeD 5581340 000 288 |R23 Taipo 5384002 000 288 |R30 Kat O 5381412 000 288
R15 Tai O 5511440 000 288 |R24 S T K 5381406 001 288 |R31 TMTuk 5384014 000 288
R16 CChau 5511813 000 288 |R25 PT Au 5361279 000 288 |R32 Hi Is 5361061 001 288
R17 Green 5531530 000 288 |R26 SKong 5371546 000 288 |R42 YLFSD 5437006 000 288
R18 LHWan 5361338 000 288 |


Gauge:22 Datapak: 5321 786                                 13:35:58 03-APR-92
Data pending:  MV - 001  Archives - 001
Drive B: 01324KB free (030 day)
```

Fig.7 (d) Sample screen display -- page 4.

```
R.O. RAIN DATA PG.5 - DAILY SINCE 15:00                    13:35  03-APR-92

| STN  15:00 | STN  15:00 | STN  15:00 | STN  15:00 | STN  15:00 | STN  15:00 |
|---+------  |---+------  |---+------  |---+------  |---+------  |---+------  |
| R11    0   | R15    0.5 | R19    0   | R24    4.0 | R28    0   | R31    0   |
| R12    5.0 | R16    4.0 | R21    ///| R25    2.0 | R29    0   | R32    4.0 |
| R13    2.0 | R17    0.5 | R22    ///| R26    2.5 | R30    1.0 | R42    0   |
| R14    3.0 | R18    0   | R23    0   | R27    9.5 |

Gauge:22 Datapak: 5321 786                                 13:35:58 03-APR-92
Data pending:  MV - 001  Archives - 001
Drive B: 01324KB free (030 day)
```

Fig.7 (e) Sample screen display -- page 5.

APPENDIX 1
SPECIFICATIONS OF RDAS II

i. FIELD STATION

1. Raingauge sensor

(a)	Diameter	:	400 cm^2 tipping bucket raingauge
(b)	Resolution	:	0.5 mm per tip
(c)	Output	:	contact closures

2. Processing

(a)	Processor	:	MSM80C31 CMOS 8-bit Single Chip Microcontroller
(b)	Program	:	Stored in one 4kB EPROM 2732
(c)	RAM	:	128 bytes on-chip RAM
(d)	Date/time	:	A software-generated Real-time Clock with accuracy of about 10 seconds per month
(e)	Output	:	A report of the three latest 5-minute accumulative rainfall data
(f)	Report frequency	:	As and when required by the Central Station. The default is every five minutes.
(g)	Report format	:	ASCII codes
(h)	Communication protocol	:	2400 bps, 1 start bit, 8 data bits, no parity bit, 1 stop bit

3. Communication Channel

(a)	Type	:	Minilink circuits of the Datapak Packet Switching Services supplied by Hong Kong Telecom.
(b)	Communication equipment	:	Network Terminating Units at both ends are provided by the Hong Kong Telecom.

4. Power requirements

(a)	A.C. Power	:	220 V / 50 Hz @ less than 100 mA (depends on the Network Terminating Unit provided)
(b)	Battery	:	6 V/6.5 AH Dry Rechargeable
(c)	Backup	:	An Uninterrupted Power Supply of 250 VA

5. Dimensions

(a)	Field Unit	:	230mm W x 230mm D x 100mm H
(b)	Uninterrupted Power Supply	:	175mm W x 390mm D x 130mm H
(c)	Network Terminating Unit	:	Depends on the type provided (16mmW x 29mmD X 3.5mmH typically)

ii. CENTRAL STATION

1. Configuration	:	Standard PC/AT 386SX/16 set up
2. Program storage	:	Hard disk or floppy disk
3. RAM	:	3 MB on board
4. Interaction	:	Standard 101 keyboard and a remote push button for screen page selection
5. Display	:	Primary VGA, Secondary CGA
6. Date/time	:	based on DOS calendar/clock
7. Polling frequency	:	5 minutes
8. Number of field stations	:	Maximum 32
9. Output products on screen	:	running and accumulated totals, system and field status, organized in 5 pages, updated every 5 minutes selected with keyboard, composite video signal of above display
to parallel printer	:	running totals once every 15 minutes daily total since 15:00, print on completion of poll
to off-line processing		5-minute accumulated total to MV20000
10. Data format and protocol	:	all in ASCII codes with format described in Appendix 2.
11. Field communication	:	via Minilink network

Raingauge scan

The data message contains 3 tip count values covering the previous three 5-minute intervals. Even if communication fails two consecutive times the third one makes up the loss. However if it fails three consecutive times the data queue of that site breaks.

