HEWLETT® PACKARD

Electronic Program Standards

The 1997 Digital Video Test Symposium

Author: Dragos Ruiu

Discover the latest techniques and products for real-world video testing

Electronic Program Guide Standards

One of the advantages that the newly deployed MPEG-2 digital video (DV) broadcast systems have over conventional analog TV systems is a set of clearly defined standards for transmission of Electronic Program Guide (EPG) information. In the older systems, viewers had to refer to paper listings or an adjunct box that received proprietary RF broadcasts with channel listings, or view a dedicated channel that broadcast show listings on some sort of scrolling list. Now, with the inclusion of powerful computers in the digital set-top box (or integrated receiver decoder-IRD—as it is sometimes called) more powerful functions can be created that will allow viewers to navigate through the available channels. This is good news, because one of the features of most of these new DV systems is a phenomenally large selection of number channels and programs. Viewers will need new systems to tell them what is being broadcast on the hundreds of new video and audio/radio channels—so menu-based and hypertext navigational systems are now being designed into the next generation of consumer electronics.

The new EPG systems take advantage of the digital nature of the new MPEG broadcasts. In order to let the IRD de-multiplex the streams, data structures that identify which packets mixed together in a multiple program multiplex belong to a specific program are defined in the ISO13818/ITU H.222 Section 1 Systems specification. EPG extensions to this specification that add information about current and future programs have been specified by both the EU's DVB Project, working with the European Telecommunications Standards Institute, and the FCC's Advanced Television Standardization Committee (see chart 1).

Standards Group	Description
International Telecommunications Union (ITU)/ International Standards Organization (ISO/IEC)	ITU H.222/ISO 13818 Section 1: Generic Coding of moving pictures and assoc. audio info: Systems
European Telecommunications Standardization Institute (ETSI) / Digital Video Broadcast (DVB) Project	ETSI ETS 300 468: Digital Broadcasting systems for television sound and data services; Specification for Service Information (SI) in Digital Video Broadcast (DVB) Systems
Advanced Television Standardization Committee	A/53 ATSC Digital Television Standard A/54 Guide to the use of the ATSC Digital Television Standards A/55 Program Guide for Digital Television A/56 System Information for Digital Television A/57 Program/Episode/Version Identification A/58 Harmonization with DVB-SI in the use of the ATSC Digital Television Standard

Chart 1:
EPG Standards

The two extensions are unfortunately largely incompatible, and they differ greatly in their scope and functions. The differences arose because the standards committees developing each system worked on the extensions in parallel, with little communication back and forth. The guidelines of ATSC A/58, however, offer a possible means of creating an MPEG multiplex broadcast that can be decoded by both DVB and ATSC compliant decoders. To do this requires the transmission of two redundant sets of EPG/SI information. Fortunately, the overhead imposed by the EPG information is relatively low, on the order of 0.5% to 4% of the available bandwidth, so the carriage of two sets of information is not such a stiff penalty. In practice, the creation of a fully compliant dual-mode multiplex is quite difficult, as we'll see later.

In an unfortunate repetition of NTSC vs. PAL, current data indicates that most North American DV broadcasts will follow the ATSC EPG specifications while most European implementations will deploy the DVB EPG specifications. Since both will inevitably be part of the video systems of the future, the remainder of this paper presents a brief overview of each system. Let's begin with the common ground between the systems: the ITU/ISO spec.

ISO MPEG-2 Systems Program System Information

To identify and separate the different programs being transmitted on individual PID streams, special control data structures are transmitted on reserved PIDs. The root "anchor" of these data structures is the special reserved PID of 0. This PID is never used for programs; it always contains periodic transmissions of a special data structure called the program assignment table or PAT. The PAT is the initial point at which the set-top can decipher the incoming stream. In the PAT is transmitted a list of other "special" reserved PID numbers. These special PIDs contain periodic, continuous low bandwidth transmissions of special data tables called program map tables or PMTs. There is one PMT transmitted for each program or channel being broadcast. The PMTs contain the list of PIDs for the audio, video, data, and PCR streams of each program.

A similar system is used to transmit scrambling keys. Such as PID 0 for the PAT, PID 1 is reserved for the conditional access table, or CAT. The CAT is transmitted continuously at a low bandwidth and lists PIDs that are used to transmit entitlement management messages (EMMs). EMM is another name for scrambling keys, which typically identify the addressable decoders that are allowed to receive a particular enhanced or non-basic service for which a subscriber has paid. The set-top receives the list of addresses, and if it finds its own address in the list, it will allow the subscriber to view that service.

The different tables structures are defined in the ISO specification and are collectively known as the program system information (PSI) tables. The tables are protected from receiving corrupted information by CRC checks, which can be used to discard corrupted information. Since the tables are sent periodically and repeatedly, losing one table is not a serious error, because the information will be transmitted again. However, in the design of equipment, it is important to ensure that these updates are sent neither too frequently nor too sporadically. Typically the PSI bandwidth consumed is less than 100 kbps on links carrying an excess of 20 Mbps.

Chart 1: ISO Table

ISO Table	PID #	Description
Program Association Table	0x0000	Associates Program Number and Program Map PID=20
Program Map Table	By PAT	Specifies PID Values for PRograms
Network Information Table	By PAT	Physical Network Parameters
Conditional Access Table	0x0001	Associates EMMs streams with PID

