

How to get on-air with

5.1 audio

— the Dolby "5.1 Cookbook" for broadcasters

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This article is aimed at television broadcasters who want to go on-air with multichannel audio – using the Dolby® Digital (AC-3) audio delivery system. The necessary prerequisites to achieve this are described here, for different sections of the programme chain.

AC-3 is an *audio delivery system* that uses compression technology to carry high-quality audio at a low data rate. The data rate is selectable at the encoder and, for broadcast applications, is typically:

- **96 kbit/s** for mono;
- **192 kbit/s** for stereo;
- **384** or **448 kbit/s** for 5.1-channel sound.

As AC-3 is a *delivery system*, it can be configured to carry anything from one to six channels of audio. Consequently, AC-3 can be used to broadcast mono or stereo audio, as well as 5.1 surround sound. As an example, many of the thousands of DVD titles released have 5.1 audio tracks, but a significant number have been released with stereo AC-3. And older films are often released with the original mono soundtrack coded in mono AC-3.

At a broadcast receiver, AC-3 decoders are able to reproduce mono, stereo or 5.1 surround sound outputs from a 5.1 broadcast that has been encoded using AC-3. Importantly, this allows a wide range of consumer products to be manufactured with a range of features and prices.

Broadcasting in stereo

While the future of consumer audio is clearly multichannel sound, it may not be possible to move straight to a 5.1 home cinema style of presentation when launching a new DTV service (and, as we have seen, some older programmes will always be stereo or mono). AC-3 technology allows broadcasters to start with stereo and then choose when they first begin to offer prime-time broadcasts in 5.1. They may even use the intermediate step of the analogue Dolby Surround system. Importantly, this “at will” upgrade path is always present with AC-3.

For stereo-only broadcast applications, the tasks of programme acquisition, audio post-production and all operations through to programme play-out will be identical to normal stereo operation. When the video and audio are ready for multiplexing, the audio is encoded using an AC-3 encoder (typically at 192 kbit/s) before multiplexing this into the MPEG transport stream for that TV service. The possibility of using AC-3 in existing services is already supported by numerous manufacturers of multiplexing equipment. Any subsequent to-the-home transmission path, capable of handling a DVB transport stream, is able to include AC-3. Receivers

will need the AC-3 decoding to be *enabled*, in order to drive a stereo analogue output: typically, this will use the same IC as the MPEG video decoding. A large number of STB manufacturers are developing receivers containing licensed Dolby technology – for the satellite, cable and terrestrial TV markets.

DVB compatibility

In December 1998, Dolby Laboratories became a member of the DVB Project and, in June 1999, AC-3 was included as a fully equivalent second option for audio coding within the DVB-S, DVB-C and DVB-T standards. This means that a broadcaster may choose to broadcast AC-3 as the sole audio format for his service. The DVB specification published by ETSI as TR 101 154 [1] gives a detailed description of the use of AC-3 within DVB. It also includes the settings necessary to flag the Dolby bitstream for set-top box receivers. ITU-R Recommendation BS.1196-1 (04/01) [2] fully specifies the algorithm and the decoding requirements.

Broadcasting in 5.1

Audio post-production

5.1 for feature films

The service provider who is handling the licensed programme material has to deliver – in a discrete format – the 5.1 mix that carries the feature film soundtrack. In most cases this would be a DA-88 tape¹, often referred to as a “six-track”. These six-tracks are widely available from distributors or from the production studios themselves, for feature film productions after 1993/94.

For play-out, the broadcast master tape or server content must be assembled and edited to carry both video and audio. In order to achieve this with existing infrastructures (two- or four-channel audio environments), it may be advantageous to use a technology such as Dolby E for the internal distribution before going to AC-3 for the broadcast. Dolby E can store up to eight tracks of audio on a single AES/EBU pair, allowing for seamless editing and multiple encoding/decoding cycles.

Increasingly, film studios have started to use Dolby E for multichannel audio distributions (e.g. DVD authoring), enabling broadcasters to receive their Digital Betacam material with complete 5.1 mixes, and associated metadata, already recorded.

When such a Dolby E master is not available, it remains the task of the broadcaster or service provider to do the transfer from tape (e.g. DA-88) to Dolby E. As most broadcasters are required to edit films for transmission to suit appropriate age groups and to reflect cultural sensitivities, this transfer can be accomplished at the same time. Usually this job is completed on a suitable multichannel editing system.

