



SONORA
design associates

DIRECTV DIGITAL VIDEO DISTRIBUTION FOR CUSTOM HOMES AND MULTIPLE DWELLING PROPERTIES



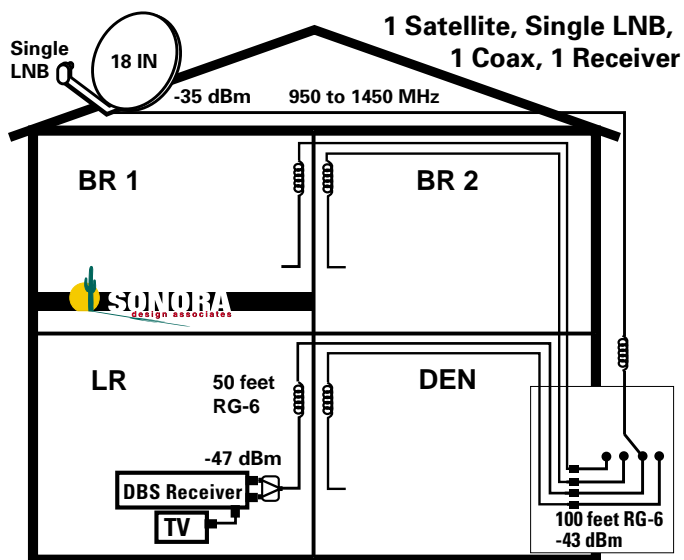
*In 1997,
Sonora Design Associates
was formed to design and
manufacture hardware for
Direct Broadcast Satellite
television systems.*



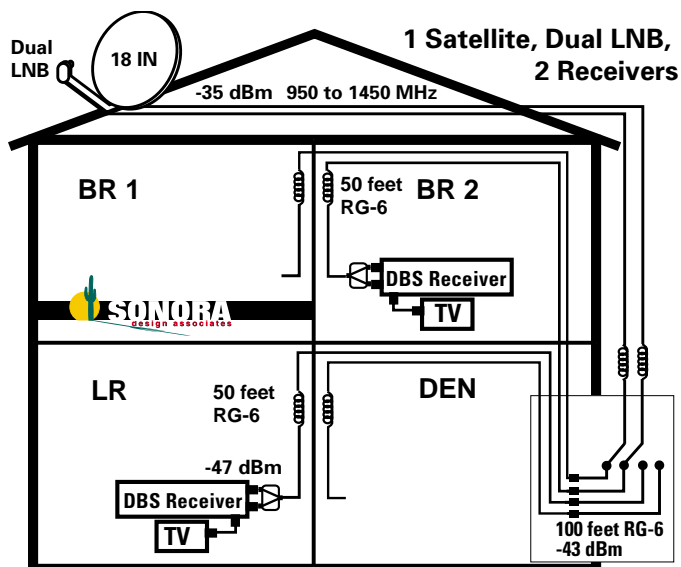
*Our Mission is to integrate digital satellite
video technology with our technical and
marketing expertise to design turn-key,
profitable systems that can be installed
quickly with minimal labor expense.*

Custom Home Installations

Custom Home Installations are illustrated in this application note beginning with simple one-dish, one-receiver models expanding in complexity to hundreds of receivers sharing signals from a distribution system. Examples focus on DirecTV signals, Sonora Design Associates distribution equipment and SONY reception and display hardware. Our goal is seamless integration of hardware that allows the best possible picture.



App_10d_1SAT1Coax1Rx.EPS



App_11d_1SAT2Coax2Rx.EPS

Early DBS systems consisted of a single output antenna and a single receiver. Systems were designed to be simple, enabling installation by typical consumers. Customers would select which outlet in their home to connect the receiver. Basic DBS math is required to understand the issues involved as distribution systems expand.

- 18" Legacy dish output (average) -35 dBm
- 18"x 24" Multi-Sat dish output (average) -38 dBm
- 16"x 20" Multi-Sat dish output (average) -38 dBm
- DBS Receiver Minimum Input -60 dBm
- RG6 cable loss 6 dBm @ 950 MHz
- RG6 cable loss 8 dBm @ 1450 MHz
- RG6 cable loss 10 dBm @ 2150 MHz

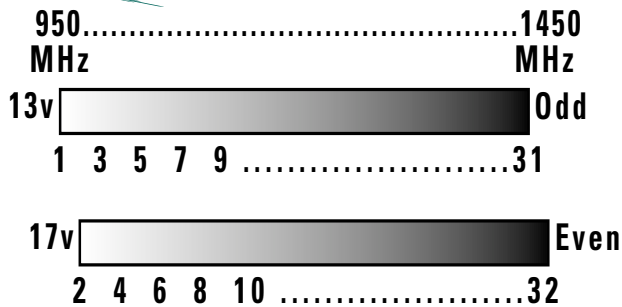
Signal levels are noted on diagrams starting at the LNB output (-35 dBm). After 100 feet of dual RG-6 the level entering the home is (-43 dBm @ 1450 MHz). Most homes are cabled using a "home-run" layout where each room is cabled back to a main point of entry (MPOE). Typical homes have another 50 feet from the MPOE to the receiver.

With decreasing receiver cost and increasing consumer pressure came the two output LNB. A second coax was required to connect the second receiver. Two DBS receivers have independent channel selection when each is connected to one of the outputs of the dual LNB.

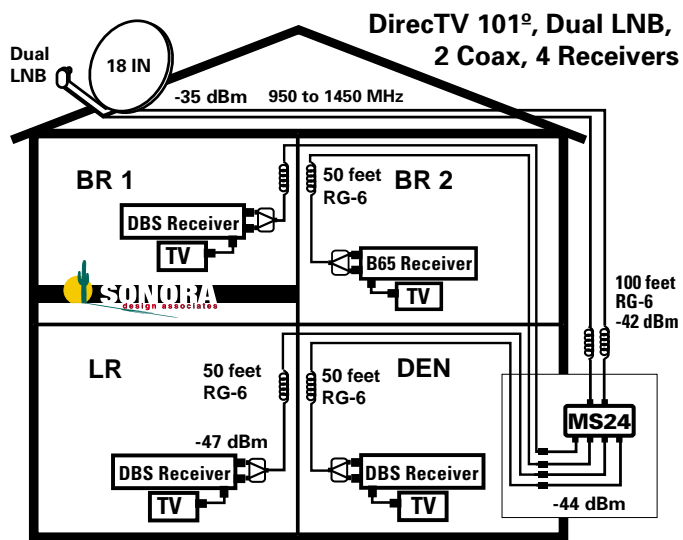
Custom Home Installations

DirectTV

DBS Switched LNB Transponder Plan

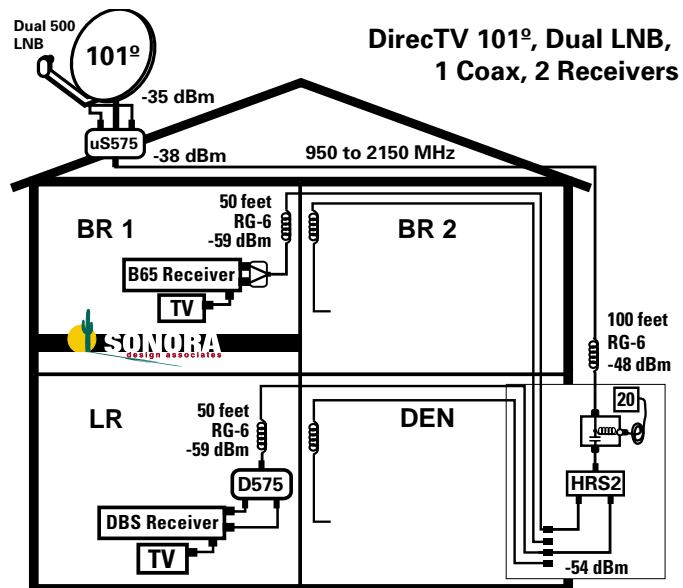


The switched DBS frequency plan is illustrated on the left. DBS satellites transmit (32) transponders in (2) blocks of (16) transponders. Each block shares the same frequency but is "polarized" in opposite directions so the blocks do not interfere with each other. DBS receivers "talk" to the LNB to select the polarity of signal that contains the program selected by the viewer. Each receiver sends out a DC voltage of either 13 or 18 volts which selects the polarity and powers the LNB.



