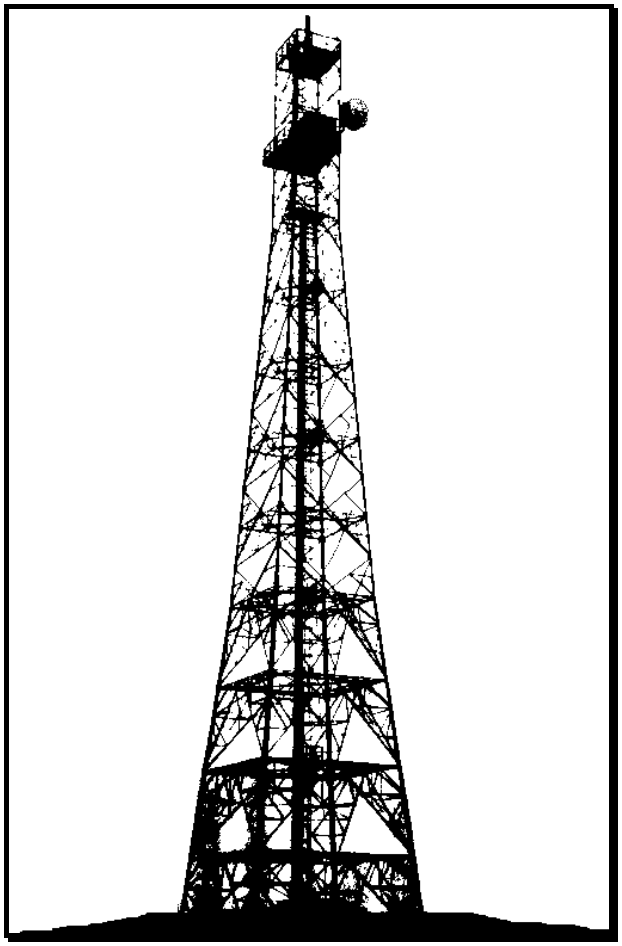
The G8CUL Repeater Logic Technical Manual

This manual is intended to contain all the information required for building, setting up and using the G8CUL Repeater Logic.

The logic itself is a relatively complex piece of electronic design, with a processor containing its own control programme, customed designed for the use of amateur repeaters. The control programme listing is currently over 100 pages in length!



Not all of us are this lucky! This is the tower where GB3TE and GB3CL are located.

From an original photograph by Tony Horsman, G0MBA.

Table of Contents

1 Introduction

The G8CUL Repeater Logic has been designed to provide most features for the control logic of a modern repeater. Nearly all these features can have their parameters individually programmed and set-up using a normal PC with the supplied SETUP.EXE programme. This can be done either locally with the PC plugged directly into the logic, or 'on-air' via a BayComm type modem and a simple adapter.

To avoid all the previously configured parameters being forgotten when the power is removed, an EEPROM device is used to store them.

All setting up is done by simple (normally) 2 character commands with associated optional parameters. This is explained later in section 9.

The control logic is controlled by a microcomputer system which operates the repeater itself, as well as controlling many of the operating parameters of the repeater.

2 Scope of this Document

This manual contains information on building, setting up and using the G8CUL Repeater Logic. Those of you (like me) who like to look at the circuit diagrams will find them in fold-out form at the back of this manual!

3 System Description

In its simplest form, the logic only required 5 connections. These are:-

- Power
- Audio in from the repeater receiver
- Squelch in from the repeater receiver
- Audio to the repeater transmitter
- PTT to the repeater transmitter

The audio signal from the repeater receiver must have its de-emphasis removed, otherwise the incoming CTCSS low frequency tone will be enhanced by the de-emphasis circuitry. Likewise the repeater transmitter must have its pre-emphasis removed otherwise the outgoing CTCSS low frequency tone will be removed. Believe me, it is true, exactly this happened to me on the first installation (GB3CL)! The through audio tailoring is thus 'neutral', with the transmitted audio being the same as that received (within the audio pass band of 300 - 3500Hz).

Audio in from the receiver is split to all devices that need it. They are:

- CTCSS tone detector and generator
- 'Normal' 1750Hz tone burst detection
- DTMF tone detector
- Computer data to the MODEM

The squelch line in from the receiver is also used by the processing system. The processor control programme detects the squelch opening and, if a valid CTCSS tone or tone burst is detected, operates the PTT signal to the transmitter, and feeds the incoming audio to the transmitter input.

Normally, the CTCSS on receive is only used for initial access in a similar way to a tone burst. Once accessed, no further CTCSS tone (or tone burst) is required to keep the repeater open. This is not the conventional PMR use of CTCSS and is basically applicable to 2m and 70cms repeaters. If the CTCSS was used in its more conventional ***continuous*** mode, then only those lucky amateurs equipped with CTCSS would be able to use the repeater at all. All others would not have their incoming audio re-transmitted as there would be no CTCSS to allow it. The outgoing CTCSS is, however, used in a continuous mode (if enabled), except when the repeater is giving its callsign on shutdown or beacon, although the CTCSS may be enabled even for these callsigns if required.

For 6m use, a conventional, continuous CTCSS on receive is required, and this mode of operation can be selected by suitable commands. Likewise, the use of toneburst to initially access the repeater can be disabled. These two features give the required access specification for 6m repeater use.

The CTCSS device itself is interesting, and deserves a bit more explanation. Any incoming CTCSS tone is filtered and detected, and the processor is then informed what the actual received tone frequency is. The processor can then decide if it is the correct tone or not, and act accordingly. The through audio is also filtered by the CTCSS device to remove any incoming tone, and an internal audio switch can be used to control the audio input to the transmitter. The transmit tone is generated independently to the receive detection, thus making the device suitable for repeater operation.

The CTCSS device thus has two outputs, through audio and CTCSS tone. Both of these are mixed together with the outputs from the tone oscillator and computer control MODEM before being peak clipped and finally filtered ready for the transmitter input.

Other facilities include the control of a second receiver/transmitter combination which should be used for remote control on a different frequency (or even band) to that of the repeater itself. Control signals are also provided for the option of a synthesised voice, as well as inputs for repeater linking.

The control programme built in to the repeater logic contains many commands to allow the simple control of all the parameters that can be varied. All control in this way is contained in 'packets' (not to be confused with packet radio

packets!), which contain 'to' and 'from' callsigns, as well as a checksum for data integrity. To simplify this control, a programme written for a PC is freely available, which provides simple keyboard access to all the built-in commands.

These commands consist of:

1. Enable commands - turning options ON.

2. Disable commands - turning options OFF.

3. Read commands - reading things from the logic.

4. Write commands - writing things directly to the memory, ***used with extreme care!***

5. Set commands - setting things to required values.

6. Test commands - control of individual devices for testing.

Of these commands, all can be used with the PC plugged directly into the logic, while only some can be used remotely while 'on-air'.

The original design used a Plessey MV8870 for the DTMF decoder which has now become obsolete. A similar device is now available from MITEL, the MT8870. Unfortunately, the codes it gives for the '0', '*' and '#' keys are different! The firmware provides a command to select which part is used. See sections 8.4.4.8, 9.1.1.3 and 9.1.2.3 for details. Note that a small wiring modification to the PCB is required if a MITEL device is used *and* the DTMF digits 'A' - 'D' are also required.

4 Specification

Power requirements	+8 to +20V DC at about 100 mA. Normal or Standby power input.
Audio input	300 - 400 mV P:P (adjustable) into 10kΩ composite signal: Through audio (reference), CTCSS at ≅ -16 dB, Tone burst at -6 dB, DTMF at -6 dB, Data tones at 0 dB.
Audio output	≅ 0.5V rms. into 1kΩ, (adjustable) composite signal: Through audio (reference), CTCSS at ≅ -16 dB, Ack/callsign tone at -6 dB (high) -16 dB (low), Data tones at 0 dB.
Squelch input	5V logic signal, either polarity (other voltage levels possible).
PTT output	Diode protected open collector output, 100 mA max. (ON), 25V max. (OFF).
Control	9 pin RS232 connector for direct connection to PC for logic set-up and 'fine-tuning'. Data tone decoder/encoder for limited 'on-air' control. N.B., the DTMF and data signals can be linked to a separate RX/TX combination if required. This is highly recommended.
Shutdown	Local (via switch) or remote (DTMF or computer data).
Voice	Control signals to and audio input from external synthesised voice unit (Maplin board suitable).
Repeater linking	Extra squelch and audio input for second (link) receiver.
Configuration	All configurable parameters held in non-volatile EEPROM for easy modification via built-in serial port.
Temperature Range	Standard 0°C to 50°C Extended -20°C to 50°C.

5 Operational Characteristics

5.1 Setup

To provide simple control and versatility for a wide variety of uses, a 128 byte EEPROM is included to store all the configuration data which give the repeater its characteristics. These data include the following:-

- Callsign
- Locator/location
- DTMF tone sequence for shutdown/start-up
- Beacon time
- Option selection
- Various timings, etc.

All modifiable features are stored in the EEPROM, so are relatively easy to change. All features are accessible via a direct connection to the logic board itself (RS232), some may also be changed 'on-air' while the repeater is operational by using the datalink and a 'BayComm' modem. These latter changes are only simple ones, and do not affect the fundamental operation of the repeater. They are also protected by a password scheme which, although not unbreakable, is sufficiently difficult to break so as to deter the casual 'hacker'.

All modifiable features are controlled by a set of simple commands via the built-in RS232 serial port. A normal PC is suitable for this control, and a PC programme is freely available to implement all the configurable features (including automatic password generation).