Chart 2: ISO, DVB-SI Table

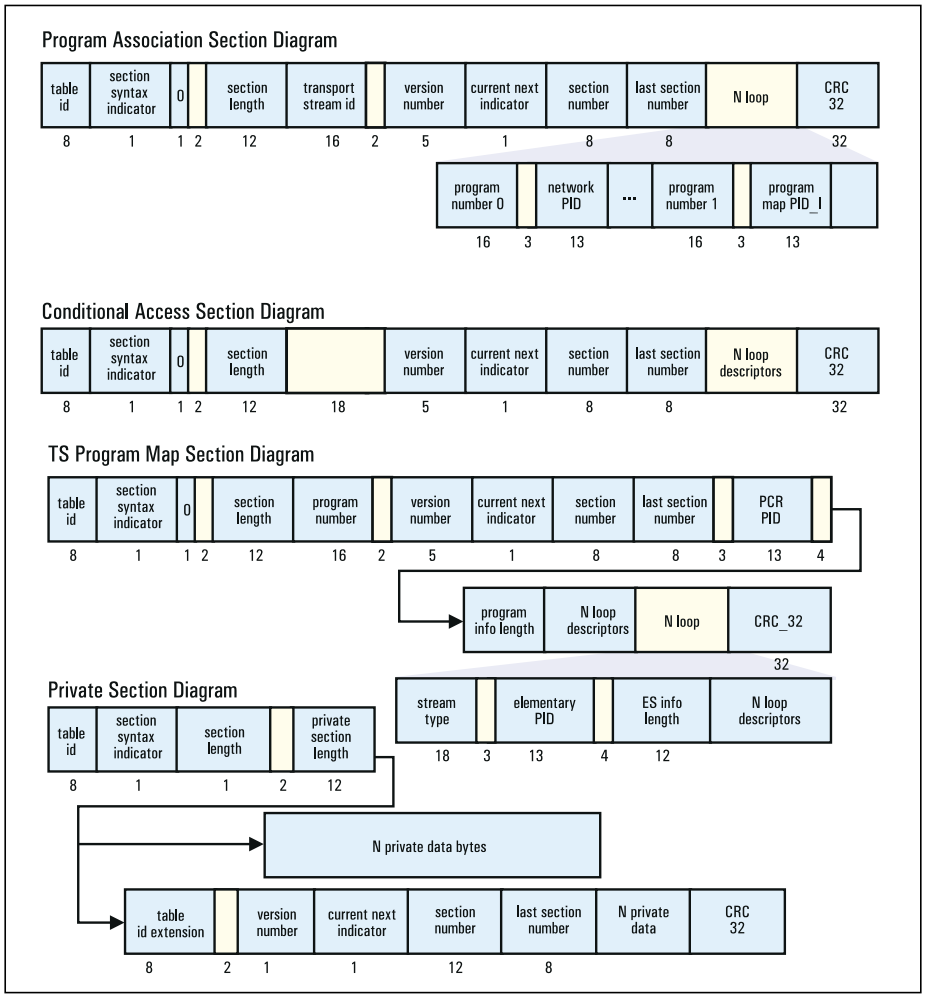
DVB-SI Table	PID #	Description
Network Information Table	0x0010	Physical network info for this and other delivery systems
Bouquet Association Table	0x0011	Names of and lists of service bundles
Service Description Table	0x0011	Service data, names, service provider
Event Information Table	0x0012	Program info on current future programs on this and other networks
Running Status Table	0x0013	Used for rapid event status updates
Time and Date Table	0x0014	Present time and date
Time Offset Table	0x0014	Shift in time-zone for current location
Stuffing Table	0x0010 - 0x0014	Invalidate existing tables at network boundaries

Chart 3: ATSC Table

ATSC Table	PID #	Description
Master Guide Table	0x1FFD	Data stream contents, time, PID list, channel grouping
Additional Guide Data Table	0x1FFD	Transmission channels, Program Guide Map, Default Override Records
Special Program Guide	by MGT	Additional program guides
Channel Information Table	by MGT	Non changing info, PID #'s, physical channel...
Event Information Table	by MGT	Program info (event title, start time...)
Descriptive Information Parcel	by MGT	Detailed descriptions of Channels & Programs
Private Information Parcel	by MGT	Private/Proprietary description info
Carrier Definition Table	PAT Network PID	Carrier Frequencies
Modulation Mode Table	PAT Network PID	Specifies modulation systems for each transmission syst.
Satellite Information Table	PAT Network PID	Positional information and transponder count
Transponder Data Table	PAT Network PID	Polarizational and waveform description
Network Text Message	PAT Network PID	Text names of transmission systems, currency, rating syst.
Program Identifier Table	By PMT	Creator information about program contents

There are four table structures standardized in the ISO specifications (see chart 2 and diagram 1). These tables share some similarities in their structure and coding conventions. These similarities are also used by the DVB and ATSC extensions. There are several coding conventions used when the tables are inserted into 188 byte transport stream packets. Typically, the tables are larger than TS packets, and they are segmented and inserted into the appropriate PID stream.

Diagram 1: PAT, CAT, PMT and NIT (Private Section) Structure



Some tables such as the PAT have reserved PID streams associated with them, while in the ATSC and DVB extensions some tables are mixed on the same PID stream, such as the ATSC network information tables that are carried on the network PID specified in the PAT. For these mixed table streams, the tables begin with unique Table_ID identifiers that enumerate the table types (See Chart 3).

To identify the beginning of the tables so that the Table ID can be decoded, the pointer_field of the transport stream is used. This is a one byte field that is present at the beginning of the payload when the payload_unit_start indicator is a 1 in the transport stream header. When a table starts in a particular transport stream packet, the payload_unit_start=1, and the first byte of the TS payload (after the optional adaptation field) is the pointer_field that indicates the offset to the table beginning. If the table begins at the start of the packet, then the pointer_field would be 0x00. At the end of a table, if there is not enough room left over in the transport packet to begin the coding of another table, then the reserved Table ID of 0xFF (null table) is used to pad the remainder of the packet. Another common convention used by ISO, DVB, and ATSC is to segment the tables themselves into sections. Most tables have section_number and last_section_number fields that allow the descriptors and repetitive field loops in the tables to be split up and transmitted in multiple sections. This is done for error resilience, so that in the case of long tables, a corrupted packet doesn't disturb the entire table, potentially making the receiver wait for a long retransmission time in order to identify the beginning of the table and restart the decoding process. DVB specifies that the NIT be transmitted at a rate of at least 8 TS packets every 10 seconds. If an implementation sends a lot of NIT information at this minimum 1.4 kbps rate, it may take several seconds to re-receive a lost or corrupted section. The sectioning of the tables is also mandatory in the DVB case, which imposes a 1K size limit.

Chart 6: PSI Rate and Size Limits

ISO

- Up to 1024 bytes in a PSI or PMT table section; up to 256 sections
- Up to 4096 bytes in a private table section such as the NIT
- No rate limits imposed or any recommendations made

DVB

- Table sections limited to 1024 bytes, except for EIT sections limited at 4096 bytes
- Minimum inter-table gap for the same table is 25 ms for TS streams 0 to 100Mbps (approx 40 Hz max rate)
- Minimum rate of 1.4 kbps for NIT (8 packet every 10 seconds)
- Minimum rates:
  – Actual multiplex SDT and EIT: every 2 s
  – NIT, other SDT, and EIT; 8 day EIT schedule: every 10 s
  – TDT, +8 days EIT schedule: every 30 s

ATSC

- Maximum data rate of MPG: 100 kbps
- Maximum PG size: 64K
- Maximum MPG packets: Fixed value dependent on number of multiplexes 35 packets or 1 multiplex - 350 for 10
- Less than 100 packets per channel grouping
- Max table section size 4096 bytes
- Max PAT time between repetition: 100 ms
- Max PMT time between repetition: 400 ms
- Program guide adherence to STD buffer model (100 kbps leak rate, 1K byte smoothing buffer size)
- System info adherence to STD buffer model (20 kbps leak rate, 1K byte smoothing buffer size)

Another table coding convention is the inclusion of a version number field. This field is incremented every time the contents of the table are updated. A related convention and field is the current_next_indicator field, which can be used to notify the receiver of an upcoming change. If the current_next_indicator=1, then the table being sent applies to the current stream. Otherwise, if it is 0, the table being received will apply in the near future, when the active table version number will change and the tables will start being received with current_next_indicator=1.