Another big advantage of using a 5.1 audio soundtrack is the possibility of generating two-channel versions of the film soundtrack (Dolby Surround mix) “on the fly” in the broadcast facility, thereby reassuring the broadcaster that audiences receiving the analogue signal will also get the best possible audio quality.

On the other hand, even the most sophisticated play-out setup – for example, 5.1 and Dolby Surround in two different languages for a pay-per-view service – can be stored on a single Digital Betacam tape, using Dolby E.

5.1 for live production

Any outside broadcast, such as live concerts, sports events, etc., can easily be upgraded to 5.1 following a process similar to the one described above. Dolby E can be used to contribute multichannel content over exist-

1. DA-88 tape carries up to eight tracks of discrete PCM audio and timecode to be played on machines such as a Tascam DA-X8.

ing two- or four-channel infrastructures. Inside the broadcast facility, the material can then be stored, post-produced or sent out directly as a live broadcast.

At the production centre ...

Programme planning

After the decision has been made on which kind of programming will be broadcast with AC-3 5.1 sound, programme planners will regularly choose individual events and series, and forward their decision to the programme advertising department (for printed, on-air, online or Teletext announcements) and to various external media such as TV guides, online information sources, etc.

Content for 5.1 audio can vary according to the type of broadcasting station. Recent feature films are often a first choice, as almost all major Hollywood and European film productions (starting in 1992) are available in 5.1. However, it is possible to broadcast many other sorts of programme content in 5.1: for example, sports events, live concerts, music events in general, talk shows, TV movies, even sitcoms.

Copyright issues and licences

Dolby does not collect any licence fees for the production, distribution or broadcasting of encoded programmes. The only requirement is a trademark agreement in the event that the broadcaster wishes to identify or announce programmes with a logo. The agreement, artwork and video graphics are supplied at no cost.

As almost all films are produced with a 5.1 audio track, a vast and continually growing catalogue of film masters is available for consumer formats such as DVD and DVB. The film copyright owners or suppliers should be able to supply the appropriate materials if they know that the broadcaster needs a 5.1 soundtrack.

At the play-out facility ...

Transmission suite

If Dolby E is used for distribution, once the broadcast material containing the multichannel mix is prepared, it is merely a matter of passing the Dolby E signal through the play-out facility. As long as the audio infrastructure provides transparent AES/EBU audio channels, this shouldn't be a problem. In early 2000, Dolby Laboratories established a partnership programme with manufacturers, to simplify the certification of Dolby E compatibility with broadcast equipment products.

In order to allow for seamless switching between various sources and modes (e.g. between stereo and 5.1 material), a suitable distribution format such as Dolby E is recommended, even if 5.1 broadcasts are present only from time to time. This may be the case, for example, with mixed films and commercial ads. Usually the

Abbreviations

| | | | |
|--------------|--|---------------|--|
| AES | Audio Engineering Society | IEC | International Electrotechnical Commission |
| DTV | Digital Television | ITU-R | ITU - Radiocommunication Sector |
| DVB | Digital Video Broadcasting | MPEG | Moving Picture Experts Group |
| DVB-C | DVB - Cable | PCM | Pulse Code Modulation |
| DVB-S | DVB - Satellite | QAM | Quadrature Amplitude Modulation |
| DVB-T | DVB - Terrestrial | QPSK | Quadrature (Quaternary) Phase-Shift Keying |
| ETSI | European Telecommunication Standards Institute | S/PDIF | Sony/Philips Digital InterFace |
| IC | Integrated Circuit | STB | Set-Top Box |

advertisements will reside on a play-out server. In the case of Dolby E, if the PCM output of the server is encoded to the distribution format by default, fast and seamless switching between stereo and 5.1 can be guaranteed on the receiver side. For all other existing stereo or surround material provided as PCM, the Dolby E decoder offers a “pass-through” function.

In summary, play-out of the assembled broadcast signal is passed through a Dolby E decoder followed by the AC-3 encoder to produce the bitstream that is actually broadcast to the consumer.

Multiplex and uplink

From play-out, the AC-3 bitstream is then added into the programme and transport stream, along with the MPEG video, subtitles and data services. In situations where (i) existing DVB transmissions provide MPEG-1 Layer II stereo audio services and (ii) receivers that do not include AC-3 decoders must be serviced, then it will be necessary to continue to carry the legacy Layer II audio signal to maintain compatibility with the existing consumer STBs. In this case, the multiplex for one channel of a TV service would consist of one video bitstream, two audio bitstreams and any additional services. In 5.1 mode, the AC-3 bitstream requires a minimum data rate of 384 kbit/s. In two-channel mode, the requirement decreases to 192 kbit/s. The AC-3 encoder can automatically adjust the data rate. The possibility to adapt AC-3 into existing services is already supported by numerous manufacturers of multiplexing equipment.