5.2 Operating

During normal use, the G8CUL Repeater Logic gives the repeater the normal repeater characteristics. The intention is to provide a control system which makes the repeater simple for users to operate through, yet versatile for set-up purposes. All the normal features are available; tone burst minimum length, input carrier minimum length before the repeater will stay up, etc. Long over time-out is also provided if required. If this is enabled, the repeater will shut off the incoming audio if required, replacing it with or super-imposing upon it the normal time-out 'pips'. This stage of time-out can also be set to eventually time-out itself, when the repeater will give its callsign and shutdown. In this situation, when the incoming signal eventually goes away, the repeater transmitter will briefly come on, and send 'OK' on CW, to inform all the bored listeners that the talkative operator has finally let go his/her PTT! During the normal time-out 'pip' phase as well as after the timeout shutdown, the time-out may be reset, and the incoming audio re-enabled, by a tone burst of the correct length detected on the input. This signal will, of course, have to be stronger than the 'timed-out' signal.

6 Component List

6.1 Resistors

Value	Type	Number Off	Location
100Ω	1/8 W, 2%	7	R27,R31,R32,R33, R60,R61,R62
220Ω	1/8W, 2%	3	R2,R4,R5
1kΩ	1/8W, 2%	2	R47,R76
2.2kΩ	1/8W, 2%	4	R28,R30,R34,R48
2.7kΩ	1/8W, 2%	2	R57,R58
3.3kΩ	1/8W, 2%	1	R63
3.9KΩ	1/8W, 2%	1	R15
4.7KΩ	1/8W, 2%	11	R3,R6,R9,R16, R19,R20,R26,R29, R52,R71,R72
6.8kΩ	1/8W, 2%	1	R24
10kΩ	1/8W, 2%	15	R14,R17,R18,R35, R38,R39,R40,R41, R42,R43,R53,R54, R59,R73,R79
12kΩ	1/8W, 2%	1	R37
15kΩ	1/8W, 2%	1	R25
18kΩ	1/8W, 2%	2	R50,R74
22kΩ	1/8W, 2%	2	R13,R36
33kΩ	1/8W, 2%	1	R45
47kΩ	1/8W, 2%	3	R1,R12,R68
56kΩ	1/8W, 2%	1	R7
82kΩ	1/8W, 2%	1	R46
100kΩ	1/8W, 2%	4	R10,R44,R51,R55
150kΩ	1/8W, 2%	4	R8,R23,R49,R56
330kΩ	1/8W, 2%	1	R11
390kΩ	1/8W, 2%	1	R22
1MΩ	1/8W, 2%	1	R21
10MΩ	1/8W, 2%	1	R7
1kΩ	10 pin, 9 way SIL	1	R75
4.7kΩ	Variable Resistor RS187_012	1	R65
22kΩ	Variable Resistor RS187_034	4	R66,R67,R77,R78
47kΩ	Variable Resistor RS187_040	3	R64, R69,R70

6.2 Capacitors

Value	Type	Number Off	Location
22pF	Ceramic, 100V	2	C45,C66
33pF	Ceramic, 100V	1	C28
47pF	Ceramic, 100V	2	C27,C30
56pF	Ceramic, 100V	1	C29
4700pF	Polystyrene, 63V	5	C31,C32,C33,C34,C35
0.01µF	Polyester, 100V	3	C37,C40,C41
0.1µF	Polyester, 100V	21	C36,C38,C39,C42,C43, C46,C47,C48,C49,C50, C51,C56,C57,C58,C59, C60,C61,C62,C63,C64, C67
1µF	Polyester, 63V	3	C44,C52,C53
1µF	Radial electrolytic, 63V, RS107_561	7	C9,C10,C14,C15,C20, C21,C65
10µF	Radial electrolytic, 35V, RS107_397	15	C1,C2,C3,C4,C5,C6,C7, C12,C13,C16,C17,C18, C19,C54,C55
22µF	Radial electrolytic, 35V, RS107_404	1	C8
47µF	Radial electrolytic, 16V, RS107_325	1	C11
100µF	Radial electrolytic, 25V, RS105_969	5	C22,C23,C24,C25,C26

6.3 Discrete Semiconductors

Type	Part Number	Number Off	Location
Diode	1N4006	2	D1,D9
Zener Diode	BZY79C4V7	1	D10
Diode	BAY74 or 1N916 or 1N4148	7	D2,D3,D4,D5,D6,D7,D8
Transistor	ZTX109C	5	TR3,TR4,TR5,TR6,TR8
Transistor	ZTX450	3	TR1,TR2,TR7
Miniature LED (RED)		4	LED1,LED2, LED3,LED4

N.B. The values of C37, C40 and C41 may be varied to produce different audio frequencies for the CW ident according to the following table.

C37, C40, C41 Value (uF)	Audio Frequency (Hz)
0.01	~1700
0.015	~1200
0.022	~850

6.4 Integrated Circuits

Part Number	Number Off	Location
MC68HC705C8CS	1	IC1
UA7805	1	IC4
NMA0505S	1	IC5
XLS93C46P	1	IC6
LT1080	1	IC7
74HCT4053	1	IC8
MV8870	1	IC2
FX805	1	IC3
FX614	1	IC9
NE567	1	IC10
74HCT14	2	IC16,IC17
TLC272	3	IC18,IC19,IC20

6.5 Other Components

Description	Parameter	Number Off	Location
Crystal, HC18u	3.579545MHz	2	XL1,XL2
Crystal, HC18u	4.000MHz	2	XL3,XL4
Links	2 pin	3	LK1,LK6,LK7
Links	3 pin	4	LK2,LK3,LK4,LK5
Inductors	10µH, Axial RS240_494	1	L1
Inductor	100µH, Axial RS240_523	2	L2,L3
Test points		11	TP1,TP2,TP3,TP4, TP7TP11, TP12, TP15,TP16,TP17, TP20
Connection Pins		39	P1 - P39
PWB	Repeater Logic, G8CUL, Issue 2	1	
IC Socket	8 pin DIL 0.3"	5	For IC6, IC10, IC18, IC19, IC20
IC Socket	14 pin DIL 0.3"	2	For IC16, IC17
IC Socket	16 pin DIL 0.3"	2	For IC8, IC9
IC Socket	18 pin DIL 0.3"	2	For IC2, IC7
IC Socket	24 pin DIL 0.6"	1	For IC3
IC Socket	40 pin DIL 0.6"	1	For IC1
Serial Connector	9PIN 'D' Socket, PCB entry, Upright	1	PL1

7 Build Instructions

The method of construction of the repeater logic is really no different to any other similarly complex piece of equipment. I would certainly not recommend that a total newcomer to soldering should attempt it, but anyone with reasonable soldering experience should have no problems. As in all these things, a stage-by-stage methodical approach should be taken.

Initially, it is probably advisable to inspect the PCB, and check that it appears fault-free. There **should** be no problem, as the PCB's have been designed and produced using high-quality professional techniques, but faults do sometimes occur!

I would ***strongly*** advise the use of IC sockets for ***all*** IC's. Their cost is small compared with the rest of the components, and the advantages soon come to the fore if a fault is discovered. Certainly, a socket ***MUST*** be used for the processor. I cannot provide future software updates for free if the processor has been soldered in!

The best method is probably to solder in all the IC sockets, followed by all the discrete passive components, (resistors, capacitor and pins/links). The 9 pin 'D' type can be put in at this stage. Note that it should be mounted up on pillars bolted to the PCB. Ensure that none of the pillars or nuts make connection with any of the adjacent tracks. I have tried to ensure that there is plenty of clearance, but a quick check will not come amiss. Follow these with the active components, (LED's, diodes and transistors) and the ±5V power supply (NMA0505S). LED1 (which indicates when in local set-up mode), can be mounted directly on the PCB, but the other three (which indicate 'on-air', channel 1 transmit and channel 2 transmit) can be either board or box mounted, the latter giving external indication of their relevant states.

The +5V regulator should have some minimal heat sink. Its leads and location on the PCB allow it to be bolted to the side of the logic box, which gives ample heat sink capability. With no heat sink and +12V on the input, it will get quite warm, but a minimal TO220 tab type heat sink is quite sufficient. With +12V on the input, the power dissipated by the regulator is about 700mW.

Having completed soldering in all the components, the IC's may be inserted ready for the big moment of initial switch on! This is dealt with in greater detail in section 8 below.

When completed, the logic can be mounted in any convenient box/housing. The PCB was designed to fit an Eddystone diecast box, type 7970P, (what DID we do before Eddystone diecast boxes?), but any suitable housing should be sufficient. It is probably best to put the logic in a metal box of some kind, just in case any RFI from it gets into the repeater receiver, or RF from the transmitter gets into the logic. The logic has been in use in 70cms, 2m and 6m repeaters without any RFI problems, but individual installations will vary greatly.

8 Test and Set-up Specification

8.1 Introduction

This section gives instructions for the testing and board setting up of a new, recently assembled board. The general procedure is initially to visually inspect the Unit Under Test (UUT) and then check for no shorts on the supply rails. The UUT may then be powered and further tests implemented. Finally the on-board presets can be adjusted followed by configuration set-up using a PC computer.

8.2 Equipment Required

The following equipment is required for the testing and setting-up of a new board:-

8.2.1 Power Supply

Power supply providing 8 - 20V DC. at about 100 mA.

8.2.2 Audio Signal Generator

Calibrated audio signal generator, capable of giving 1.0 and 1.75 kHz with variable output amplitude.

8.2.3 Oscilloscope

Oscilloscope with calibrated Y amplifier with 1 MHz B/W or greater.

8.2.4 Multimeter

Multimeter, such as Avo 8 or DMM.

8.2.5 PC

PC computer with G8CUL Repeater Logic set-up programme, SETUP.EXE and serial cable with 9 pin 'D' plug.

8.2.6 Test Leads

Various test leads.

8.3 Hardware Set-up

8.3.1 Visual Inspection

After completing assembly, visually inspect the UUT, checking for dry solder joints, shorts or solder slivers etc. Visually check that all polarised components such as electrolytic capacitors, diodes, transistors and integrated circuits are in their correct orientation.