The tables are protected against transmission errors with a 32 bit cyclical redundancy check sum (CRC-32) that can be used to identify corruption of the data. By checking this field the decoder can discard data garbled during transmission.

The system table information is contained in fixed fields and lists of optional fields called descriptors. Roughly analogous to information elements used in ISDN and ATM SVC signalling messages, these descriptors are identified by a beginning identifier number called a descriptor tag. The descriptor tag identifies what kind of information is contained in the following bytes. Unlike ISDN, the descriptors do not have to be sorted in increasing order—in MPEG they may be mixed and matched as needed. ISO defines a number of descriptors, and DVB defines most of its extensions as new descriptors. ATSC on the other hand does not really extend the list of standardized descriptors, and conveys most of the information content in fixed or optional field lists without descriptor tags. The ATSC format is more space efficient, but suffers the penalty of complexity for this space savings.

ISO Descriptor Tag	Descriptor Identification
0x00 - 0x01	Reserved for ISO
0x02	Video Stream
0x03	Audio Stream
0x04	Hierarchy
0x05	Registration
0x06	Data Stream Alignment
0x07	Target Background
0x08	Video Window
0x09	Conditional Access
0x0A	ISO 639 Language
0x0B	System Clock
0x0C	Multiplex Buffer Utilization
0x0D	Copyright
0x0E	Maximum Bit-Rate
0x0F	Private Data Indicator
0x10	Smoothing Buffer
0x11	STD
0x12	IBP
0x13 - 0x3F	ISO Reserved
0x40 - 0xFF	User Private

ATSC Descriptor Tag	Descriptor Identification
0x81	AC-3 Descriptor
0x83	Program (producer) Identifier

DVB Descriptor Tag	Descriptor Identification
0x51	Mosaic
0x52	Stream Identifier
0x53	Conditional Access Identifier
0x54	Content
0x55	Parental Rating
0x56	Teletext
0x57	Telephone
0x58	Local Time Offset
0x59	Subtitling
0x5A	Terrestrial Delivery System
0x5B	Multilingual Network Name
0x5C	Multilingual Bouquet Name
0x5D	Multilingual Service Name
0x5E	Multilingual Component
0x5F	Private Data Specifier
0x60	Service Move
0x61	Short Smoothing Buffer
0x62 - 0x7F	DVB Reserved
0x80 - 0xFE	User Defined Private
0xFF	Forbidden
0x40	Network Name
0x41	Service List
0x42	Stuffing
0x43	Satellite Delivery System
0x44	Cable Delivery System
0x45 - 0x46	DVB Reserved
0x47	Bouquet Name
0x48	Service
0x49	Country Availability
0x4A	Linkage
0x4B	NVOD Reference
0x4C	Time Shifted Service
0x4D	Short Event
0x4E	Extended Event
0x4F	Time Shifted Event
0x50	Component

Chart 7: Descriptor Tags

Program Association Table

As we mentioned earlier, the PAT is transmitted on the reserved PID=0. It contains a list of program number available on this multiplex and the list of associated 13 bit PID numbers for each 16 bit program number. The PIDs point to PMT tables.

Conditional Access Table

The CAT is transmitted on the reserved PID=1. It contains a list of descriptors (typically CA descriptors).

Program Map Table

The ISO Program map table is transmitted on a PID assigned in the PAT. There is one PMT for each program. A program's PMT lists descriptors about that program, stream types, PIDs for each stream that is associated with that program, and descriptors for each stream.

ISO Program and Program Element Descriptors

Video Stream Descriptor:	Contains frame rate (or still picture), profile and level indication
Audio Stream Descriptor:	Contains compression layer used, and variable rate indication
Hierarchy Descriptor:	Describes the hierarchy for scaleable (SNR, spatial, temporal) profiles
Registration Descriptor:	Used to identify formats of private data
Data Stream Alignment Descriptor:	Describes elementary stream header used for alignment (slice, GOP, etc.)
Target Background Descriptor:	Describes overall stream picture size
Video Window Descriptor:	Used in conjunction with target background to display a subset/window of picture information

Conditional Access Descriptor:	Points to PIDs used for EMMs
ISO 639 Language Descriptor:	Specifies language of component
System Clock Descriptor:	Describes clock accuracy
Multiplex Buffer Utilization Descriptor:	Describes STD buffer model of stream
Copyright Descriptor:	Identifies creator
Maximum Bit-Rate Descriptor:	Maximum bit rate in units of 50 bps
Private Data Indicator Descriptor:	User defined
Smoothing Buffer Descriptor:	Describes bit rate in terms of leak rate and buffer size
STD Descriptor:	Chooses leak method or vbv-delay buffer method
IBP Descriptor:	Describes number of I-B-P pictures and ratios in structure of video stream
ISO Reserved Descriptor:	Future extension
User Private Descriptor:	Proprietary data

In summary, the ISO13818 Section 1 specifications for the PSI tables standardize a description of the physical contents of a transport multiplex, locating in particular the PID streams within the multiplex. For each stream, the defined ISO descriptors allow specification of the physical parameters of the stream, such as bit-rate, video/audio coding, display size and window, profiles, and levels.

The gaps left in the ISO specification as far as applications to EPG are in such areas as identification of program types, names, and scheduling information. ISO also avoids describing the system level organization of physical multiplexes and the parameters of the transmission system by simply specifying the network information PID in the PAT and labeling the contents of the NIT as private data. Similarly in the area of scrambling, the CAT tells you how to find the EMM PID streams, but does not specify what kind of conditional access scrambling should be used. It is these gaps that the DVB and ATSC specifications attempt to standardize.

