DIGITAL TERRESTRIAL TELEVISION BROADCASTING IN AUSTRALIA

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1 Summary

Australia is served by an extensive network of DVB-T[1] digital transmitters covering approximately 600 geographic areas. Digital terrestrial television broadcasting transmitting sites operate in both VHF Band III and UHF Bands IV and V on a 7 MHz raster and predominately operate with the following transmission parameters: 8k carrier mode, 64-QAM, 2/3 or 3/4 FEC. Digital terrestrial television services commenced in major metropolitan regions on 1 January 2001 and have been progressively deployed in regional and some remote areas.

A feature of the Australian transmitter deployment is that a large percentage of the population receives signals from a small number of high power "main station" transmitters with typical coverage areas of up to 150 km. For digital services the radiated power levels of the main station transmitters are up to 150 kW e.r.p. at VHF and up to 895 kW e.r.p. at UHF. In addition to high power main station services, repeater stations to cover deficient coverage areas are extensively used. They are implemented using either a multi-frequency network (MFN) or a single frequency network (SFN) approach.

HDTV was a key feature of the introduction of digital terrestrial television in Australia and has been an important driver in the uptake of digital television. The Australian Government committed to ensuring that digital television would be as affordable as possible. Initially broadcasters were required to provide at least a minimum amount of high definition television programming for those who have HDTV sets, they were also required to provide their broadcasts in SDTV format. Transmission of SDTV format programming not only provided viewers with the ability to access the additional features of digital broadcasting, but it also gave viewers a cheaper conversion path for obtaining digital services.

The Australian Government announced that 31 December 2013 would be the date by which the last analogue transmitter would be switched off.

2 Digital terrestrial television broadcasting in Australia

2.1 Introduction

Australia is served by an extensive network of DVB-T digital, terrestrial television broadcasting transmitting sites. A feature of the transmitter deployments in Australia is that a very large proportion of the population receives signals from a relatively small number of high power "main station" transmitters that have large coverage areas, typically 100-150 km in diameter. Radiated power levels at main station VHF Band III digital transmitters can be up to 150 kW e.r.p. The radiated power levels at main station UHF Band IV and V transmitters can be up to 895 kW e.r.p..

As a consequence of an initially sparse distribution of terrestrial transmitter sites, analogue main station assignments in Australia were generally planned [1] on the basis of noise-limited reception rather than interference limited reception. This meant that the so-called analogue

[1] www.dvb.org

taboo channels (e.g. adjacent channels, image channels and local-oscillator channels) were usually unencumbered by other (out-of-area) TV signals[2]. Most of the population of Australia had access to five free-to-air analogue TV services. Australian digital television services commenced in metropolitan regions on 1 January 2001 and were progressively deployed in regional areas and then to some remote areas. The relevant federal government legislation originally stipulated a simulcast period of eight years. During the simulcast period, existing analogue television transmissions continued and an additional digital signal was brought into service. The digital service was required to carry a standard definition (SDTV) digital version of the programmes being provided on the analogue service (more discussion on the regulatory framework for the introduction of digital television services is given in section 1.7).

In December 2007 the Australian Government changed the simulcast period, announcing that 31 December 2013 will be the date by which the last analogue transmissions will be switched off. Subsequently, a timetable was set for the progressive area by area switchover from June 2010 to December 2013.

2.2 DTTB System Selection

The first step in the DTV conversion process was a comparative assessment process that led to the selection of DVB-T as the preferred digital television transmission standard and the determination of system planning parameters such as interference protection ratios and minimum required signal levels.

The availability of this information permitted the conduct of a preliminary study of possible DTV channel allocations. The conclusions of this preliminary study showed that it would be possible to allocate a complete TV channel (7 MHz wide in Australia at both VHF and UHF) to each existing analogue service to permit its conversion to DTV as well as provide additional channels for new digital-only services.

In 1998 legislation[3] that set the framework for the establishment of DTV services was passed by the Australian Parliament. In that legislation the government determined that each broadcaster would be loaned spectrum to provide a digital service that matched the coverage of the analogue service as closely as possible. Further legislation was also enacted to establish the detail of the regulatory regime to apply to the provision of digital television and datacasting.