Port used: COM2 at 02F8H
Protocol: 2400 b/s, 8 bit/char, no parity, 1 stop bit.

Format:
<SOH>SN D2 D1 D0 CK <ETX>

whereas
<SOH> = 01H;
<ETX> = 03H;

SN	= site number	2-byte ASCII hex;
D2	= previous 10-15 min tip count,	2-byte ASCII hex;
D1	= previous 5-10 min tip count,	2-byte ASCII hex;
D0	= previous 0-5 min tip count,	2-byte ASCII hex;
CK	= check sum of binary values from SN to D0,	2-byte ASCII hex.

Data communication with MV20000

After the data message is sent, it waits for the receiving end to send the acknowledge character <ACK> (06H). If <ACK> comes in, the transmission is deemed successful; the pending count decreases by one. This repeats with next pending set until the count reads zero. If <ACK> is not received in timeout the count does not decrease; the same set will be retried every ten seconds. The pending count will increase by one after each polling up to 36.

In the message the entry for any site with unavailable data is omitted.

Port used: COM1 at 03F8H

Protocol: 2400b/s, 8 bit/char, no parity, 1 stop bit

Format:
<SOH><CR><LF>
YYMMDDhhmm<CR><LF>
SSSK_DDDD<CR><LF>
SSSK_DDDD<CR><LF>
...
...
SSSK_DDDD<CR><LF>
<ETX>

whereas

<SOH>	= 01H;
<ETX>	= 03H;
<CR><LF>	= 0DH, carriage return; 0AH, line feed;
_	= 20H, space;
YYMMDD	= year,month,day, 2-byte decimal each;
hhmm	= hour, minute, 2-byte decimal each;
SSS	= site mnemonic, e.g. R11, R12;
K	= 4BH, identifier;
DDDD	= 5-minute amount in 0.1mm, any leading zero blanked.

Data archival

When a set of rainfall tip counts is to be written to the archival disk, the program searches or creates in the root a primary directory named "RAINDATA". The year-month combination (e.g. 9105 for May 1991) of the poll time is used as a sub-directory under "RAINDATA". The rainfall data set is then appended to a file named with the day time (e.g. 910527 for 27th May 1991) with "TIP" as the extension. At the end of the day the file 910527.TIP will be a file containing 288 sets of rainfall data each having a format as below.

On a successful write the pending count decreases by one. This repeats with next pending data set until the count reads zero. On failure the counts does not decrease; it will repeat with the same data set after the next polling. The pending count will increase by one after each polling up to 288.

Format:

YYMMDD_hhmm<TAB>
SSS=TTT_SSS=TTT_..._SSS=TTT<CR><LF>

whereas

YYMMDD	= year,month,day, 2-byte decimal each;
hhmm	= hour and minute, 2-byte decimal each;
<TAB>	= 09H, tab
<CR><LF>	= carriage return 0DH, line feed 0AH;
_	= 20H, space;
SSS	= site mnemonics, e.g. R11, R12;
TTT	= tip count in 3-byte decimal.

APPENDIX 3
OVERLAY FILE RDASOVR.R2

The file has explanatory comments. The parameter list determines the polling sequence and thus the order with which field data appears on screen, data messages, printer copies, etc. The first one is by default the central outgoing NTU.

```
;-------------------------------------------------
;     -----*** OVERLAY FOR RDAS2 ***-----
;-------------------------------------------------
;     IT SPECIFIES:
;
;     1. DISK DRIVE AS DATA ARCHIVES (A,B,C,D)
;     2. LIST OF RAINGAUGES
;
;     (NOTE: CHARACTERS AFTER ';' ARE IGNORED.)
