Version 1 16/1/03

Notes on the RSGB Investigation of PLT Systems in Crieff

12th and 13th November 2002

1 Object

The primary object was to obtain information on levels of interference generated by PLT systems and how this will affect radio amateurs and short wave listeners. In addition it was hoped to obtain a more general view of the effect of PLT on the electromagnetic environment.

2 Arrangements

SSE Telecom had invited HF radio users to visit Crieff and make measurements on their two PLT systems. The BBC and the RSGB arranged to go up to Crieff at the same time. SSE had organised visits to three private houses and also their own shop in Crieff. The intention being to have one day looking at the MAINNET system and one day looking at the ASCOM system. Generally the RSGB and BBC carried out independent activities at each location, thereby maximising the amount of information acquired in the limited time available. Unfortunately the weather was poor with rain on and off throughout the trial period. This hampered outdoor operations resulting in fewer measurements than would have been possible in better conditions.
SSE were helpful throughout the trial, including briefing us on the system deployment on the evening of Monday 11th and holding a short "wash-up" meeting on the morning of the Thursday 14th.

Day 1 (12/11/02). MAINNET installations. Morning and most of the afternoon. at 31 Commissioner Street. Later in the afternoon the BBC went to the SSE shop in Crieff. I stayed at Commissioner Street to complete some work there.
The householder at 31 Commissioner Street is Mr Graham Taylor (GM6JDZ/MM5JDZ) an RSGB member. Mr Taylor has a professional IT background and was very helpful in our activities at this location.

Day 2 (13/11/02). ASCOM installations. Morning 15 Victoria Terrace. Afternoon 24 Drummond Terrace. The householders at both addresses were very accommodating.

3 The systems

1 MAINNET

This is described as a direct sequence spread spectrum system. The audible effect in and around the house is interference in the form of continuous "crackles" while downloading from the PLT system. When not downloading (quiescent) there are short pulses of signal. These quiescent signals were very short and were not a serious problem to audio reception (But see also "Results" 1(d) below for comment on the effect of white noise)
At this location there was a strong white noise emission extending from about 3MHz to above 6MHz. (measurements were not made above 6MHz). This could have been related PLT but on the other hand it could be an independent

source. For practical commercial reasons the PLT system could not be switched off to check. .

2 ASCOM
This system uses blocks of frequencies. Three frequency bands are used for delivery to the (main) modem situated near the electricity meter. Three other bands are used to distribute the data in house - from the main modem to the computers. Frequencies used are:

Delivery. 2.4, 4.8 and 8.4 MHz
The nominal occupied band is +/-500KHz
On the delivery frequencies the signal consists of bursts of data.

In-house frequencies. 19.8, 22.6 and 25.2 MHz.
The occupied bandwidth is not known but appears to be at least several hundred kHz either side of nominal. In practice emissions outside the nominal bandwidth seem to be fairly well down, but this may depend on the traffic density.
On the in-house frequencies signals consisted of bursts of data superimposed on a background buzz which sounded to be about 100Hz. For convenience of reference, these two conditions have been called "burst" and "buzz"

4 Equipment and Techniques

The intention of RSGB is to highlight areas of concern and to indicate practical methods of measurement of interference which relate to the real radio reception conditions.
All levels quoted in this report are presented in good faith as an indication of the levels of interference. They are not intended to be taken as formal engineering measurements.

The equipment was as follows:
A loop antenna. This is a portable unit consisting of a tuned loop 0.19m in diameter, mounted on a box containing battery powered pre-amplifier and tuning circuit. In the configuration used in this trial it could only measure up to 6MHz.. A coaxial output feeds to the 40A receiver.

An active dipole antenna by Datong. This is a commercial active antenna for amateur and broadcast listening. It consists of two elements 1.25m long. These mount on the sides of a plastic box containing a high impedance amplifier. In this trial the antenna was always mounted so that the elements were horizontal about 2.7m above ground on a post made of insulating material. A coaxial lead can feed to either the 40A or the FRG-7 receivers.
In these trials the antenna was powered by batteries.

A 40A measuring receiver. This is a battery operated receiver designed in the seventies for general purpose field work. It has a switched attenuator and centre-zero meter read-out. The detector is quasi-peak. Apart from requiring no mains supply it has the advantage of simple manual operation which is ideal in an investigative situation.
All figures quoted for field-strength and RF current are quasi-peak

An FRG-7 general coverage receiver. This is a battery operated receiver. It uses the Wadley loop synthesiser and is easy to operate in field conditions. Comparative signal strength is indicated by an "s" meter.