8.3.2 Initial Link Settings

There are 4 'change-over' and 3 'on-off' links. These are used for a variety of uses. The initial settings should be as follows:-

- LK1 SET-UP link. IN for normal repeater running, OUT for set-up.
- LK2 Processor reset. Set to A-B for normal running. The processor can be reset by setting this to A-C, and back again.
- LK3 Source of DTMF and computer inputs. A-B repeater input, A-C auxiliary input.
- LK4 Destination of computer data output. A-B repeater output. A-C auxiliary output.
- LK5 Auxiliary tone output. If LK4 is set to use auxiliary output, this link provides a tone output to the auxiliary output.
  A-B No auxiliary tone.
  A-C Auxiliary tone output.
- LK6 'Spare' inverter input. Link to P34 to provide the DTMF controlled digital output1 on P29, or GND if not used.
- LK7 'Spare' inverter input. Link to P35 to provide the DTMF controlled digital output2 on P30, or GND if not used.

8.3.3 Resistance Checks

In good QA fashion, the following resistance, monitored voltages and current should be recorded for posterity. I'll leave that for you to decide. If you do wish to record the results, a suitable form may be found in section 8.6.

Connect the multimeter to the power supply pins, P1 and P2, and measure the resistance. It should be greater than 10k Ω.

8.3.4 Initial Powered Checks

If all appears correct in 8.3.1 and 8.3.3 above, connect a nominal 12V DC. power supply to the UUT, with 0V to P1 and +12V to P2 with the multimeter in circuit to measure supply current. Switch the power supply ON and measure the supply current. It should be in the range 80 mA - 100 mA. Switch OFF, disconnect the multimeter and re-connect the power supply. Switch back ON and measure the following voltages:-

8.3.4.1

Digital +5V at the top end of L1, just to the left of the 9 pin 'D' socket.

8.3.4.2

Analogue +5V at the right hand end of L2.

8.3.4.3

Analogue -5V at the right hand end of L3.

These should all lie between 4.8V and 5.2V.

Remove the set-up link LK1, just to the left of the processor, and measure the following voltages:-

8.3.4.4

RS232 +10V at TP2 (near LK1).

8.3.4.5

RS232 -10V at TP1 (near LK1).

These should both lie between 6V and 11V.

8.3.4.6

With the oscilloscope, measure the wave form at TP4. This should be a 4 ms period, TTL amplitude square wave, indicating that the processor is correctly running its programme.

8.3.5 Initial PC Setup

Connect the PC to the UUT with the serial cable. Remove LK1, and run the G8CUL Repeater Logic set-up programme, SETUP.EXE. This can use either COM1 or COM2 by invoking it with 'setup' or 'setup 1' to use COM1 or 'setup 2' to use COM2.

For more information on the use of SETUP, refer to section 10. In fact a read of section 10 before commencing the set-up procedure would probably help in the understanding of the use of the SETUP programme.

All commands and callsigns MUST be entered in uppercase, so to avoid forgetting, press the <Caps-Lock> key.

8.3.5.1

Press <F3> (the F3 key on the PC!) and enter YOUR callsign (*not* the repeater's callsign!) followed by <enter>.

8.3.5.2

Press <F4> and enter '---' (3 minus signs) followed by <enter>. This is the default callsign which the logic will respond to via the serial port, when in SET-UP mode (LK1 removed).

Set the repeater callsign by issuing the following command:-

8.3.5.3

SCGB3xx<enter> where GB3xx is your repeater callsign.

This should provoke an '-OK-' reply.

8.3.5.4

Press <F4> again and enter your repeater callsign followed by <enter>. This will set the destination callsign that SETUP will use.

Now set the Logic Serial Number which should be supplied with the documentation. There is no direct command to set the serial number, so it is done by using the WR (Write ROM) command 5 times. The serial number digits have to entered in ASCII HEX, which basically means putting a '3' in front, i.e. the serial number 0123 would require 5 WR commands with data of 30, 31, 32, 33 and the terminating NULL. Enter the following commands. Each command should provoke an '-OK-' response:-

8.3.5.5

WR103w<enter>

8.3.5.6

WR113x<enter>

8.3.5.7

WR123y<enter>

8.3.5.8

WR133z<enter>

8.3.5.9

WR1400<enter>

Where w, x, y and z are the 4 digits of the serial number in order. The 'WR1400' at the end is the 'NULL termination' for the serial number string.

This can now be tested by entering a read serial number command:-

8.3.5.10

SN<enter>

Which should get a response with the serial number just entered:-

8.3.5.11

☺GB3DI,G8CUL,0123xx↓

Where 'GB3DI' and 'G8CUL' are the repeater and your callsigns respectively, and '0123' is the serial number. The 'xx' at the end is the hex representation of the packet checksum. The ☺ and ↓ are the packet start and end flags respectively.

8.3.6 Pre-set Adjustments

Having set the repeater callsign and serial number, the on-board adjustments can be made. Within the command set, there are a number of 'test' commands which switch certain things on and off to allow on-board adjustments. All commands should be followed by <enter>, and, with one exception, all should provoke an '-OK-' response This should be done as follows:-

8.3.6.1

Set the audio signal generator to 1 kHz with the output level expected from the repeater receiver at full system deviation, and connect it to the audio input on P21 (0v) and P22. Adjust R78 to give 340 mV rms (960 mV P:P) at TP7 using the oscilloscope. If this cannot be achieved, the gain of the first stage can be varied by adjusting the R13/R35 combination.

8.3.6.2

Connect the oscilloscope to the output P28, and issue the TE command to open the audio gate and allow input audio through to the output. Adjust R77 to give some nominal output level for full system deviation into the transmitter. This is adjusted for correct output level later. Issue the TF command to switch off the through audio.

8.3.6.3

Issue the SIc command to set the required CTCSS tone group to 'c', where 'c' is in the range 'A - J'. Issue the EE command to enable CTCSS encode and then issue the TI command to enable the CTCSS tone, and adjust R70 to give the correct CTCSS output level. This should be 0.16 of the required output level for full system deviation as set in 8.3.6.2 above. This corresponds to 800 Hz deviation (for 5 kHz full system deviation), or 400 Hz deviation (for 2.5 kHz full system deviation) which is -16 dB. Issue the TJ command to switch the CTCSS off.

8.3.6.4

Issue the TH command and adjust R69 to give the CW ident output level of 0.5 of full system deviation as set in 8.3.6.2 above. Issue the TL command and the output level should drop to about 0.1 of full system deviation level. Issue the TO command to switch it off again.

8.3.6.5

Issue the TH command again, and change LK5 to A-C. This sets the auxiliary ident tone output, and adjust R67 to give full system deviation level output. Issue the TO command, and change LK5 back to A-B.

8.3.6.6

Issue the TMA command and adjust R66 to give the computer data output at full system deviation. Issue the TN command to switch it back off again.

8.3.6.7

Set the audio signal generator to 1750 Hz, and a level of ½ that expected from the receiver at full system deviation (i.e. -6 dB). Connect the oscilloscope to TP16, and adjust R65 to give a low logic level on the oscilloscope. There will be a range of adjustment of R65 where TP16 will be low. Try to adjust R65 to the middle of this range.

8.3.6.8

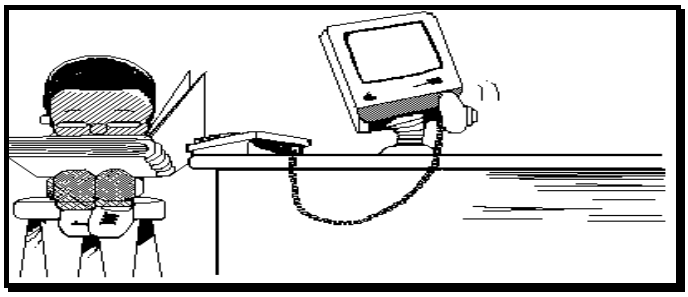
Connect the oscilloscope to TP20, and issue the TMA command again. This will put the computer data ON at full system deviation. Adjust R64 to give the desired clipping level. This clipping level is not very 'hard' and is only designed to guard against over-deviation of the repeater transmitter. The best setting of this pre-set is probably just at or before the onset of clipping with full system deviation. By not providing any

audio tailoring, transmitted audio should be the same as received audio.

8.3.6.9

Connect the oscilloscope to the audio output, P28, and re-adjust R77 to give the required output level for full system deviation into the transmitter. This pre-set may be adjusted later, in conjunction with any peak deviation control in the transmitter, to set the desired output level. This control adjusts the output level, leaving the relative amplitudes of all the individual signals onstant. Issue the TN command to switch off the computer data.

This completes the setting-up of the presets on the board. The next stage is probably to sit down and have a cup of tea (or coffee)! Following this, the configurable parameters need to be set to the desired values.



8.4 Main Parameter Set-up

This section deals with the main set-up features within the logic. There are a number of commands that need implementing. These are split into 5 groups. These are:-

8.4.1 'Ack' Characters

The normal, main 'ack' character is set using the SAx command, where 'x' is the character required. This is the normal 'end of over pip', and can be set to any normal CW character. The SRx command sets the auxiliary 'ack' character, which is used in place of the main one if the logic is powered from P31 rather than P2, which would normally be connected to a standby battery supply.

Issue the following commands, remember all should be ended with <enter>, and the logic should respond with '-OK-' :-

8.4.1.1

SAx sets the main 'ack' character to 'x'.
e.g. - SA**K**<enter>.

8.4.1.2

SRy sets the auxiliary 'ack' character to 'y'.
e.g. - SR**B**<enter>.