2.3 Simulcast of SDTV and HDTV programmes

The Australian Government committed to ensuring that digital television would be as affordable as possible. Although broadcasters were required to provide at least a minimum amount of high definition television programming for those who could afford HDTV sets, they were also required to provide their broadcast in SDTV format. SDTV programming provided viewers with a picture quality that is generally superior to the analogue television service. Two additional SDTV digital-only programme streams were transmitted on national broadcaster's networks and three more commercial SDTV programme streams were available from 1 January 2009. The transmission of SDTV format

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2 As the number of services and the density of transmitter sites has increased, planning of later services, especially repeater services, has more typically been on an interference limited basis.

3 Television Broadcasting Services **(**Digital Conversion**)** Bill 1998

programming not only provided viewers with the ability to access the additional features of digital broadcasting, but also gave viewers a digital conversion path that was cheaper than the alternative approach of purchasing a HDTV set or a HD set top box.

HDTV was a key feature of the introduction of digital terrestrial television in Australia. Broadcasters were required to transmit HDTV programmes for a minimum of 1 040 hours per year. The government did not specify any particular technical parameters for HDTV, and broadcasters have been able to adopt and use the MPEG-2 MP@HL format for transmission (i.e. 576/50p, 720/50p, 1080/50i). However, Australian broadcasters expressed a preference that programme production and exchange should be based on 1080i line formats.

By requiring both SDTV and HDTV programming, viewers were given a choice in digital television products but at the same time allowed broadcasters scope to demonstrate the appeal of HDTV.

2.4 Use of single frequency networks

Digital television services were introduced in Australia, using either a multi-frequency network (MFN) or a single frequency network (SFN) approach. In either case, the digital television service is provided from a network that consists of a high-powered central (or parent) transmitter that may be supported by, or contribute signal to off-air feed, a number of low-powered in-fill or area-extension re-transmitters.

In the MFN case, the re-transmitters operate on a different channel (or channels) from the parent transmitter while, in the SFN case, the re-transmitters either operate on the same channel as the parent transmitter (if not an off air feed); or on another channel in one or more SFN re-transmission networks, which could be off air feed from the parent[4].

In the latter case, the parent transmitter is operated in the MFN mode, albeit with SFN timing information embedded into the signal for use by the SFN re-transmission network(s). In a few cases more than one parent transmitter, together with their re-transmitters operate as an SFN.

2.5 Planning parameters and interference threshold limits

Australia's planning for digital television services has taken into account a legislated requirement that "... in SDTV digital mode in that area should achieve the same level of coverage and potential reception quality as is achieved by the transmission of that service in analog mode in the same area". Following this approach, Australia's digital services were typically planned with a maximum e.r.p. of 6 dB less than same band analogue television services.

Planning guidelines [2] in Australia also specified minimum median field strengths (referred to
a measurement height of 10 m above local terrain) of 44, 50 and 54 dB(μV/m) for Band III, IV and V digital television services respectively[5]. To minimize the "cliff-effect", digital television services were planned to achieve the required protection ratio for better than 99% of the time, irrespective of whether the interference is considered to be continuous or tropospheric in nature.

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[4] In a limited number of cases a parent station may feed several SFNs that may each operate on a different channel.

[5] Refer to the ACMA website, www.acma.gov.au.

2.6 Comparison of ITU-R and Australian television planning parameters

The following text summarizes differences between Australian television planning parameters, including minimum field strengths and protection ratios and the corresponding Recommendation ITU-R BT.1368 [3] parameters for the protection of DVB-T digital television services.

Australian planning for digital terrestrial television is based on an assumption of fixed reception using outdoor receiving antennas. Therefore protection ratios relevant to Ricean channels are used where available. The DVB-T mode 64-QAM with 2/3 FEC and a 1/8 guard interval was originally adopted as the basis for digital television planning. Subsequently the guard interval assumed in planning was revised to 1/16 (refer section 4). However to achieve a higher picture quality for the SD/HD simulcast, most broadcasters selected 64-QAM with 3/4 FEC and 1/16 guard interval.

2.6.1 Digital television minimum median field strengths

Australian digital television planning is based on provision of minimum median field strength levels in rural environments of 44, 50 and 54 dB(μV/m) in Bands III, IV and V respectively. These values are reasonably close to the values that can be derived from the sample calculation value provided in Table 53 of Section 6, Annex 2 to Recommendation ITU-R BT.1368-10, once a location correction factor[6], bandwidth adjustment[7] and interference margin[8] are applied. The Australian values for rural environments are, respectively, 0.3 and 0.1 dB lower, and 1.8 dB higher than values that would be derived from the Recommendation, for Bands III, IV and V, respectively.