A current transformer. This is a clip-on device used in conjunction with the 40A receiver.

A mains test circuit. This is a simple unit to isolate the mains voltage and apply a known RF load to the mains supply. Provision is made to measure both differential and common-mode (C-M) current.(See fig 2)

5 Results

1 31 Commissioner street. (Mainnet System)

a) **Loop measurements**

The loop was mounted on work-mate 3m from the rear wall of the house (see Fig 1). Spot frequency checks were made between 2.2 and 6MHz
When downloading emissions ranged from 20 to 38dBuv/m.
When the PLT modem was quiescent only the white noise was evident. The level of this white noise varied from 17 to over 30dBuV/m but this came from a different direction.

b) **RF Currents on mains.**

Using the test circuit of fig 2 connected to a 13 amp socket in the hall. The output socket of the test circuit was open circuit in this test.
Only one frequency was checked, 4.7MHz. When downloading the differential current was about 11dBuA. With the current transformer on all three conductors (L, N and E) the effective current was too small to measure on the 40A receiver. This was not surprising since there was no C-M load. (The measurement technique was changed when measurements were made at Victoria Terrace and Drummond Terrace next day.)

c) **Subjective Observations.**

Recordings were made of signals received on the FRG-7 receiver.
First the receiver was located in the house using a makeshift wire antenna about 4m long strung up across the room.
Second the receiver was connected to the Datong active dipole in the yard behind the house. The antenna was located 3m from the rear wall of the house, elements parallel to the house wall (in the same place as the loop in fig 1). The dipole was approximately 2.7m above ground, supported on an insulating pole.
Subjective assessment of interference for the indoor antenna was that interference was very severe, being worse on lower HF frequencies.
On the outdoor Datong antenna 7 and 3.5Mhz bands and the were badly affected. On 14MHz the interference was present but much less severe than at 7MHz.

d) In all the above observations the white noise was significant but cannot be assessed subjectively because it sounds similar to the ambient noise floor. The effect is that noise simply makes signals seem weaker. It also masks much of the incidental noise giving the false impression of a quieter radio reception location, than is actually the case.

2 **15 Victoria Terrace (ASCOM System)**

a) **Loop measurements**.
Loop mounted 1m from the electricity box containing the electricity meter and modem. This is mounted on the outside of the house (see fig 3). The loop was on the side of the box opposite the electricity feed. Spot measurements were taken between 3 and 6MHz. Levels ranged from about 35 and to over 50dBuV/m.

b) **RF Current measurement**.
Using the test circuit of fig 2 plugged into a 13amp socket in the dining room. Differential readings were taken with the output socket open circuit. C-M readings were taken on a measuring receiver connected to the output socket.

<u>Delivery frequencies</u>. Where a frequency was in use differential currents were in the range 8 to 14dBuA and C-M currents in the range 17 to 29dBuA.

<u>In-house frequencies.</u> Only the 25.2MHz frequency was in use when differential readings were taken. This showed readings of 8 and 11dBuA on line and neutral respectively. When C-M was measured, all three frequencies were in use, C-M current ranged from 7 to11dBuA on bursts with about 3dB lower on the background "buzz".

c) **Subjective Observations.**
Recordings were made of signals received on the FRG-7 receiver from the Datong active dipole antenna set up about 4m from the left hand corner of the front of the house. (See fig 4).
Subjective assessment of the interference. It was noted that signals were very strong on all the bands of frequencies used by ASCOM, and particularly the in-house frequencies. When a specific frequency band was not in use interference on that frequency band was significantly less.
Checks were carried out on the 3.5, 7, 10, 14, 21 and 28MHz amateur bands. Apart from some interference between 3.7 and 3.8MHz, no significant interference was noted. It was noted that the level of interference on 5.1MHz from the 4.8MHz ASCOM band was severe. The 18, and 24MHz bands were not checked. This is unfortunate since the 24.9 MHz band would almost certainly be severely affected by the 25.2MHz ASCOM signal.
Time permitted a check on only one broadcast band. Two signals were checked, on frequencies towards the lower end of the 9MHz broadcast band. Significant interference was noted.

