交通部電信總局委託研究計畫期末報告

計劃編号：SEC 88057

有線電視系統工程技術管理研究計畫

執行期間：87/10/06～88/05/31

計畫編號：SEC-88-057

委託機關：國立交通大學

計畫主持人：尉應時 教授

（電信工程學系）

中華民國八十八年六月

有線電視系統工程技術管理研究計畫

Inspection Techniques for Digital CATV Networks

期末報告

委託機關：國立交通大學

計畫主持人：尉應時（教授）

助理研究員：吳明佳（博士生）

林玉明（博士生）

張春雲（行政助理）

目　　錄

中英文摘要及關鍵字

關鍵字：雙向數位有線電視系統、網路查驗方法

Key words：Digital HFC System, Network performance evaluation

本報告是為如何查驗雙向數位有線電視網路提供數項參考指數標及測試方法。同時並對上行信號品質所可能受到網路的影響，做了實際的量測。

This report provides guidelines for evaluating the performance of digital hybrid fiber coax (HFC) systems. These guideline include testing parameters and procedures. In addition, this report provides measurement results on upstream ingress and impulse noise in HFC systems. The implication of these noise terms on the evaluation guidelines are also presented.

一、緒論

寬頻擷取網路(Broadband Access Networks)是廿一世紀用戶迴路網路的主要趨勢。寬頻網路的擷取技術包括(1)用既有雙絞銅線(twisted pair copper wires)的 ADSL (Asymmetric Digital Subscriber Lines)，(2)用 28 GHz 載波的 LMDS (Local Multipoint Distribution System)，(3)用直播式數位衛星(Direct Broadcast Satellite)下行及電話線上行的 Direct-TV 或 Direct-PC，以及(4)用雙向有線電視網路的 HFC (Hybrid Fiber Coax)傳輸及擷取技術。這四項 Broadband Access 技術都有其發展的潛力，而其中 HFC 技術更在最近因為(A) AT&T 以 480 億美金收購美國第二大有線電視公司 TCI 以及用 560 億美金收購第三大的 Media One，以期切入寬頻擷取網路市場，以及(B) Microsoft 的 Bill Gates 以 10 億美金投資美國第六大的有線電視公司 Comcast 以期成為 TV 王國的主宰，這兩大投資案說明了 HFC 網路的潛力極大。

我國有線電視網路的普及率早已達 70%~80%，近來以力霸、和信集團為主的有線電視經營者亦開始裝設纜線數據機(Cable Modem)提供上網際網路的服務。待今年底或明年初，標準化(MCNS 標準)的纜線數據機能普遍在消費性電子商店買到時，此經 HFC 網路提供網際網路的服務將趨於普遍。另外，數位有線電視節目也將隨著無線電視台自今年底試播數位有現電視而逐漸會由各有線電視台轉播該類數位信號。中程(約兩年後)的數位有線電視服務則將包含經 Cable modem 傳送的網際網路電話(Internet Telephony)及架設在 HFC 網路上的數位無線電話務(如 GSM，DCS)服務。

本計畫主要是針對近程的數位 Cable modem 信號傳輸(包括上下行傳輸)及數位電視信號的下行傳輸，所需要的信號品質查驗方法，提出一先期研究及具體建議。

本計畫最嚴僅的做法，原應是建立一雙向的有線電視 HFC 網路的測試平台，但因為此測試平台的建立將耗資近千萬元，非本計畫的經費所能支援，故決定採取兩個「先期」的研究方法：(1)收集國外雙向有線電視網路的測試方法，並做仔細分析後選取其中適合電信總局實際做查驗的技術方法，以供總局做參考。(2)借用新竹振道建於交大計算機中心的有線電視網路做一基本的測試平台。如此，方能在最節省經費的情況下達成既定目標。

在本期末報告中，我們將詳述目前計劃的工作進度及成果，其中包括：

(1) 界定數位有線電視系統之量測參數。

(2) 回顧各類電信標準的系統性能目標。

(3) 量測儀器性能之比較。

(4) 上行 5~42 MHz 間 ingress noise 之量測儀器、方法及成果。

(5) 上行 5~42 MHz 間 impulse noise 之量測儀器、方法及成果。

(6) 實際量測之考量及參數之選定。

二、混合式光纖同軸(HFC)網路中數位信號之量測參數

在參考過各類國際電信標準[1，2，3]之後，我們認為以下的量測參數是比較重要的：

(1) 錯碼率(Bit Error Ratio，BER)：在一定的量測時間內，錯碼的數目和收到的總碼數之比值。

(2) 含錯秒(Errored Second)：含有至少一個錯碼的一秒鐘。

(3) 含突錯秒(Burst Errored Second)：是任一有 100 個以上錯碼的含錯秒。

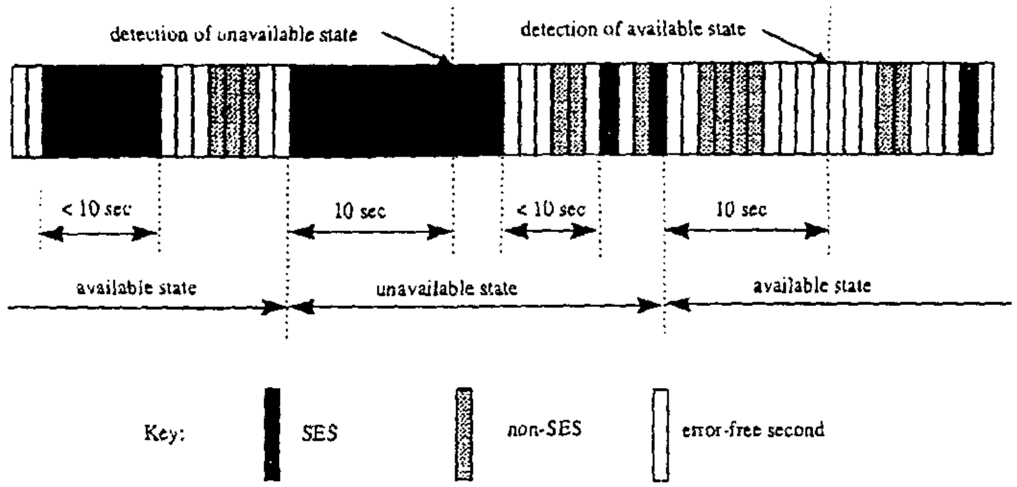
(4) 含重錯秒(Severely Errored Second，SES)：含錯碼率超過 10^{-3} 的一秒鐘。

(5) 堪用率(Availability)：在一長時間中(一天、一月或一年)，一網路或網路元件之功能與規格均能達到既定要求之時間比例。

(6) 不堪用時期(Unavailable Time)及堪用時期(Available Time)：

「不堪用時期」是自有連續十個 SES 開始算起(含該十秒)，如附圖一[2]。

而「堪用時期」是自有連續十個 non-SES 開始算起(含該十秒)，如附圖一。



圖一　Transitions between the availability states

(7) 當機時間(Downtime)：是指網路或網路元件在一長測量時期(如一個月或一年)中一段不堪用的時間。

(8) 含錯秒率(Error Second Ratio，ESR)

$$=\frac{\sum ES}{\text{(total seconds in available time during a fixed measurement interval)}}$$

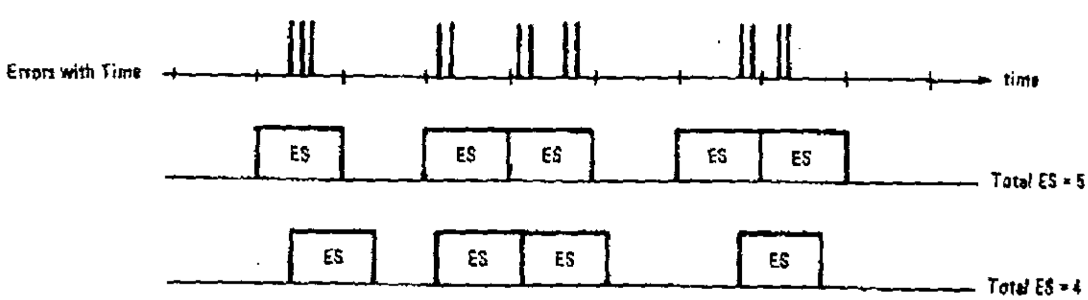
$$=\frac{\text{含錯秒數}}{\text{堪用時期總秒數（在一　固定測量時間內）}}$$

(9) 含重錯秒率(Severely Error Second Ratio，SESR)

$$=\frac{\sum SES}{\text{(total seconds in available time during a fixed measurement time)}}$$

$$=\frac{\text{含重錯秒數}}{\text{堪用時期總秒數（在一　固定測量時間內）}}$$

以上參數中，(2)至(9)的量測對於一個突發性雜訊(burst noise)特多的 HFC 上行網路而言，比傳統的 BER 量測更為重要。由於現在的數位信號傳輸多是以一個封包(packet)為單位(例如 IP packet)，並不是以 bit 為單位，所以當一個封包遭到突發性訊號干擾，雖然只有數個 bits 受到污染，但可能因此造成整個封包都錯了。所以，對於上行頻道的量測而言，(2)～(9)項是比較適當的參數，以下為一簡單的示意數：



但對於下行數位頻道而言，因為 bursty 的雜訊幾乎不存在，所以用 BER 量測即可。

有關 unavailability 即 “outages”或 “availability” 這兩項參數在 HFC 網路的應用，茲舉例如下：如果一個有線電視系統總共有 400 個放大器，其中 100 個放大器在一個 60 分鐘的時間內皆因颱風而不能正常運作，則我們說此系統的 outage 時間是 $\frac{100}{400}\times 60=15$ 分鐘。通常 outage 是以一個月(或一年)裡的百分比來算，也就是 $\frac{15}{30\times 1440}\approx 0.035\%$，則此系統的堪用率是

99.965%。至於究竟一個系統的堪用率要多好，我們應該回顧一下各類電信系統的標準規定—這便是下一章的主要內容。

三、回顧各類電信標準的系統性能目標(Performance Objectives)

A. G.821 國際(25000 Km)ISDN (N×64 Kbps)連結之系統性能目標[3]

性能分類(Performance Classification)	目標(Objective)
SESR (Local grade)**	＜0.002 (0.00015)
ESR (Local grade)**	＜0.08 (0.012)

＊ 量測時間未定

＊＊Local grade 指的是自地方電話局至用戶終端

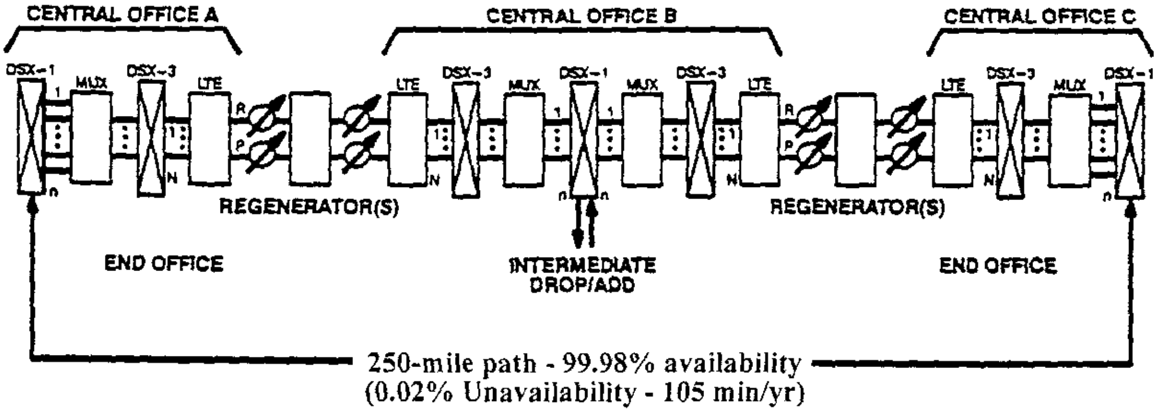
B. G.826 國際(27500Km)>1.5 Mbps 之 end-to-end 系統性能目標[4]

Rate (Mbps)	1.5~5	＞5 to 15	＞15 to 55
Bits/block	800-5000	2000-8000	4000-20,000
ESR	0.04	0.05	0.075
SESR	0.002	0.002	0.002
BBER*	2×10^{-4}	2×10^{-4}	2×10^{-4}

＊ Background block error ratio, defined as the ratio of background block errors to total blocks in available time during a fixed measurement interval. The count of total blocks excludes all blocks during SESs.

＊＊建議之量測時間為一個月。

"Average" 250-Mile DS1 Path



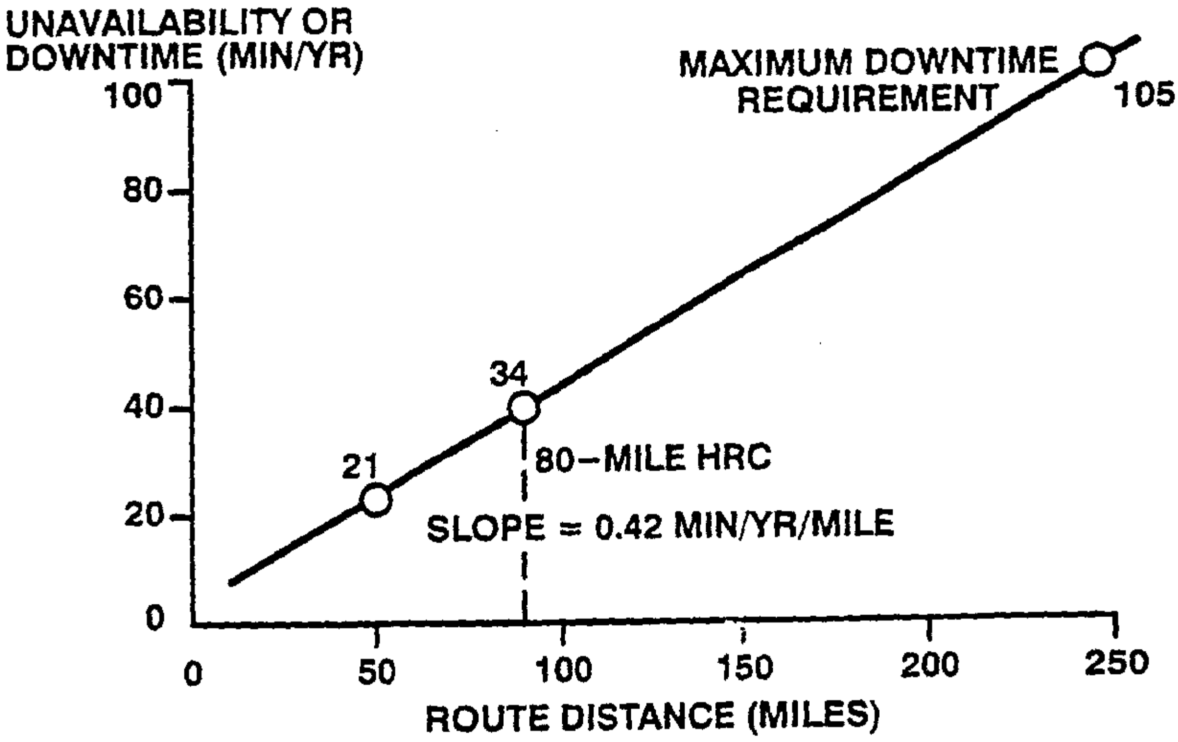
圖二　Interoffice Transport System Availability Objective