DVB Extensions

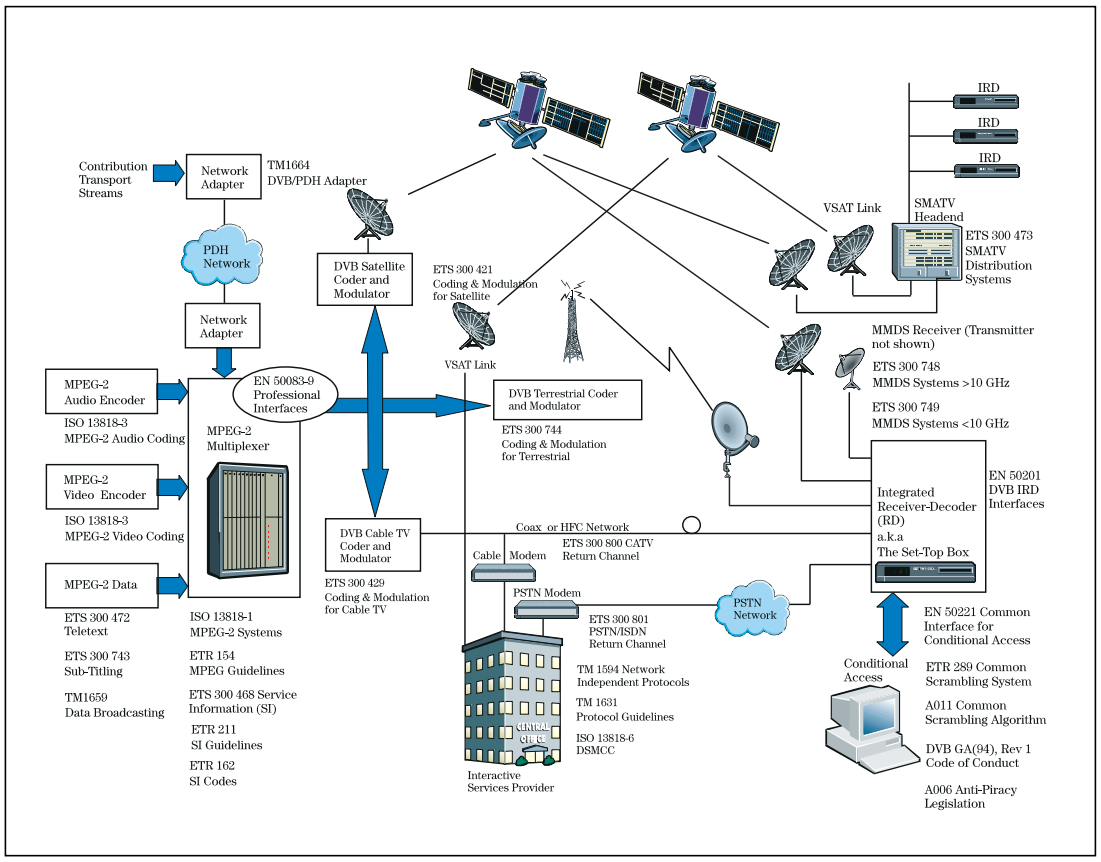


Diagram 5: DVB Specifications

To fill in the gaps in the ISO specification, the EU's DVB project has added a number of tables and descriptors for conveyance of EPG information, and has introduced several important concepts into the MPEG world. Diagram 5 shows the relevant DVB specifications. The DVB SI system extends the ISO specification for the following functions:

- Describe the physical network, name, frequencies, satellite location, modulation, FEC
- Further describe the multiplex contents and service locations within the physical multiplexes
- Transmit time, local time offset and scheduling information

- Describe service, name, contents, content categories, parental ratings, country availability, languages
- More efficiently describe time shifted NVOD programs than does ISO
- More efficiently describe bit rate specifications than does ISO
- Send rapid status updates for accurate VCR recording
- Specify a standardized conditional access scheme
- Allow logical groupings of services
- Allow efficient physical network transitions and unique program identification
- Describe multiple languages and character sets
- Define mosaic services

Bouquet of services

One new term that the DVB brings us is "bouquet of services"—that is, a bundle of different services from within one or more multiplexes. MPEG transmission systems such as cable, MMDS, and satellite partition channels, programs, and services into multiple physical multiplexes across different transponders and multiple 6 MHz and 8MHz RF frequency allocations. The concept of a bouquet allows services that physically reside on separate multiplexes be logically grouped together.

In the DVB system, all the multiplexes of associated services can carry some SI table information about the other transport stream multiplexes also associated with the physical transmission system. For example, in a cable system, one 6 or 8 MHz channel can carry SI information about the other multiplexes on other channels. This additional information is optional and not mandated to be repeated at as high a frequency as the information about the current multiplex, but having it easily available may greatly increase the response time and speed of the set-top if the user requests EPG information about channels on other multiplexes. If this optional information is included, the need for the set-top to tune and re-acquire the other multiplex is avoided.

Physical Network Transition

Another important issue addressed in the DVB-SI specification is the ability of the network to cope gracefully with physical network transmission. Consider the case of a DVB service that is transmitted via satellite and then re-transmitted on a cable system. The cable system also receives MPEG multiplexes from a terrestrial receiver for local content. It is desirable to be able to mix the two services without having to fully re-multiplex and re-generate the PSI information. DVB makes this possible in a number of ways.

DVB assigns a program or service two identifiers: one for the current network and another for the original network. To avoid potential numeric conflicts in services originating on different networks, each program is uniquely identified by the numeric bundling oforiginal_network_id, transport_stream_id, and service_id. The current_network_id is not used, so that programs originating on different networks but having the same TS_id and stream_id do not conflict with each other.

To further assist the transit of SI information across such boundaries, DVB introduces the concept of a stuffing table. A stuffing table can be inserted into the stream to overwrite or "stuff" a portion of the PSI information that no longer applies to the new network. A stuffing table can be written (at a cable head end) over the offending SI information but will still retain the integrity of the section number information so that the system does not have to regenerate all PSI/SI information.

DVB Network Information Table

Chart 8: NIT

Two sub-tables/sections:
- Actual network (table_id=0x40)
- Other network (table_id=0x41)

Contains numeric network_id and two descriptor loops

First Loop
- Network name, e.g., "Astra"
- Linkage to network information service and EPG

Second loop for services contained in network:
- original_network_id/transport_stream_id
- service descriptors:
  - Delivery system parameters (cable channels, satellite location, etc.)
  - Service list (service type such as PAL/NTSC/radio, service name, provider name)

DVB further defines two kinds of network information table sub-tables or sections, each differentiated by different table_ids (see Chart 4, Diagram 8). One table type lists the parameters of the current network, and the other lists the parameters of another network, potentially one from which the services have been translated. The network table lists the names of the services, contains optional linkages to information services about the network itself, and lists the services and multiplexes contained on the network.