3 **15 Drummond Terrace**

a) **Loop measurements**
The loop set up on the roof of a car parked near the front door 5m from the house wall (see fig 5). Due to continuous heavy rain there was a problem keeping the equipment dry. Measurements were taken at only two frequencies, 2.4 and 4.8MHz. The interference field-strength measured was 38 and 40dBuV/m respectively.

b) **RF Current measurement**.
Using the test circuit of fig 2 plugged into a 13amp socket in the dining room. Differential readings were taken with the output socket open circuit. C-M readings were taken on a measuring receiver connected to the output socket

Delivery frequencies. Only the 2.4 and 4.8MHz frequencies were in use. Differential currents were in the range 13 to 19dBuA and C-M currents in the range 21 to 29dBuA.

In-house frequencies. Only the 19.8 and 25.2 MHz frequencies were in use when differential readings were taken. Differential currents were in the range -11 to +5dBuA on buzz and -6 and +8dBuA on burst. All frequencies were in operation when C-M was measured. C-M current ranged from 8 to15 dBuA on buzz and 12 to18dBuA on burst.

c) **Subjective Observations**
Recording were made of signals received on the FRG-7 receiver.
The receiver was connected to the Datong active dipole which was set-up 5m from the wall of the house (see fig 6). The receiver was in the boot of a car. Heavy rain hampered operations.
Interference on the delivery bands was less severe than at Victoria Terrace. This points up the variability of this type of interference since the loop measurement (3.a above) made less than half an hour earlier, showed a high level of emissions at these frequencies. Interference on the in-house frequencies was severe, possibly greater than at Victoria Terrace.

6 Conclusions and Comments

1 The ASCOM system

a) This was relatively easy to characterise because the interference was confined to specific frequency bands, enabling the interference to be tuned in on the receiver like any other radio signal. The only difference being that the interference signal was very much broader than a normal HF radio signal.

b) If the levels of interference observed in the "ASCOM bands" were present in the amateur bands, then radiated interference would deny the use of these bands to the occupants of the house and would cause very severe interference to HF radio listeners in neighbouring properties.

c) It was not possible to ascertain the interference emanating from properties not subscribing to the service. It would be particularly relevant to know the effect of interference from the in-house frequency bands propagated into neighbouring properties by conduction along the mains supply.

d) The measurement of RF current on the mains was a useful exercise in that it indicated the presence of significant RF currents at the appropriate frequencies. However no conclusion can be drawn from attempts to determine differential and C-M currents, except perhaps to underline the fact that attempting to represent the house wiring main system in terms of a balanced pair simply leads to confusion.

2 **The Mainnet system**

a) This was more difficult to characterise. Strong interference with a white noise characteristic was present at the Commissioner Street location. Because it was not possible to turn the system completely off it could not be determined whether this was related to the PLT system or not. It appeared to come from the general direction of No 25, a house known to be fitted with a (Mainnet) PLT repeater. On the other hand the interference was present at a local lamp post, and at the two lampposts further up the street (in the direction of the Primary School). This interference was present as a radiated signal inside No 31 but it seemed to come from the general direction of No 25. It did not appear to be radiated from the house wiring of No 31.
No conclusion can be drawn from this except that there is an urgent need to clarify the situation by further investigation.

b) It was relatively easy to characterise the interference from the PLT system operating inside No 31. When the system was downloading the effect was a strong "crackling" type of noise. When the system was quiescent only short pulses were present, separated by relatively long intervals (in the order of a second). These pulses could not be measured on the 40A which has a traditional meter read out, and could not respond in the short duration of the pulses.

c) Under download conditions there would be very severe interference to amateur radio and broadcast reception inside the house and for a significant distance around it. Under quiescent conditions the short "keep alive" pulses would not be so intrusive. However it is very important to keep in mind that in subjective assessments, the high level of white noise interference will have been masking interference which otherwise might have been much more noticeable.

d) It was not possible to ascertain the interference emanating from properties not subscribing to the service. The Mainnet system employs repeaters so that careful examination of the deployment throughout the street coupled with further measurements would be needed before overall interference situation could be assessed.

e) No meaningful conclusion can be arrived at until the nature of the "white noise" interference has been determined.

f) As reported above for the ASCOM system, no conclusion can be drawn from attempts to determine differential and C-M currents, except perhaps to underline the fact that attempting to represent the house wiring main system in terms of a balanced pair simply leads to confusion.