8.4.2 Timings

There are a lot of timing settings that need configuring. These are basically split into two groups, in-over timings, and end-of-over timings. The in-over timings use ticks of 0.5 seconds each, while the end-of-over timings use ticks of 2ms each. A 1 second timing is therefore 2 ticks for in-over and 500 ticks for end-of-over timers.

8.4.2.1

SWx sets the minimum tone burst length before access is allowed. Typically this would be set to **125**, giving a minimum tone burst for access of 250ms. The maximum allowed is 255, giving 510ms.
e.g. - SW**125**<enter>.

8.4.2.2

S3x sets the tone burst gate delay. When a tone burst is detected, the through audio is gated out, after a delay, to remove the tone burst. Some incoming audio can 'trip' the tone burst detector, thus removing some of the incoming audio if this delay is set too short. Setting this delay stops this 'chopping' of the incoming audio, but does allow a short tone burst to get through. Typically this would be set to **50**, giving a gate delay of 100ms. This can be fine-tuned later when 'on-air' if desired.
e.g. - S3**50**<enter>.

8.4.2.3

SKx sets the minimum post tone burst carrier latch time for the repeater to stay open. Typically this would be set to **4**, giving a carrier 'latch' time of 2 seconds. The maximum allowed is 65535, giving a latch time of 32767.5 seconds!
e.g. - SK**4**<enter>.

8.4.2.4

S4x sets the squelch delay. No 'ack' will be given after an over which is shorter than this squelch delay. Typically this would be set to **4**, thus only giving 'acks' on overs longer than 2 seconds.
e.g. - S4**4**<enter>.

8.4.2.5

STx sets the repeater time-out time. An over time longer than this time will have its incoming audio gated out (or not as selected in 8.4.2.8), and replaced by 1 second 'pips'. Typically this would be set to **600**, giving a time-out of 300 seconds (5 minutes). Note that this must be enabled with the ET command for the time-out to operate.
e.g. - ST**600**<enter>.

8.4.2.6

ES to enable the 2 second carrier ‘hang’ on access, or
DS to disable the 2 second carrier ‘hang’ on access,
e.g. - ES<enter>
or - DS<enter>.

8.4.2.7

ET to allow repeater time-outs, or
DT to have no repeater time-out at all.
e.g. - ET<enter>
or - DT<enter>.

8.4.2.8

EH to allow through audio with time-out pips, or
DH to only have time-out pips when in time-out.
e.g. - EH<enter>
or - DH<enter>.

8.4.2.9

SZx sets the time-out stop time (in seconds). Typically this would be set to **10**, giving 10 time-out 'pips' before shutdown. If a time-out has occurred, time-out pips more than this will cause the repeater to issue its callsign and closedown. Re-access with a tone burst is possible during the timeout 'PIP' phase or the shutdown phase, if the re-access signal is strong enough. After having shutdown, the repeater waits for the timed-out signal to go away, then will put its transmitter on, issue an 'OK' on CW and put its transmitter off again. Normal access is

then possible. Note that this must be enabled with the EZ command for the timeout end to operate.
e.g. - SZ**10**<enter>.

8.4.2.10

EZ to allow time-out end and closedown, or
DZ to have continuous time-out until input signal goes away.
e.g. - EZ<enter>
or - DZ<enter>.

8.4.2.11

SFx sets the time from the end of an over to when the 'ack' character is sent. Typically this would be set to **500**, giving a time of 1 second.
e.g. - SF**500**<enter>.

8.4.2.12

SHx set the 'ack' delay. This is the time between double 'acks'. Typically it would be set to **2000**, giving 4 seconds between 'acks'. If set to 0, only a single 'ack' is given.
e.g. - SH**2000**<enter>.

8.4.2.13

SGx sets the time from the end of an over to when the 'START' signal is given to the optional voice synthesiser board. Typically this would be set to **5000**, thus starting the synthesised voice at 10 seconds after the over has finished Note that while the voice is running, the end-of-over timer is **NOT** running, so subsequent timings, such at CTCSS off and shutdown times should not include the time taken for the voice to complete. Note that this must be enabled with EV for the synthesised voice to operate.
e.g. - SG**5000**<enter>.

8.4.2.14

EV to enable the synthesised voice on closedown, or
DV to have no voice on closedown.
e.g. - EV<enter>
or - DV<enter>.

8.4.2.15

SVx sets the synthesised voice time-out. Typically this would be set to **2500**, giving a time-out of 5 seconds. This is only used if the voice is enabled, but the voice board is not present, or does not work.
e.g. - SV**2500**<enter>.

When the voice synthesiser board has completed its replay, it issues a 'VOICE_COMPLETE' signal. This signal is used by the logic to re-enable the end-of-over timer and continue with normal operation. If this voice complete signal does not occur, the logic will, in theory, wait for ever! The voice time-out will allow the logic to continue with normal operation without a voice complete signal on completion of the time-out period.

8.4.2.16

SXx sets the CTCSS off time. Typically this would be set to **7000**, giving a time of 14 seconds from the end of over to when the CTCSS on transmit is switched off prior to the callsign and closedown. This allows those of us lucky enough to have CTCSS in our radios not to hear the repeater callsign!
e.g. - SX**7000**<enter>.

8.4.2.17

SOx sets the callsign and closedown time. Typically this would be set to **7500**, giving a time of 15 seconds from the end of over to when the repeater gives its callsign and closes down.
e.g. - SO**7500**<enter>.

8.4.3 Beacon

Beacons are sent every 'beacon-time'. A beacon consists of a 'DE', (if enabled), the repeater callsign and CTCSS tone group, (if enabled). If enabled, the locator, location and synthesised voice (the latter with transmit CTCSS ON) can also be sent. These last three can be set so they are not sent *every* beacon, but every *'nth'* beacon, where 'n' can be different for each.

8.4.3.1

SBx set the time between beacons. Typically this would be set to **600**, giving a beacon every 300 seconds (5 minutes).
e.g. - SB**600**<enter>.

8.4.3.2

EF to have 'DE' on CW before the callsign, (de GB3DI for example), or
DF to have just the callsign, (GB3DI for instance).
e.g. - EF<enter>
or - DF<enter>.

8.4.3.3

EC to not have CTCSS on when giving beacons, or
DC to have CTCSS on for all beacons.
e.g. - EC<enter>
or - DC<enter>.

8.4.3.4

SLs.s set the text sent as a *location* to 's.s' when sending beacons. This can be any normal text string up to 20 characters.
e.g. - SL**OXFORD**<enter>.

8.4.3.5

EL to send the *location* text string with the beacon, or
DL to not send any *location* text string.
e.g. - EL<enter>
or - DL<enter>.

8.4.3.6

SSLnsets the *location* to be sent every 'nth' beacon, if enabled. Typically this would be set to **12**, giving a location sent every 12th beacon.
e.g. - SSL**12**<enter>.

8.4.3.7

SQiiiiii sets the *locator* to 'iiiiii'. Although this would normally be a 'Maidenhead' type locator, it can in fact be any text string up to a maximum length of 6 characters, even an old fashioned QRA if desired!
e.g. - SQ**IO91JO**<enter>
or even SQ**ZL33H** <enter>!

8.4.3.8

EQ to send the *locator* text string with the beacon, or
DQ to not send any *locator* text string.
e.g. - EQ<enter>
or - DQ<enter>.

8.4.3.9

SSQn sets the *locator* to be sent every 'nth' beacon if enabled. Typically this would be set to **4**, giving a locator sent only every 4th beacon.
e.g. - SSQ**4**<enter>.

8.4.3.10

EA to send the synthesised voice with the beacon, or
DA to not send the synthesised voice with the beacon.
e.g. - EA<enter>
or - DA<enter>.

8.4.3.11

SSVn set the *voice* to be sent every 'nth' beacon if enabled. Typically this would be set to **12**, giving a voice sent only every 12th beacon.
e.g. - SSV**12**<enter>.

8.4.4 Remote

Remote control can be with either a sequence of DTMF tones, or computer bitstream data. The DTMF can be used to shutdown and startup the repeater, control the two digital outputs, or 'chop' the incoming audio until the end of the current over .The computer bitstream data can provide quite extensive control and data read-out if desired. The computer bitstream commands are protected by a password scheme, when 'on-air', to deter the 'hacker'. It can also be used via a second channel to avoid the use of the repeater main channel. The use of this second control channel, for both DTMF and computer data is highly recommended.

8.4.4.1

SD1 to use the main repeater as the data input and output, or
SD2 to use the auxiliary channel as the data input and output. See 8.3.2 above for link setting associated with this selection.
e.g. - SD1<enter>
or - SD2<enter>.

8.4.4.2

EM to enable the 'on-air' use of DTMF tones, or
DM to not use DTMF tones.
e.g. - EM<enter>
or - DM<enter>.

8.4.4.3

SJn..n sets the sequence of DTMF numbers to be used for remote repeater startup. This can be any sequence of numbers including A - D, up to a maximum of 10 digits.
e.g. - SJ**0123456789**<enter>.

8.4.4.4

SYn..n sets the sequence of DTMF numbers to be used for remote repeater shutdown. This can be any sequence of numbers including A - D, up to a maximum of 10 digits.
e.g. - SY**9876543210**<enter>.

8.4.4.5

S51 sets the sequence of DTMF numbers to be used for control of digital output 1. This can be any sequence of numbers including A - D, up to a maximum of 3 digits.
e.g. - S51**123**<enter>.

8.4.4.6

S52 sets the sequence of DTMF numbers to be used for control of digital output 2. This can be any sequence of numbers including A - D, up to a maximum of 3 digits.
e.g. - S52**456**<enter>.

8.4.4.7

S53 sets the sequence of DTMF numbers to be used for the audio chop feature. This can be any sequence of numbers including A - D, up to a maximum of 5 digits.
e.g. - S53**456**<enter>.