C. 另外應注意的是 SES 的定義在 G.821 和在 G.826 並不相同。G.821 的 SES 是定義給 N×64Kb/s，在 BER ≥ 10^{-3} 的情形下。而 G.826 的 SES 是定義給 primary rate (1.5 Mb/s)以上，在 ≥30% errored blocks 的情況下。

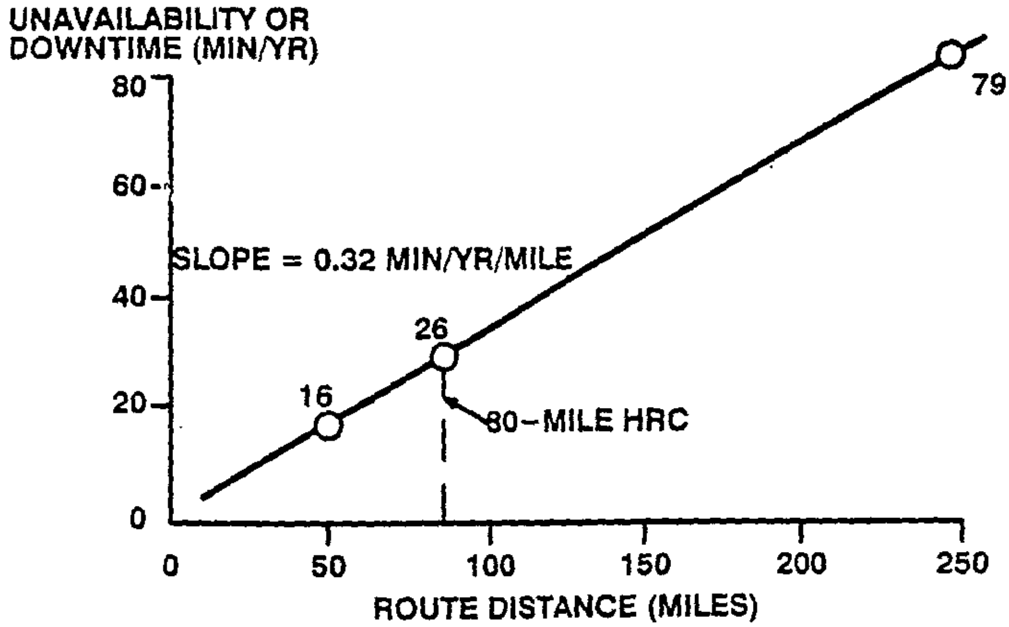
D. ITU-T M.2101,1 Series M：TMN and Network Maintenance：International Transmission Systems, Telephone Circuits, Telegraphy, Facsimile and leased circuits -- Performance limits for bringing-into-service and maintenance of International SDH paths and multiplex sections 中所定之系統性能目標：ES 與 SES 均為 G.826 的 50%。例如，SESR 為 0.001。

E. Bellcore TR-NWT-000499 中所定之局際系統性能目標(係針對局際--平均間距 250 英哩--的傳輸/交換系統所訂的，其網路架構如附圖二)

有關局際「不堪用時間」(unavailable time)或「當機時間」(downtime)之規定，可參見附圖三及附圖四。

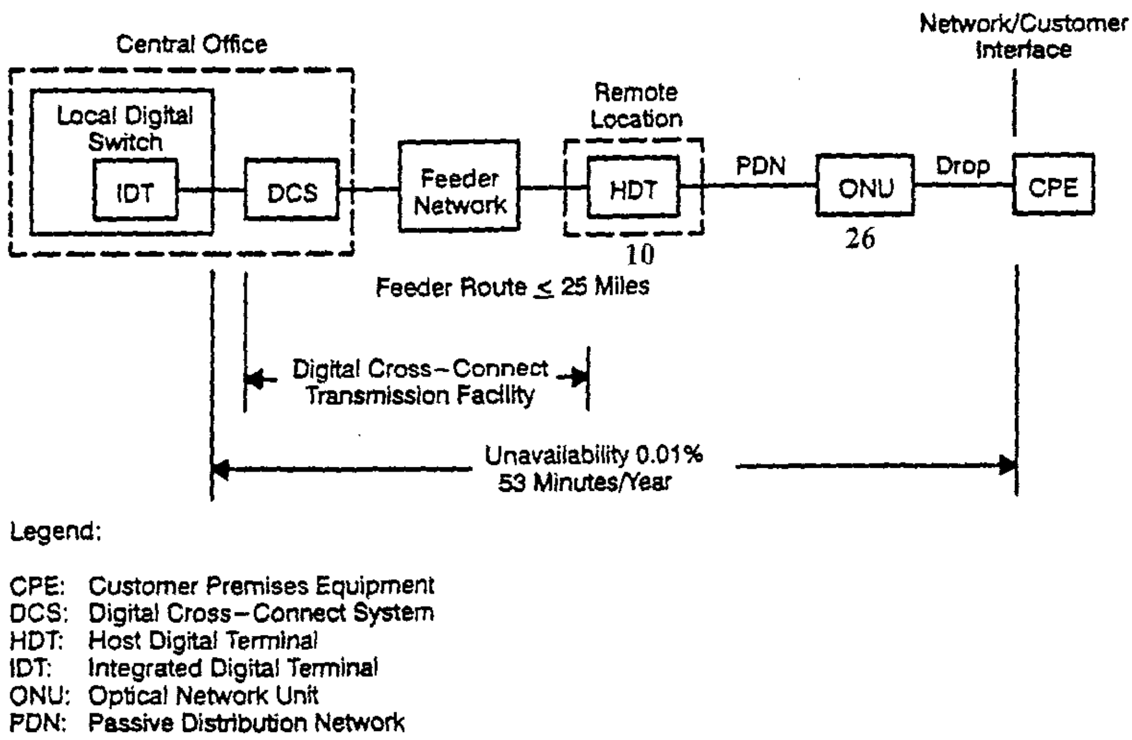


圖三　局際傳輸/交換系統之「不堪用時間」目標--DSX-1 to DSX-1
(Interoffice Transport System Availability Objectives - DSX-1 to DSX-1)



圖四　局際傳輸/交換系統之「不堪用時間」目標--DSX-3 to DSX-3
(Interoffice Transport System Availability Objectives - DSX-3 to DSX-3)

F. Bellcore TR-NWT-000499 中所定之用戶迴路系統性能目標(係針對用戶迴路--從地方電信局到用戶終端，不含用戶終端機，之距離不大於 25 英哩，其網路架構如附圖五所示)為每年不堪使用時間不得超過 53 分鐘。



圖五　光纖用戶迴路示意圖

而在指定的一年 53 分鐘不堪用時間裡，有 8 分鐘是配合地方電信局的數位連接系統(digital cross-connect)及饋線系統(feeder network)。有 10 分鐘是配給主數位終端機(Host digital terminal)。有 26 分鐘是配給光纖網路終端機(Optical network unit)。另有 9 分鐘則未指定其分配對象。總結如表一:

表一　Distribution Transport Network Downtime -- Fiber

Network Segment/Element	Downtime
Digital Cross-Connect Transmission Facility - (R) DCS (R) Feeder Network †	 2 min/yr. 6 min/yr.
(R) HDT	10 min/yr.
(R) ONU	26 min/yr.
(R) Unassigned	9 min/yr.
(O) Total Downtime	53 min/yr.

† 25 route miles or less

G. Bellcore TR-NWT-000499 中所定之一般 50~250 miles 局內網路(Intra LATA network)之錯碼率目標

(G.1) 對於操作在 DS1 速率的系統，其長期 ESR＜0.0004 (即 99.96%無錯秒)等效於在一個 7 小時，單向 loopback 的測試中，不可有超過 10 個 ES。或等效於一年中有 214 分鐘的時間是含有錯碼的。

(G.2) 對於操作在 DS3 速率的系統，其長期 ESR＜0.004 (即 99.6%無錯秒，error-free-seconds)。等效於在一個 2 小時，單向 loopback 的測試中，不可有超過 29 個 ES。或等效於一年中有 2410 分鐘是含有錯碼的。

H. Bellcore TR-NWT-000499 有關「平均修復時間」(MTTR：Mean time to Repair)之規定

(H.1) 如損壞部份為管線等(非可攜式組件)，則平均修復時間必須為 48 小時以內。

(H.2) 如損壞部份為設備或模組，則平均修復時間為

(a) 頭端(局內)設備：2 小時。

(b) 饋線(feeder)部份：4 小時。

(c) Hub 或 HDT 部份：4 小時。

(d) 室外光接收/發射機或 ONU：6 小時。

I. Bellcore TR-NWT-000499 有關「傳輸延遲」之規定

系統之最大迴路延遲(round-trip delay)為

$$RTD_{max} = 0.32 + 0.0168 \times M \quad (ms)$$

其中 M 為單向之距離(以英哩為單位)。

J. ANSI 及 AT&T 的相關規定

LE Office Connection Performance Objectives

Le Access Service			
Impairment	Switched Service	Dedicated Service	
	G.821 Test Interval＝30 days	ANSI Test Interval＝1 day	AT&T T1.5 Test Interval＝1 day
SESR	0.015%	0.008%	0.0023%
ESR	1.2%	0.17%	0.023%

Service Availability Performance Objectives

LE Access Performance Reference Values Summary			
Impairment	Switched Service	Dedicated Service	
	Bellcore Test Interval＝30 days	ANSI Test Interval＝1 day	AT&T T1.5 Test Interval＝1 day
Availability (Downtime per year)	99.99% (53 min.)	99.925% (394 min.)	99.975% (131 min.)

四、量測儀器性能之比較表

(各儀器皆為 ITU-T J.83 Annex B Compatible)

	Tektronix DMA-120	Hukk CR1200QAM	Sencore QAM-B 970
64/256QAM (5.057~5.36 Msps)	√	√	√
頻率範圍	54~860 MHz	54~802 MHz	5~750 MHz
無失真動態範圍 (Distortion-free Dynamic Range)	＞40 dB	?	40 dB
最大信號雜訊比 (Max. Channel Power-to-noise Ratio)	40 dB	34 dB	
功率讀值之準確度(dB)	±2.1	±2.0	±1.0
Average BER (before R-S decoding)	10^{-4}~10^{-9}	9×10^{-4}~10^{-15}	9.9×10^{-4}~10^{-10}
可被鎖定之 RF 輸入水平	-20 dBmV	-20 dBmV (64QAM) -15 dBmV (256QAM)	-10 dBmV
Average BER (after R-S decoding)	√		10^{-4}~10^{-10}
Time-period	(In-service measurement) 1~60 minutes	?	?
System Availability statistics Time period	1~60 minutes	hr.min	
Errored seconds	√	√	?
SES	√	?	?
Unavailable Time	√	?	?
Corstellative diagram display	√	√	?

HP 37701B and HP 37702A T1/Datacom Tester

HP 37701B 或 37702A T1/datacom 測試儀可提供 T1 (1.544 Mb/s)或 fractional T1 (64 kb/s × N)的錯碼分析及信號量測，其中包含 ES，ESE，availability 等重要參數。在新一代測試設備未開發出來之前，此儀器應可做為測試上行網路品質的重要工具。CableLabs 在 1993 年即使用此套設備測試上行網路的品質。

五、HFC 上行頻道雜訊之實際量測

對於未來要提供雙向的數位服務來說， 網路上遇到最大的問題就是上行的放大器與雜訊干擾的問題。將網路升級之後，雙向放大器就可以將上行的訊號放大。但是，位於 5-42 兆赫的上行通道上的雜訊與干擾卻是無法避免。目前為大家所知道的雜訊與干擾有下列幾種：

(i) 注入雜訊：因為在上行的頻帶內，空氣中有許多的短波電台，調幅電台，汽車的無線電訊號及呼叫器的訊號，造成許多窄頻的雜訊由遮蔽效果不好的纜線進入網路中，這些雜訊稱為注入雜訊。注入雜訊出現的時間通常持續幾個小時到幾天，而大小則是看許多環境因素決定，天氣，大氣離子層，太陽黑子的活動等都會有影響。

(ii) 脈衝雜訊：在有線電視的網路中， 在上行的頻帶內超過一半的雜訊都是由用戶家庭內所造成的。原因可分為兩部分，第一，家庭用的訂戶引進線通常是在附近的電子材料店買的，屏蔽比較差，所以容易被空氣中的電波干擾。其次，許多的家庭電器有馬達，一旦啟動或開關，會造成時間很短但是功率卻很大的脈衝，稱為脈衝雜訊。脈衝雜訊的長度約在數個毫秒，強度通常蠻大的。

想要了解這些雜訊對通信的影響，須要進一步對不同的系統做分析與模擬。國際上的 IEEE 802.14 建議如下圖之通道模型，其中包括了網路上各個元件的頻率響應，雜訊參數及非線性元件特性。唯有先能描述各項參數，才能準確的模擬或預測網路的傳輸品質。

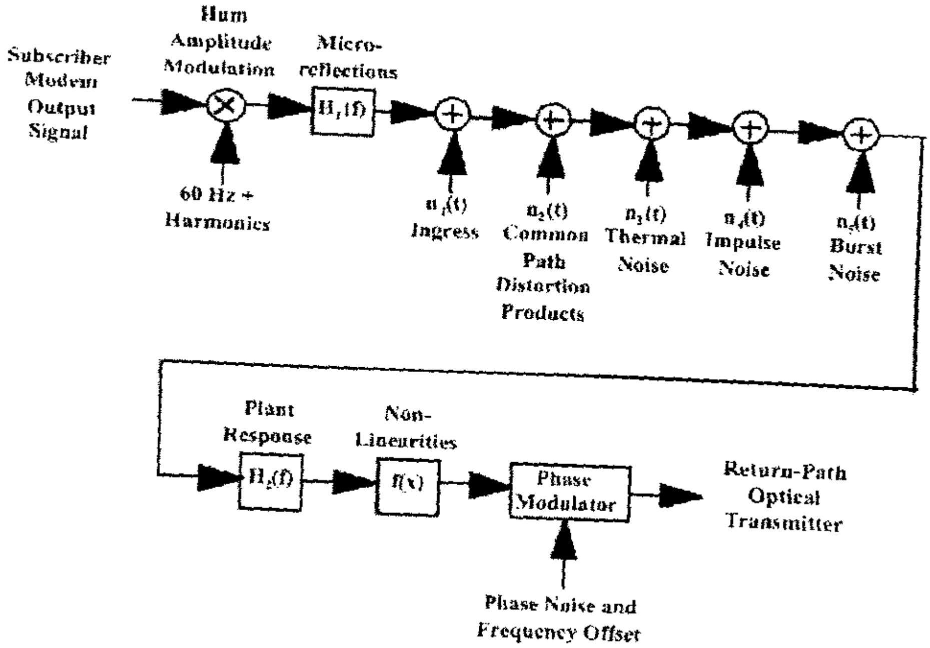

Subscriber Modem Output Signal
Hum Amplitude Modulation
60 Hz + Harmonics
Micro-reflections
$H_1(f)$
$n_1(t)$ Ingress
$n_2(t)$ Common Path Distortion Products
$n_3(t)$ Thermal Noise
$n_4(t)$ Impulse Noise
$n_5(t)$ Burst Noise
Plant Response
$H_2(f)$
Non-Linearities
f(x)
Phase Modulator
Phase Noise and Frequency Offset
Return-Path Optical Transmitter