The differences are due to: inclusion of a 1 dB higher receiver noise figure allowance in Bands III and V; inclusion of a 1 dB allowance for man-made noise in VHF Band III; different combinations of antenna gain/feeder loss in Bands III and IV; and, use of frequencies at the top rather than the middle of each band as the reference frequency for the calculation.

2.6.2 Digital television protection ratios

Protection ratios for digital-digital co-channel and adjacent channel interference from other television broadcasting services were first defined in July 1999[9]. Only minor changes have been made to those original values. The values used in Australian planning are the same as the 64-QAM, 2/3 FEC values set out for DVB-T interfered with by DVB-T in Tables 15 and 17 of Recommendation ITU-R BT.1368-10.

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6 Australian planning is based on provision of a service at 80% of locations within 200 m by 200 m areas for rural environments. A 4.5 dB correction factor is applied to convert from a 50% of locations to an 80% locations field strength value.

7 A 0.5 dB lower noise power applies due to the receiver bandwidth being 6.7 rather than 7.6 MHz.

8 The minimum field strength calculations also include a 1 dB "interference margin" for the support of co-channel frequency re-use planning.

9 The original 1999 values were adopted following protection ratio measurements made in 1998 using the "traditional" wanted-to-unwanted protection ratio measurement approach, rather than the $C/(I+N)$ approach that is now included in Recommendation ITU-R BT.1368.

The relevant protection ratios are not to be exceeded for more than 1% of the time. That is, the E(50,1) value is used for the interfering field strength.

2.7 Regulatory framework

To facilitate the transition from analogue to digital broadcasting the Australian Communications and Media Authority (ACMA) was required to prepare digital channel plans (DCPs) that determined the channels to be allotted in each area and assigned to each broadcaster as well as the technical limitations and characteristics of those channels. The ACMA's objective in preparing the DCPs was to enable a broadcaster to plan its digital transmission coverage to match its analog coverage. Further, each broadcaster was required to prepare implementation plans relating to the conversion of their services to digital.

To underpin the development of the DCPs the ACMA developed and promulgated technical planning documents setting out the general and technical assumptions that were to be used for planning the rollout of digital television services.

Digital channel plans were developed in four stages. During the first stage, main station channels for the metropolitan licence areas of Sydney, Melbourne, Brisbane, Adelaide and Perth and some other priority areas were completed. These areas were revisited in the second stage through a variation to the DCP. Variations included planning for additional digital services and digital repeater sites. DCPs for regional areas of Australia were developed during stage three and DCPs for remote areas prepared during stage four.

3 Digital switchover

The Australian Government established a Digital Switchover Taskforce to coordinate and oversee the transition to digital from analogue television.

Its objectives were to:

– advise government on policy settings, implementation and issues connected with digital switchover;

– develop and implement a program framework, including a switchover timetable, to complete the switchover from analogue to digital television transmission in Australia by the end of 2013;

– manage an information and education program explaining the switchover process to all Australians setting out what they will need to do and how to get further information; and

– convene meetings of an industry advisory group consisting of stakeholders – including broadcasters, retailers, manufacturers, antenna technicians and public and commercial housing agencies, government departments – and coordinate these to utilise their expertise in delivering switchover by the end of 2013.