Two other keys on the DTMF keypad are also used, <*> for 'cancel', and <#> for 'complete'. A typical sequence to use the DTMF control would be:-

- Go to transmit
- Press the '*' key, this will clear any numbers already received
- Press the digit keys for the action required
- Press the '#' key to indicate number sequence complete
- Go to receive

For the digital output sequences, a '0' or '1' should be added to the end of the programmed sequence. '0' will put the selected output LOW, and '1' will put it HIGH.

If the number sequence matches one of the set sequences, the repeater will come 'on-air' and send on CW either 'OFF' if the command was to shut the repeater down, or 'ON' if it was to start it up. For the digital output DTMF commands, the repeater will send '1H', '1L', '2H' or '2L', signifying output 1 high or low or output 2 high or low. For the Audio chop feature, no positive response is given – just the through audio disappearing!

e.g. - to set digital out 1 HIGH, (using the above number sequence example):-

- Go to transmit
- Type '*'
- Type '1231'
- Type '#'
- Go to receive

8.4.4.8

EB to use 'on-air' computer bitstream control, or
DB to not use 'on-air' computer bitstream control
e.g. - EB<enter>
or - DB<enter>.

8.4.4.9

EP if using a Plessey MV8870, or
DP if using a MITEL MT8870 DTMF decoder
e.g. - EP<enter>
or - DP<enter>.

8.4.4.10

ER to enable the repeater - i.e. start-up, or
DR to disable the repeater - i.e. shutdown.
e.g. - ER<enter>
or - DR<enter>.

8.4.4.11

E1 to set digital output 1 HIGH, or
D1 to set digital output 1 LOW.
e.g. - E1<enter>
or - D1<enter>.

8.4.4.12

E2 to set digital output 2 HIGH, or
D2 to set digital output 2 LOW.
e.g. - E2<enter>
or - D2<enter>.

8.4.4.13

DO to shut off the through audio for the remainer of the current over. This can be used during a QSO to remove objectionable audio. It's use it transparent to the offender (he is on transmit after all!). The ACK response is no different and subsequent overs are normal.

8.4.5 General Commands

8.4.5.1

S1H if the main repeater squelch input is HIGH with signal, or
S1L if the main repeater squelch input is LOW with signal.
e.g. - S1H<enter>
or - S1L<enter>.

8.4.5.2

S2H if the auxiliary squelch input is HIGH with signal, or
S2L if the auxiliary squelch input is LOW with signal.
e.g. - S2H<enter>
or - S2L<enter>.

8.4.5.3

SMx sets the CW speed to x words per minute (WPM). This may be in the range of 10 to 30 WPM. Typically it would be set to **18**.
e.g. - SM**18**<enter>.

8.4.5.4

SIc set the CTCSS tone group to c, where c is A - J, as determined by the RSGB.
e.g. - SI**J**<enter>. Note, this may have been set in 8.3.6.4.

8.4.5.5

ED to enable CTCSS decode, (i.e. repeater access), or
DD to disable CTCSS decode.
e.g. - ED<enter>
or - DD<enter>.

8.4.5.6

EE to enable CTCSS encode, i.e. on transmit, or
DE to disable CTCSS encode.
e.g. - EE<enter>
or - DE<enter>. Note, this may have been set in 8.3.6.4.

The toneburst access can be disabled, mainly for 6m repeater use.

8.4.5.7

EK to enable Toneburst access, or
DK to disable Toneburst access.
e.g. - EK<enter>
or - DK<enter>.

The CTCSS decode system can also be set to require *continuous* CTCSS – which is the 'normal PMR type use - . This is a requirement for 6m repeaters.

8.4.5.8

EN to enable continuous CTCSS on decode, or
DN to disable continuous CTCSS decode.
e.g. - EN<enter>
or - DN<enter>.

8.4.5.9

EG to give the callsign on successful access, or
DG to not give the callsign on access.
e.g. - EG<enter>
or - DG<enter>.

8.4.5.10

EI to give the callsign on shutdown, or
DI to not give the callsign on shutdown.
e.g. - EI<enter>
or - DI<enter>.

8.4.5.11

EW to give time-out like 'pips' (actually 'T's) if a CTCSS tone is received during a QSO, but the tone is the wrong group, or
DW to ignore any wrong CTCSS tone during a QSO.
e.g. - EW<enter>
or - DW<enter>.

Due to a 'feature' in the CTCSS integrated circuit used in the logic, this facility seems not to work very well. It is suggested that it is left OFF (use the DW command), as it is likely to be removed in future firmware issues.

8.4.5.12

EJ to allow CTCSS going away OR squelch closing to signify end of over, or
DJ to only allow squelch closing to signify end of over.
e.g. - EJ<enter>
or - DJ<enter>.

8.4.5.13

SEd..d sets the set-up date. This would normally be set to the date when the repeater logic was configured, or the configuration modified. It is not used for anything, but can be read out later as a record.
e.g. - SE**23/6/95**<enter>.

8.4.6 Configuration Dump

The complete configuration set-up can be read out by pressing <F5> in the SETUP programme. This will read the complete configuration, and display it on the PC screen. This can then be printed locally, if desired, by using the <print screen> key, or saved to a file for later printing.

The configuration set-up screen shows the current settings of the configurable parameters, with timings converted from their 'tick' values to seconds, etc. For each entry, the relevant command is also shown, together with the 'tick' value (either 0.5s or 2ms) for the timing values, as an aide-memoir. The <F7> key can be used to give a simple help screen.

8.5 Password Setup

Finally the Master Password should be set by pressing <F6>. This will encrypt the 'From' callsign, (hopefully the repeater keepers!), and store it in the logic for later use with the SP command.

When using the computer bitstream data 'on-air', a password is needed for all commands. This password is changed every time that it is used, so a method of initially setting it is required. This is done with the SP command (automatically using <F2>). The logic then checks that the Master Password received with the SP command matches that which was set previously with <F6> AND the encrypted 'From' callsign. Note that the command for setting the master password (via <F6>) is only available locally, and so the master password cannot be changed 'on-air'.

8.6 Records Result Sheet

Test Record Result Sheet
G8CUL Repeater Logic

Serial Number .....

Repeater .....

Tester .....

Date .....

Inside Leg Measurement .....

Test Para Number	Actual Test	Measured Result
8.3.3	Supply Resistance	
8.3.4	Supply current	
8.3.4.1	Digital +5V	
8.3.4.2	Analogue +5V	
8.3.4.3	Analogue -5V	
8.3.4.4	RS232 +10V	
8.3.4.5	RS232 -10V	
8.3.4.6	TP4 Waveform	

9 Commands

This section gives a list of the commands which can be used to control the logic system. It is intended as a reference and should be treated as such. The set-up implemented in section 8 uses these commands for the initial configuring of the logic.

9.1 Computer Commands

All variable parameters are modified by simple commands which are embedded within a 'packet' which contains a header (for source and destination callsigns), and a checksum to improve overall data integrity.

These 'packets' should not be confused with those used in 'packet radio', which are a completely different format!

The packet format is as follows:-

SOH	(byte value 1), (☺)
Source callsign	i.e. G8CUL
Delimiter	Comma (,)
Destination callsign	i.e. GB3DI
Delimiter	Comma (,)
Data field	Maximum of 20 characters (Packets IN) Maximum of 18 characters (Packets OUT)
Checksum	2 HEX digits representing the modulo 256 algebraic sum of all the bytes in the packet, NOT INCLUDING the checksum.
EOM	(byte value 25), (↓)

This packet format is used for all data transfers between the computer and the logic either via the RS232c port locally or the Bell 202 tones while 'on-air'. For commands from the computer to the logic, the first 2 or 3 characters in the data field are used for the command itself.

These commands consist of 2 or 3 UPPER-CASE characters, with optional extra parameters which are used as data for the command specified.

These commands allow setting up of the configurable parameters for individual repeater requirements, and are listed below.

For example, a packet containing a 'read serial number' command would be :-

☺G8CUL,GB3DI,SNBF↓

Where ☺ and ↓ represent the SOH and EOM respectively. These normally appear on a PC as a small face (SOH) and a down arrow (EOM). The 'BF' after the SN command is the hex representation of the checksum. In this

example the source of the packet is G8CUL and the destination GB3DI. The reply to this could be:-

☺GB3DI,G8CUL,0001DF↓

The reply has the source and destination callsign 'swapped' and the data field just contains the reply, that is the serial number (0001) followed by the checksum (DF).

All commands will return some information or other. A read command will return the requested information, while other commands will return a packet with '-OK-' in the data field. In this way, a command issued which is either incorrect in itself, or has incorrect parameters associated with it will be ignored, and nothing will be returned to the computer. If there is no answer to a command, then you have done something wrong!

All commands can be used locally, that is with the PC plugged directly into the logic unit, with LK1 removed. Some commands may also be used remotely, that is via the radio while the repeater is 'on-air'. These commands are referred to as global commands. In the following list, each command is listed as being local (L) or global (G). LK1 acts as a 'switch' to select local set-up or not. Normal repeater operation is with LK1 IN. To use local set-up, LK1 must be removed, this will also stop any repeater action while LK1 is OUT.

Commands used locally do not require the use of any passwords, but when used remotely, two 4 hex digit passwords are required for ALL global commands. The first password is used for *this* command, and is tested against the password previously saved in the logic. The second password, if the first was correct, is then saved and used for the *next* command. This scheme gives a password which can change every time it is used. There is, of course, an immediate flaw in this, how is the first password set the first time? The SP command implements this, and uses for its first password a *master* password which does not change, and is held in the EEPROM in the logic unit. The master password can be set by the S0 (zero not 'O') command (local only), and would normally be encrypted from the repeater keeper's callsign. It cannot be read remotely, as the only command available to interrogate it is a local only command.