App_12d_2Coax4Rx.EPS

Competition with CATV multi-outlet services required the DBS broadcasters to allow for more than (2) receivers per home. Multi-switches were added to the system. Up to (4) receivers had independent channel selection. Locating the multiswitch at the point of entry, only two cables were required from the dish. Multiswitches are typically loss-less so the signal levels remain the same as calculated previously. The switches fool the receivers into thinking they are "talking" to the LNB. MS24 multiswitches are receiver powered and pass power back up the coax to power the LNBs.

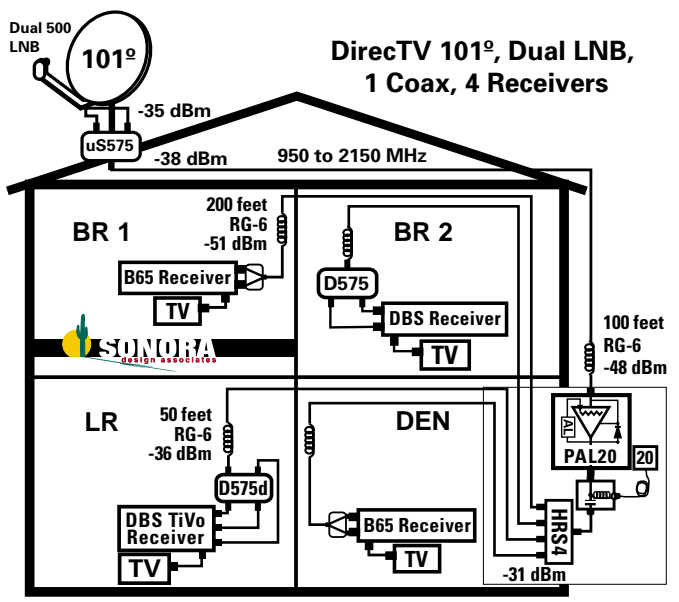
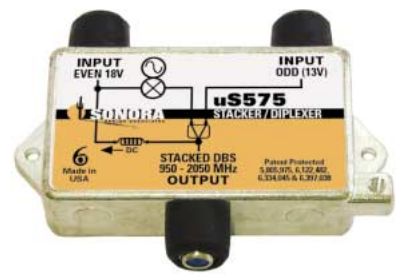
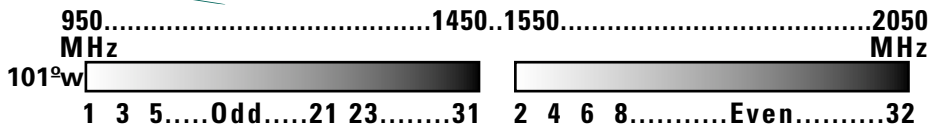


App_15d_1Coax2Rx.EPS

Sony advanced past other DirecTV receiver manufacturers with a technology that "stacked" both polarities from one satellite on a single coax cable. Sony receivers were manufactured with a hidden feature that allowed professional installers to eliminate the need for multiswitches. The immediate advantage was upgrading old single receiver DBS installations to multiple receivers without the need for pulling another cable from the dish to the house (see first illustration App_10d).

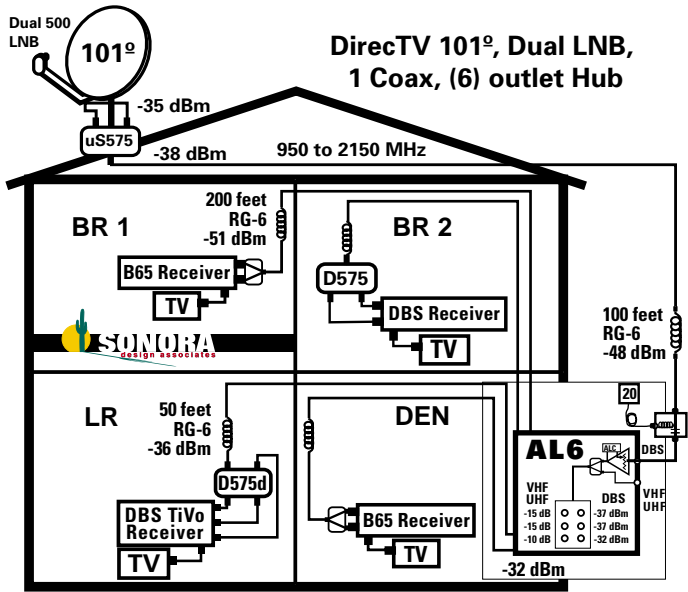
Custom Home Installations

DirecTV Stacked 101°w Transponder Plan



App_15d_PAL20.EPS

Amplification may be added to boost the stacked 950 to 2150 MHz signal. The example uses a model PAL20-T amplifier to power and amplify the signal. Automatic gain in the PAL20 allows the dish to be between 10 feet and 150 feet from the amplifier. The automatic gain “window” is from -31 dBm to -51 dBm. The output will be a constant -20 dBm per transponder for inputs within the window. Lower input levels result in a fixed 30 dB of gain. Model D575 de-stackers are used on non-Sony receivers. Model D575D dual de-stackers are used on Tivo dual tuner receivers to allow independent channel selection using a single coax.



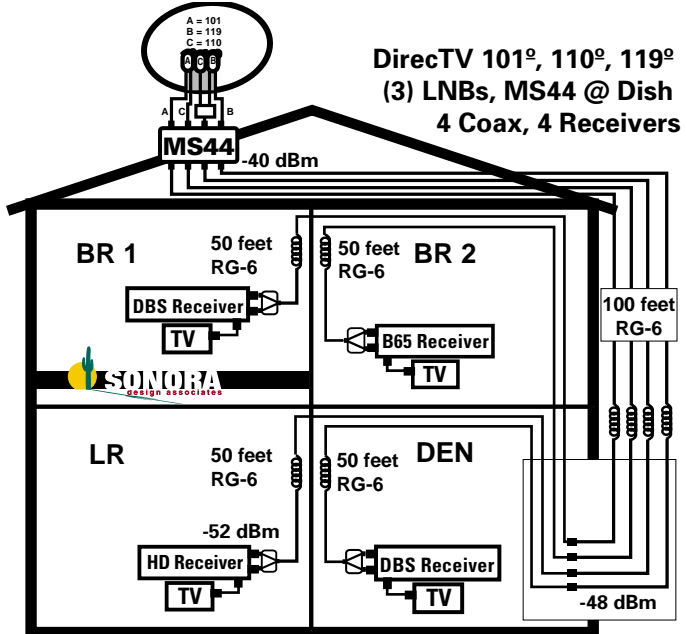
App_17d_AL6.EPS

Integration of amplifiers and high frequency passives minimizes on-site labor and results in a more reliable and repeatable installation. Minimal sku's are required to install (6), (8), (12), (16) or (24) receivers off a single 119° antenna. Models AL6, AL8, AL12, AL16 and AL24 distribution HUBS make installations simple to quote and install.