圖 六

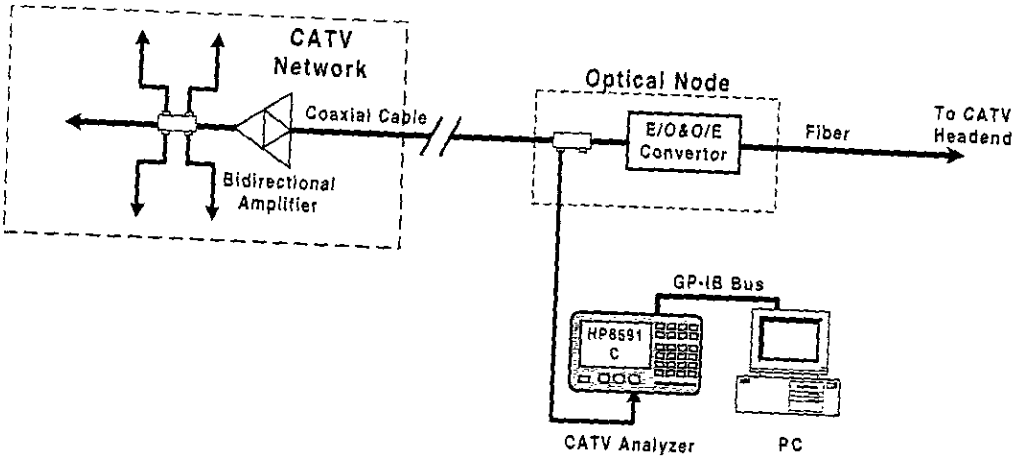

CATV Network
Coaxial Cable
Bidirectional Amplifier
Optical Node
E/O&O/E Convertor
Fiber
To CATV Headend
GP-IB Bus
HP8591 C
CATV Analyzer
PC

圖 七

5.1 上行注入雜訊之自動化測試

儀器需求：

1、可變衰減器。

2、頻譜分析儀。

3、個人電腦內建 GP-IB 介面卡及 GP-IB 控制軟體。

測試步驟：

1、測試裝置詳圖二。

2、手動調整頻譜分析儀的參數設定如下：
頻率範圍：同系統上行放大器之頻寬。
解析頻寬：100 千赫。
視頻頻寬：30 千赫。
垂直尺度：每格 10 分貝。
掃瞄時間：設定為自動。

3、將上述參數輸入電腦 GP-IB 控制軟體中。

4、關閉所有上行信號源，執行自動化量測。

5、分析所得資料。

自動化量測程式流程：

1、設定頻率範圍；

2、設定解析頻寬；

3、設定視頻頻寬；

4、設定參考準位；

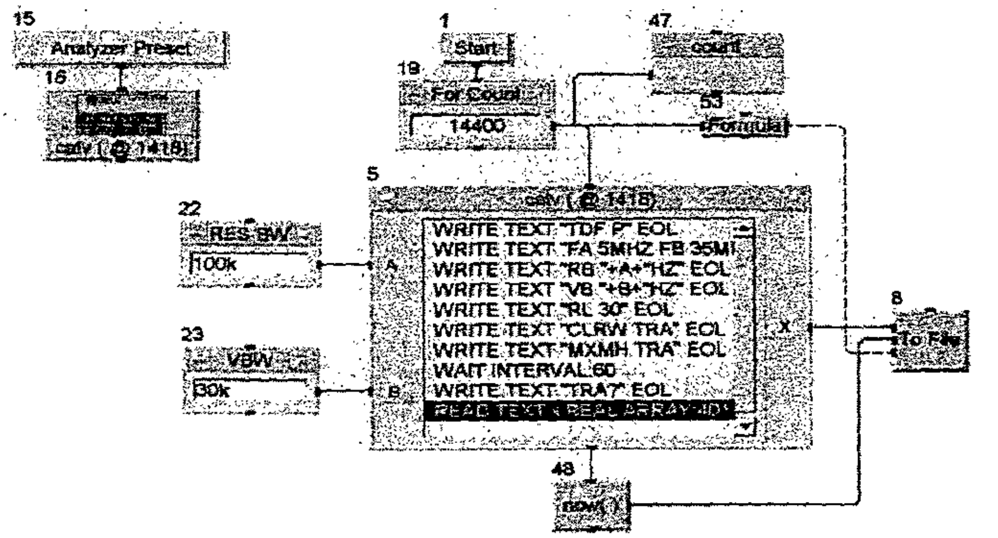
5、清除痕跡；

6、保留最大值；

7、等待 60 秒鐘；

8、讀取頻譜分析儀資料，存放在電腦的硬碟中；

9、重覆 1-8，1440 次 (每分鐘一次, 連續 24 小時)。



圖八

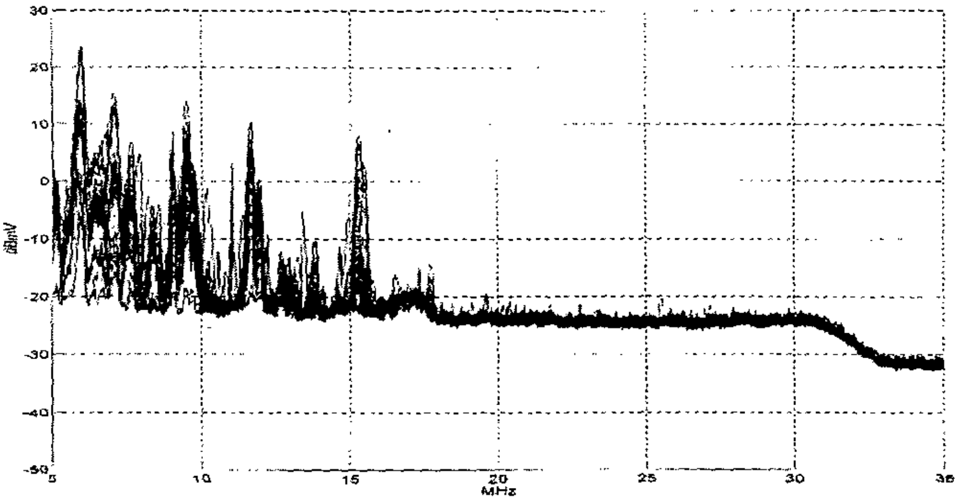
資料統計與分析

到目前為止，我們所收集的資料量非常大，不適合以人工的方式逐一檢視。但是它的優點是忠實地記錄了這般時間內上行網路的注入雜訊變化。只要稍加統計分析，我可以得到很多有用的資訊，如：(1) 雜訊在頻譜上的分佈；(2) 雜訊出現的時間；(3) 可用頻道…。我們所採用 Matlab 這一套數學軟體來做量測資料的統計與分析。程式說明如附錄 B

實測結果與討論

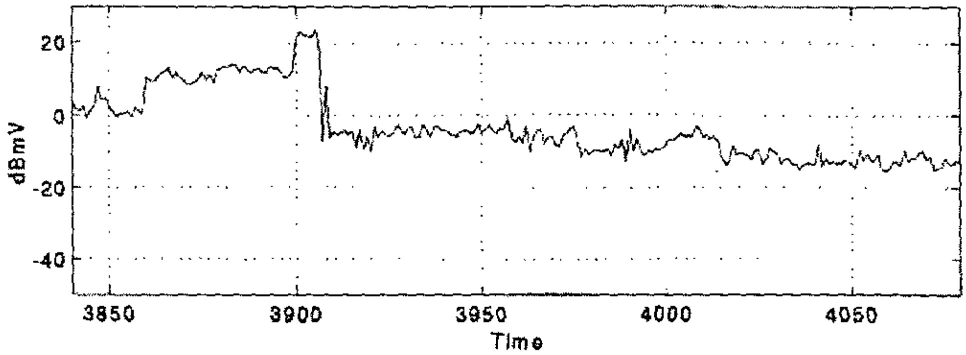
因為新竹市振道有線電視公司目前的網路上行放大器的頻寬只有 5-30 兆赫，所以我們對上行頻道的量測也限制於這個範圍內。

(1) 雜訊在頻譜上的分佈，(圖九 a) 是我們所量到的新竹市振道有線電視網路上行頻道(5-30 兆赫)的注入雜訊。這張圖是連續記錄 4 小時，240 組資料在頻率軸上重疊顯示的結果，所以這張圖上線條較粗黑的部份表示發生的次數較多。我們可以看到在某些特定頻率(如 5.9、7、11.7、14.1 兆赫…)有很強的注入雜訊，而大致上 15 兆赫以上的頻帶都是比較乾淨可用的。



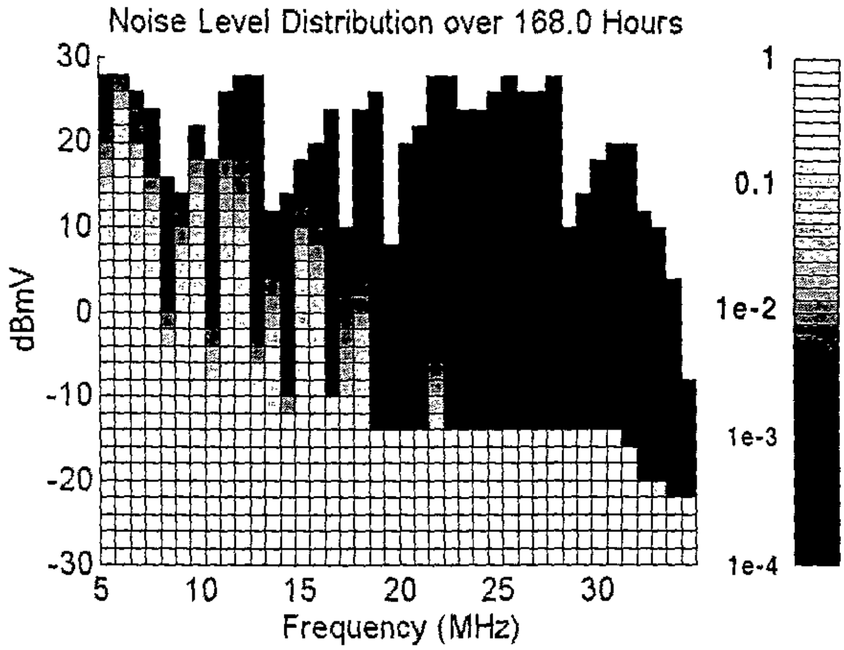
圖九 a

(2)雜訊出現的時間，(圖九 b) 是將同一組資料對時間軸做圖。由這張圖我們可以明顯地看到注入雜訊的強度隨時間的變化有 30 分貝之多，有某些時段雜訊很低，某時段卻很高，而且似乎看不出來是否有任何週期性存在，這就是為什麼我們要做長時間紀錄的原因。



圖九 b

(3)可用的頻道，(圖九 c) 每一個上行頻道注入雜訊強度的統計，這一張圖可以讓我們很清楚的看出來每一個頻道的注入雜訊的強度分佈及出現的機率。其中顏色越深的表示出現的機率越小。



Noise Level Distribution over 168.0 Hours
30
20
10
0
-10
-20
-30
dBmV
5
10
15
20
25
30
Frequency (MHz)
1
0.1
1e-2
1e-3
1e-4

圖九 c

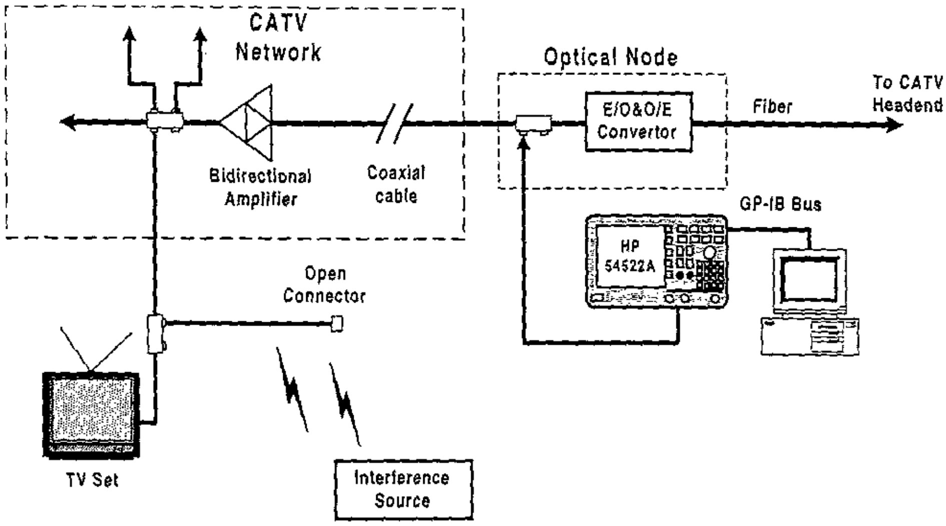
5.2 上行 5~42 MHz 間脈衝雜訊之測試

儀器需求:

1. 高速數位示波器一台(具有 HP-IB BUS)，有關其原理可參考附錄。
2. 個人電腦一台(具有 HP-IB BUS)
3. 可變衰減器
4. 干擾源(可利用家庭電器)

測試步驟:

1. 測試裝置詳圖五
2. 在頭端或光纖投落點將回傳的訊號輸入示波器，示波器之輸入阻抗應設定成 50 歐姆。
3. 調整衰減器以避免燒毀示波器，
4. 數位示波器重要的參數設定如下：
   取樣頻率：250 兆赫
   取樣點數：4096 點
   取樣時間: 16 微秒
   觸發準位: 3 毫伏特
   取樣解析度: 8 位元/點
   水平尺度: 每格 1.6 微秒
   垂直尺度: 每格 2 毫伏特
5. 將示波器之觸發模式設為“停止/單次”。
6. 觀察示波器是否被輸入的訊號觸發。
7. 若有必要，可在用戶端開啟干擾源。
8. 利用 PC 把儲存在示波器的波形抓取到硬碟中。
9. 回到步驟 3 做下一次的量測。
10. 可用 PC 上的 HP VEE 程式自動化的執行 3~9 的步驟，詳圖六。



圖十

自動化量測程式(圖六 a)流程說明:

1. Write Text "rst"：重置示波器

2. Write Text "timebase：range 16 us"：設定取樣時間為 16 微秒

3. Write Text "timebase：reference left"與"timebase：delay"：設定顯示波形位置

4. Write Text "timebase：sample clock 250e6"：設定取樣頻率為 250 兆赫

5. Write Text "timebase：rlength 4096"：設定取樣點數為 4096 點

6. Write Text "timebase：mode triggered"：設定為觸發模式

7. Write Text "chan1：coupling dcfifty"：輸入阻抗設定成 50 歐姆

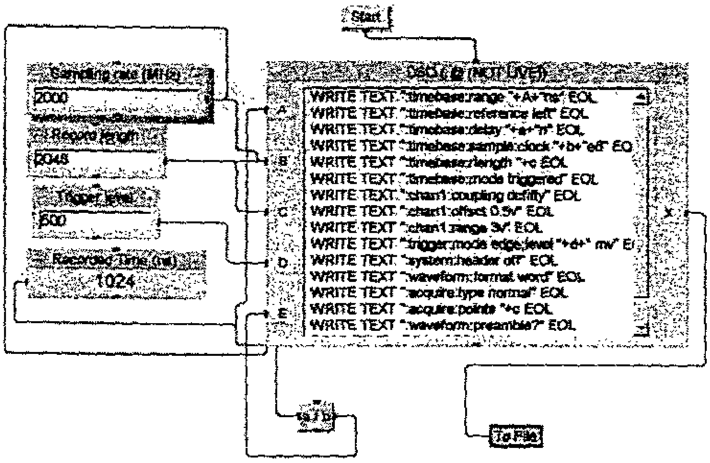
8. Write Text "chan1：range 20mV"：設定垂直尺度為每格 2 毫伏特

9. Write Text "Trigger：mode edge；level 3.0mv"：設定觸發準位為 3 毫伏特

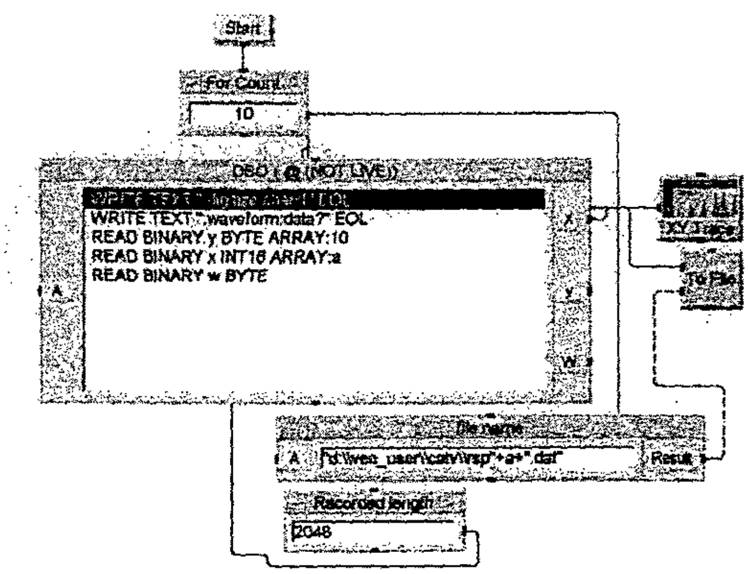
10. Write Text "system：header off"與"waveform：format compressed"：設定 GP-IB bus 上的傳訊介面

自動化量測程式(圖六 b)流程說明:

程式中有一個迴圈,可設定抓取波形的次數，在 write text "digitize chan1"與"waveform: data?"這兩個命令下，示波器會等待會被觸發的訊號，然後從 GP-IB bus 傳回波形,，而右上角的方塊即是指定欲存檔的檔名。



圖十一 a



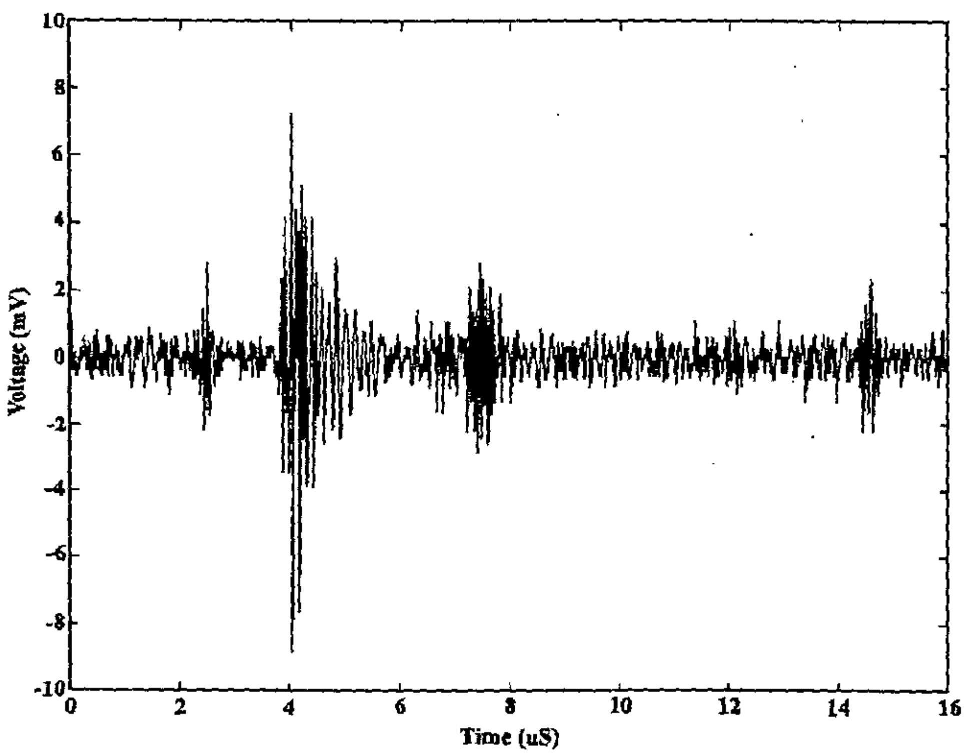
圖十一 b

測試結果:

經由 HP54522A 這台高速數位示波器所量測到的脈衝雜訊，利用 PC 上的後續處理得到如圖七所示的波形。我們可以清楚的看到，大部分的能量集中在 1~2 微秒之間，尾巴最多可達 10 微秒左右，與之前國外的研究大致符合。

測試討論:

我們利用現有的實際網路來當量測的目標。圖十二中的光纖投落點位於交大計中，而用戶端則是交大的教授宿舍。因為一路上的同軸電纜皆有反向放大器，對於在光纖投落點 e 下的脈衝雜訊都會累積在光纖投落點，所以我們採取在光纖投落點做量測。因為脈衝雜訊出現的時間的很短，從之前的文獻報告中，我們知道出現的時間約在數個微秒左右，若用頻譜分析儀做量測，時間上會來不及，因為頻譜分析儀掃一次的時間約為 20 毫秒。結合 PC 與數位示波器，我們可以做自動化長時間量測，以得到比較正確的網路狀況。此外我們不但可以利用示波器所偵測到突發的脈衝雜訊，也可以在用戶端做一些電器的開關，使我們評估各種電器所發出來的脈衝雜訊特性。



圖十二

六、實際量測之考量及參數之選定

從第五章，我們知道在實際查測網路品質時，網路上連有多少用戶，會對量測結果有極大的影響。而網路查測之初，電信總局可能會遇到兩種情形。其一是如和信、力霸等的某些經營區，屆時可能有部份用戶已在使用纜線數據機上網。其二是雙向網路剛剛啟用，尚無用戶(或很少用戶)連至上行網路。對於前者而言，只要連上網的用戶數目超過數百以上，便是極為真實的實際網路。查測時，我們可以用合理的量測參數範圍做為通過的標準。對於後者而言，我們則應以較嚴格的量測參數範圍做為通過的標準。因為零客戶(或極少客戶)時若不能通過嚴格的標準，將來大量客戶上網時，情況將更糟糕。

根據在第四章各國際標準的 review 結果，我們整理出 ESR 和 SESR 對傳輸長距離的關係圖，如圖 A 所示。另外，我們也整理出不堪用時間或當機時間對傳輸距離的關係圖，如圖 B 所示。其中後者是屬於長期的監測結果，可做為每年總局對各網路品質的評估參考，但似乎只能靠客戶舉發網路當機的時間為準，無法有真正量測的數據。前者，也就是量測 ESR 及 SESR，則是可以在短期內查測的數據。

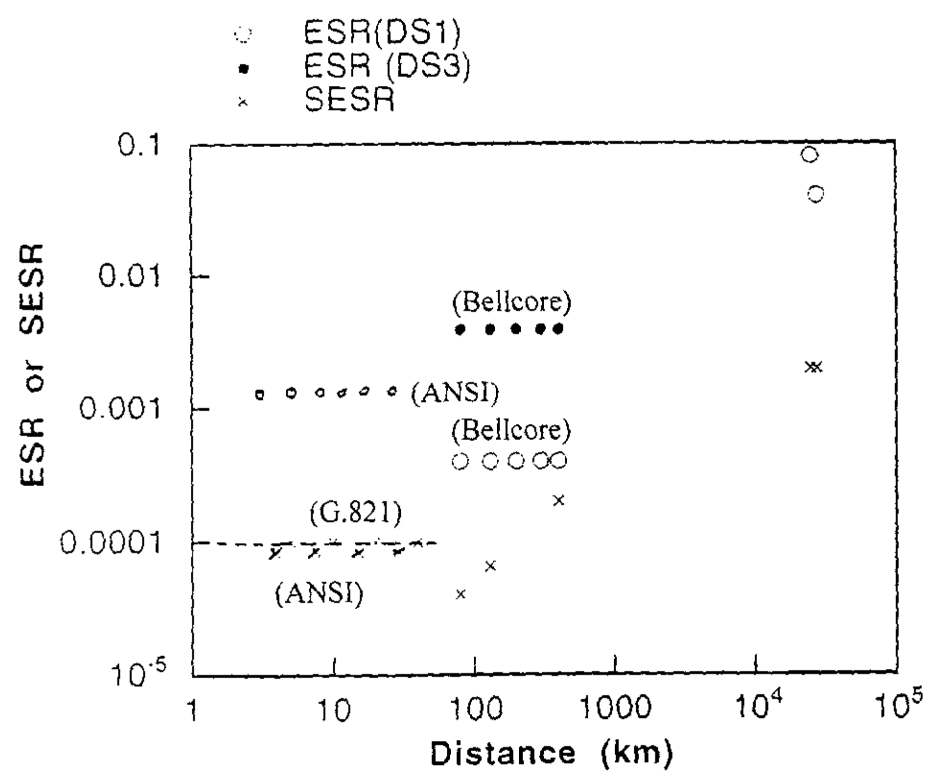


圖 A　含錯秒率(ESR)及含重錯秒率(SESR)對距離

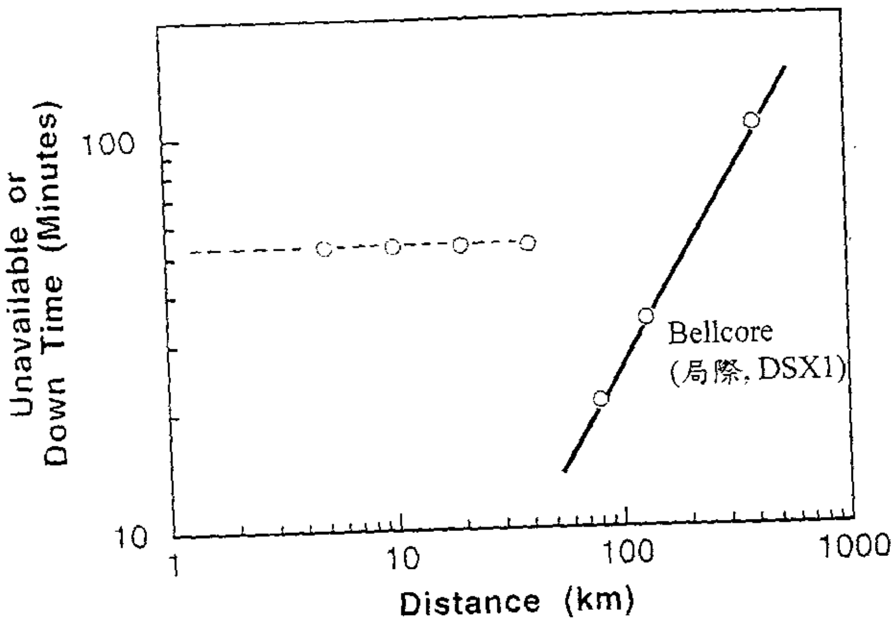


圖 B　當機時間對距離

我們根據目前市面上可買到的量測儀器之功能，及圖 A 的結果，訂定以下的查測方法：

(1) 對下行網路(架構圖如圖 C 所示)，使用三種廠牌之任一種量測 15 分鐘。在此 15 分鐘內，錯碼率均應≦10^{-9} (after RS decoding)或≦2×10^{-4} (before RS decoding)。

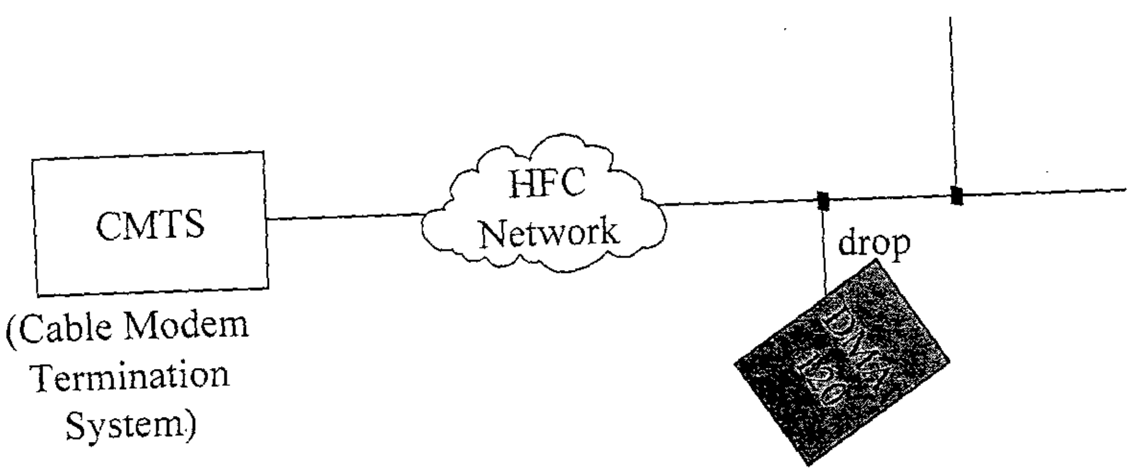
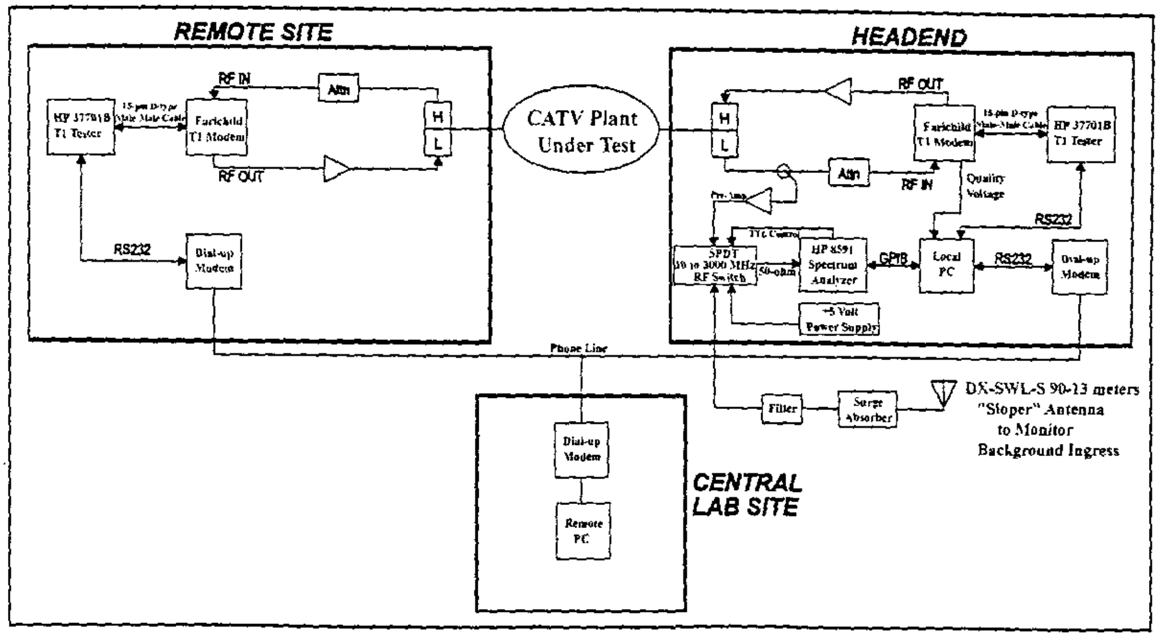