Digital TV Timetable by Region

Type	Switchover Area	Window	Switchover Date
VIC	Mildura / Sunraysia	1 January – 30 June 2010	30 June 2010
SA	Broken Hill	1 July – 31 December 2010	15 December 2010
SA	Riverland	1 July – 31 December 2010	15 December 2010
SA	Mt Gambier / South East South Australia	1 July – 31 December 2010	15 December 2010
SA	Spencer Gulf	1 July – 31 December 2010	15 December 2010
VIC	Gippsland	1 January – 30 June 2011	5 May 2011
VIC	North Central Victoria	1 January – 30 June 2011	5 May 2011
VIC	South West Victoria	1 January – 30 June 2011	5 May 2011
VIC	Goulburn Valley / Upper Murray	1 January – 30 June 2011	5 May 2011
QLD	Wide Bay	1 July – 31 December 2011	6 December 2011
QLD	Capricornia	1 July – 31 December 2011	6 December 2011
QLD	Queensland Central Coast & Whitsundays	1 July – 31 December 2011	6 December 2011
QLD	Darling Downs	1 July – 31 December 2011	6 December 2011
QLD	North Queensland	1 July – 31 December 2011	6 December 2011
QLD	Far North Queensland	1 July – 31 December 2011	6 December 2011
NSW	Griffith / Murrumbidgee Irrigation Area	1 January – 30 June 2012	5 June 2012
NSW	South West Slopes & Eastern Riverina	1 January – 30 June 2012	5 June 2012
NSW	Illawarra and the South Coast	1 January – 30 June 2012	5 June 2012
NSW	Central Tablelands & Central Western Slopes	1 January – 30 June 2012	5 June 2012
NSW	ACT & Southern Tablelands	1 January – 30 June 2012	5 June 2012
NSW	North West Slopes & Plains	1 July – 31 December 2012	27 November 2012
NSW	Richmond / Tweed	1 July – 31 December 2012	27 November 2012
NSW	Northern Rivers	1 July – 31 December 2012	27 November 2012
NSW	Hunter	1 July – 31 December 2012	27 November 2012
Metro	Tasmania	1 January – 30 June 2013	9 April 2013
Metro	Perth	1 January – 30 June 2013	16 April 2013
Metro	Brisbane	1 January – 30 June 2013	28 May 2013
Metro	Melbourne	1 July – 31 December 2013	10 December 2013
Metro	Adelaide	1 July – 31 December 2013	2 April 2013
Metro	Sydney	1 July – 31 December 2013	3 December 2013
Metro	Darwin	1 July – 31 December 2013	30 July 2013
Remote	Remote Central & Eastern Australia	1 July – 31 December 2013	10 December 2013
Remote	Regional & Remote Western Australia	1 July – 31 December 2013	25 June 2013

Source: Department of Communications.

4 Digital dividend

In June 2010, the Australian Government announced that a digital dividend of 126 MHz of 700 MHz band spectrum, comprised of Australian UHF television channels 52 to 69, would be realised. The digital dividend was made possible by the move to digital-only television broadcasting under the digital television switchover program. The final step to realising the digital dividend was for a significant number of digital television services to be moved to new channels so that channels 52 to 69 can be cleared and made available for new services such as wireless broadband.

The digital dividend channel changes took place affecting approximately 450 geographic coverage areas across Australia.

5 Planning the restack of DTTB to achieve the digital dividend

The process of clearing digital television services from the digital dividend band (694-820 MHz) is often referred to as the restacking of digital services or 'restack'. After the restack was to be completed all digital television services would operate in the remaining UHF broadcasting spectrum of 520-694 MHz and VHF broadcasting spectrum of 174-230 MHz.

At the outset of the restack planning process the Australian Government provided a series of Ministerial objectives:

– the requirement to clear the dividend band (694-820 MHz);
– the requirement to complete restack as soon as possible after the final switchover day (with a target of end 2014);
– the number of services to be planned at each location (generally 6 but 9 in licence overlap areas);
– the retention of VHF spectrum for digital radio purposes (14 MHz); and
– specific planning arrangements for metropolitan area main transmission sites (all services to be in VHF).

The requirement to consider viewer and broadcaster costs and viewer disruption resulting from any changes that were not necessary for, or consequential to, the achievement of the policy objectives of the Minister's direction. The restack activity had two major phases of work. The first was the development of revised channel plans and sequencing plans that identify the final channels that digital television services will move to and the order in which the moves will need to occur. The second was the implementation of those channel changes by broadcasters.