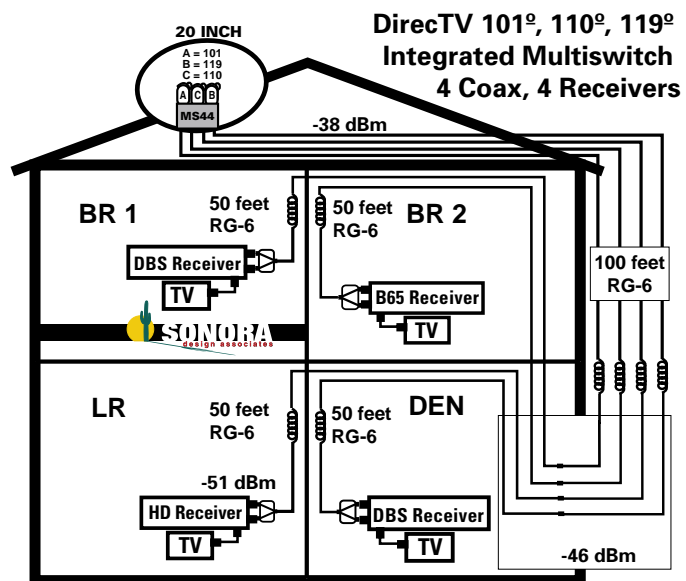
Custom Home Installations

DirectTV



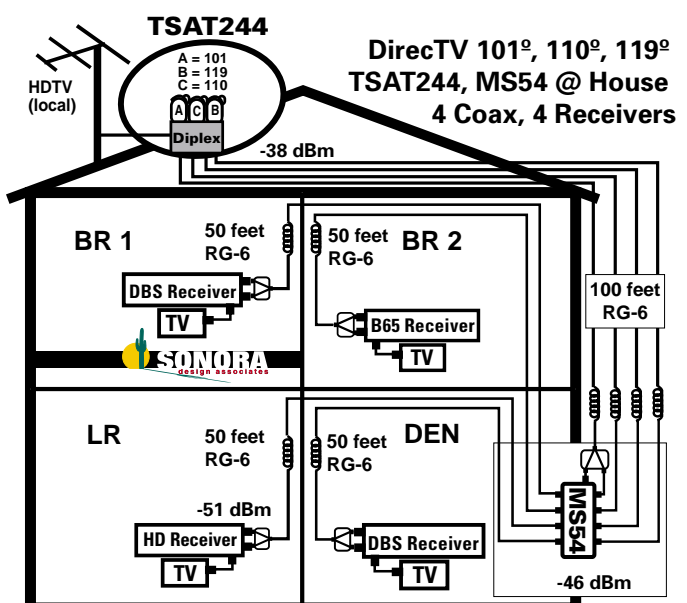
App_20d_3Sat_DishMS44.EPS

Engineers at DirecTV in the summer of 2002 specified an integrated dish and switch system that could be consumer installed. Simplification eliminated common mistakes of cross-connecting jumper cables. Simplification also resulted in a less flexible system for professional installers. They shrank the dish from 18" x 24" to 16" x 20" to make it more attractive. Fiberglass versions were too expensive, so only pressed metal dishes are sold. The gain of the LNBS was increased to compensate for the lower signal output.



App_21d_INHeadMS44.eps

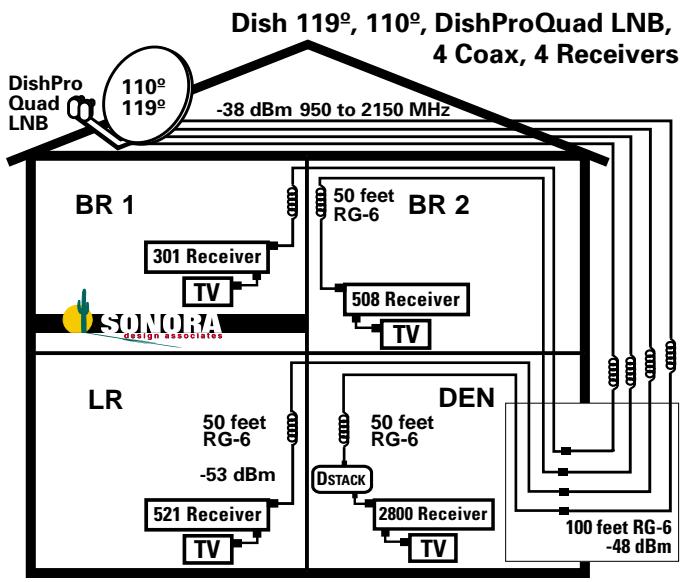
Sonora approached the multi-satellite antenna from a custom installer point of view. Installers willing to pull (4) coax cables from the dish to the home could take advantage of the better signal-to-noise of a larger dish and include the local terrestrial ATSC digital signals. Model TSAT244 is an integrated 24-inch elliptical dish with discrete LNBS and pre-connected diplexer and jumper cables. Model TSAT354 is a 35-inch version for better signal-to-noise. Switching is done within the residence. Models MS54 and MS58 are (4) output and (8) output switches.



App_21d_TSAT244_HomeMS54 .eps

Custom Home Installations

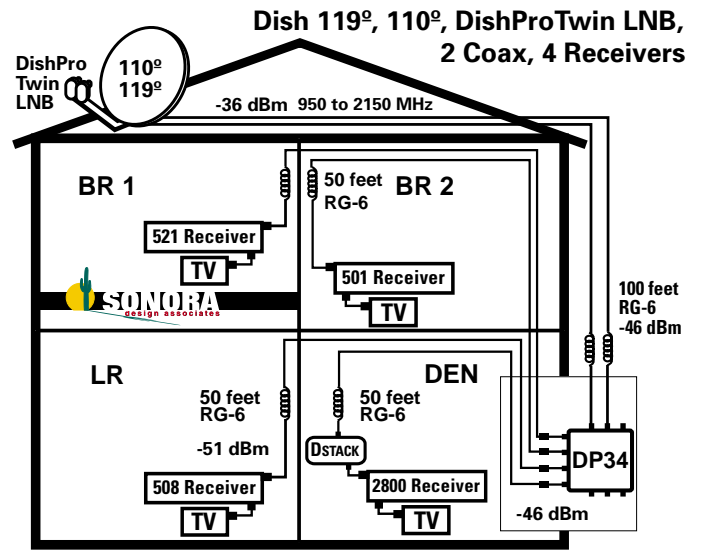
DirectTV



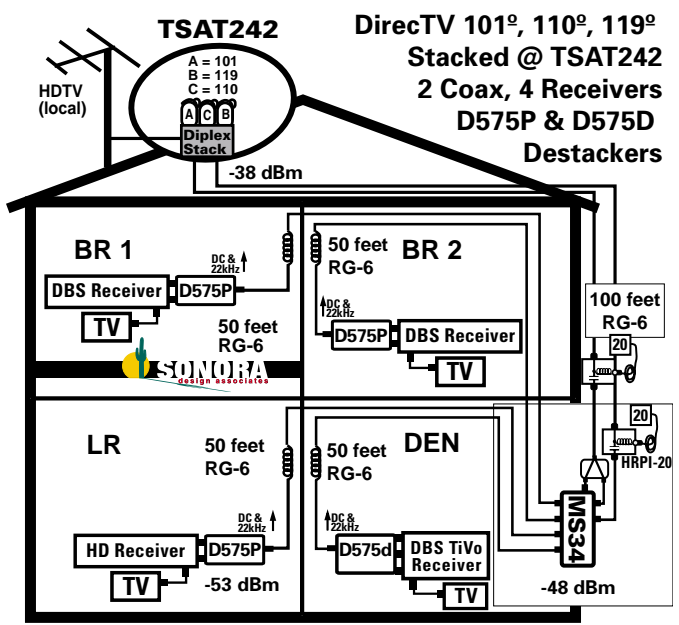
App_21e_4Coax_ProQuad.EPS

Engineers at Echostar anticipated upgrading existing systems having only (2) coax cables from the dish to the home to the new DishPro stacked architecture. The DP34 switch can be added to standard DishPro (2) coax systems to add receivers. DP34 switches select one of the two available stacked signals.

The switched DirecTV integrated head antenna is similar in architecture to the DishPro Quad LNB with the exception that DishPro changed to a “stacked” LNB and stacked receivers. The similarity of architectures coincided with the near merger of the two companies.