圖 C　下行網路查測聯結圖

(2) 對上行網路之查測，由於 Tektronix，Hukk 及 Sencore 都仍未推出相關測試設備。如果在他們發展出這些設備之前，總局就得開始查測的話，我們可以暫時使用 CableLabs 在 1993 年的測試方法，如圖十三所示。

TEST PLATFORM FOR TWO-WAY PLANT CHARACTERIZATION



圖十三

其中 Fairchild T1 modem 由於已停產，我們建議以 WavStar Model 6420 QPSK microwave modem 取代之。用圖十三的測試方法之優缺點如下：

優點：

(1) HP 37701B 或 37702A 及 T1/Datacom tester 可量測 G.821 所規定的 ES、SES、BER 等各項參數。對突發性雜訊之偵測甚有幫助。

(2) WavStar 6420 之載波範圍為 0.5 至 40 MHz，剛好適合上行傳輸測試。

缺點：

(1) HP37701B 報價$ 13,671 USD，WavStar 6420 報價$ 6,300 USD，均比下行測試的設備(Tektronix、Hukk、Sencore)貴出很多。尤其，我們需要兩套設備做收、發。

(2) 測試之信號並非真實的 MCNS Compatible，所以此測試方法只能提供最基本的通過標準參考。

使用此方法量測，我們建議量測時間為一天(參考 ANSI 及 AT&T T1.5 標準)。

● 通過量測之標準如下：

A.

	標準	來源
ESR	1.2%	G.821
SESR	0.015%	G.821
Downtime	53 min/yr	Bellcore

其中 ESR=0.17%，相當於一天之中有 147 秒含有錯碼。而 SESR=0.015%，相當於一天之中有 13 秒含錯之比例超越 10^{-3}。

注意此標準暫定為上、下行頻道均須符合。至於上、下行頻道測試標準如何區分，則必須在台灣的實際 HFC 網路中量測之後再決定之。

B.零客戶網路應有更嚴格之標準。

七、結語

在這次的研究計畫裡我們建議的量測方法和查測標準只是一初步的結論。有關量測方法，在下行方面應的比較簡單，馬上可實行。但在上行方面，由於所有的相關廠商均未設計出適當的儀器設備，我們只能建議用一參考性的做法--做為短期內(六個月內)查測的暫行辦法。六個月之後，希望市場上已能有適合 MCNS 標準的上行測試設備。在查測通過標準方面，我們希望能將此計畫中所建議的數值與在科學園區的 testbed 所量得的數值做一交叉比對，以確定這些數值的可行性(太鬆或太嚴均不好)。最後再做查測正式標準的確認。

另外，值的一提的是，有關 HFC 網路量測的方法和標準，我們可以領先世界先進的國家，而不需要非等到歐美定出標準之後，我們才收集其資料做參考。衡諸國情，我們固網開放在即，只要對自己訂定的標準有各方面的參考(國際標準及國內測試平台的數據)，我們就應對自己的一套辦法有信心，而去實行。否則，一昧的追隨國外，不但時間上不許可，而且標準之訂定可能也不符國情。

八、參考文獻

[1] Bellcore Technical Analysis Report, Transport Systems Generic Requirements (TSGR)：Common Requirements, TR-NWT-000499, Issue 5, December 1993.

[2] ETSI EN300 416 v1.2.1 (1998-08), Network Aspects (NA)；Availability Performance of path elements of international digital paths, August 1998.

[3] ITU-T G.821 Series G：Transmission systems and media (Digital transmission systems - digital networks -- Quality and availability targets, August 1996.

[4] AT&T CableLabs PCN/PCS Project Task III - SOW #CLO3 "Transport Performance and Availability Characterization Test Plan" prepared for Cable Television Laboratories, Inc.

[5] B. Currivan and B. Xenakis, "Considerations for upstream channel communications in CATV systems," Electron. Design, pp.67-74, Feb. 1997.

[6] K. Haelvoet, D. De Bal, K. De Kesel, B. Vanlandschoot, and L. Marrtens, "Procedure for measurement and characterization of upstream channel noise in CATV networks," Tech. Digest, 49th ARFTG Conference, pp. 19-23, Denver, Colorado, June 1997.

[7] C. A. Eldering, N. Himayat, and F. M. Gardner, "CATV return path characteristics for reliable communications," IEEE Commun. Magazine, pp.62-69, August 1995.

[8] R. Wells, "Return path noise: Testing tool aids diagnosis," Commun. Eng. And Design, pp.24-37, January 1997.

附錄 A 「數位示波器簡介」

數位示波器之主要架構:

數位示波器已經是現代量測上的驅勢，它主要的架構如圖八，透過探針或 coaxial cable，訊號進入 channel 1 或 channel 2，隨後是一個衰減器，目的是保護後面的電路；接著是 Analog to Digital Converter(A/D)的 preamplifier，讓訊號的大小能落在 A/D 的 Full Range 內；經過高速的(A/D)取樣後，數位的資料存入 A/D memory 中，最後，有一個 microprocessor 把 memory 中的波形利用 CRT 顯示出來。以上是把示波器內的主要元件做一簡單的描述，在下面的文章中，我們來討論與數位示波器能力最有關係的取樣方法與類比頻寬。

取樣的原理:

根據 Nyquist's Theorem，若取樣的頻率為訊號最高頻率的兩倍以上，則取樣後的 samples 點可以完整的重建原來的訊號。在一般的取樣方法中，數位示波器的取樣速度是符合 Nyquist's Theorem 的，不過，我們常常會忽略一個真實世界的訊號並沒有一個明確的最高頻率，或把 300MHz 的方波當成只有 300MHz 的頻寬，而忽略了奇數階的 harmonics；所以，在量測一個未知訊號時，應先估計它的最高頻率約在哪裡，使用示波器才能正確的取得波形。有些數位示波器可以用一些數位的技巧來增加它 sample 的能力，關於這點，請看下面介紹的取樣方法。

類比頻寬:

數位示波器的類此頻寬指的是從輸入端到 A/D 之間路徑上的濾波器，放大器合成的頻寬，它代表能進入 A/D 的最高頻率。例如我們輸入 600MHz 的正旋波到一台有 2GHz 取樣頻率，500MHz 類比頻寬的數位示波器，雖然 2GHz 大於 600MHz 的兩倍，但是此 600MHz 的旋波根本到不了 A/D，因為示波器的類比頻寬不到 600MHz。

數位示波器的取樣方法:

目前的數位示波器的取樣方法可約分為兩種 (1) Real-Time Sampling (即時取樣)(2)Repetitive Sampling(重覆取樣)。分別介紹如下:

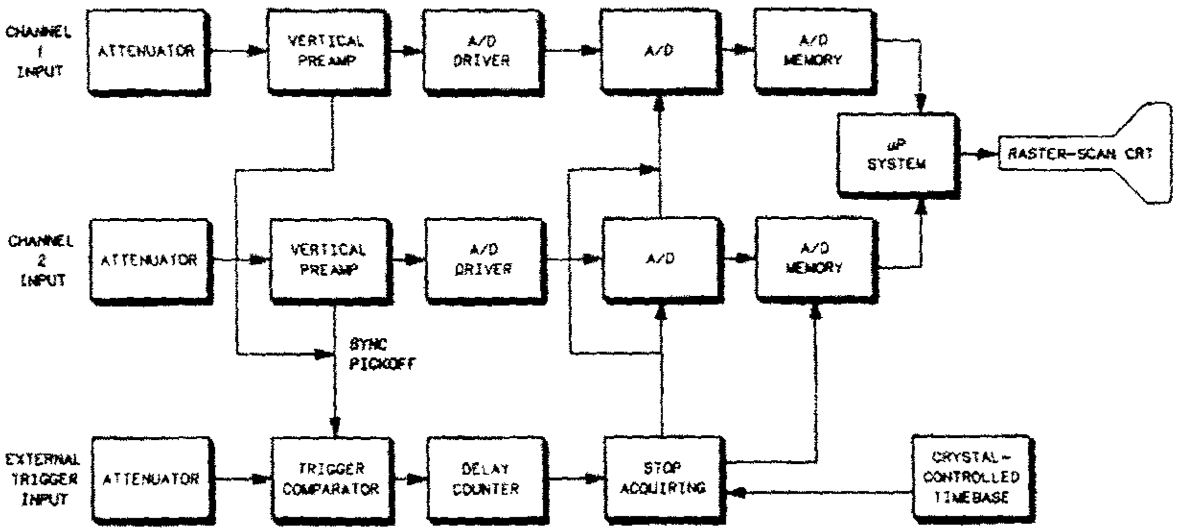
(1) Real-Time Sampling (即時取樣):

在 Real-Time Sampling 中，取樣的方式如同 Nyquist's Theorem 所描述的，Time-Domain 的波形輸入 A/D，然後 A/D 以它最快的速度循序取樣，如圖九，而我們在 CRT 所看到的就是一次取樣時間的波形，若示波器在 Free Run 的模式，CRT 上的波形會一直更新。Real-Time Sampling 的優點為不管波形為何，示波器都可以正確的抓住，不像類比示波器只能觀測週期訊號；它的缺點則是 A/D 的速度要夠快，現在的量測常常會遇到高速的訊號，A/D 速度的要求也跟著提高，一般來說，Sampling Speed 通常要高於訊號十倍以上， 也造成了整台示波器的成本上升。

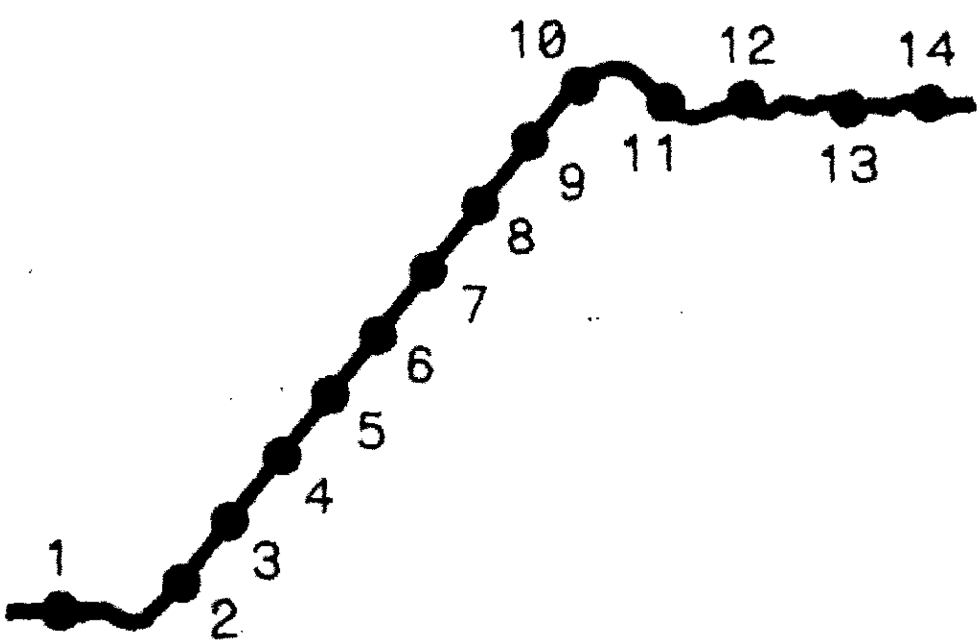
(2) Repetitive Sampling(重覆取樣):

Repetitive Sampling 的方法是，針對週期性訊號，每個經過一個週期，A/D 只隨機(Random)或循序(Sequential)的在週期內選一個點做取樣，如圖十所示；因為是數位的資料，示波器可以把這的點的值儲存在記憶體中，並顯示在 CRT 上，所以在 CRT 上的點並不是一次連續的取樣，如此一來，Repetitive Sampling 可大幅降低取樣頻率的要求。因為波形並不是一次連續的取樣，所以 Nyquist's Theorem 並不適用。Repetitive Sampling 的優點為它對 A/D Speed 的要求很低，只要訊號的頻寬小於示波器的類比頻寬就可以顯示在 CRT 上；它的缺點就是要求訊號必須是週期性的，若在量測中，訊號有一點變動，示波器所顯示的波形就不正確，另一個缺點是因為它要累積許多次的取樣點才能得到完整的波形，所以速度比較慢。

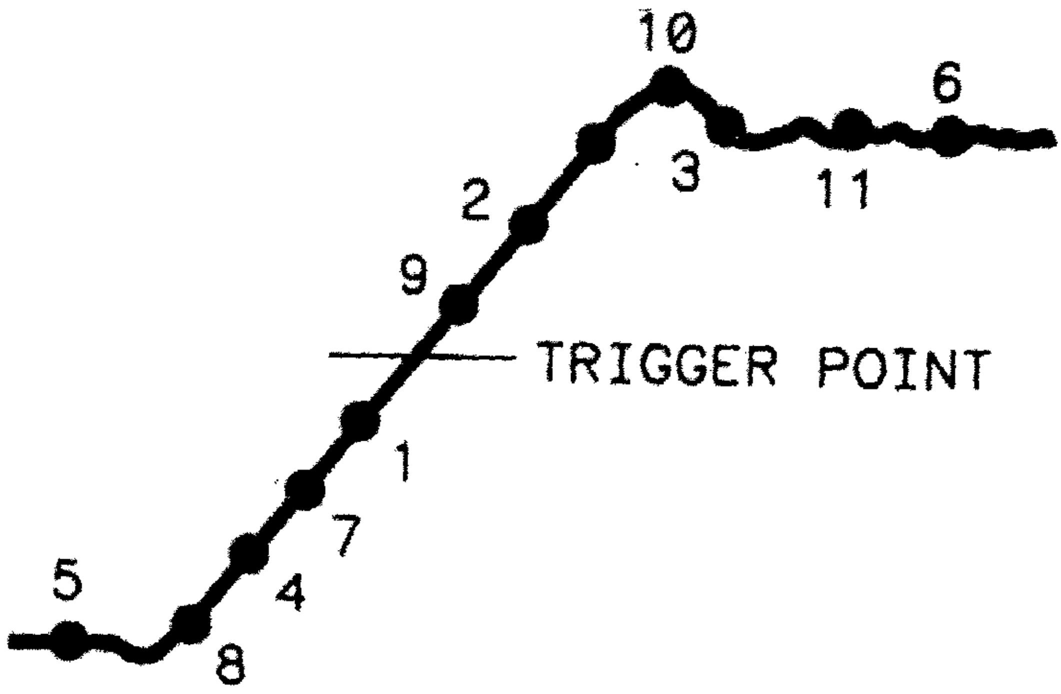
最後，針對我們的量測來說，因為 impulse noise 是突發的訊號，並且每一次的波形都不一樣，所以不能用 repetitive sampling 方法。在我們實際量測中，都是用 one-shot real-time sampling 的模式。