When using SETUP locally, there is no need for the use of any passwords. When used remotely, a password *must* be used for all commands. This password can be automatically generated and inserted into the packet on pressing the <F1> key. This key should be pressed between the command itself and any associated parameters. It must therefore be used every time that any command is used remotely.

The freely available set-up PC programme implements all of this automatically, including the insertion of both 'to' and 'from' callsigns and the encryption of the master password from the repeater keeper's callsign, on pressing of the <F6> key.

9.1.1 Enable Commands

None of these commands require any extra parameters, and are used for ENABLING internal options.

9.1.1.1 Timings

EH (G) Enable through audio when in time-out
ET (G) Enable repeater time-out
EV (G) Enable the repeater 'Voice' on closedown
EZ (G) Enable repeater time-out 'End'

9.1.1.2 Beacon

EA (G) Enable the 'Voice' when giving beacons
EC (G) Enable CTCSS encode inhibit when giving callsigns.
EF (G) Enable 'DE' before callsign
EL (G) Enable the sending of the *location* when giving beacons
EQ (G) Enable the sending of the *locator* when giving beacons

9.1.1.3 Remote

EB (G) Enable the remote bit stream data control
EM (G) Enable DTMF commands
EP (G) Enable the use of the PLESSEY MV8870

9.1.1.4 General

ED (G) Enable CTCSS decode, i.e. on receive
EE (G) Enable CTCSS encode, i.e. on transmit
EG (G) Enable sending the callsign on initial access
EJ (G) Allow CTCSS or squelch to signify end of over
EI (G) Enable sending the callsign on closedown
EK (G) Enable tone burst access
EN (G) Enable continuous CTCSS operation
ER (G) Enable the repeater - i.e. startup
*EW (G) Enable 'time-out' pips when wrong CTCSS received
E1 (G) Put digital output 1 HIGH
E2 (G) Put digital output 2 HIGH

9.1.2 Disable Commands

As above, none of these commands require any extra parameters. They are all used for DISABLING internal options.

9.1.2.1 Timings

DH (G) Disable through audio when in time-out
DT (G) Disable repeater time-out
DV (G) Disable the repeater 'Voice' on closedown
DZ (G) Disable repeater time-out 'End'

9.1.2.2 Beacon

DA (G) Disable the 'Voice' when giving beacons
DC (G) Disable CTCSS encode inhibit when giving callsigns.
DF (G) Disable 'DE' before callsign
DL (G) Disable the sending of the *location* when giving beacons
DQ (G) Disable the sending of the *locator* when giving beacons

9.1.2.3 Remote

DB (G) Disable the remote bit stream data control
DM (G) Disable DTMF commands
DP (G) Disable the use of the PLESSEY MV8870, i.e., use the MITEL MT8870

BEWARE! **If you use the DB command remotely to disable the computer bit stream data control, the only way of re-enabling it would be to take a visit to the repeater site with a PC computer and re-enable it locally!**

9.1.2.4 General

DD (G) Disable CTCSS decode
DE (G) Disable CTCSS encode
DG (G) Disable sending the callsign on initial access
DI (G) Disable sending the callsign on closedown
DJ (G) Allow squelch only to signify end of over
DK (G) Disable tone burst access
DN (G) Disable continuous CTCSS operation
DR (G) Disable the repeater - i.e. shutdown
*DW (G) Disable 'time-out' pips when wrong CTCSS received
D1 (G) Put digital output 1 LOW
D2 (G) Put digital output 2 LOW

* These commands are likely to be removed in future firmware issues.

Notes:

EV/DV enable/disable the control of an external voice synthesiser unit.

ER/DR enable/disable the repeater itself, i.e. remote shutdown etc.

EW/DW enable/disable time-out like pips on receipt of incorrect CTCSS. See the note in 8.4.5.11. They are likely to be removed in future firmware issues.

EZ/DZ enable/disable a time-out time-out, that is whether to switch the repeater off after a given time of time-out 'pips'.

EN/DN enable/disable the use of *continuous* CTCSS operation. When enabled (EN), only received signals with the correct CTCSS will be passed to the transmitter.

EK/DK and EN/DN are for firmware version V2.0a onwards only! Their intended use is for 6m repeaters.

9.1.3 Read Commands

Some of these commands require extra parameters, while others do not.

RD (G)	Read diagnostics. Two numbers are returned, followed by the firmware version number. The numbers are counters which correspond to the number of packets received with a bad checksum and bad length respectively.
RMaaaa (L)	Read the contents of processor memory aaaa (in HEX). Processor addresses lie in the range 0000 to 1FFF.
RRaa (L)	Read the contents of EEPROM address aa (in HEX). EEPROM addresses lie in the range 00 to 7F.
RS (G)	Dump EEPROM, all 128 bytes are read. Note that this is normally implemented using <F5>.
RV (G)	Read variables. Two 8 digit HEX numbers are returned. These are the oncount and offcount counters, which correspond to the time the repeater has been in use and 'idle' (in beacon mode) respectively. Each counter counts 0.5 second 'ticks'. i.e. the time in seconds is the counter ÷ 2. The SETUP programme will convert these numbers to total time and in-use time as a percentage of total time.
SN (G)	Read the serial number of the logic unit.

9.1.4 Write Commands

These are only included to give very low level control. In normal use they should NOT be used. If they are, they must be used with EXTREME care. Failure to do so could easily end up with a non-functioning logic system.

WMaaaadd (L) Write byte value dd to processor memory address aaaa, (both in HEX).

WRaadd (L) Write byte value dd to EEPROM address aa, (both in HEX).

In fact, the only time I can visualise the use of WR is the initial setting up of the logic serial number. I can not think of any need for the WM command at all!

9.1.5 Set Commands

These are the main commands for setting up the repeater logic configurable parameters. They all need extra parameters, the format of which depends upon the command in question.

9.1.5.1 'Ack'

SAx (G) Set the 'Ack' character to x. This is used for the end of over 'pip'. For example, an 'E' gives a short pip, a 'T' gives a longer one! Any normal CW character can be used.

SRx (G) Set the 'Ack' character used when on battery supply to x. This character is used in place of the normal one (set by the SA command) when the logic is running on battery supply.

9.1.5.2 Timings

SFxx (G) Set the 'Ack' time to xx * 2ms. This is the time from the end of 'over' to the 'Ack'.

SGxx (G) Set the 'Voice' time to xx * 2ms. This is the time from the end of the 'over' to the start of the 'Voice'.

SHxx (G) Set the pip delay to xx * 2ms. This is the time between double 'Acks'. If set to 0, a single 'Ack' is used.

SKxx (G) Set the access 'latch' time to xx * 0.5 seconds. This is the minimum carrier ON time required (after tone burst time) to get the repeater to latch on. It may be set to 0.

SOxx (G)	Set the time to callsign and closedown to xx * 2ms. This is the time from the end of the 'over' to the start of the callsign and closedown.
STxx (G)	Set the repeater time-out time to xx * 0.5 seconds. This is the 'over' time before the audio input is shut-off (if selected) and time-out starts. See ET/DT above for enabling/disabling the time-out feature and EH/DH. See also SZ below.
SVxx (G)	Set the 'Voice' time-out to xx * 2ms. i.e. 2500 gives 5 seconds. This is used if the 'Voice' is enabled, but is not connected or does not work! This time-out will allow the repeater to continue functioning.
SWxx (G)	Set the tone burst length required for access to xx * 2ms. The maximum is 510ms, (xx = 255!). This sets the minimum tone-burst length that will allow access.
SXxx (G)	Set the CTCSS off time to xx * 2ms. This is the time from the end of the 'over' when the CTCSS encode is inhibited. Also see EC/DC.
SZxx (G)	Set the time-out stop time in seconds. This is used to determine the time for which time-out pips are given. At the end of this time, the repeater will go into a normal closedown procedure. See the EZ/DZ commands for enabling/disabling this feature.
S3xx (G)	Set the tone burst delay time to xx * 2ms. This is the length of tone burst required before incoming audio will be gated out. Setting this too low may cause slight breaks in normal speech.
S4xx (G)	Set the squelch delay time to xx * 0.5 seconds. This is the minimum 'over' time that will give an 'ack'. Times shorter than this will not produce an 'ack', thus deterring the insistent 'bleeper'!

9.1.5.3 Beacon

SBxx (G)	Set the beacon time interval to xx *0.5 seconds. For example, 600 gives 300 seconds (5 minutes).
SLcccc (L)	Set the location to the string cccc. The maximum string length is 20 characters, and can be anything you want! It is used when sending beacons.
SQxxxx (L)	Set the locator to xxxx. The locator is used when sending beacons. The maximum length is 6 characters.
SSLxx (G)	Set how often the location is sent with the beacon. For example, if the location is enabled with the EL command, setting this command to 3 will give a location every 3rd beacon. The allowed range is 0-255. *BEWARE* - a value of 0 will have the effect of 256! A value of 1 will send the location with every beacon.
SSQxx (G)	Set how often the locator is sent with the beacon. For example, if the locator is enabled with the EQ command, setting this command to 2 will give a locator every 2nd beacon. The allowed range is 0-255. *BEWARE* - a value of 0 will have the effect of 256! A value of 1 will send the location with every beacon.
SSVxx (G)	Set how often the voice is sent with the beacon. For example, if the voice is enabled with the EA command, setting this command to 6 will give a voice every 6th beacon. The allowed range is 0-255. *BEWARE* - a value of 0 will have the effect of 256! A value of 1 will send the location with every beacon.

9.1.5.4 Remote

SDn (L)	Set main (n = 1), or auxiliary (n = 2) for the data channel. This also requires LK3, LK4 and LK5 to be set to A-C on the logic board. See the set-up instructions for more details.
SJx...x (L)	Set the DTMF sequence for remote repeater startup. The maximum length is ten digits.
SYx...x (L)	Set the DTMF sequence for remote repeater shutdown. The maximum length is ten digits.
S5nxxx (L)	Set the DTMF sequence for remote control of output 1 or output 2. n must be either 1 or 2, and the maximum length for xxx is 3 digits.