App_18e_2Coax_DP34.EPS



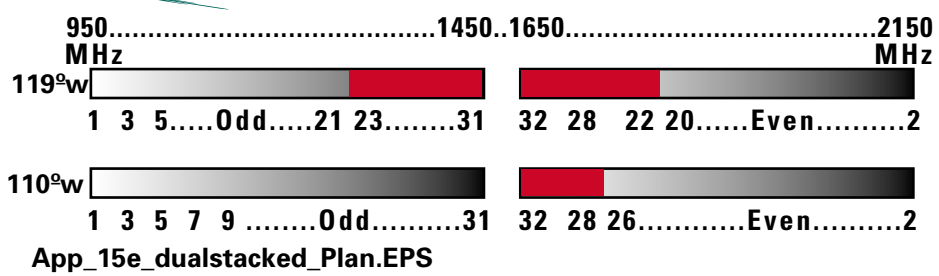
App_22d_TSAT242_MS34 .eps

Sonora model TSAT242 antenna is similar in function to the DishPro Twin LNB architecture. The antenna system multiplexes all three DirecTV satellites and the local terrestrial broadcast signals on (2) coax cables from the dish to home. DirecTV and Sony receivers are set to the “unstacked” mode and connected to model D575P de-stackers. The D575P passes the voltage and 22 kHz tone back to the MS34 switch. The tone selects the satellite, the voltage selects the polarity.

Custom Home Installations

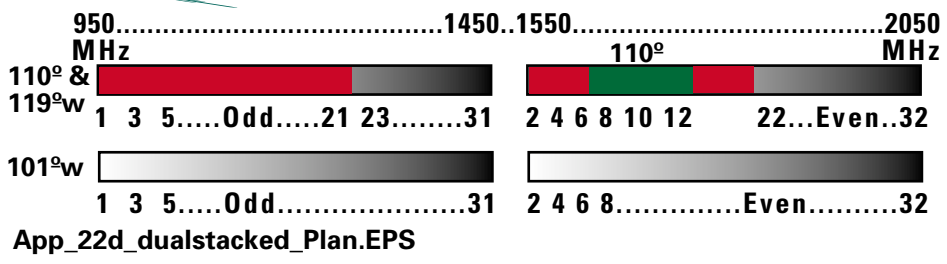
DirectTV

DishPro Dual Stacked LNB Transponder Plan

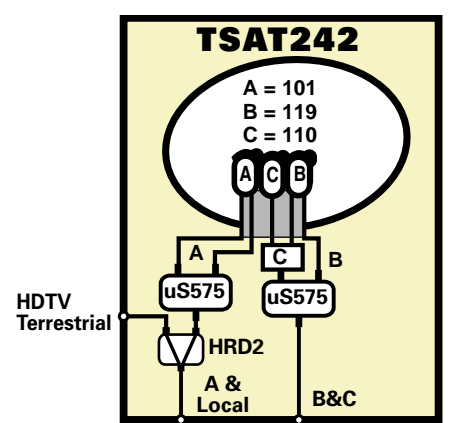


EchoStar engineers devised a stacked frequency plan that was different than the plan initiated by Sony. The plan took advantage of the frequency assignments of the shared 119° w orbital location. An inverted stacked spectrum allowed filtering of the DirecTV signals from their signal distribution. Transponders 22 through 32 (shaded in red) on the 119° orbital slot belong to DirecTV. Transponders 26, 28, 30 & 32 of the 110° orbital slot belong to DirecTV.

DirecTV dualStacked Transponder Plan

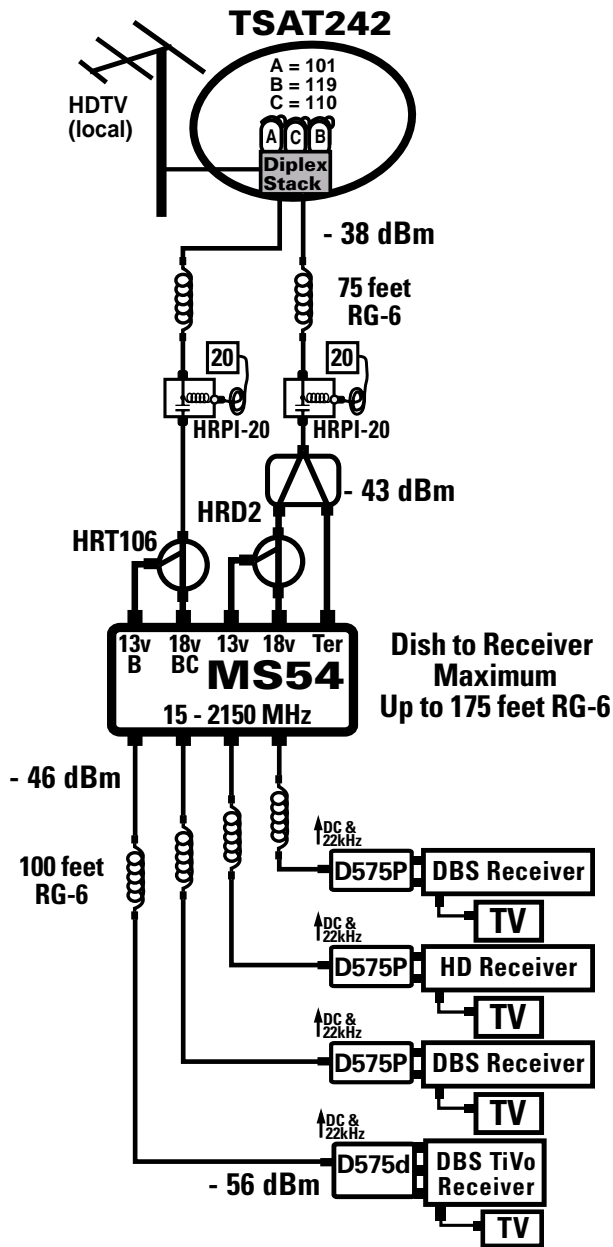


Sonora followed the Sony stacked plan in creating a dish that stacked the local terrestrial broadcast signals and the two polarities of the 101° orbital slot on one coax cable. Integrated on the same dish is a special DirecTV "SAT C" LNB and diplexer for the even polarity of the 110° orbital slot. The even polarity of the 119° slot is filtered and combined with the even polarity of the 110° w slot. The combined signal is stacked above the odd polarity of the 119° w transponders. The resulting spectrum appears in the illustration.

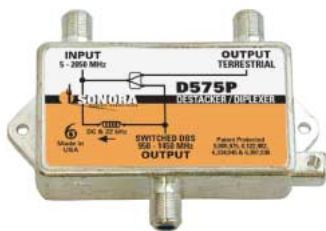


Custom Home Installations

DirecTV



App_22d_MS34_BLOCK.eps



Sonora integrated distribution hardware originally developed for the single 101° w DirecTV plan into a system that is similar in architecture to the EchoStar DishPro multiple satellite plan.



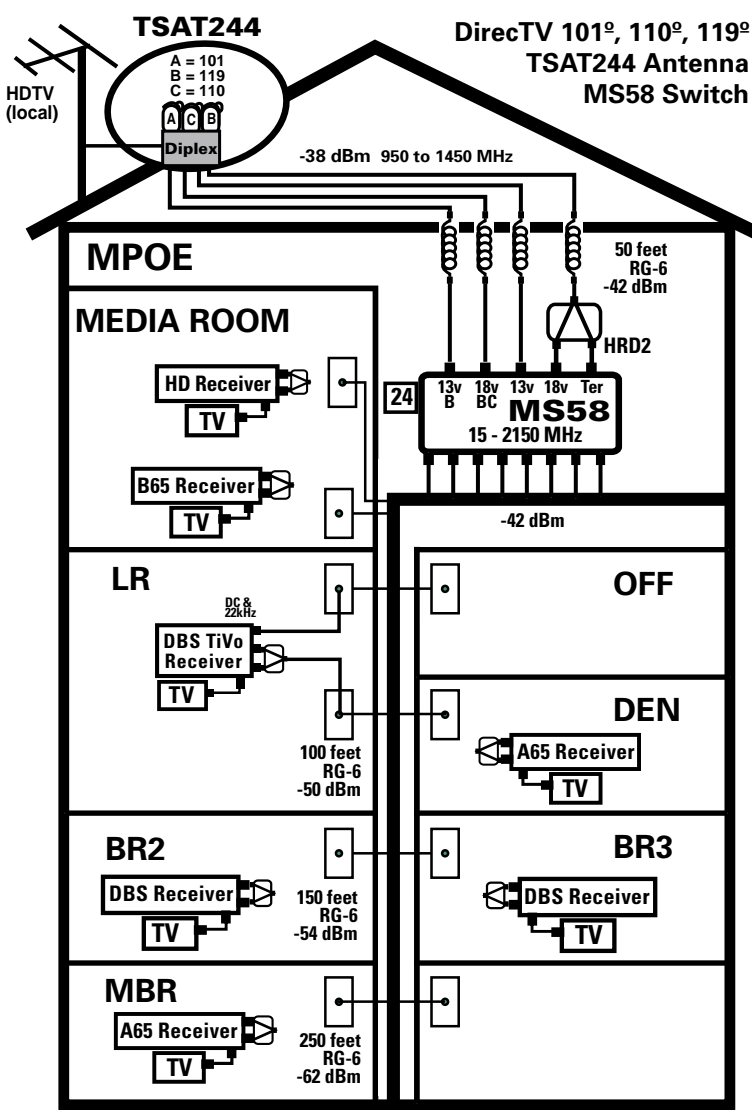
Model TSAT242 or TSAT352 antenna systems receive, diplex and stack the three orbital locations (101°, 110° & 119°) and the local terrestrial ATSC signals on (2) coax cables. Power for the dish electronics is provided with the included HRPI20 power inserters. Only (2) cables are required from the dish to the home. At the home, the signals are diplexed to feed a 2 GHz capable MS54 multi-switch.