CHANNEL 1 INPUT
ATTENUATOR
VERTICAL PREAMP
A/D DRIVER
A/D
A/D MEMORY
µP SYSTEM
RASTER-SCAN CRT
CHANNEL 2 INPUT
ATTENUATOR
VERTICAL PREAMP
A/D DRIVER
A/D
A/D MEMORY
SYNC PICKOFF
EXTERNAL TRIGGER INPUT
ATTENUATOR
TRIGGER COMPARATOR
DELAY COUNTER
STOP ACQUIRING
CRYSTAL-CONTROLLED TIMEBASE

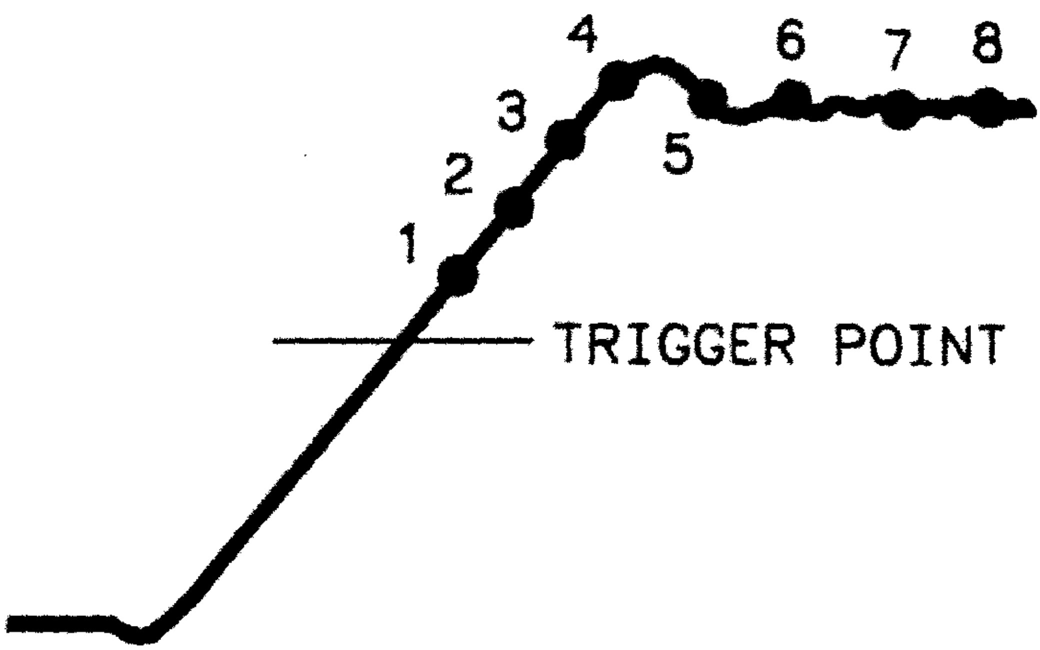
圖十四


1
2
3
4
5
6
7
8
9
10
11
12
13
14

圖十五



圖十六 a



圖十六 b

附錄 B　Matlab 程式

磁片 (附於正本期末報告中)

附錄C　專有名詞中英文對照

堪用率	Availability
可用頻道	Available channel
堪用時期	Available Time
錯碼率	Bit Error Ratio，BER
含突錯秒	Burst Errored Second
通道模型	channel model
清除痕跡	clear trace
同軸電纜	coaxial cable
分貝	DB
當機時間	Downtime
訂戶引進線	Drop line
含錯秒率	Error Second Ratio，ESR
含錯秒	Errored Second
頻率響應	frequency response
混合光纖同軸電纜	Hybrid Fiber Coax
脈衝雜訊	impulse noise
注入雜訊	ingress noise
輸入阻抗	Input Impedance
千赫	kHz
保留最大值	maximum hold
兆赫	MHz
微秒	microsecond
毫伏特	millivolt
毫秒	msec
網路	Network
非線性元件	nonlinear device
光纖投落點	optical node
參考準位	reference level
解析頻寬	resolution bandwidth
含重錯秒率	Severely Error Second Ratio，SESR
含重錯秒	Severely Errored Second，SES
屏蔽	shielding
頻譜分析儀	spectrum analyzer
掃瞄時間	sweep time
可變衰減器	tunable attenuator
不堪用時期	Unavailable Time
視頻頻寬	video bandwidth

Tektronix

DMA120 Series Digital Modulation Analyzers

DMA120 • DMA121

In-service Digital Channel Performance Verification Measurements At An Affordable Price

Measurements Compliant With DVB (ETSI) Standard ETR290

Troubleshooting Aided By Constellation, Spectrum, and Equalization Display Modes

Most Measurements Require Only Two Keystrokes

Pass/fail Indication Reduces Training Requirements For Technicians New To Digital Signal Measurements

PC Card (PCMCIA) Slot For Easy Memory Expansion

Small and Light Weight

Easy-change Battery

Affordable, portable, ready for cable system technicians: digital channel 64QAM transmission performance verification measurements

The DMA120 Series Digital Modulation Analyzers provide answers to nagging questions about how to test and verify performance of your digital plant. Quantification of digital transmission performance – at any point in your system – will greatly enhance technical management and decision making. The DMA120 provides analysis of ITU-T-J.83, Annex B 64QAM and the DMA121 verifies DVB-C 64QAM.

The DMA120 Series provides the intelligence cable TV technicians need to efficiently install and maintain HFC distribution plant using 64QAM transmission. Measurement results provide a clear picture of system performance, minimizing the need to re-visit an installation site or make additional service calls. The DMA120 Series field tools are housed in a rugged, weather resistant package and are powered by an easy-to-change NiMh battery. Standard accessories include a protective soft case, mains power supply, and user's manual.

Qualify System Performance

The built-in digital demodulator makes possible in-service measurements of:

- Modulation Error Ratio (MER)
- Error Vector Magnitude (EVM)
- Estimated Noise Margin
- BER before Reed-Solomon (R-S) decoder
- Estimated BER after R-S decoder with system availability statistics

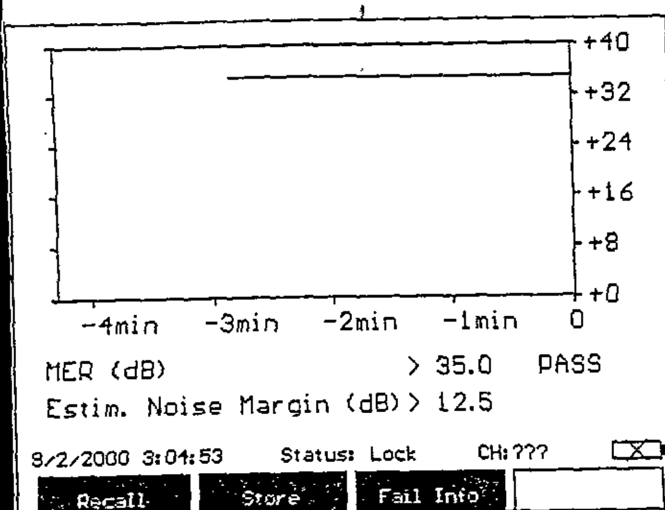
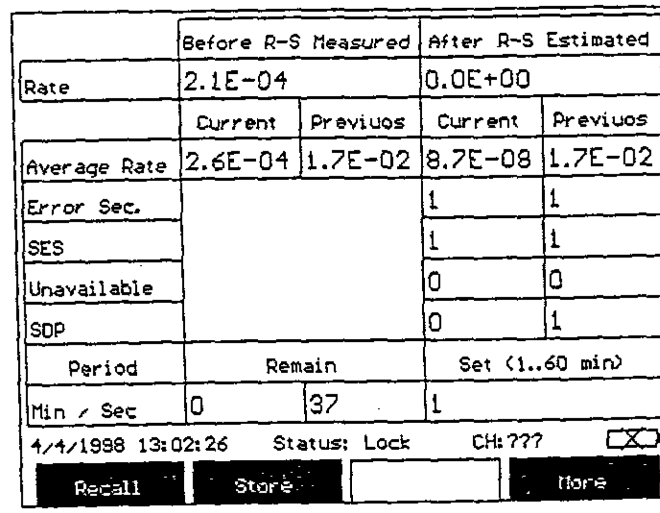


Figure 1. MER and Estimated Noise Margin screen.



	Before R-S Measured		After R-S Estimated	
Rate	2.1E-04		0.0E+00	
	Current	Previuos	Current	Previuos
Average Rate	2.6E-04	1.7E-02	8.7E-08	1.7E-02
Error Sec.			1	1
SES			1	1
Unavailable			0	0
SDP			0	1
Period	Remain		Set (1..60 min)	
Min / Sec	0	37	1	

Figure 2. BER screen.

Modulation Error Ratio (MER): ETSI ETR290 indicates that MER is the best overall "figure of merit" measurement to determine 64QAM signal quality. Although bit error rate (BER) has been widely addressed as an important digital transmission "figure of merit" measurement, MER provides a much earlier indication of transmission impairments. MER indicates the ratio of average total signal power in the ideal constellation to average error power in the constellation as received by the DMA120 Series. The measurement includes error power due to any impairment. If the only impairment in the test channel spectrum is noise, MER is equal to signal-to-noise. Technicians will feel familiarity with MER because results are expressed in dB, similar to analog transmission carrier-to-noise or signal-to-noise measurements. The DMA120 Series measurement screen (see Figure 1) shows MER vs. time, providing trend information.

Error Vector Magnitude (EVM): EVM is an alternative "figure of merit" measurement. It has been a performance measurement for digital communication systems in the past and provides a means of system comparability for some engineers. The same distortion elements are measured as in MER. However, the calculation of error is different and is expressed as a percentage (%) of the maximum voltage in the constellation (at sampling times) as received by the DMA120 Series.

Estimated Noise Margin: The legacy of RF broadband system maintenance has been based on measurements in the frequency domain. Technicians are conditioned to thinking of system "headroom" in terms of dB carrier-to-noise or dBc for CSO, CTB, or cross modulation. Estimated Noise Margin indicates the "headroom" for digital channels and results are reported in dB, similar to legacy analog measurements. Essentially, simulated gaussian noise is added to the input signal until a critical pre-FEC BER of 10^{-4} is measured. The added, simulated noise equals the Estimated Noise Margin which answers the question, "how many dB until the TV receiver shows picture impairment?"

Bit Error Rate (BER) before Reed-Solomon (R-S) decoding: BER is an important measurement to document system performance. The typical system operating goal is to achieve a BER of 10^{-9}. Picture impairments will typically be observed at bit error rates greater than 10^{-4}. The BER measurement is the average ratio of bit errors to total bits received in a specified time period. The DMA120 Series BER measurement may be set for any period from 1 to 60 minutes. Results from successive periods can be compared to show a 24-period trend.

Estimated BER after R-S decoding: BER after R-S decoding represents the service level that the cable system is providing to the subscriber's TV receiver. The R-S decoder is typically able to correct errors up to an input BER of $\approx 10^{-4}$. Beyond this value, uncorrected errors pass through the decoder – this is the value reported by Estimated BER (see Figure 2).

System availability statistics are also reported by the DMA120 Series, including:

- Errored seconds (number of seconds that include an errored block)
- Severely errored seconds (one-second periods with greater than specified number of errored blocks)
- Severely disturbed periods (duration of sync loss)
- System unavailability time (time period containing at least 10 consecutive severely errored seconds)

System availability statistics are very useful for tracking intermittent impairments that may not be observable based on MER or average BER measurements.

Maintain and Troubleshoot Your Digital Video Plant

When performance quality measurements indicate 64QAM transmission problems, the DMA120 Series can provide assistance to find out what's wrong. Additional measurements and display modes that can help the technician include:

- Channel Average Power (Signal Level)
- Adjacent Channel Levels
- Spectrum Display Mode
- Constellation Display Mode with zoom capability
- Adaptive Equalizer Display Mode

Digital Channel Average Power: RF signal level measurement is made by integrating all the channel power through a channel bandwidth IF filter. A user-settable offset is available to accommodate probe loss. The Signal Level measurement screen plots signal levels vs. time, providing a convenient display from which to make gain or attenuation adjustments or judge other variables that can impact signal level.

Adjacent Channel Levels: Potential interference to adjacent channels can be verified using this measurement. The Adjacent Channel Levels display compares the test channel average power to the average power in each of the two higher and two lower adjacent channels. The measurement results screen includes a bar graph comparing the test channel and adjacent channels power. This measurement may be used to check flatness across five 64QAM channels or verify spectral purity of a QAM modulator.

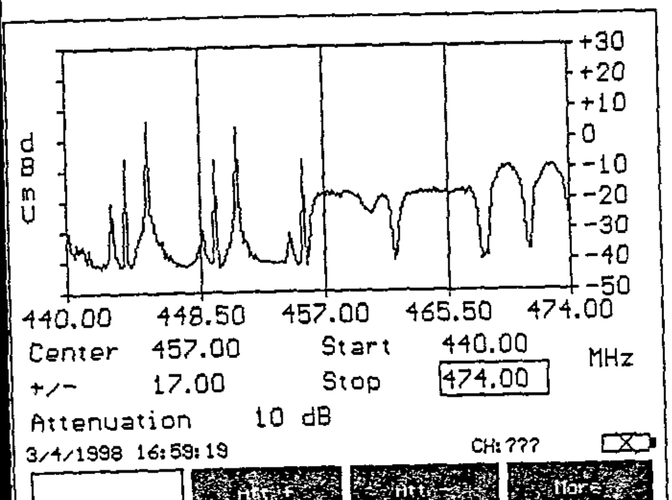


Figure 3. Spectrum mode.

Spectrum Display Mode: The channel or system spectrum can be viewed in this mode – channel symmetry and flatness, and relative signal levels can be visually confirmed (see Figure 3).

Constellation Display Mode: Digital modulation quality can be visually estimated by viewing the constellation of the transmitted signal (see Figure 4). Distribution impairments can be identified including noise and coherent interferers or modulator impairments such as I/Q imbalance or quadrature error. The DMA120 Series also includes a zoom mode – a single constellation box can be selected and magnified to closely examine the distribution of symbol landings. Decision boundaries are displayed along with adjacent boxes to make it easy to see the symbol landing patterns (see Figure 5).