;-------------------------------------------------
;
      B                          ;archive drive
;
; PARAMETER LIST FOR SITE #00 - #32
; <TAB>SSS<TAB>LLLLL<TAB>NNNNNNN<TAB>;remark<CRLF>
;
      R00  Centl  5321786  ;Central station at Royal Obseratory
      R11  Ngong  5511661  ;Ngong Ping Tea Farm
      R12  Discv  5511502  ;Discovery Bay Water Treatment Works
      R13  Lamma  5513204  ;Lamma Police Station
      R14  CapeD  5581340  ;Cape D'aguilar
      R15  Tai O  5511440  ;Tai O Royal Navy Coastal Station
;
      R17  Green  5531530  ;Green Island signal station
      R18  LHWan  5361338  ;Sam Yuk Middle School
      R19  Quary  5571367  ;Quarry Bay Tide Gauge House
      R21  TSKok  5321821  ;Tap Shep Kok Power Station
      R22  T B T  5491023  ;Tsim Bei Tsui Meteorological Station
      R23  TaiPo  5384002  ;Wong Shiu Chi Middle School
      R24  S T K  5381406  ;Sha Tau Kok Police Station
;
      R25  PT Au  5361279  ;Pak Tam Au Country Park Management Centre
      R26  SKong  5371546  ;Shek Kong RAF Airfield
      R27  YLong  5391330  ;Yuen Long R.G. Filters
      R28  AuTau  5371523  ;Au Tau Fish Farm
      R29  LokMa  5371547  ;Lok Ma Chau Police Station
      R30  Kat O  5381412  ;Kat O Fisheries Research
      R31  TMTuk  5384014  ;Tai Mei Tuk Pumping Station
      R32  Hi Is  5361061  ;Leung Shuen Wan Public School
;
;     R40  RNest  -------  ;Robins Nest (to be installed)
;     R41  C Hil  -------  ;Cloudy Hill (to be installed)
      R42  YLFSD  5437006  ;Fire Services Dept. Training School
;                              ;Pat Heung, Yuen Long
```

APPENDIX 4
INSTALLATION

i. FIELD STATION

Installation of the field station

The following guidelines are useful to the technical personnel in the installation of the field station :

- Connect the Field Unit, the NTU, the raingauge and the UPS in the order shown in Figure 1. Remember to face the LCD panel of the field unit away from direct sunlight to prolong its life.

- Set the DIP switch on the PCB for station number and the communication baud rate as shown in Fig 2. Adjust the real-time clock to current time as follow.

  a. Select the wanted page of the LCD panel by pressing pushbutton 'NEXT'.

  b. Press the two pushbuttons labelled SET and NEXT simultaneously to invoke the LCD to set-clock mode for which the element to be set will start to blink.

  c. Advance the element value by pressing the pushbutton 'SET'. A firm touch will make a rapider change. Press 'NEXT' to move to next element.

  d. When the setting is alright, just leave the buttons untouched. It will automatically resume to normal operation mode in a few seconds.

- Pour a known amount of water into the raingauge for checking accuracy of measurement. Call the field manually from the central station. See if the correct data are received.

- If the readings are consistent, keep an eye on the field unit for a few more automatic calls. Simulated test data can be inserted in between calls for further accuracy ensurance.

- Test the battery by switching off the a.c. input of the field unit. See if any abnormalties occur.

- Test the UPS by turning off its a.c. input . Observe whether the field station still works properly.

- Make sure that all the equipment are switched on before leaving the station.

- It is advisable to have Hong Kong Telecom staff present on the installation day as they may help to clear any faults found in the communication channel. Otherwise, one trip may be wasted.

ii. CENTRAL STATION

Central unit pre-intallation

The central unit is actually a standard personal computer readily purchased from the market. The supplier has already adapted it with features up to customer's requirements. Thus, for details of installation of individual modules within the personal computer, refer to the supplier's user manual. These include the on board 3M RAM, floppy disks, hard disk, printer and serial ports, video adaptors etc.

There are two major changes to the origin version: the addition of a CGA video adaptor to one of the spare slot inside the personal computer, and the modification of the keyboard for remote control of screen display.

The personal computer includes integrated VGA as the primary video display adapter. However VGA has no composite video output which is required as one of the inputs for a remote multi-channel display. The least expensive choice is the use of a CGA card which has two composite video outputs. Adding-in the CGA card requires no change to the orignial system board switch settings. However, the VGA can only work in monochrome mode then.

The keyboard must be of contact-closure type (not those using reactance effect). The contact electrodes of the space bar key is connected to the normal-open contacts of a small 5V relay housed inside the keyboard. The actuating coil is fed with the 5V from the keyboard via a phone jack. The phone jack is installed on the rear edge of the keyboard. It allows long wiring for remote actuation of the relay, and thus the space bar key with a push-button switch.