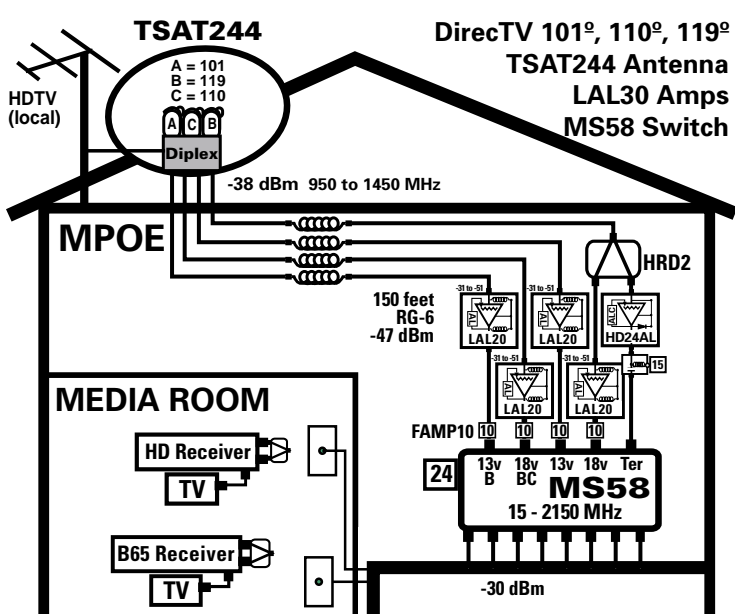
Receivers are set to unstacked and connected to a model D575P power and 22kHz passing destacker. Receivers power the MS54 switch. A 22 kHz tone generated by a receiver selects the 110°/119° satellite. The receiver voltage selects the polarity, odd or even. The D575P destacks the even polarities when presented with 18 volts from the receiver.

Custom Home Installations

DirectTV



App_32d_TSAT244_MS58.EPS



Sonora believes professional installers should have all the digital signals available at the best quality for distributing to Sony televisions. We offer both a 24-inch and 35 inch fiberglass antenna that incorporates hardware for combining terrestrial signals on (4) coax cables. The system requires the installer to connect the correct cable to each of the five inputs on our model MS58 switch. The switch diplexes the terrestrial signal on each of the (8) outputs. The maximum distance from any receiver to the dish is 200 feet.

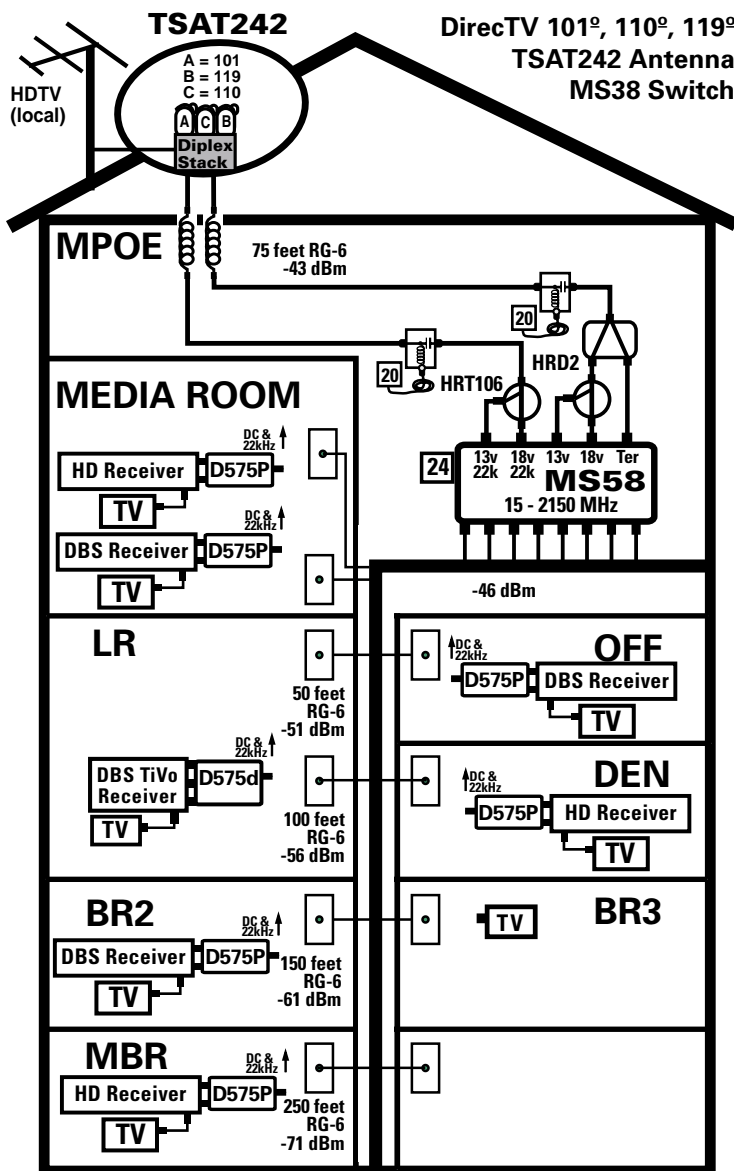


Amplification of the (5) TSAT244 signals is possible. However, the DBS amplifiers must pass the 22 KHz tone without loss. The amplifiers draw their power from the MS58 supply or can be powered by external DC wall transformers. Model LAL20 amplifiers pass 22 kHz and draw 70 mA.