7 Final Comment.

It is clear that the characterisation of systems such as those discussed above requires a great deal more work than was possible in a brief visit. It seems likely that, even when all the available data from RSGB, BBC and the RA, has been assessed, further measurements will be required, coupled with a detailed analysis of the characteristics of the operating systems to permit a proper engineering assessment to be made.

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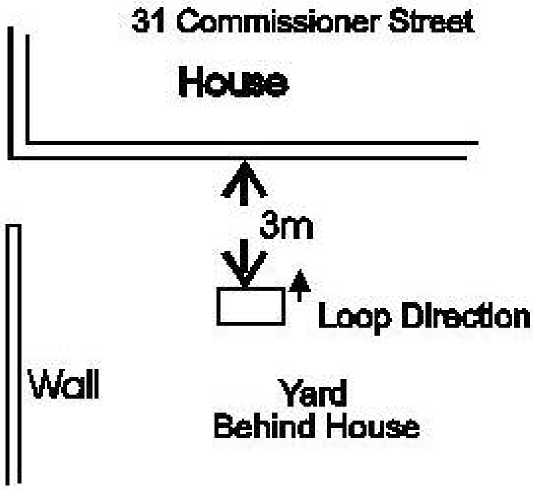
31 Commissioner Street
House
3m
Loop Direction
Wall
Yard
Behind House

Fig 1

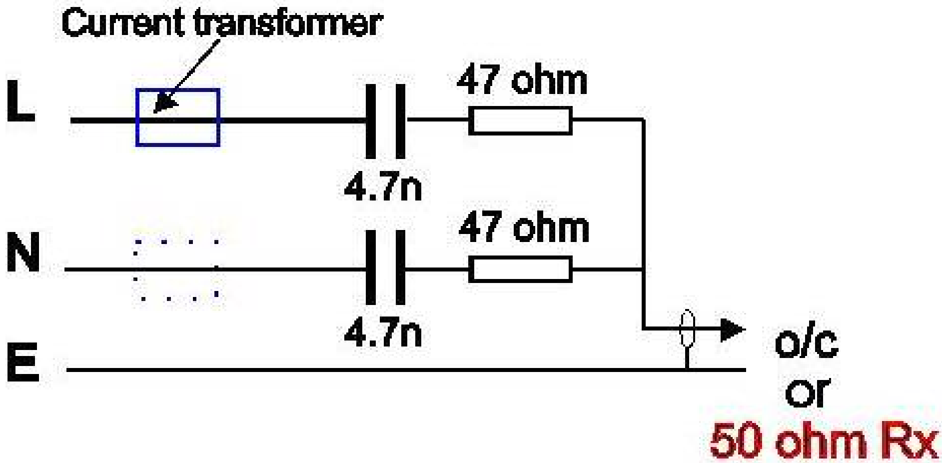
Current transformer
L
47 ohm
4.7n
N
47 ohm
4.7n
E
o/c
or
50 ohm Rx

Fig 2

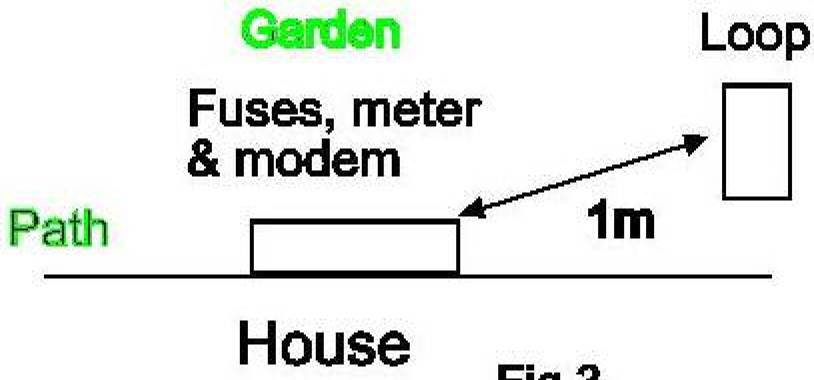
Garden
Loop
Fuses, meter
& modem
Path
1m
House