Bouquet Association Table

The BAT has the same structure as the NIT (see chart 8). It groups services into a logical bouquet and contains services that can be carried by multiple networks. A transport stream can contain services from multiple bouquets within a network. The system could, for instance, be used to group together channels from different service providers that share the same satellite; for example, USSB and DirectTV.

Service Description Table

Chart 9: SDT

Describes contents of a transport stream
One table per TS
Identifies TS by numeric original_network_id/transport_stream_id

Two types
- Actual physical stream (table_id=0x42)
- Other TS (table_id=0x46)

Descriptor loop
- service_id
- EIT flags indicate presence of EIT schedule for service
- running status: running, pausing, stopped, starts in a few seconds(for VCR)
- scrambling on/off

Inner service descriptor loop for each service in multiplex:
  - Country availability
  - Service descriptor (name, provider's name)
  - NVOD information (for efficient time shifted descriptions)
  - Bouquet name
  - Linkage (e.g., teaser channel)
  - Conditional access information
  - Telephone descriptor (for interactivity)
  - Mosaic
  - Private data

The service description table is used to describe what is contained on a particular multiplex. It lists primarily service names. There are two kinds of SDTs that can be carried in a multiplex: the information for the current multiplex, and the information for other multiplexes so that set-top access times can be sped up. The SDT doesn't list actual program contents, that is the job of the EIT. There are two descriptor loops in the SDT, one that identifies information about the service, and another, inner loop that lists information about the channels and bouquets contained inside the multiplex.

Two interesting notes about the SDT relate to descriptors of services inside the multiplex. The first is the telephone descriptor, which can be used in conjunction with a modem and the PSTN to implement interactivity. (This is currently an area of standardization work in the DVB's Interactive Services group.) The other is the mosaic service descriptor, which can be used to implement tiling of video, text, and stills in order to implement menus and summary overviews of channels. Tiled small versions that cycle through the contents of many channels are common on European cable systems, and this kind of service and descriptor allows implementation of this kind of service in a DV environment.

Event Information Table

Provides content description and scheduling information for programs

Chart 10: EIT

Four types of schedule sub-tables are supported

- Present/following events, actual TS (table_id=0x4E), other TS (table_id=0x4F)
- Future event schedule, actual TS (table_id=0x50-0x5F), other TS (table_id=0x60-0x6F)

Identifies service by numeric original_network_id/transport_stream_id/service_id

Descriptor Loop

- event_id
- start_time
- Duration
- Running status: running, pausing, stopped, starts in a few seconds(for VCR)
- Scrambling on/off
  - Inner event descriptor loop
  - Short event descriptor, a text description of program
  - Extended event descriptor, one or more longer 2 column descriptions of the event
  - Content, from a fixed, two level categorization (e.g., Sports, Tennis/Squash)
  - Parental rating, minimum user age (3 to 18)
  - Linkage (e.g., to teaser or info channel)
  - Time shifted event (for efficient coding of NVOD channels)
  - Teletext
  - Multilingual components, a list of ISO639 languages for this event
  - Short smoothing buffer, compact representation of bit rate from pre-defined list of 64
  - Private data

The EIT (see chart 10) provides the information about the actual event scheduling. As in the NIT and SDT, different sub-table types are used to differentiate between information on the current multiplex and system and information about others provided to speed set-top access. An additional table-type distinction is made between information about the current and following events and programs and future schedule information, presumably to allow for different repetition rates and acquisition times in the set-top.

The event itself is described in terms of a numeric identifier (the original_network_id/stream_id/service_id that we referred to earlier) start time and duration, and a series of optional descriptors that allow multi-lingual text descriptions of the event to be transmitted to the set-top for presentation to the user.

Time and Date Table, Time Offset Table, Running Status Table

The remaining extension tables that the DVB Project has added are the time and data table (TDT), the time offset table (TOT), and the running status table (RST). The TDT transmits universal coordinated time (UTC) to maintain an accurate clock in the set-top. The TOT describes the UTC as well as offset information about the current local time zone.

In order to have a mechanism that will trigger automated VCR recording of an event, DVB defines another optional table, the RST. The EIT, because of its large size, may take several seconds to transmit at its assigned low bit-rates. To achieve accurate triggering of VCRs, an RST can be used to rapidly update the running status of an event without having to wait for all the EITs to be transmitted.

DVB Extensions to the PMT

In addition to adding new table types and new descriptor types within the tables, the DVB project also expanded the number of descriptors available in the PMT to define stream types and information about the streams. The following descriptors have been added to the PMT:

- Teletext, to identify streams that carry EBU teletext pages
- Subtitling, to identify subtitling data stream
- Mosaic, to identify tiled video/still/text service streams
- Service move, to identify services that shift from one multiplex to another
- Stream Identifier, to be used with DVB PMT extension to link EIT and PMT entries

Advanced Television Standardization Committee Extensions System Information and Program Guide Functions

- Describe physical network for terrestrial, MMDS, cable, SMATV, and DBS
- Describe the physical network, name, frequencies, satellite location, modulation, FEC
- Further describe the multiplex contents and service locations within the physical multiplexes
- Transmit time and scheduling information
- Describe service, name, contents, content categories, parental ratings, copyright, and taping allowed
- More efficiently describe time shifted NVOD programs than ISO
- Describe multiple languages
- Create a users' virtual channel map that can span physical delivery systems and integrate analog channels
- Define other special program guides for future information

- Describe currencies and regions used on the system
- Override standard ratings and content category descriptions
- Rapidly map content sources into channel numbers

The extensions to ISO defined by the ATSC are similar in scope to the DVB SI tables, but they are different in some areas of coverage. There are many similarities between the structures and the information they provide to the set-top, but a few key differences exist. We'll compare the two systems in the next section.

ATSC Restrictions

Chart 11: ATSC Restrictions

- Base PID # in PMT = program_id * 0x10
- Video, PCR PID = Base PID +1, Audio PID = Base PID +4, Data PID = Base PID +0x0A
- Main Profile @ High Level max allowed
- Max bit rate for terrestrial 19.4 Mbps, high data rate 38.8 Mbps
- Restrictions on frame rate and interlace combinations
- Closed captioning data inline in user_data
- Dolby AC-3 audio compression
- No adaptation field in PAT and PMT except for version number discontinuity
- No support for still pictures

One key aspect of the ATSC specifications is that the A/53 standard restricts the audio and video formats that it supports. The audio information must be coded with the Dolby AC-3, and the coding parameters of the MPEG-2 video are more constrained (i.e., main profile must be used) than they are in the DVB implementation. Similarly a fixed program_id to PID value mapping is wired into the standard to separate programs by ranges of 16. The PSI tables in an ATSC system must have PID = program_id * 0x10. Similarly the PIDs for video, audio, data and so on are hard-wired into the 16 PID space allocated to each program_id. This specification leads to some difficulties in areas such as copyright identification.