S53xxx (L) Set the DTMF sequence for the audio chop. The maximum length for xxx is 5 digits.

9.1.5.5 General

SCccccc (L) Set the repeater callsign to ccccc. The maximum callsign length is 6 characters.

SEddddd (L) Set the set-up date. This would normally be of the form dd/mm/yy. This has a maximum length of 8 characters, and is only held in EEPROM for later perusal. It is recommended that it is set when any configuration is changed, for future reference.

SIc (L) Set the CTCSS group to use. 'c' should be in the range 'A' - 'J'. Note that 'I' is not used, and is treated as though it were 'J'. The sub-audio tone then used is as decided by the RSGB!

SMxx (G) Set the CW speed to xx WPM. It can be in the range of 10 to 30 WPM. This speed is used for all characters sent on CW, 'Ack' characters, beacon etc.

SPoonn (G) Set the new password number to nn. See below for use.

S0xxxx (L) Set the master password to the 4 hex digit number xxxx. This is implemented by the <F6> key when in local set up.

S1x (L) Set the squelch polarity of the main receive input . 'x' should be either 'H' or 'L', meaning an incoming signal giving a HIGH or LOW level on the squelch line. Note that this is on input to the logic board itself, not any prior level shifters!

S2x (L) Set the squelch polarity of the auxiliary receive input. As above, 'x' should be either 'H' or 'L'.

9.1.6 Test Commands

These commands can only be accessed locally, and give test features to enable setting up of the various level adjustments etc.

TA	(L)	Put the main transmitter ON.
TB	(L)	Put the main transmitter OFF.
TC	(L)	Put the auxiliary transmitter ON.
TD	(L)	Put the auxiliary transmitter OFF.
TE	(L)	Open the audio gate (put RX audio through to TX input).
TF	(L)	Shut the audio gate.
TH	(L)	Switch on tone oscillator at HIGH level.
TL	(L)	Switch on tone oscillator at LOW level.
TO	(L)	Switch off tone oscillator.
TI	(L)	Switch on currently selected CTCSS tone.
TJ	(L)	Switch off CTCSS tone.
TMA	(L)	Switch on bitstream data tone from FX614.
TMC	(L)	Switch on bitstream test data from FX614. Note [1].
TN	(L)	Switch off bitstream data tone.

Note [1] - This command will send a continuous 10101010 bitstream to the FX614 The only exit from this state is to reset the logic, either by turning power off and on, or by using LK2.

Some commands can be used all the time, (whether local or remote), while others may only be used locally, that is when the computer is plugged into the RS232c port directly. When a command is used remotely, the use of a password is mandatory to access the command. The password must occur BETWEEN the 2 character command and its parameters (if any). The password should consist of a 4 digit HEX number, followed by another 4 digit HEX number. The first number is used as the password for THIS command, and the second number is used as the password for the NEXT command. In this way the password will change every time that any command is accessed remotely. There is no need for any password action when any command is accessed locally.

The only exception to the above is the Set Password (SP) command itself. The first password must match both the *master* password held in the EEPROM and the encrypted 'from' callsign in the packet header. The second password is then used to set the password for the NEXT command. This allows forgetful repeater keepers to set a new password number when they have forgotten the old one!

The master password is set by the S0 command, which can only be used locally. This master password would normally be encrypted from the repeater keeper's callsign.

The intention of this rather complicated changing password scheme is to give some limited security if the repeater is to use the remote bit stream data control.

9.2 DTMF Control

The use of DTMF tones while 'on-air' gives some remote control. This limited control allows the repeater to be shut down and re-started, the setting high or low of 2 digital output signals and the ‘chopping’ of through audio. Having set the DTMF digits required for the various functions, the use of this control is the same for all of the DTMF remote control functions. Two other keys on the DTMF keypad are also used, <*> for 'cancel', and <#> for 'complete'. The DTMF keys 'A' to 'D' may also be used, but if the MITEL DTMF decoder is used, a minor wiring modification is required to the PCB. This modification requires pin 5 of IC2 ('SEL') to be connected to 0V rather than +5V.

A typical sequence to use the DTMF control would be:-

- Go to transmit
- Press the <*> key, this will clear any numbers already received
- Press the digit keys for the action required
- Press the <#> key to indicate number sequence complete
- Go to receive

For the digital output sequences, a '0' or '1' should be added to the end of the programmed sequence. '0' will put the selected output LOW, and '1' will put it HIGH.

If the received number sequence matches one of the set sequences, after the input squelch has closed (or 2 seconds, whichever is first), the repeater will come 'on-air', and send on CW either 'OFF' if the command was to shut the repeater down, or 'ON' if it was to start it up. For the digital output DTMF commands, the repeater will send '1H', '1L', '2H' or '2L', signifying output 1 high or low or output 2 high or low. The audio chop feature gives no reply, but will remove the through audio until the end of that over.

e.g. - to set digital out 1 HIGH, (using the number sequence example shown before):-

- Go to transmit
- Type '*'
- Type '1231'
- Type '#'
- Go to receive

10 PC Setup Programme

A SETUP.EXE programme is freely available which, when run on a PC compatible computer, encodes the packets described above, and controls the use of passwords etc. This setup programme is capable of using either COM1 or COM2 as an RS232c port to communicate with the repeater logic either locally in SETUP mode, or remotely while the repeater is 'ON-AIR'.

When used remotely, a normal BayComm type modem (with a suitable 9-pin adapter, as shown in section 15) connected to radio equipment capable of communicating with the repeater, is required to control all the 'remote' commands.

10.1 Setup Invocation

Setup can be used with either COM1 or COM2. To invoke setup type:

SETUP or SETUP 1, to use COM1.

SETUP 2, to use COM2.

SETUP requires a configuration file to operate, which, if not present, will be generated by SETUP itself, after suitable prompting. This SETUP.CFG file contains the repeater callsign, the repeater keeper's callsign and the next password number to be used. When SETUP is invoked, SETUP.CFG is read and the callsigns and the password number set accordingly. When setup is exited, the current values are written to SETUP.CFG.

10.2 SETUP Function Keys

Setup uses a number of function keys to control various things. These function keys and their uses are described below.

F1 - Send the NEXT password number - this automatically changes each time it is used.

F2 - Set password number. This probably needs to be used each time a remote control session is started. It will set the password number in the PC AND send it to the logic. A 4 figure HEX number should be typed in response to the request. This number will be used the next time <F1> is pressed.

F3 - Set the 'FROM' callsign. The callsign put in here and in F4 below set the callsigns used for every transaction from then on. This and the 'TO' call are saved in the SETUP.CFG file when the programme is exited, so will appear automatically next time. (As does the next password number!).

F4 - Set the 'TO' callsign. See F3 above. *Must* be the repeater callsign.

F5 - Dumps the contents of the EEPROM out to the PC. This is then displayed in tabular form for simple (!) perusal. Options are then available to save and/or print the setup information.

F6 - Set Master Password. This encrypts the 'FROM' callsign and sends it to the logic. This command (in the logic) only works in local mode, so the master password can't be changed unless you are actually connected directly to the logic.

F7 - Gives a help screen. This is in the same format as the screen produced by the F5 key, but just gives the commands. No data is read from the logic, so this operation is faster than using the F5 key!

X - (UPPER CASE) to exit the programme.

NOTE - ALL COMMANDS AND ALL PARAMETERS MUST BE IN UPPER CASE. HIT THE 'CAPS LOCK' KEY ON THE KEYBOARD!

After each command, a key press will normally get command prompt back again and be the first character of the next command. Due to the rather large 'TXDELAY' built in each end of the communications link, the response is not immediate!

During remote operation, each command requires the use of the <F1> key to insert the password numbers into the packet. The current password, (i.e. the next one to be used) is thus held in the logic *and* in the SETUP programme. If for any reason these two passwords get out of synchronisation with each other, by the mis-typing of a wrong command for example, the logic will no longer respond to commands, as it is checking for a different password than that being sent by the SETUP programme. The <F2> key can then be used to re-synchronisation the passwords, by *telling* the logic what the next password will be. As described elsewhere, this requires the use of the *master* password and the repeater keepers callsign.

11 Hardware and Circuit Description

11.1 Introduction

The hardware design is based around a single-chip micro-controller from Motorola, the MC68HC705. This device contains up to 32 Input/Output lines, a timer, a serial port, RAM and about 7 kbytes of EPROM to contain the programme. The processor is interfaced to other devices within the circuit design to provide the required functions.

Other features incorporated are implemented by the usual NE567 for tone burst detection, an FX805 for CTCSS, MT8870 for DTMF decoding and FX614 for serial data input and output. Non-volatile parameter storage is provided by a 128byte EEPROM.

11.2 Analogue Sheet

Incoming audio from the receiver is amplified by one half of IC19 (TLC272). The level at the input of this amplifier may be adjusted by R78 (fine gain), or by changing the ratio of R13/R35. This signal is then split to feed all the devices which require it. These are IC10, the NE567 tone burst detector, IC2, the MV8870 DTMF decoder and IC9, the FX614 data decoder. The remote control signals to IC2 and IC9 may be routed from a separate receiver, by changing LK3 from A-B to A-C. This would then necessitate the use of a separate transmitter, changing LK4 from A-B to A-C, LK5 from A-B to A-C and using the SD command to inform the control programme of the use of a separate receiver/transmitter combination.