Custom Home Installations

DirectTV

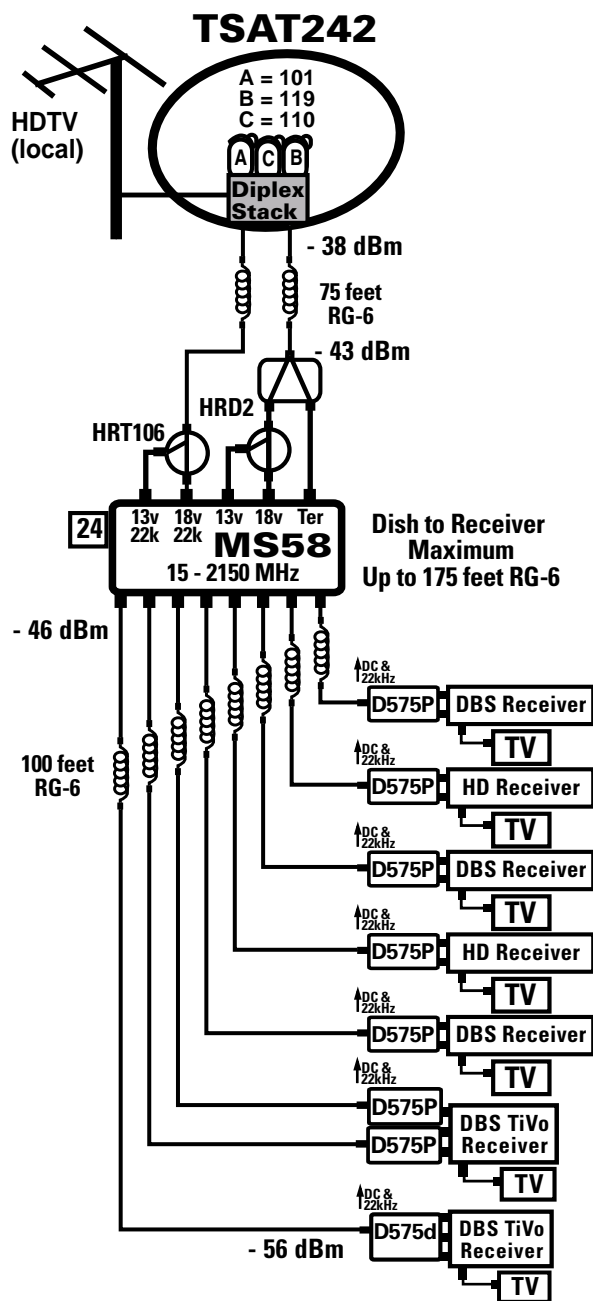


App_34d_TSAT242_MS38.EPS

Only (2) cables are required from the dish to the home. At the home, the signals are diplexed to feed a 2 GHz capable MS58 multi-switch. Receivers are set to unstacked and connected to a model D575P power and 22kHz passing destacker. Power for the MS58 switch is supplied by a 24 volt wall transformer. A 22 kHz tone generated by a receiver selects the 110°/119° satellite. The receiver voltage selects the polarity, odd or even. The D575P destacks the even polarities when presented with 18 volts from the receiver.

Sonora integrated distribution hardware originally developed for the single 101° w DirecTV plan into a system that is similar in architecture to the EchoStar DishPro multiple satellite plan.

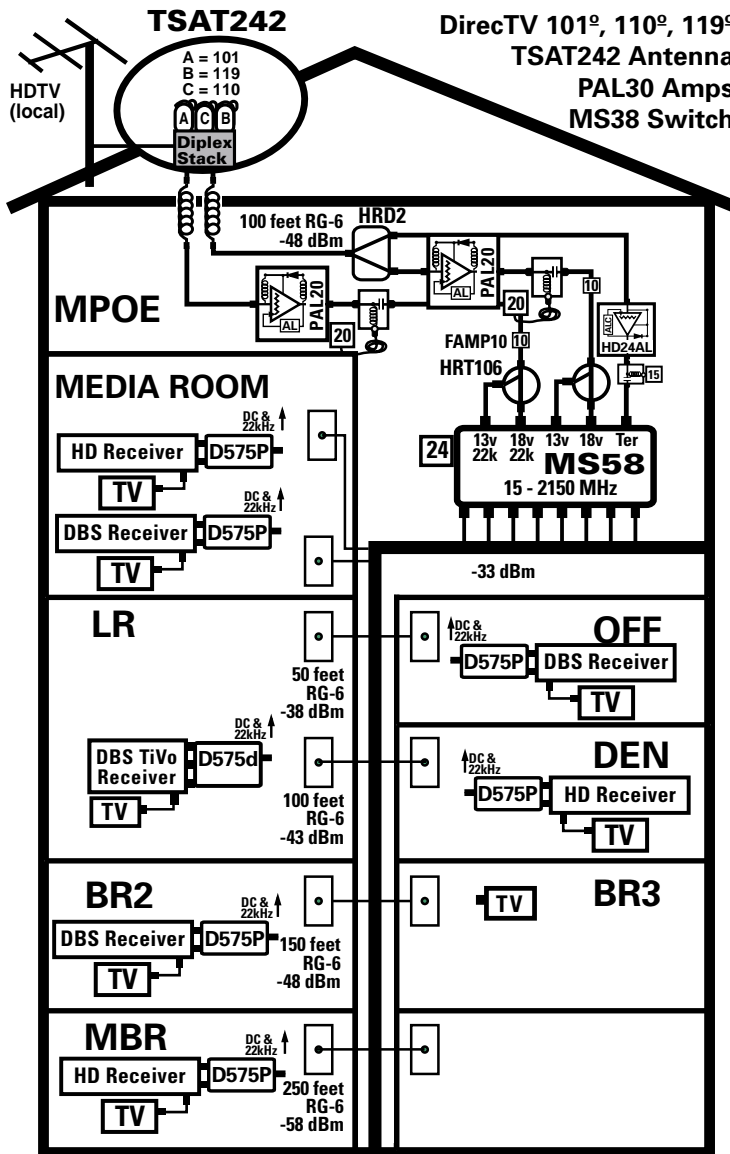
Model TSAT242 or TSAT352 antenna systems receive, diplex and stack the three orbital locations (101°, 110° & 119°) and the local terrestrial ATSC signals on (2) coax cables. Power for the dish electronics is provided with the included HRP120 power inserters.



App_34d_TSAT242_MS38_block.eps

Custom Home Installations

DirectTV

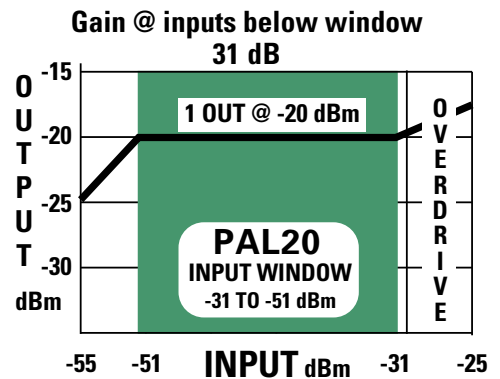


App_35d_TSAT242_PAL30_MS38.EPS

DirectTV 101^o, 110^o, 119^o
 TSAT242 Antenna
 PAL30 Amps
 MS38 Switch

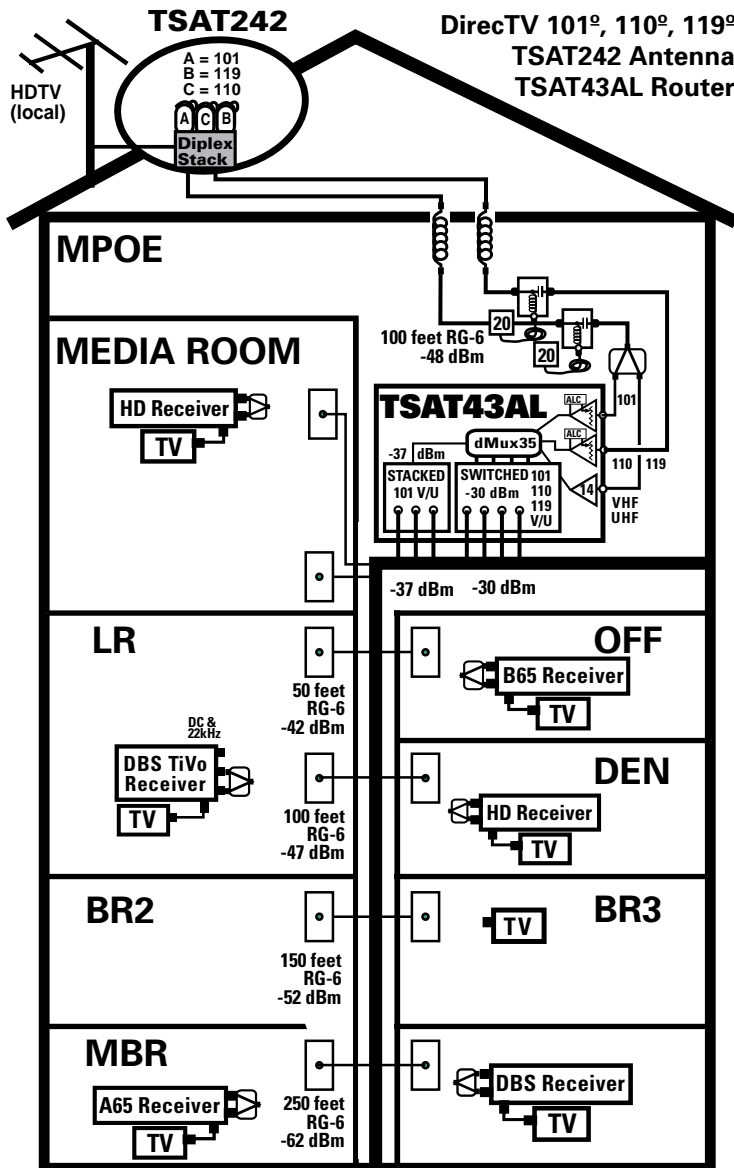
Expansion of the TSAT242 / MS38 stacked system for larger homes requires amplification. Without amplifiers, the system is limited to a maximum receiver-to-dish distance of 175 feet. That limit may be 50 feet dish-to-home Main Point Of Entry (MPOE) and 125 feet MPOE to receiver. The limit could also be 100 feet from dish to MPOE and 75 feet from MPOE to receiver.