Network terminating unit

This unit is supplied with features specified on leasing of the minilink service. The defaulted data transfer protocol cannot be altered by the user. Parameters have been set as follow:

001:001, 002:001, 003:002, 004:000, 005:002, 006:001
007:021, 008:000, 009:000, 010:000, 011:012, 012:000
013:016, 014:000, 015:001, 016: bs, 017:can, 018:dc2
019:002, 020:000, 021:000, 022:000, 118: bs, 119:can
120:dc2, 121:000, 122:000, 123:000, 125:005, 126:016

Number	Description	Value	Parameter meaning
1	PAD recall	1	possible, using DLE (10H)
2	echo	1	echo
3	data forwarding	2	using CR (0DH)
4	idle timer timeout	0	not forwarding on timeout
5	ancillary control	2	XON/XOFF terminal control
6	service signals	1	signal from network
7	on break signal	21	discard output and break
8	discard output	1	normal data delivery
9	padding after CR	0	no padding after CR
10	line folding	0	no line folding
11	binary speed	12	2400 bits/s
12	flow control	0	no XON/XOFF flow control
13	LF after CR	16	add after PAD-generated CR
14	padding after LF	0	no padding after LF
15	editing	1	in command & data mode
16	character delete	bs	bs (08H)
17	line delete	can	can (18H)
18	line display	dc2	dc2 (12H)
19	editing signals	2	for display terminal
20	echo mask	0	echo all characters
21	parity treatment	0	parity ignored
22	page wait	0	page wait disable
118	(same as 16)		
119	(same as 17)		
120	(same as 18)		
121	forward signals	0	no extra forwarding signals
122	(same as 121)		
123	(same as 21)		
125	o/p pending timer	5	delay in sec before o/p
126	(n.a.)		

Setting up

Put the PC, NTU, printer, VGA monitor and green monitor on to the computer stand provided. Rest the UPS on floor next to the table. Install signal cables first then power cables. Make as tidy as possible. Connect power to the UPS. The UPS supports all modules of the station: PC, NTU, displays and printer.

Connect the carrier signal line from the NTU to the data signal socket. Note the data network address as labelled on the socket jacket. This should match with that stated as the outgoing NTU in the overlay file. Connected the NTU 25-pin D plug to serial port 2 of PC with a full 25-way flat cable.

Connect serial port 1 of PC as output to MV20000. Only the TX, RX and GND signal are used here. Connect printer port to the printer using another 25-way flat cable.

Connect the VGA 15-pin output plug to the VGA monitor. For the CGA card, connect one of the RCA output plug to the green monitor. Connect the other one to the video co-axial cable linking to the multi-channel display at CFO. Also connect the phone jack output on the rear edge of keyboard up to CFO alongside with the former video cable for remote screen page control.

Load print form on the printer. Align to top of form. Insert a formatted 1.4M 3.5" floppy disk to drive B. Leave drive A empty. Power up all modules. Switch the PC to top speed using CTL-ALT-arrow combination key.

The central station is to be run continuously around the clock, thus the hard disk is kept spinning all the time. Any shock to the PC may tremendously reduce its working life.

When the DOS prompt appears on the VGA monitor, check the time and day, amend if necessary, key in "mode co80" to switch the video console to the green monitor. Invoke the RDAS2 program. System starts. Refer to section 3 (d) for further detail.

APPENDIX 5
FIELD UNIT CIRCUIT DESCRIPTION

The enclosure of the field unit is as a black painted metal equipment cabinet with a matt aluminium front panel (see Plate 1). The major modules inside include a micro-controller based PCB and a regulator DC power supply.

On the front panel there is (i) a 2 x 20 characters Liquid Crystal Display (LCD) showing time, rainfall data and site status, (ii) 2 LED dots named LINE and NUA to indicate the availability of Data Carrier Detect (DCD) and Data Set Ready (DSR) signals from the NTU respectively, (iii) a push-button labelled RESET for resetting the field unit in case of abnormalities, (iv) two other push-buttons that serve to select LCD display (see Figure 5) and set clock (see Appendix 4).

On the rear panel there is another push-button for simulating the raingauge tipping contact closure.

The PCB is detailed below. Refer to the circuit diagram in FIGURE 2. The single chip CMOS 8-bit microcontroller MSM80C31, U1, is the main component. It performs the following functions :

a. to monitor the tipping of the raingauge,
b. to compute the 5-minute and daily accumulative totals,
c. to encode the processed data in user-defined format,
d. to serialise the encoded data ,
e. to update the time and rainfall data on the LCD
f. to change the parameters of the serial output and
g. to recognize the data request command from the Central Station.