5.1 Restack channel planning

A Restack Planning Advisory Group (RPAG) was established by the ACMA to consult industry on the restacking of digital television services to clear the digital dividend. The RPAG was an informal group as it was not constituted under any legislative provisions. The RPAG provided a forum for the ACMA and industry to discuss proposals relating to replanning of digital television channels to facilitate the restack as well as restack implementation and timing issues. The RPAG was an important part of the process for the development of formal instruments but it did not replace public consultation on formal instruments. After discussion within the RPAG forum, and a formal public consultation, in May 2011 the ACMA adopted a series of restack objectives and principles. The objectives were:

1 clear the digital dividend band of broadcasting services as soon as practicable;
2 plan for six digital channels at each transmission site[10];
3 plan for six VHF channels at all metropolitan main station sites;
4 plan such that coverage of all six channels is similar;
5 maintain or improve digital television coverage;
6 simplify viewer reception of terrestrial digital television;
7 establish spectrum planning arrangements that support future needs;
8 retain 14 MHz of spectrum in VHF Band III for possible expansion of digital radio;
9 comply with the legislated framework;
10 consistent with the minister's direction, the ACMA should wherever possible:
   a) minimise viewer costs and disruption;
   b) minimise commercial and national broadcaster costs.

The restack planning principles were as follows:

Principle 1: Replan digital television services to use VHF channels 6-12 and UHF channels 28-51.

Principle 2: Create a digital radio sub-band, comprising VHF television channels 9 and 9A,
that is clear of digital television in metropolitan and regional licence areas. Where practicable,
also avoid planning new services on these channels in remote licence areas.

Principle 3: Plan for six digital channels at each transmission site, except for
i) licence area overlaps where two sets of three commercial services will require channels (a total of nine channels) and;
ii) where broadcasters operate from different sites but cover the same area.

Principle 4: Plan channels so that viewers in metropolitan and regional licence areas can receive all services using a single band antenna (i.e. plan all channels in either the VHF or UHF band). Consider the benefit of single band operation in other areas on a case-by-case basis. The current polarisation of the existing transmissions in a particular band at each transmission site is to be maintained.

Principle 5: Plan all six services on channels within defined blocks of channels as follows:
Block A: 6, 7, 8, 10, 11 and 12*
Block B: 28, 29, 30, 31, 32 and 33
Block C: 34, 35, 36, 37, 38 and 39
Block D: 40, 41, 42, 43, 44 and 45
Block E: 46, 47, 48, 49, 50, and 51.
* Channels 9 and 9A may be used for digital TV in some remote areas.

[10] In licence area overlap regions, nine services per site would be planned at existing transmission sites.

Principle 6: Assign channels within a block as follows.

VHF: Existing VHF services to retain current channels unless they have to move to clear channels 9 and 9A under Principle 2. New or changed channel assignments do not need to follow any particular order, except in all Metropolitan areas where SBS should move to channel 7. Where it is possible without moving existing services, channel 10 should be the unassigned channel to align with the metropolitan area unassigned channel.

UHF: Channel assignments should be made after considering and balancing a number of objectives including:

– avoiding off-air input issues (adjacent channel and N+5)
– avoiding changes to existing services within the block
– using the unassigned channel to remove restack timing constraints and manage band edge interference potential.

If none of the above issues apply, UHF channels should be assigned in the following order: SBS, ABC, Seven (or affiliate), Nine (or affiliate), Ten (or affiliate), Unassigned.

Principle 7: In selecting the channel block for a transmission site:

– Consider the channels used by existing digital services and any information available on the operating frequency range of broadcaster transmission equipment.
– Avoid use of a block outside the likely bandwidth of viewer antennas. In particular, avoid Block B where there is no current or past use of UHF Band IV channels. Where this cannot be avoided, minimise the total population affected.
– Wherever sites utilise UHF channel blocks, attempt to place high power services on lower UHF channel blocks.

Principle 8: Break up wide area single frequency networks (SFNs) known to have associated reception problems and minimise use of new SFNs where possible.

Principle 9: Plan on the basis of broadcasters using the DVB-T standard with transmission parameters of 8k, 64QAM, 2/3 forward error correction (FEC) and 1/16 guard interval.