Program Identifier Table

- Overcomes difficulty in copyright identification with fixed PID numbers
- New 1200 bps PIT stream identified in PMT
- Defines unique event identifier for each transmitted program
- Identifier first part is SMPTE-assigned producer ID
- Identifier second part is producer-assigned event ID

Because the ATSC PID values are hard wired to the program and channel, they cannot change when the program content changes. This makes it difficult to identify program copyright. For this reason specifications A/57 define a new low bit rate (1.2 kbps) stream identified by the PMT called the program identifier table stream. This stream carries PIT tables that describe the creator of the current program, commercial, and so on. The program is identified by a numeric creator ID, which is assigned by SMPTE to major producers of content, and a producer assigned event identifier.

System Information

Network Information Message

Chart 12: Network Information Message

Defines physical channel parameters for:
cable, satellite, MMDS, SMATV, terrestrial over the air
Carried on network PID Contains several tables in one message (different form DVB tables):

• Carrier definition table(CDT)	identifies carriers and frequency spacing
• Modulation mode table (MMT)	identifies modulation and FEC coding
• Satellite information table (SIT)	optionally defines position, polarization and transponders
• Transponder data table (TDT)	optionally defines information about each transponder

Network Text Message

Chart 13: Network Text Message

Defines names of signal sources, currency, and ratings system
Carried on PAT Network PID
Contains the following tables

• Transponder name table (TNT)	Multilingual name of transponders
• Satellite text table (STT)	Multilingual name of satellite (short reference and full)
• Ratings text table (RTT)	Multidimensional scale and names for parental control
• Currency system table (CST)	Defines currency names and regions

• Source name table (SNT)	Multilingual names of signal sources on the system
• Map name table (MNT)	Multilingual text names of virtual channel tables

Virtual Channel Message

Chart 14: Virtual Channel Message

Contains VCT identifier for referencing the VCT channel group name in MNT (e.g., Fishing and Carpentry SuperChannels)

Delivers three table types

Virtual channel map(VCM)—a list of virtual channel physical locations

Contains number of VC records (up to 4096)
For each VC contains:

- VC #
- Channel type (normal, hidden, NVOD, local access)
- Application_ID or Source_ID for referencing channel content in EIT and CIT
- Transmission type (analog, broadcastcast, satellite, cable, MMDS, SMATV)
- Channel physical location (e.g., satellite id, frequency, transponder, modulation mode, program # for reference in PAT of TS)
- NVOD pointer-to-base channel in case of NVOD

Defined channels map (DCM)—a list of defined and undefined channels (0 to 999)

Inverse channels map (ICM)—a list of source_id/virtual_channel pairs sorted by source_id

DVB calls the system information about the physical channels the NIT, while ATSC calls it the Network Information and Text Messages. A network information message (NIM) is transported in the network PID specified in the PAT. The NIM contains several tables that define the physical channels (see Chart 13). Also carried on this PID is the network text message (NTM). The NIM describes the physical parameters of the transmission; that is, frequencies, spacing, orbital location, and modulation systems. The NTM gives service names to the physical channels and services, and defines rating and currency systems.

The other information contained on the Network PID is the virtual channel table, which creates a list of physical locations of the channel and describes the content of the physical channel by assigning it an application_id or source_id. The physical location includes the physical transmission channel location of the multiplex and the PID within the multiplex. This information fully describes where the packets for this channel may be found through the program number and the rules for PID mapping. In ATSC systems it is not necessary to reference the ISO PAT and PMT because of the fixed PID to program number mapping described above. In ATSC systems the PAT and PMT are only transmitted for standards compliance. The source name table and the inverse channel map allows rapid lookup of channels; for example, the source_ID of the service with the name HBO can be rapidly translated into a virtual channel number.

The virtual channel table can also include channels from multiple sources, concatenating the sources together into one seamless channel list similar to a DVB bouquet. One interesting feature of this system is its ability to mix analog channels into the channel map. Channels 1 through 999 are available for the user, while up to 4096 channels can be defined in the virtual channel table. One explanation is the fact that some virtual channels for NVOD applications can be referenced through one base channel. NVOD channels can be placed above 1000. Also, the defined channels map allows gaps to exist in the channel numbering scheme.

The final message type sent on the Network PID is the System Time Message, which delivers the calendar time derived from the GPS system.

ATSC Program Guide

Master Guide Table

Chart 15: Master Guide Table

Transmitted on PID 0x1FFD

Defines channel grouping (up to 16 channel groups of
up to 64 channels)

Defines coverage time for current program guide (in terms of 30 min slots)

Includes notification of next planned change to the guide

Includes private data fields

Coverage time can be extended with ADGT special program guides for future events

Defines PID for private information parcel (PIP) stream

Defines PID for descriptive information parcel stream

Defines PID user private EPG data stream

Describes size of MGT and AGDT tables in packets

For each channel group describes the size of CIT and EIT in packets

Each ATSC transport multiplex optionally can contain EPG information. The EPG is transmitted as a set of tables. The "root" of these tables is the Master Guide Table (MGT) transmitted on the reserved PID 0x1FFD (PG PID). Also transmitted on the PG PID are additional guide data tables (see diagram 17), which allow overriding of default rating labels, and the extension of program guide coverage through definition of special program guide streams that transmit more channel information tables (CITs) and event information tables (EITs). The MGT defines two important PIDs, the PIP stream and the DIP stream.

PIP and DIP ID Construction

Implicit Channel ID:
- Channel #, 0

Implicit Event ID:
- Channel #, Start Time

Explicit Event or Channel ID:
- 0, Assigned #

These two special PIDs carry streams of packets of descriptive data, or information parcels. The information parcels contain the descriptions of the channels, and programs to be displayed on the EPG screen. Descriptive information parcels (DIPs) contain compressed multilingual text descriptions of the channel or event. Private information parcels (PIPs) contain other data about the channel or program. The DIPs and PIPs contain an identifier of the channel or program to which the information is relevant. This ID can be explicitly specified in the channel or event information table or may be constructed implicitly. The ID consists of two fields, the channel number and the start time. A channel's implicit ID consists of the channel number with 0 as the start time. An event's implicit ID is the channel number and start time of the event. Explicit IDs take the form of a zero channel number and an arbitrarily assigned number in the date field. These IDs are used as pointers to the textual and data descriptions of programs and channels in the event and channel information tables, respectively.