The received audio signal is also fed to IC3, an FX805, onto pin 10 for the audio path and pin 16 for the CTCSS tone. The audio path within IC3 also contains the through audio gate and a 300Hz high pass filter to remove the incoming CTCSS tone. The audio out from pin 11 is then added to the outgoing CTCSS tone from pin 9, as well as all other outgoing audio signals. This outgoing information consists of through audio, CTCSS transmit tone (generated by the FX805), CW ident and data tones. This combined audio is then peak clipped by IC19, to guard against over-deviation of the transmitted signal, and filtered by a 40dB per decade low-pass filter (IC20). The output of this filter is fed to the repeater transmitter via an output level control, R77.

No de-emphasis or pre-emphasis is included in the logic. In fact the repeater transmitter ***must*** have its pre-emphasis removed to avoid attenuation of the outgoing CTCSS tone. Likewise on receive, any de-emphasis in the repeater receiver ***must*** also be removed, to give neutral audio tailoring and avoid excessive received CTCSS amplitude. The overall effect of not having any in-built audio tailoring is that signals are transmitted as they are received, with the exception of the peak clipping and subsequent low pass filtering.

The tone burst detect frequency is set by R65, and has a nominal bandwidth of about 100Hz.

When IC2, an MT8870 (or MV8870) detects a valid DTMF tone it produces an interrupt signal to the processor, and puts the DTMF tone binary code on its output for the processor to read.

IC9, an FX614, detects the standard Bell 202 tones, producing the decoded serial data into the processor serial input. The serial output from the processor is routed to IC9, which gives either a 1200Hz or 2200Hz tone on its analogue output on pin 7, which is switched on and off into the transmitter input under processor control.

The 'ack' and CW ident tones are produced by the usual phase shift oscillator, using TR4. TR3 buffers the oscillator output, and TR5 is used to vary the gain of TR4 under processor control, which has the effect of stopping and starting the oscillating action. The tone output level can be switched between a high

and low level, (depending upon input signal presence) by TR6. The tone frequency is set to a nominal 1700Hz by C37, C40 and C41 (0.01uF). Changing these values to 0.015uF or 0.022uF should give nominal frequencies of 1200Hz and 850Hz respectively.

11.3 Digital Sheet

At the heart of the logic is the micro-controller, or processor, IC1, an MC68HC705C8. This contains all the usual micro-processor hardware elements, CPU, clock, timer, I/O, EPROM (for the control programme), RAM and serial interface. All these features are used by the control programme.

Two squelch signals are buffered by IC17, 74HCT14, and fed to the processor. These are for the main and (optional) auxiliary receivers.

Another squelch input is available for an extra link receiver, which may be used for repeater linking. An extra audio input to the transmitter summing amplifier is also provided for link receiver use, (or synthesised voice). However, the current control programme does not yet support repeater linking, but a beta version is undergoing tests. This requires the use of external linking hardware. The protocols involved are not yet sufficiently defined to allow full implementation - yet. Watch this space, however, as both our repeaters (GB3DI and GB3OX) are due to be linked in the near future. GB3TE and GB3CL, at Clacton-on-Sea, are currently operating as a co-sited linked pair.

The RS232c interface is connected via PL1, a 9 pin 'D' type SOCKET, via the RS232c interface device, IC7, an LT1080, to the serial in and out of the processor on pins 29 and 30. These signals are fed via 2 'gates' of an analogue multiplexer, IC8, 74HCT4053. This allows the serial input and output of the processor to be switched between the RS232c interface and the MODEM IC, IC9. The control for this switching is the link LK1, which is also applied to the processor so the control programme can also 'know' when LK1 is removed for set-up. IC7 generates its own ±10V (ish) for the RS232c interface levels by a simple internal charge-pump system. LED1 indicates when the logic is in set-up mode (with LK1 removed), AND a PC is present with the correct handshake signal.

Outputs to the two PTT signals, for the main and (optional) auxiliary transmitters, is via open collector transistors to operate conventional PTT type controls. These signals also drive two LED's, LED3 and LED4 via two inverters of IC16, to give indication when the transmitter(s) are on.

The repeater may be shut down by the remote commands described above, or by shorting P8 to P7 locally. Another LED, LED2, is used to indicate when the repeater is 'on-air' or shut down/in set-up mode.

Incoming power at a nominal +12V is applied to a 3 terminal regulator, IC4 from either the main, P2, or auxiliary, P31, power . The application of +12V

on the main power inputs is sensed by the processor via R74, D10, R73 and IC16, and is used to select the main or backup 'ack' character. If a battery supply system is used, this facility will give indication of mains failure.

Power for the analogue circuitry, at ±5V is generated by IC5, an NMA0505S, which is a low power isolating switching power converter. Inputs and output from IC5 are filtered to reduce interference from the digital to the analogue circuitry.

IC6, XLS93C46P, is a 128byte EEPROM connected to the processor by a serial data link. The DATA_OUT and SER_CLK signals are shared by the CTCSS IC, IC3, each having separate Chip Select (CS) and DATA_IN signals. All the configuration data is held in this EEPROM, which does not forget its contents when power is switched off.

12 Block Diagram

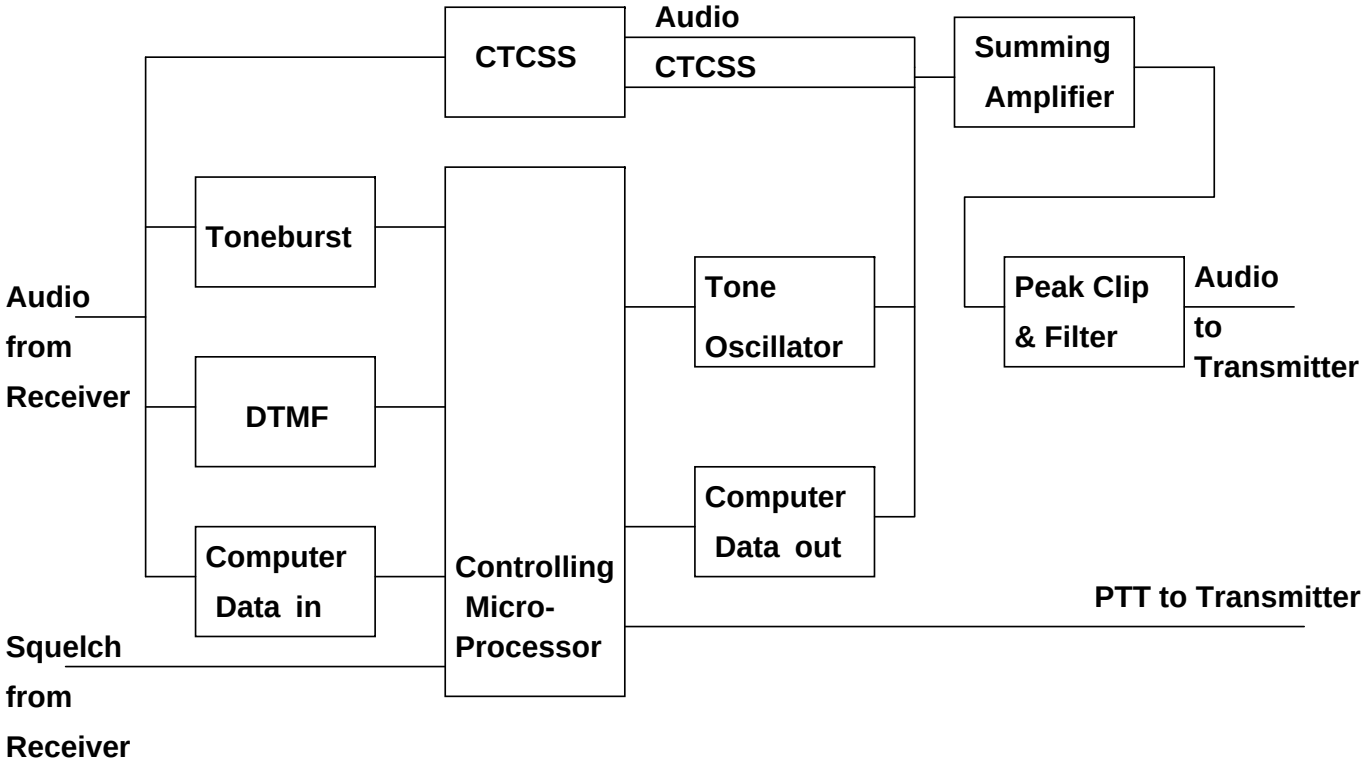


Figure 1 Control Logic Block Diagram

13 Board Layout

The PCB layout is shown on this page, and is given for reference only!

14 Circuit Diagrams

The two circuit diagrams, the analogue and digital sheets, are provided on the next two pages in fold-out A3 fashion.

15 BayComm Adapter

To use the remote computer control, a simple pin-swapping adapter is needed between the PC and the BayComm modem. This swaps the data in/out pins from those used by BayComm to the normal asynchronous data in/out pins, and the PTT control.

The adapter is made up using a 9 pin 'D' plug and a 9 pin 'D' socket. The pins should be connected as follows:-

Signal Function	PC 9 pin Socket	BayComm 9 pin Plug
Receive Data	2	8
Transmit Data	3	4
Signal Ground	5	5
PTT	7	7
Control Lines	4, 6 & 8	3

This adapter can be made by bolting a plug and socket together, and then wiring between them. This assembly is then put on the end of the cable between the PC and the BayComm modem, at either end.

16 Current Installations

The G8CUL Repeater Logic has been successfully running the GB3CL (70cms) and GB3TE (2m) repeaters in Essex since May 1994 and October 1994 respectively. Tony Horsman (G0MBA), who has been responsible for installing the new logic, would be happy to talk to you about it, and about me! He can be contacted on 01255 822265 or QTHR. Of our own repeaters, for which the logic was originally designed, GB3DI has been running since September 1995, GB3OX since 1997 and GB3WO since 1999 There are an increasing number of other repeater installations in the UK currently using the G8CUL Repeater Logic.