The figure illustrates the use of model PAL20 amplifiers for the DBS stacked signals and a model HD24AL for amplification of the terrestrial ATSC signals. Note the use of 10 dB power passing pads after the amplifiers. The switch has a maximum input of -30 dBm. A higher input will cause overdrive distortion. The PAL20 amplifiers have automatic gain for a constant output of -20 dBm over an input window of -51 dBm to -31 dBm. This automatic gain feature is key to successful operation of the system over a range of conditions.

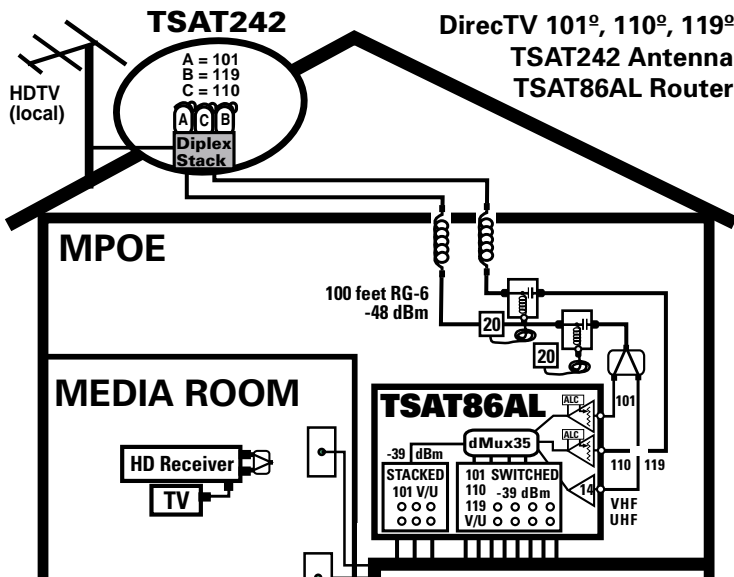


Custom Home Installations

DirectTV



App_34d_TSAT242_43AL.EPS



Sonora's support of Sony began with providing signal for multiple DBS receivers at trade shows. Initial systems were built on plywood boards. While the systems did their job, the collage of parts and jumpers did not impress Sony marketing. The same applies to the installation of custom home systems. Good technicians can build on-site, systems as described in previous examples. However, one mistake, one bad connector, or a customer "adjustment" can cause a system failure. The customer sees a mess.



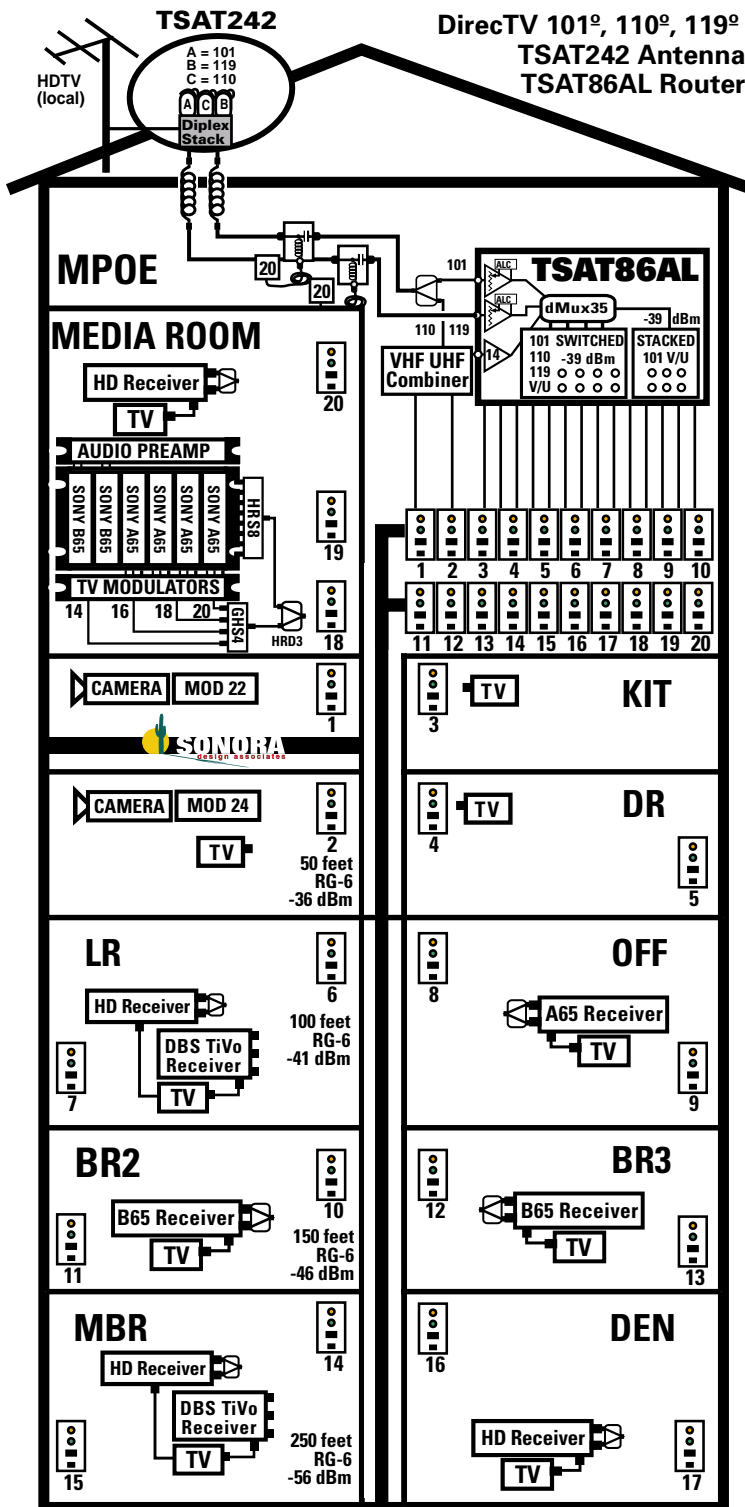
The figure illustrates the preferred Sonora solution for Custom Home DBS distribution. The total system consists of (2) SKUs, a TSAT242 antenna system and one TSAT43AL router. Amplification, destacking, switching is all done with the TSAT router. Automatic gain allows the router to be placed up to 150 feet from the dish while receivers can be located up to 250 feet from the router.

The system is scalable. Router models TSAT43AL, TSAT86AL, TSAT126AL and TSAT166AL exist for (7), 14, 18, and 22 outlets respectively. Routers may be placed in parallel for larger systems.



Custom Home Installations

DirectTV

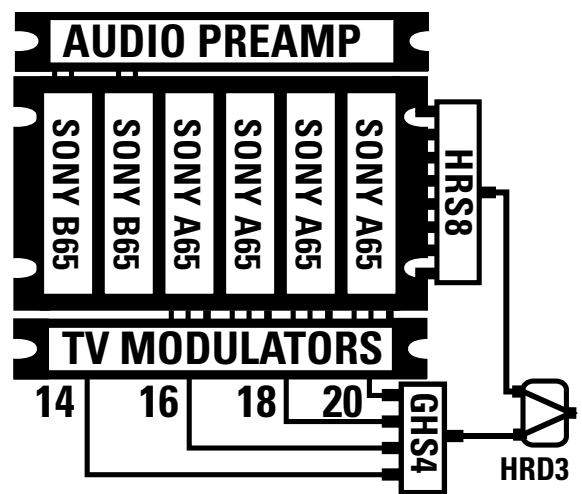


App_40d_TSAT242_86AL.eps

Structured wiring was installed in 42% of new homes built in 2002. Structured wire is defined as an integrated bundle of cables containing a minimum of (2) RG-6 coax and (2) CAT 5 cables. The structured wire is home-run to each room in the custom home. Structured wire wall-plates are indicated with (2) round outlets and (2) rectangular outputs. Each CAT 5 cable will support multi-line phones or high speed data.