Fig 3

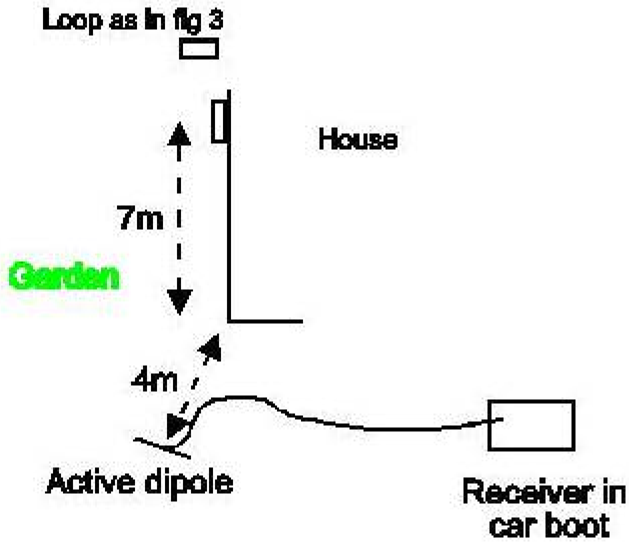
Loop as in fig 3
House
7m
Garden
4m
Active dipole
Receiver in
car boot

Fig 4

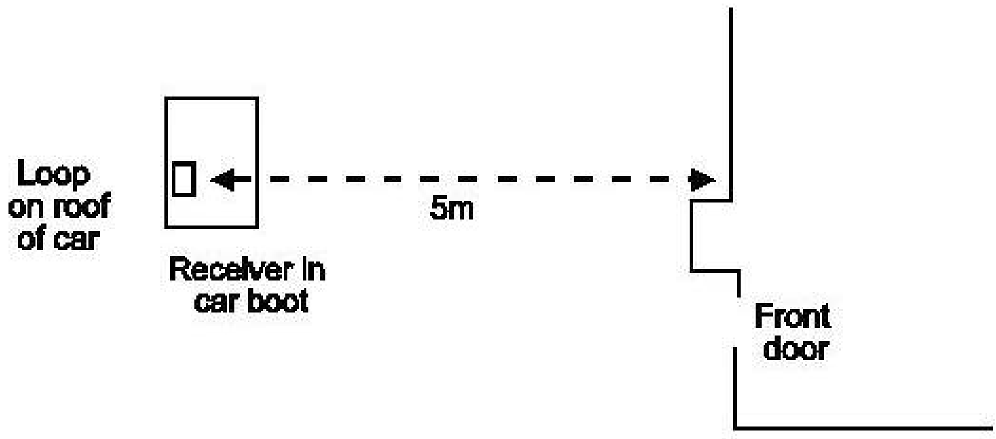
Loop
on roof
of car
5m
Receiver in
car boot
Front
door

Fig 5

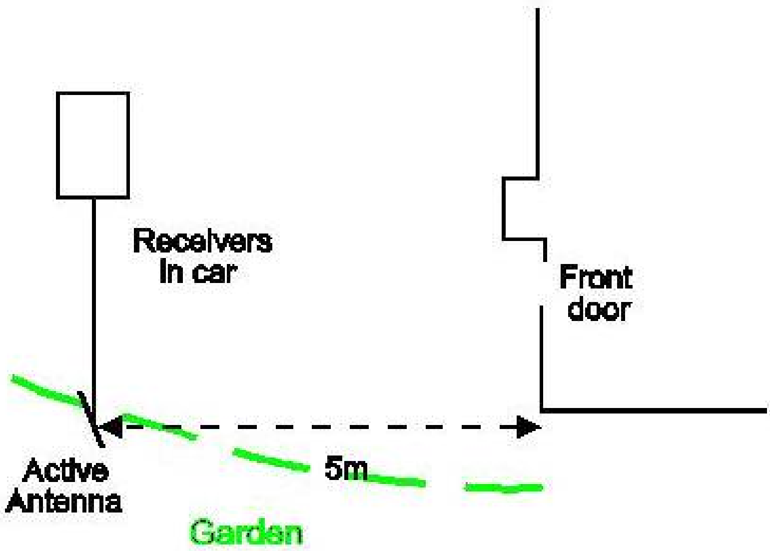
Receivers
in car
Front
door
Active
Antenna
5m
Garden

Fig 6