Channel Information Table

Chart 16: Channel Information Table

Describes the channels in a group
Lists number of channels in group.
For each channel lists:
- User channel number
- Channel name
- Physical channel of TS
- # of PIDs and layout (default, custom)
- DIP/PIP IDs and physical PIP/DIP channel of TS

The MGT defines up to 16 groups of up to 64 channels. For each channel group, a multi-section channel information table (CIT) defines the information about the channels in the group. For each channel in the group, the CIT gives the name and the PIP/DIP ID of the information about that channel, so that descriptive labels can be displayed. (See diagram 15.)

Event Information Table

Chart 17: Event Information Table

Describes programs on a channel
Contains a Table ID: channel group and channel #
Lists number of events on channel in guide
For each event lists:

- Title
- Flags for taping, closed captioning, PIP/DIP existence, NVOD
- Category
- Ratings (advisory, MPAA, violence, sex, language)
- Start time (or start time list for NVOD)
- Duration
- PIP/DIP ID
- Program Event ID for copyright)

For each channel a multi-section event information table (see Diagram 17) lists the schedule of events on the channel. For each event, names, categories, ratings, start times, and duration are listed. A PIP/DIP ID pointer for each event identifies packets in the PIP/DIP streams that give more detailed information about the event. More EIT and CIT tables and information for future events can be transmitted on other PID streams by extension Special Program Guides (SPG) defined in the additional guide data table (AGDT).

Additional Guide Table

Chart 18: Additional Guide Table

Transmitted on PID 0x1FFD
Includes time base list that defines
- number of physical channels accessed from MPG
- a list of PCR PIDs for each channel

Includes a program guide map (PGM) that

- defines up to 15 Special Program Guides
- describes time coverage, name and size of SPGs
- defines unique PID for each SPG

Includes default override records (DOR) that
- override default names for categories, ratings, violence, language, and sex rating

The following diagram outlines the overall ATSC EPG format:

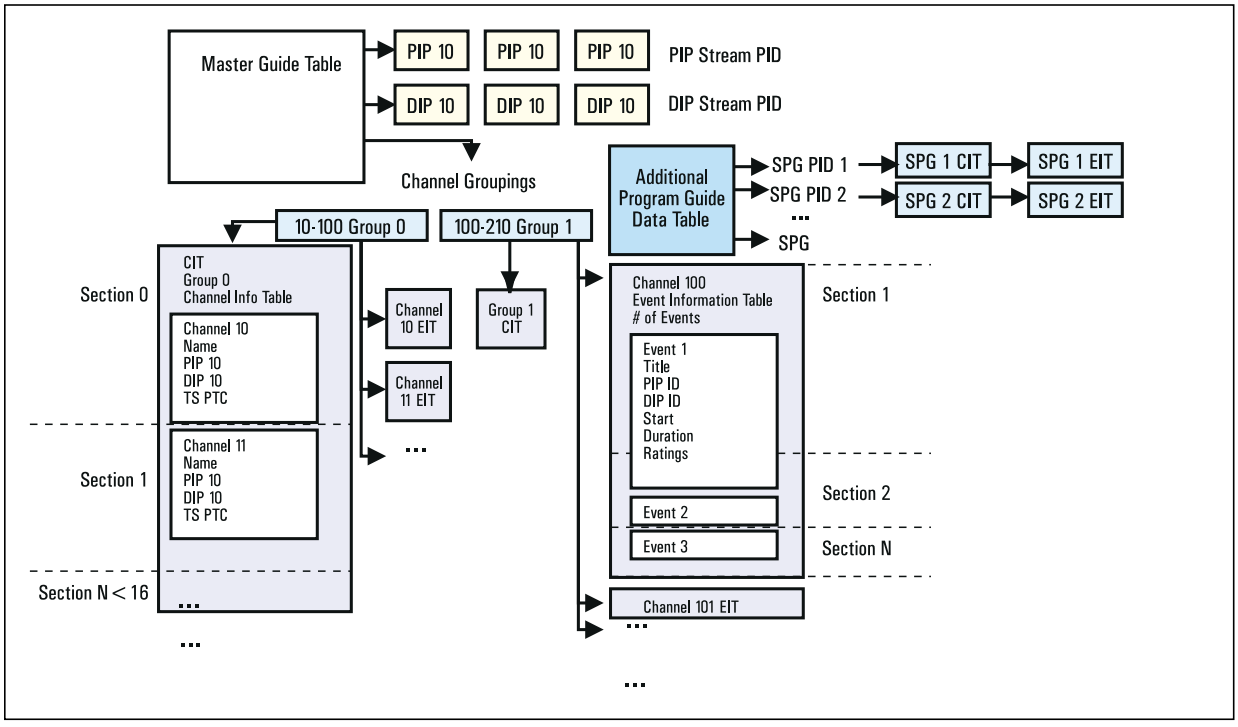


Diagram 6: Overall ATSC Program Guide Structure

DVB vs. ATSC and the Real World

As you can see, there are a lot of similarities in the capabilities of the DVB and ATSC systems, but there are also some major key differences, which we outline below.

DVB Not ATSC	ATSC Not DVB
Still Picture Support	Mixing of Analog and Digital channels
Default bit rate categories	Fixed multiplex structure and PID mapping
Short rate descriptors	Dolby AC-3 Audio
1536 byte default smoothing buffer	Video coding constraints
Mosaic Services	2K smoothing buffer
Unidimensional parental rating (3-18 years)	6 dimensional parental advisory ratings
Service Moves	Different program categorization scheme
Teletext	Currency description
Out of Band Closed Captioning	GPS timing
MPEG-2 Audio	Explicit user channel numbers
No profile restrictions	Inline data for closed captioning in video
Free-form multiplex PMT structure	Content creator and copyright identification
Network transitions	
Different program categorization scheme	
UTC Timing	
Service Linkages	
Interactivity	

Diagram 7: Key Differences Between ATSC and DVB

These differences will cause some difficulties in the exact translation of the information across the two systems. Since for political and historical reasons we now have two systems, it is highly desirable to also have multi-mode interoperability transport streams that can be sent/received by either a DVB or ATSC transmission system and set-top without re-multiplexing. To do this is possible—and is covered by ATSC specification A/58 and forthcoming DVB documents—if the DVB and ATSC PIDs are assigned so as to not interfere with the reserved PIDs of each other's specification. This means taking care not to use program_id 1 and making sure that PIDs selected for EPG information do not use the other specification's reserved regions.