Adaptive Equalizer Display Mode: This display indicates linear impairments such as poor frequency response reflection. Tap values show how hard the equalizer is working to compensate for impairments. The display includes a bar graph which compares the values of the different taps against a DVB template. Bars approaching or exceeding the template value indicate that there is noticeable system impairment detected at the test point.

New Measurement Technology That's Easy-to-Use

Using the DMA120 Series is easy. Most measurement functions are no more than two menus deep. Navigation through menus is straight forward and there's a MENU key on the front panel that instantly gets the user to the instrument's Main Menu screen. Universal set up

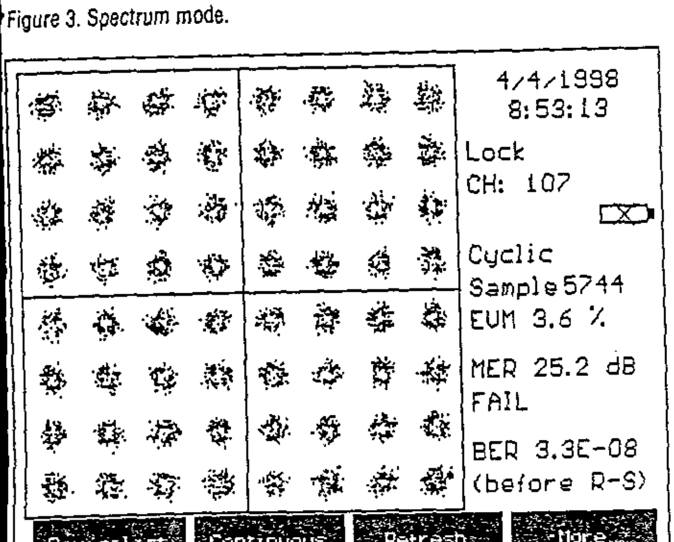


Figure 4. Constellation display mode.

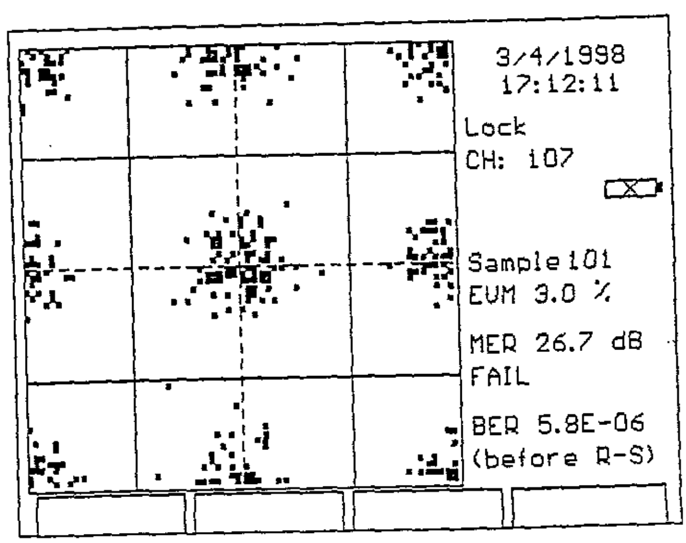


Figure 5. Constellation Box Evaluate mode.

parameters are part of a Set Up screen. Measurement specific set up parameters are part of the individual measurement screens.

Digital transmission is new to most cable TV system technicians and so are measurements to verify performance. Technicians may not understand exactly how these measurements function or how to interpret measurement results. However, measurements are still required to continue system installation and maintenance activities. The DMA120 Series helps technicians to continue working by providing measurement pass/fail indicators. The system engineer or chief technician can determine the measurement-result threshold values. This enables the technician to continue working if measurements are passing or follow an Engineering directive if failures are encountered. Pass/fail indicators are available for: MER, RF Signal Level, Adjacent Channel Level, Channel Power-to-Noise, Severely Errored Seconds (BER mode).

Status indicators also help clarify measurement conditions: the DMA120 Series notes if it's locking to the incoming QAM signal and also if it's locking to the R-S decoder output. The actual received symbol rate is also reported.

Operating Convenience

The DMA120 Series uses a moisture- and dust-proof keypad. It uses a high-resolution LCD display with backlight. Contrast controls are conveniently located on the front panel.

The DMA120 Series includes many capabilities designed to simplify the job of digital plant installation and maintenance. Ancillary enhancements include:

- Print screen: Any measurement or display mode screen can be directly printed via RS-232 interface
- Up to 30 constellations or 100 other measurement results can be stored in internal memory with real-time clock/date stamp, measurement site name, operator name, and ambient temperature
- User-changeable input adapter (type F or BNC – optional accessory)
- PC Card (PCMCIA) input for 2 and 20 Megabyte memory cards to store additional measurement results and/or system channel tables
- User-changeable, NiMH battery to extend the operating day; battery capacity indicator; user-selectable automatic power down

DMA120 Series Digital Modulation Analyzer Characteristics

NOTE: All specifications apply across the operating temperature range (–5 to +40° C) unless otherwise stated. All values refer to measurement after 25-minute warmup. All power measurements referenced to 75 Ω impedance.

RECEIVER

Frequency Range (channel center frequency) –
DMA120: 54 to 860 MHz.
DMA121: 50 to 866 MHz.

Resolution Bandwidths (typical) –
DMA 120: 135 Mhz, 6 MHz.
DMA121: 135 kHz, 8 MHz.

Input Impedance – 75 Ω, nominal.

Maximum Input –
RF Power: 120 dBµV (60 dBmV).
AC Volts: 90 V peak.

Distortion-free Dynamic Range – >40 dB.

Sensitivity – <20 dBµV (–40 dBmV).

DISPLAY MODES

Spectrum –
Displayed Level (average power of 64QAM signal at 6.875 Msymb/s):
Minimum: 40 dBµV (–20 dBmV).
Maximum: 100 dBµV (40 dBmV).
Attenuation Steps: 5 dB, typical.
Attenuation Range: 35 dB, typical.
Vertical Scale: 10 dB/div, 10 to 90 dBµV, –50 to 30 dBmV, –100 to –20 dBm.
Span Settings: 2 to 824 MHz (fixed to 135 kHz RBW).
Flatness: ±1 dB.

Constellation –
Size: 64QAM.
Evaluation: Full constellation, single point (box).

Adaptive Equalizer –
Number of Taps:
DMA120: 8 feed-forward; 8 feed-back.
DMA121: 8 feed-forward; 24 feed-back.
Scale: +10 to –40 dBc.
Mask: DVB.

MEASUREMENT MODES

Signal Level –
Channel Bandwidth:
DMA120: 6 MHz.
DMA121: 8 MHz.
Level (channel average power):
Minimum: 40 dBµV/–20 dBmV.
Maximum: 100 dBµV/40 dBmV.
Accuracy: ±1.5 dB, referenced to 25° C.
Reference Units (selectable): dBµV, dBmV, dBm, dBpW.
Pass/Fail Indication: User-adjustable threshold.
In-service Measurement.

Channel Power-to-Noise –
Channel Bandwidth:
DMA120: 6 MHz.
DMA121: 8 MHz.
Maximum Ratio: 40 dB.
Accuracy: ±2.1 dB.
Pass/Fail Indication: User-adjustable threshold.
In-service Measurement: Noise measurement frequency out of channel.

Adjacent Channel Level –
Difference Amplitude Range:
DMA120: +10 to –25 dB.
DMA121: +15 to –25 dB.
Accuracy: ±2.1 dB referenced to 25° C.
Display Vertical Scale: 40 to 100 dBµV, –20 to 40 dBmV, –65 to –5 dBm, 25 to 85 dBpW.
Pass/Fail Indication: User-adjustable threshold.
In-service Measurement.

Modulation Error Ratio (MER) –
Range: 22 to 35 dB.
Accuracy: ±1.5 dB at 65 dBµV/5 dBmV, referenced to 25° C.
Pass/Fail Indication: User-adjustable threshold.
In-service Measurement.

Error Vector Magnitude (EVM) –
Range: 1.2 to 4.1%.
Accuracy: ±0.4% over 1.2 to 2.0% range; ±0.8% over 2.1 to 4.1% range at 65 dBµV/5 dBmV.
In-service Measurement.

Average Bit Error Rate (BER), Before R-S Decoding –
Range: 10^{-4} to 10^{-9}.
User-selectable Time Period: 1 to 60 minutes.
Number of Periods Comparable: 24.
In-service Measurement.

Estimated Average Bit Error Rate (BER), After R-S decoding –
User-selectable Time Period: 1 to 60 minutes.
Number Periods Comparable: 24.
In-service Measurement.

System Availability Statistics –
User-selectable Time Period: 1 to 60 minutes.
Errored Seconds.
Severely Errored Seconds:
Pass/Fail indication: User-settable threshold.
Unavailable Time.
Severely Disturbed Period.
In-service Measurement.

Estimated Noise Margin –
Range:
DMA120: 1 to 12 dB.
DMA121: 1 to 10 dB.
Accuracy: ±1.5 dB at 65 dBµV/5 dBmV.

Symbol Rate –
Range:
DMA120: 5.057 to 5.360 Msymb/s.
DMA121: 5.000 to 6.956 Msymb/s.

eneral
haracteristics

ENVIRONMENTAL

Temperature –
Operating: –5 to +40° C.

Altitude –
Operating: Up to 4,600 m (15,000 ft.).
Non-operating: Up to 15,000 m (50,000 ft.).

EMC COMPLIANCE

Qualified Per The Following Standards –
U.S.A./FCC: CFR 47, Part 15, Subpart B, Class A.
Australian EMC Framework: AS/NZS 2064.1/2.
EU (EMC Directive 89/336EEC (and IEC 61326)):
- EN 55022 Class A (radiated and conducted emissions).
- IEC 1000-4-2 (ESD immunity).
- IEC 801-3 (RF field immunity).
- IEC 1000-4-4 (EFT/burst immunity).

POWER

DC Input Range – 12 V, 2 A.

Battery Run Time – >2 hours, typical.

Battery Charge Time *(instrument off)* – 4 hours, typical

PHYSICAL

Dimensions	cm	in.
Height	32	12.5
Width	17	6.75
Depth	6	2.25

Weight	kg	lb.
Net	2.1	4.6

WARRANTY

One year parts and labor.

OTHER

Communication Interface – RS-232; speed 9600 to 115,200 baud.

Channel Tables – User-defined tables in *standard memory*. Additional stored in PC Card (PCMCIA) memory cards.

...ering ...ormation

DMA120 Digital Modulation Analyzer for ITU-T-J83, Annex B 64QAM

DMA121 Digital Modulation Analyzer for DVB-C 64 QAM

Includes: User's Manual, Reference Card, Padded Carrying Case, 120 VAC North American Power Pack with DMA120, 220 VAC Euro Universal Power Pack with DMA121, Precision Female-Female Type F Adapter,Vehicle Power Adapter, Channel Table Loader Software with Manual, RJ45 to 9-pin Adapter, RJ45 Cable.

DMA120 SERIES OPTIONS

Option C3 – Three years calibration services.

Option C5 – Five years calibration services.

Option D1 – Calibration data report.

Option D3 – Test data (order with Option C3).

Option D5 – Test data (order with Option C5).

Option R3 – Three years post-warranty repair protection.

Option R5 – Five years post-warranty repair protection.

AC ADAPTER OPTIONS

Option A0 – North American 115 V, 60 Hz (standard with DMA120).

Option A1 – Euro Universal 220 V, 50 Hz (standard with DMA 121).

Option A2 – U.K. 240 VAC, 50 Hz.

Option A3 – Australian 240 V, 50 Hz.

DMA120 SERIES RECOMMENDED ACCESSORIES

Type F-to-BNC Input Adapter – 103-0310-00.

Additional Battery – DMABAT.

External Battery Charger for DMABAT – DMACHG (specify power cord Option A2 or A3, as applicable).

Thermal Printer – DMAPRN.
Includes: Five Rolls Paper, Battery, AC Adapter. Select one of following AC Adapter options:

Option A0 – North American 115 V, 60 Hz.

Option A1 – Euro Universal 220 V, 50 Hz.

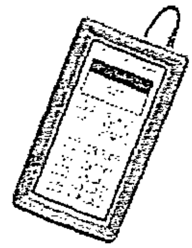
Option A2 – U.K. 240 VAC, 50 Hz.

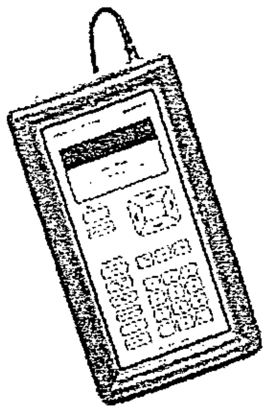
Option A3 – Australian 240 V, 50 Hz.

QAM-B970

QAM Analysis Meter

TECH CHOICE





Designed To Work With Hard-Line CATV Applications Conforming to ITU J.83 Annex B. (General Instruments,™ Scientific Atlanta,™ ...Set Top Boxes)

Zoom

Select a more detailed description of this product by application:

- CATV/MATV/SMATV Analyzing

Free Trial | Training Info | Tech Tips | Trade In | Financing

QAM-B 970 - QAM Analysis Meter

- Full tuning capabilities to test analog or digital channels and carriers throughout your system (5 to 750 MHz).
- Quick and accurate pre & post FEC estimated BER testing to help determine signal quality being delivered to the customer.
- Signal-to-Noise measurements to determine the quality of signal (MER) and identify problems with either signal or system noise.
- "Smart Charge" battery charging system.
- Digital power measurements that give you average power level across the full channel space, not corrected peak power measurements.
- Equalization measurements that help determine micro-reflections (in the system or cable drop) without interrupting service to your customer.
- Quick Good/Bad visual test to determine whether the set-top or modem will operate properly when the signal is applied.
- Exclusive 3-year warranty.