The system clock is derived from a crystal oscillator formed by an external crystal of 11.0592 MHz and the oscillator circuitry fabricated inside the MSM80C31 chip.

The program, called SITE.BIN , is stored in an EPROM 2732, U3. The Address Latch Enable signal from the 80C31 (U1) is used to clock the address signal from its port 0 which can be latched externally in the tristate latch buffer 74HC373, U2. This address, together with the address from port 2, are used to access the EPROM's contents.

A dual retriggerable monostable multivibrator MC14538, U4, serves for two purposes :

a. to act as a debouncing circuit (about 1 second) for the raingauge reed switch and
b. to act as a power up reset as well as a watch-dog that re-initialize the circuit in case of CPU traps.

U5 is a single 5V powered RS232 line driver/receiver, LT1081. It functions as an interface between the serial port of the 80C31 and the Data Communication Equipment which is the Network Terminating Unit.

The DIP switch SW1, is used to set the baud rate of the asynchronous communication the field station number. See the end note in the circuit diagram.

The D.C. voltage regulation is achieved by using a LM2940CT positive regulator. It provides an output current of 1 A, with an input/output differential voltage as low as 0.5 V. The device is particularly suited for applications where battery life and reversal installation of batteries is a concern.

A 10V tranzorb, is built on board to protect against transients on the raingauge signal line. In places where electrical interference is serious, a R.F. Line Filter is added at the A.C. input to eliminate these spurious interferences.

A = RAINGAUGE HOUSING
B = TIPPING BUCKET
C = NETWORK TERMINATING UNIT
D = FIELD UNIT
E = UNINTERRUPTIBLE POWER SUPPLY

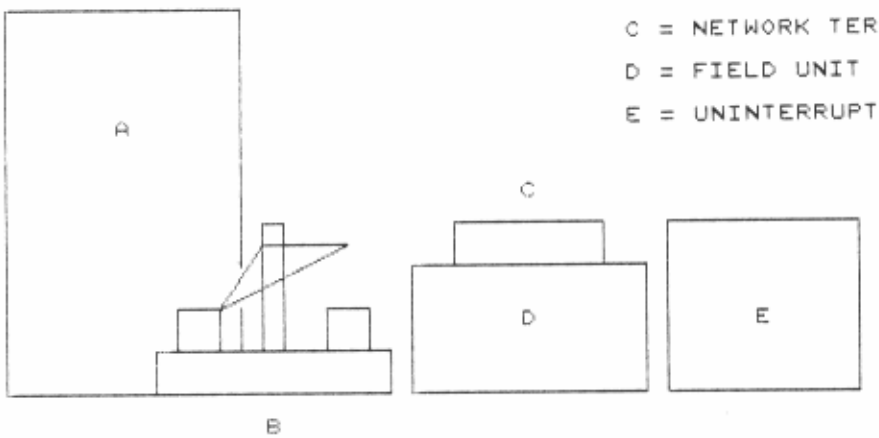


PLATE 1 FIELD STATION

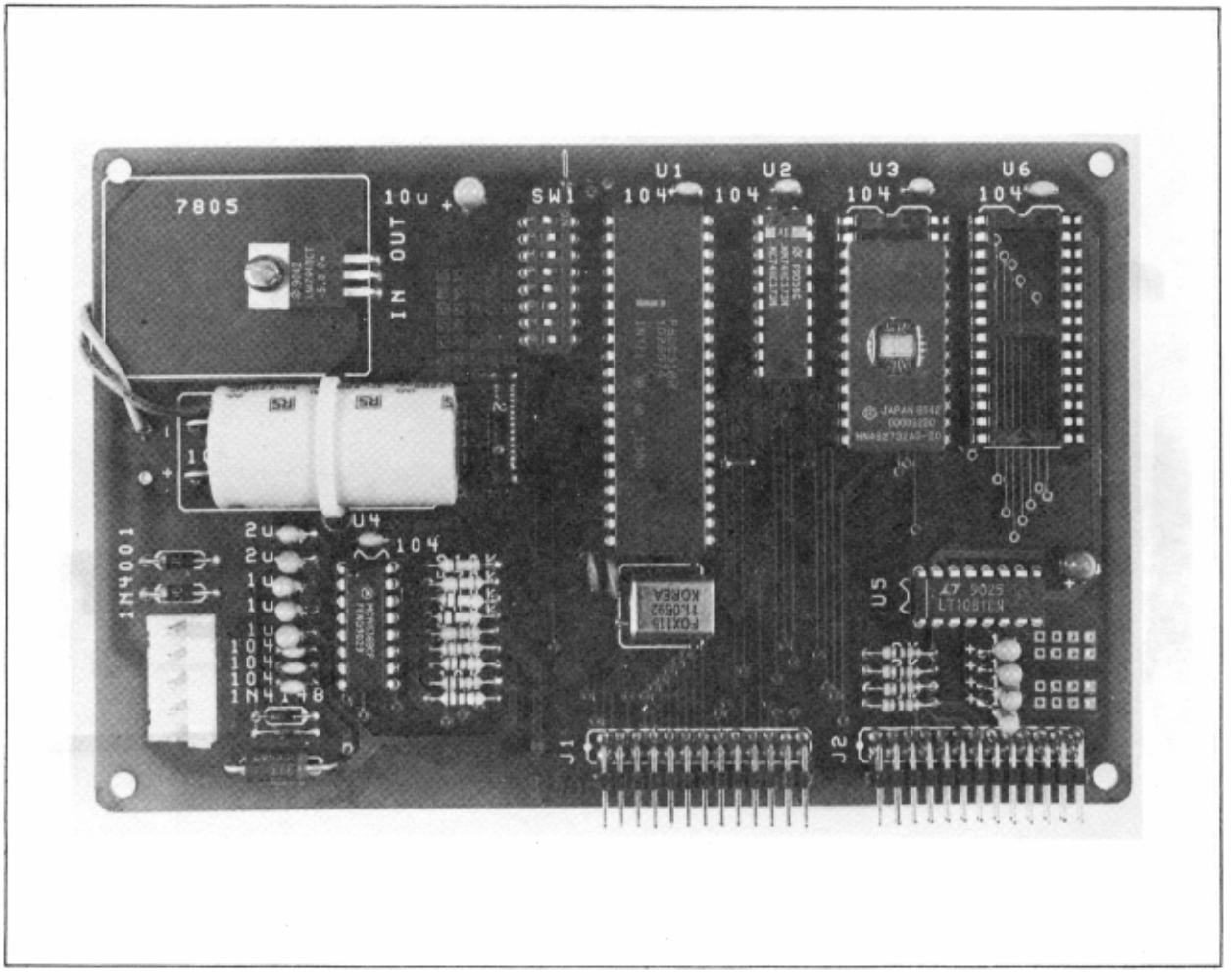
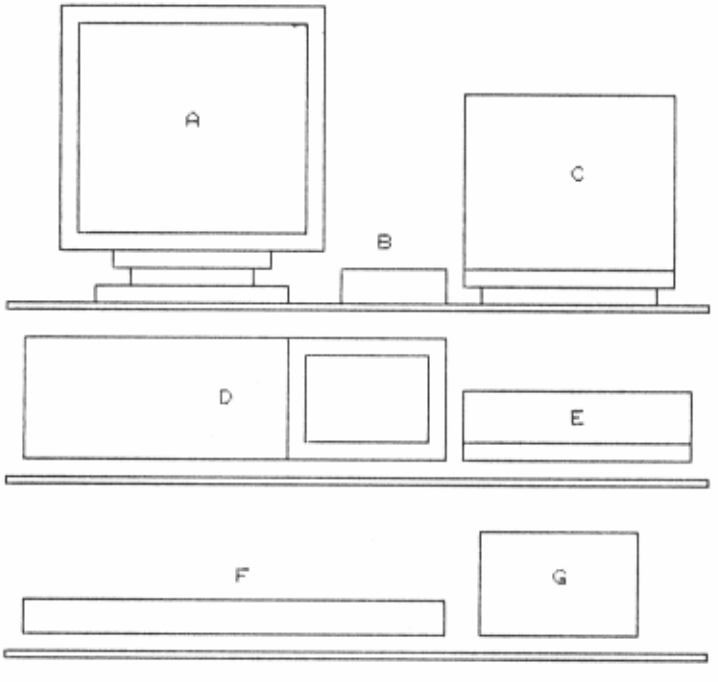


PLATE 2 PRINTED CIRCUIT BOARD FOR THE FIELD UNIT



A = VGA COLOR MONITOR
B = NETWORK TERMINATING UNIT
C = GREEN MONITOR
D = MICRO-COMPUTER 386SX/16
E = PARALLEL LINE PRINTER
F = KEYBOARD
G = UNINTERRUPTIBLE POWER SUPPLY

PLATE 3 CENTRAL STATION