The differences in coding for video, audio, and closed captioning present a thornier problem. It's possible to work around the smoothing buffer size difference by using the smaller DVB size. Audio interoperability implies sending multiple MPEG and AC-3 audio stream. Sending multiple data is also a way to work around the differences in closed captioning systems. Mosaic and teletext services will not be available in an ATSC decoder, but that should not necessarily hinder interoperable service delivery. It is possible that other "gotchas" and obstacles lurk in the path to creating a multi-mode transport stream, but for now the process seems feasible—albeit with a penalty in terms of bandwidth for the extra EPG and audio streams needed to create a multi-mode broadcast. One remaining huge problem is that of conditional access. Even though DVB attempted to standardize a CA scheme, there seems to be little will to adopt it.

Although it is theoretically possible to create an MPEG transmission that would be capable of being decoded universally, the unfortunate reality is that the industry s not really focused on interoperability. Indeed, it seems that manufacturers and service providers are more concerned about locking consumers into a particular vendor's equipment choices than establishing true standards. In a recent survey we conducted, most vendors and service providers indicated that they will be carrying proprietary EPG information on their system or using a proprietary conditional access scheme that will limit the number of receivers that can be used for their system (and transmission equipment in some cases). These kinds of format differences not only complicate troubleshooting (and building universal test equipment) and network interfacing, but impose hardship on the consumer.

Time and time again, the TV industry has proven that politics and protectionism are bigger drivers than the standards and competitive marketplaces that achieve lower prices for consumers—and it seems as though digital video and MPEG will be no exception. The EPG information and formats seem to be ideal candidates for subtle vendor lockout specifications. The unfortunate part of all this is that the consumer will be the one who loses—lack of true market competitiveness will keep equipment prices artificially high in some areas. When people move between geographic regions, they will be forever discarding much of their consumer electronics. This is nothing new, and we seemed doomed to repeat the debacle of PAL vs. NTSC vs. SECAM again on a much broader scale. It has been argued that the lack of a real universal analog standard brought great incremental expense to video production and distribution of video, and here we are... poised to repeat the same mistake.

Glossary:

AC-3	Dolby Audio Compression
AGDT	Additional Guide Data Table
ATM	Asynchronous Transfer Mode
ATSC	Advanced Television Standardization Committee
BAT	Bouquet Allocation Table
CA	Conditional Access
CAT	Conditional Access Table
CIT	Channel Information Table
CRC	Cyclical Redundancy Check
CST	Currency System Table
DCM	Defined Channels Map
DIP	Descriptive Information Parcel
DOR	Default Override Records
DV	Digital Video
DVB	Digital Video Broadcasting
DVB-SI	DVB-System Information
EIT	Event Information Table
EMM	Entitlement Management Messages
EPG	Electronic Program Guide
ETSI	European Telecommunications Standardization Institute
EU	European Union
FCC	Federal Communications Commission
FEC	Forward Error Correction
GPS	Global Positioning System
HBO	Home Box Office
IBP	I,B,P Frames
ICM	Inverse Channels Map
ID	Identifiers
IRD	Integrated Receiver Decoder
ISDN	Integrated Services Digital Network
ISO	International Standards Organization
ITU	International Telecommunications Union
Mbps	Megabits per second
MGT	Master Guide Table
MHz	Mega-Hertz
MMDS	Multipoint Multichannel Distribution Service
MNT	Map Name Table
MPAA	Motion Picture Association
MPEG	Motion Picture Experts Group
MPG	Master Program Guide
ms	millisecond
NIM	Network Information Message

NIT	Network Information Table
NTM	Network Text Message
NTSC	National Television Standards Committee
NVOD	Near Video On Demand
PAL	Phase Alternate Line
PAT	Program Assignment Table
PCR	Program Clock Reference
PG	Program Guide
PGM	Program Guide Map
PID	Program Identifier
PIP	Private Information Parcel
PMT	Program Map Table
PSI	Program System Information
PSTN	Public Switched Telephone Network
QAM	Quadrature Amplitude Modulation
QPSK	Quaternary Phase Shift Keying
RF	Radio Frequency
RST	Running Status Table
RTT	Ratings Text Table
SDT	Service Description Table
SI	Service Information
SMATV	Satellite Master Antenna TV
SNR	Signal to Noise Ratio
SNT	Source Name Table
SPG	Special Program Guides
STT	Satellite Text Table
SVC	Switched Virtual Channel
TDT	Time and Data Table
TNT	Transponder Name Table
TOT	Time Offset Table
TS	Transport Stream
TV	Television
USSB	US Satellite Broadcasting
UTC	Universal Coordinated Time
VC	Virtual Channel
VCM	Virtual Channel Map
VCR	Video Cassette Recorded
VCT	Virtual Channel Table

HEWLETT PACKARD

For more information

For more information on Hewlett-Packard Test & Measurement products, publications or services, please call your local HP sales office. A current listing is available at: http://www.hp.com

United States:

Hewlett-Packard Company
Test and Measurement Organization
5301 Stevens Creek Blvd.
Building 51L-SC
Santa Clara, CA 95052-8059
1-800-452-4844

Canada:

Hewlett-Packard Canada Ltd.
5150 Spectrum Way
Mississauga, Ontario L4W 5G1
905-206-4725

Europe:

Hewlett-Packard
International Sales Europe
Geneva, Switzerland
+41-22-780-4111

Japan:

Hewlett-Packard Japan Ltd.
Measurement Assistance Center
9-1, Takakura-Cho, Hachioji-Shi
Tokyo 192, Japan
(81) 426-48-3860

Latin America:

Hewlett-Packard
Latin America Region Headquarters
5200 Blue Lagoon Drive, 9th Floor
Miami, Florida 33126 U.S.A.305-267-4245, 305-267-4220

Australia/New Zealand:

Hewlett-Packard Australia Ltd.
31-41 Joseph Street
Blackburn, Victoria 3130
Australia
131-347 Ext. 2902

Asia Pacific:

Hewlett-Packard Asia Pacific Ltd.
17-21/F Shell Tower, Time Square
1 Matheson Street, Causeway Bay
Hong Kong
(852) 2599-7070

5966-1033E 06/1997 Rev A

Specifications subject to change