Transmission path

Any transmission path that can handle a DVB transport stream is able to include AC-3. This is because AC-3 has been part of the DVB standard since 1999.

As soon as the AC-3 bitstream is included in the transport stream at the multiplexing facility, any channel coding scheme such as DVB-S, DVB-C or DVB-T can carry this AC-3 audio. A change of modulation from QPSK (DVB-S) to QAM (DVB-C) will not change the content of the transport stream and will therefore maintain all audio services allocated to a certain television service. Obviously, AC-3 can also be used for audio-only applications such as radio.

At the receiver ...

To receive an AC-3 broadcast, the STB must be able to recognize and support this type of bitstream. A vast selection of AC-3-equipped set-top boxes has been established over the past two years.

In its most complete form, an STB will contain an AC-3 decoder. The S/PDIF digital audio output on the back of these STBs provides the AC-3 bitstream in IEC 61937 format. This bitstream can be transmitted to an external AC-3 home theatre system for a full 5.1-channel surround sound experience. The hardware capabilities of a product containing a decoder also mean that, in addition to being supplied as a digital bitstream, any AC-3 information received by the unit can be “downmixed” into a high-quality stereo analogue output. With the analogue outputs being driven in such a way, the user gains access to the extended capabilities offered by the AC-3 standard – such as dialogue normalization, downmixing and dynamic range compression. Backward compatibility with existing home entertainment equipment is also maintained as these high-quality, level-equalised stereo signals are also compatible with Dolby Surround Pro Logic® decoders.



Products containing AC-3 decoding capabilities carry the Dolby Digital consumer logo.

In situations where a number of existing users possess STBs which do not contain AC-3, it is necessary to simulcast an AC-3 soundtrack with an MPEG soundtrack. However, in situations where all users are mandated to possess STBs containing AC-3 decoding, only the AC-3 soundtrack needs to be transmitted. This

avoids the need to simulcast audio streams and frees up valuable bandwidth which can be used for additional channels, datacasting or other interactive services.

In certain cases, such as existing DVB systems, simulcasting is the only way to proceed. As an initial step in such scenarios, STBs are available which do not decode the AC-3 information, and only output this as a digital bitstream. Certain examples of such products can be recognized by the “Dolby Digital Bitstream Out” logo displayed on the front panel. However, not all STBs with this functionality carry this logo. The advantage of such STBs (over generic models) is that they provide owners of AC-3 home theatre equipment with access to a broadcast AC-3 bitstream. The disadvantage – in comparison to STBs containing AC-3 decoders – is that the analogue outputs are driven by standard broadcast audio and do not benefit from the aforementioned features (such as dialogue normalization, downmixing and dynamic range compression).



In addition to this, certain STBs that have just a “Bitstream Out” facility are only capable of either outputting an analogue signal or a digital bitstream, but not both at the same time. As mentioned above, several well-known STB manufacturers already offer a variety of STB models that support AC-3 audio soundtracks within the DVB specification.

A white paper on audio levels in DTV receivers is available from Dolby Laboratories [3].

Marketing

In order to market this sophisticated new technology to the consumer, user-friendly information must be provided to explain how this improved audio quality can be received. This goes hand in hand with the distribution of programme information which, in the initial phase, should be accompanied by technical support information. Thus, the same kind of information channels can be used as described in the programme planning section of this article.

Summary

Consumers have become very familiar with surround sound of late, initially with matrix stereo surround but more recently with 5.1 audio from DVDs. Content in 5.1 audio is already available on feature films but is increasingly becoming available in drama, nature and sports programming. Starting from stereo, the upgrade path to 5.1 for the broadcaster has been sketched out here, showing how productions can take advantage of the ability to transmit 5.1 audio (in an AC-3 stream) as part of the DVB specification. In particular, the distribution and play-out can be implemented by choosing a suitable distribution code (such as Dolby E), without major changes to the infrastructure that would otherwise be required to carry six or more audio channels.

Detailed drawings of how to implement 5.1 audio in any of the stages described above – from production through distribution, to transmission and the set-top box – are available from Dolby Laboratories [3].



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Before joining Dolby, Mr Spath worked for 10 years as a music recording engineer and producer, and gained a Tonmeister degree from the University of Surrey in England.

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