The co-channel protection ratio used for planning will be: 20 dB

The minimum median field strengths used for planning were:

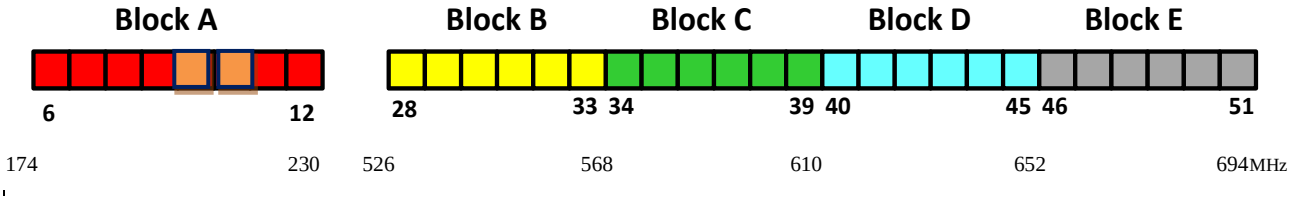
Minimum median field strengths for digital television planning (dBµV/m)

	VHF (Block A) (174-230 MHz)			UHF (Blocks B and C) (526-610 MHz)			UHF (Blocks D and E) (610-694 MHz)		
	Rural	**Suburban**	**Urban**	**Rural**	**Suburban**	**Urban**	**Rural**	**Suburban**	**Urban**
Minimum median field strength (dBuV/m)	44	57	66	50	63	71	54	67	74

Principle 10: Equalise transmissions across all broadcasters as far as practicable through planning on the basis of equal ERP levels, identical antenna patterns, closely sited transmitters and all broadcasters having the same SFN arrangement.

Principle 11: Determine the timing constraints on channel availability and specify a minimum window of six months, where practicable, when both the current digital and the final digital channels are available. When all sites and timing windows are considered together, they should result in the digital dividend channels (52–69) being cleared as soon as practicable, and by the end of 2014 at the latest.

Principle 5 gave effect to a unique characteristic of the Australian planning which was the adoption of the "contiguous channel block model".



It was considered that aggregating all broadcast services that serve a particular area into one frequency range would equalize reception quality for all services – viewers that could receive one service would be much more likely to be able to receive all services (previously, under "interleaved" planning where services were widely spread across a band or across VHF and UHF Bands, this was sometimes not the case).

It is also noted that under Principle 2 Australian VHF channels 9 and 9A were left clear for possible digital radio use in metropolitan and regional areas. DAB+ digital radio services commenced in the five major capital cities in July 2009.

5.2 Television licence area plans

Following discussion with industry through the RPAG, the proposed restack channel planning proposals were codified in draft instruments known as Television Licence Area Plans (TLAPs). These instruments identified the channel allotments each digital television service would need to move to, if it needed to change, and by when the changes needed to be made. The draft instruments were made available for a period of formal public comment before being considered for approval by the ACMA.

5.3 Indicative restack channel chart

Detailed restack channel planning work commenced in 2011 and continued until late 2012. In the early stages of channel planning, to provide a framework that allowed the detailed channel planning for each licence area to proceed relatively independently, a 'key sites indicative channel plan' was developed. It has now been superseded by a more comprehensive *Indicative Channel Chart* that consolidates in a single spreadsheet the detailed channel planning work that the ACMA has performed for each of the television licence areas.

5.4 Implementation of the restack

The Australian Government committed to:

– relocate commercial and national broadcasters' digital television services to their new channels by retuning, replacing or otherwise modifying transmission equipment to operate below UHF channel 52 (694 MHz);

– provide a project and implementation manager to manage channel changes nationally; and

– conduct a public education/information campaign about the need to retune receivers.

Generally, digital dividend channel changes took place once digital television switchover had occurred in an area.

Viewers did not need to purchase new television reception equipment, but generally needed to retune their existing television, set top box or digital recorder to be able to continue viewing free-to air services that had undergone a channel change.

The Australian Government expected that the channel changes would be completed by 31 December 2014.

A channel change timetable schedule that advised of nationwide activities and particularly public retune dates was developed to ensure the program was delivered by 31 December 2014.

6 References

1. ACMA DTTB Planning Handbook
2. ACMA Technical Planning Guidelines
3. Recommendation ITU-R BT.1368 Planning criteria, including protection ratios, for digital terrestrial television services in the VHF/UHF bands
4. Recommendation ITU-R BT.1735 Methods for objective reception quality assessment of digital terrestrial television broadcasting signals of System B specified in Recommendation ITU-R BT.1306
5. Report ITU-R BT.2140 Transition from analogue to digital terrestrial broadcasting
6. AS4599 Digital television - Terrestrial broadcasting - Characteristics of digital terrestrial television transmissions, Standards Australia
7. *Draft* Implementation of Digital Terrestrial Television Broadcasting - Case Study – Australia, an ITU Development Sector publication

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