QAM-B 970 Condensed Specifications

MEASUREMENT FUNCTIONS:
LEVEL Mode:

Amplitude Resolution: 0.1 dB
Amplitude Accuracy: 啤1.0 dB
Level Linearity: 啤0.75 dB from -40 dBmV to +60 dBmV
Flatness: 啤0.75 dB from 5 MHz to 750 MHz
Typical: 啤1.5 Total, @ 70 degrees F

Full Channel Display:

Shows channel frequency response

C/N Ratio:

Automatic Off Channel Test
Amplitude Resolution: 0.1 dB
Dynamic Range: Input Level 40 dB below actual result
(i.e. -10 dBmV input provides a maximum C/N result of +30 dB,
0 dBmV input provides a maximum C/N result of +40 dB)
(Noise Reference is set under the CONFIG section)
Noise Reference Frequency: User-defined 300 kHz wide sample anywhere from 5 MHz to 750 MHz

***S/N Ratio (digital channels only):**

Method: Statistical analysis of the QAM constellation. Errors calculated from the demodulated I and Q signals.
Range: 0 to 30 dB (normally signal lock is lost at approximately 22 dB)
n carriers with level >= -10 dBmV

TUNING:

Range: 5 MHz - 750 MHz
Channel Plans: FCC/EIA, HRC, IRC, VHF/UHF

Resolution:

Analog Channel Mode: 1 Channel (6 MHz)
Frequency Mode: 50 kHz
Digital Channel Mode: 1 Channel (6 MHz)
Frequency Mode: 1 MHz

RF Input:

Sensitivity: -40 dBmV
Maximum reading: +60 dBmV
Input Impedance: 75 ohms, unbalanced
Return Loss: 14 dB minimum
Maximum Safe Input: 100 Volts DC+AC peak < 1KHz, +65 dBmV > 1 KHz

***EQUALIZATION:**

All Equalizer Display:

Simultaneious display of all equalizers with real-time updates
Percent Display Range: 0 to 100 %
Reading is expressed in a percent of total equalizer activity
dB Display Range: -32 to 0 dBc for all 16/20 equalizers

COMPOSITE LEVEL:

Amplitude Resolution: 0.1 dB
Amplitude Accuracy: 啤1.0 dB
Dynamic Range: -40 dBmV to +60 dBmV

TEMPERATURE VARIANCE:

Typical: 啤1.0 dBmV

DROP COMP:

100 MHz and 550/750 MHz range: 0.0 dBmV up to 9.9 dBmV
Drop Cable loss levels between 100 MHz and 550/750 MHz are calculated

***ESTIMATED BER:**

Range: Pre Corrected "Raw" < 1 x 10^{e-10} to > 9.9 x 10^{e-4}
Corrected: < 1 x 10^{e-10} to > 1 x 10^{e-4}
Reed Solomon Forward Error Correction required

AUTO INSPECT:

Auto Inspect Tilt Test:

Amplitude Resolution: 0.1 dB
Amplitude Accuracy: 啤1.0 dB
Range: Any two carrier levels -40 to +60 dBmV

Auto Inspect P/V Test:

Amplitude Resolution: 0.1 dB

Amplitude Accuracy: 啤1.0 dB
Range: Any two carrier levels -40 to +60 dBmV

Auto Inspect Flatness Test:

Amplitude Resolution: 0.1 dB
Amplitude Accuracy: 啤1.0 dB
Range: Calculated from any carriers with levels from -40 to +60 dBmV

**** These tests are most accurately performed on channels with power levels between -20 and +15 dBmV.***

[Sencore Home Page]

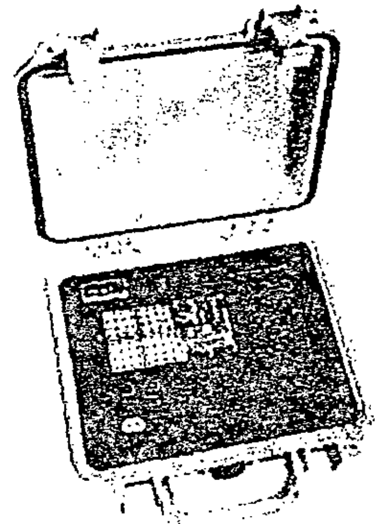
email webmaster@sencore.com for feedback on our site.
Or call 1-800-SENCORE (736-2673)/1-605-339-0100

附錄 F

CR1200 Digital Signal Analyzer

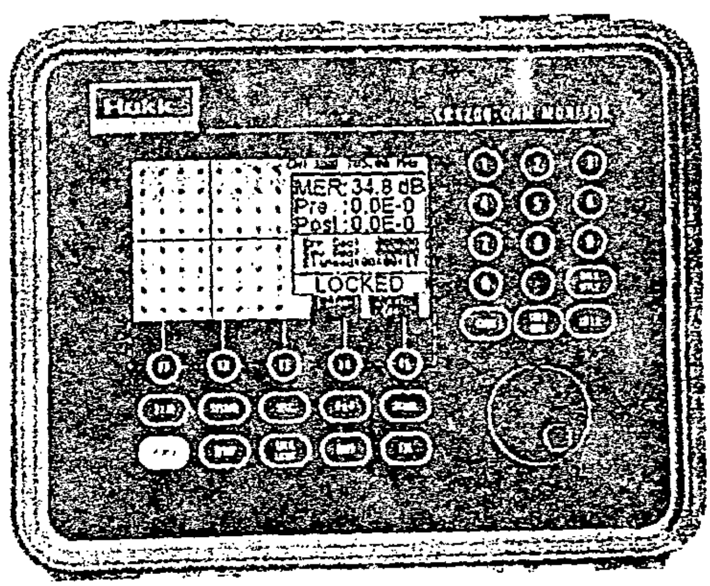
True Digital Testing Combined with Analog Measurements at a Fraction of the Cost

Features



- Compatible with ITU-T J.83 Annex B, MCNS, DigiCipher II, IEEE 802.14, and SCTE DVS-031 (Contact factory for other modulation formats)
- Conduct in-service digital measurements, including:
  Pre- and Post-FEC bit error rate — Modulation Error Ratio (MER)
  Errored seconds — Severely errored seconds
  Signal level — Display Constellation
- Conduct in-service analog measurements, including:
  Signal level — 24 hour tests
- Integral RS-232 computer/printer interface
- Battery powered
- Portable
- Weatherized

Download CR1200 Brochure



The CR1200 is a low cost CATV maintenance and troubleshooting tool that supports in-service measurements of 64 and 256 QAM-modulated digital signals and traditional analog signals. The CR1200 is rugged, portable and can be used without additional subscriber equipment.

Unlike analog video signals, digital video signals can appear to operate normally, even when they are very close to failing. Simply checking to see if there is a picture and sound does not tell the technician how close to failing the channel really is. By using the CR1200's constellation display, signal to noise functions and bit error rate tester, the technician can quickly determine the integrity of the installation to ensure that the digital performance is well within limits, helping to ensure long term subscriber reliability.

You Can't Tell the Performance of Digital Signals by Looking At the Picture!

Effect of Noise on Analog Systems (Gradually Poorer C/N)

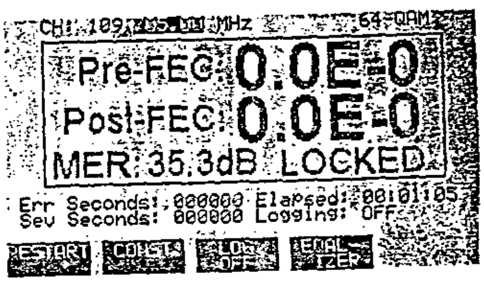
45 dB C/N 35 dB C/N 25 dB C/N 20 dB C/N

Effect of Noise on Digital Systems (Gradually Poorer MER)

34 dB MER 24 dB MER 23 dB MER 22 dB MER

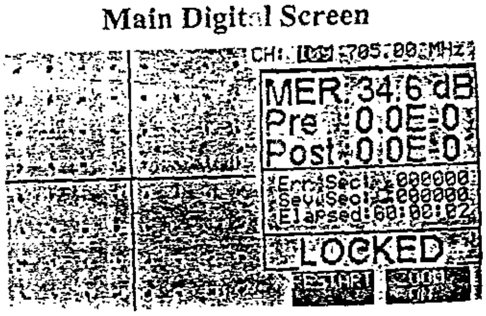
Noise has very little effect on digital systems until the system fails completely

Pre and Post FEC Bit Error Rate (BER)



Main Digital Screen

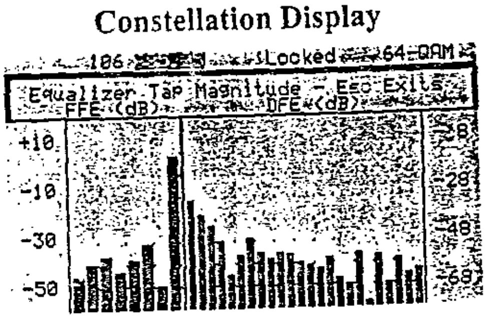
The CR1200 provides both Pre-FEC and Post-FEC Bit Error Rate (BER) testing, allowing the technician to determine if forward error correction is being used heavily to correct for errors in the path. The display will indicate the errored-seconds prior to the correction and after the correction. If the FEC codes can correct the errors, the POST-FEC will indicate zero. If the errors are so severe that the POST-FEC cannot correct them, then a severely errored second is displayed, showing that an impairment could be passed through the set top box to the subscriber's television set.



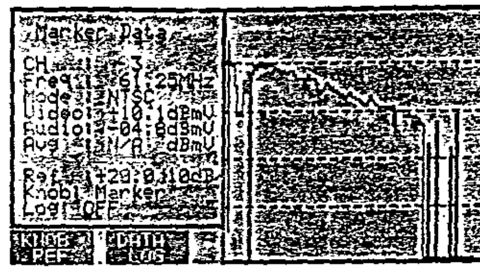
Constellation Display

Constellation Display

A constellation display provides a graphic representation of the QAM modulated signal. Ideally each of the 64 or 256 symbols should display a clean dot, indicating a perfect QAM signal. The size and shape of the build up of these dots indicates the amount and type of impairment. Technician if they are a result of noise, interference, phase noise or gain problems. Constellation displays can also indicate the presence of in-band spurs or hum. Since all of these impairments can cause bit errors, this display is a valuable tool for identifying and troubleshooting these problems.



Adaptive Equalizer Display



SLM Scan Display

Specifications

Digital Signal Analysis

Modulation

Modulation Type:	64/256-QAM (DUS-031, ITU-T J.83 Annex B)
Lock Range 64 QAM:	-20 to +50 dBmV (typical)
Lock Range 256 QAM:	-15 to +50 dBmV (typical)

Modulation Error Ratio (MER)**

Range:	21 to 35 dB
Accuracy:	基.0 dB

Digital Signal Level Meter**

Accuracy:	基.0 dB @ 25能C

Graphic Displays

Constellation:	I-Q display of QAM signal
Frequency Spectrum:	Spectrum of either a digital or analog channel
Equalizer	Display of equalizer taps

BER (Pre- and Post-FEC)

Carrier Offset:	埤00 kHz
Range:	1.0×10^{-9} to 9.0×10^{-3}
Errored Seconds:	Numerical count of errored seconds
FEC Lock:	Loss/Lock-indication
Error Count:	0 to 9.9×10^{99}
Severe Seconds:	Numerical count of severely errored seconds
Elapsed Time:	hr, min, sec

Additional Features

General

Display:	LCD with backlight
Power Reduction:	Auto unit shut down
Frequency Plans:	NTSC STD., IRC, HRC
Printouts:	RS-232 to serial printers

Analog Signal Analysis

Modulation

Modulation Type:	VSB (NTSC)
Operation Range:	-20 to +50 dBmV (typical)

Measurements**

Signal Level Meter (Video and Audio Carrier Level)

Accuracy:	埤.5 dB @ 25能C
Amplitude:	-20 to +50 dBmV

System Features

Electrical

Tuning Range:	54-802 MHz
Input Resistance:	75 ohms (nominal)
RF Input:	F81 connector (Field Replaceable)
Serial Interface:	EIA RS-232

Physical

Approx. size:	10.75"W x 9.75"D x 5"H
Weight:	<10 pounds
Operating Temperature:	0°C - 50慢

Power

Power:	Internal battery pack
Operating Time:	3 hours continuous (typical)
External Power:	120V AC adapter/charger

Ordering Information

CR1200 Digital Signal Analyzer, includes battery changer, 12V Adapter, and operations manual.

Options:

附錄 G

寄件者: Hansjoerg Haisch
收件者: wiway@cc.nctu.edu.tw <wiway@cc.nctu.edu.tw>
日期: 1999年3月1日 PM 09:33
主旨: RE: Your vugraph and ... HFC

Dear Professor Way,
I received your inquiry from my colleague Gustav Veith. Here are some answers to your HFC questions:

1. Currently no special measurement procedure of Deutsche Telekom (DT) known.
2. In Europe measurements are/will be done according to the procedures described in the standard EN50083-10 Cable networks for televisison signals, sound signals and interactive services, Part 10: System performance for return paths
3. In EN50083-7 "System performance" there are methods described for measurement of downstream path. Upgrades for digital signals are currently prepared.

Based on these standards, which by the way are also international Standards IEC60728-1 for system performance downstream und IEC60728-10 for system performance return path, you can describe your rules.

Best regards, H. Haisch

------- Forwarded Message Follows
-------From: "Winston Way" <wiway@cc.nctu.edu.tw> To: <gveith@rcs.sel.de> Subject: Your vugraph and ...
Date: Sun, 28 Feb 1999 20:46:06 +0800

....
As a side issue, I am currently helping my government to define an investigation rule for DIGITAL HFC system performances. In other words, we will have to come up with rules of measuring error-seconds, bit-error-rate, etc., for two-way cable modems.
My question is, does German government have rules in checking the CATV operators' system performance to provide digital services? If so, could you let me know who is the right person in German government for us to contact? If not, how can German CATV networks be assured to perform well when providing digital services in the future? Thank you for your help!

Best Regards,

寄件者: Cliff Brown

收件者: wiway@cc.nctu.edu.tw <wiway@cc.nctu.edu.tw>

副本抄送: Gene Faulkner <Windows/Admin/GeneF@mindspring.com>; Jim Barker <Windows/Admin/JimB@mindspring.com>

日期: 1999年1月29日 PM 10:29

主旨: CR1200 QAM Monitor

Dear Mr. Way,

Thank you for your interest in the CR1200 QAM Monitor. It demodulates and analyzes QAM-64 and QAM-256 signals that meet the ITU 83.J Annex B specification. This is also the specification adopted by the Society of Cable Telecommunication Engineers (SCTE DVS-031). It is the standard used for forward path signaling in digital video set tops deployed in North American and MCNS (DOCSIS) cable modems. If the signals that you are deploying do not meet this specification, let us know and we can look into modifying our design to meet your requirements.

In our lab, we use Scientific Atlanta, General Instrument and Wavecom modulators. Any of these modulators will generate continuous MPEG packets that will be received by the CR1200 without any input to the modulator and could be used for testing purposes. The model numbers are as follows:

S-A: D9476 (supports both QAM64 and QAM256)
GI: IRT 1000/C6U (QAM 64 only)
Wavecom: (Contact Wavecom)

There are no handshaking or training sequences involved in receiving the downstream signal.

We are looking into developing a head end product for monitoring upstream QPSK signals but will not have anything to offer for several months.

Please visit our WEB page for more information on the CR1200 (www.hukk.com).

Sincerely,

Cliff Brown
President

Cc: Gene Faulkner, International Sales Manager
Jim Barker, Senior Staff Engineer

cliff.brown@hukk.com
Hukk Engineering, Inc.
3250-D Peachtree Corners Circle

寄件者: Johnson, Brad
收件者: 'wiway@cc.nctu.edu.tw' <wiway@cc.nctu.edu.tw>
日期: 1999年1月30日 AM 12:50
主旨: e-mail response

Winston-

To answer your questions concerning the QAM970. The transmitter is not a concern with our meter, we develop our BER on-channel without a generator by calculating the BER from FEC. Our BER is actually an estimated BER, but does track very closely with an actual BER but can be done in less than 10 per channel.

As far as testing upstream bursty QPSK, we do not have this capability.

If there are any other questions, please drop me a note at
bjohnson@sencore.com

Thank you,
Brad Johnson
Sencore, Inc.