Much can be done with (2) coax cables to each room. The obvious example is Tivo DBS recorders that have (2) tuners and require (2) independent connections. Other examples include the use of modulators for security cameras and miniature headends containing a rack of receivers and modulators.

Miniature headends could be used to place all the local broadcast programs on TV channels that could be accessed by any TV in the home without the need for a DBS receiver at the TV. The modulated channels would all be combined at the MPOE, amplified if necessary, and diplexed with the TSAT86AL router.

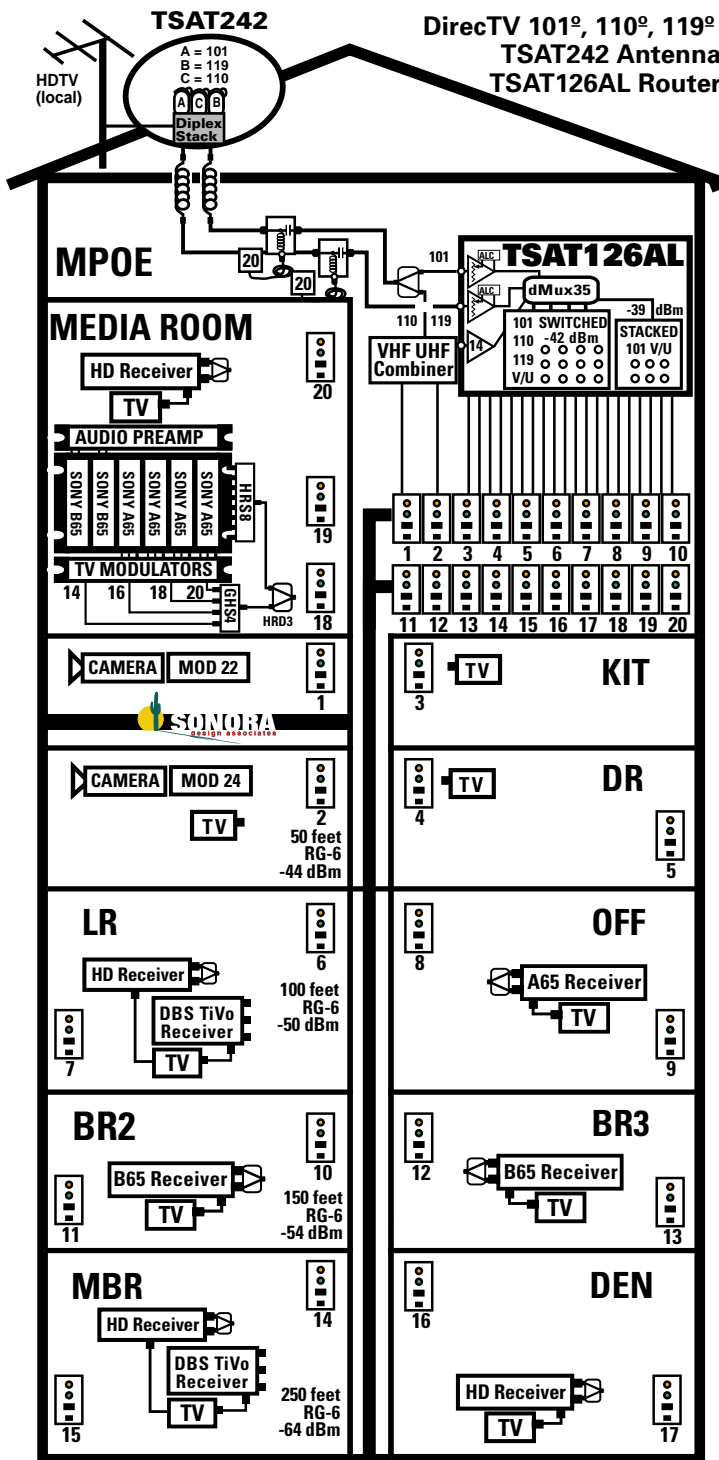


App_42d_6PackHE.eps

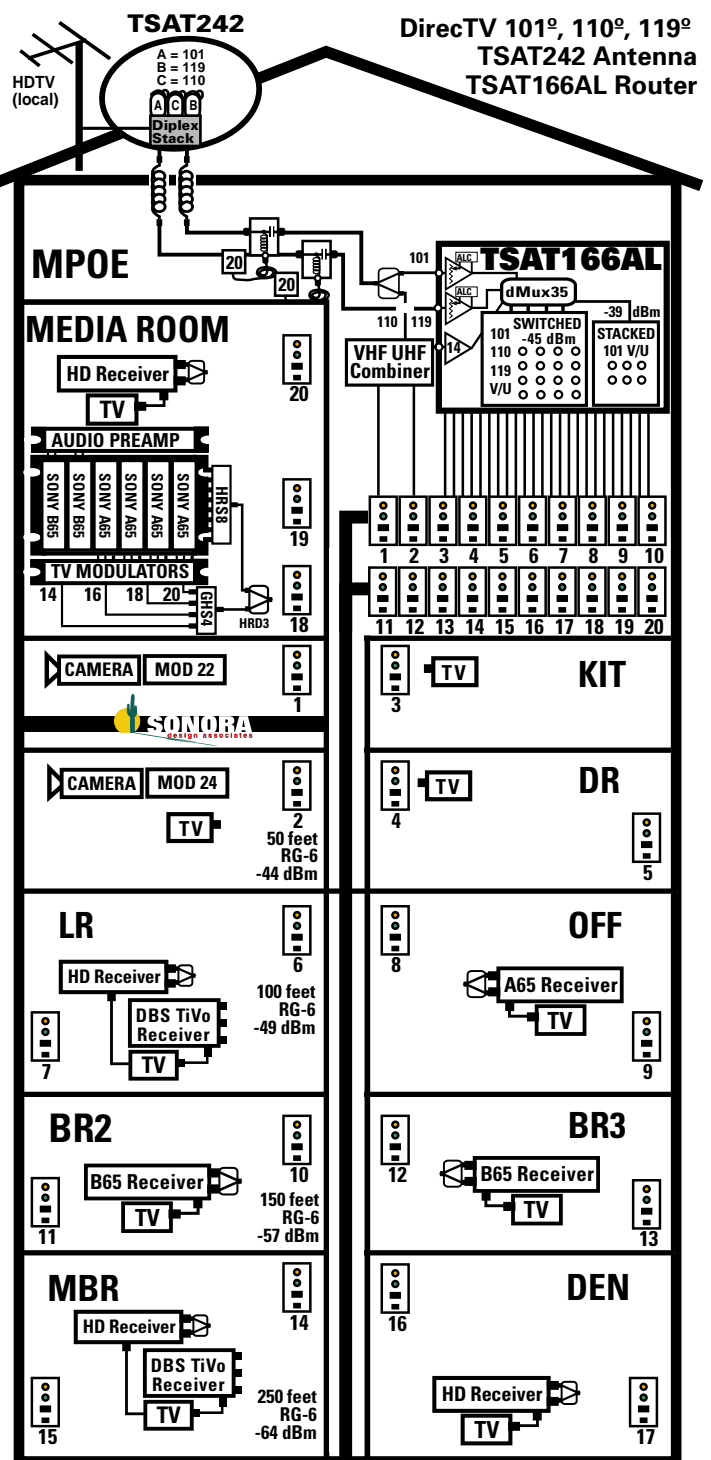
• April 2003 Consumer Electronics Association conducted by National Home Builders Research Center.

Custom Home Installations

DirectTV



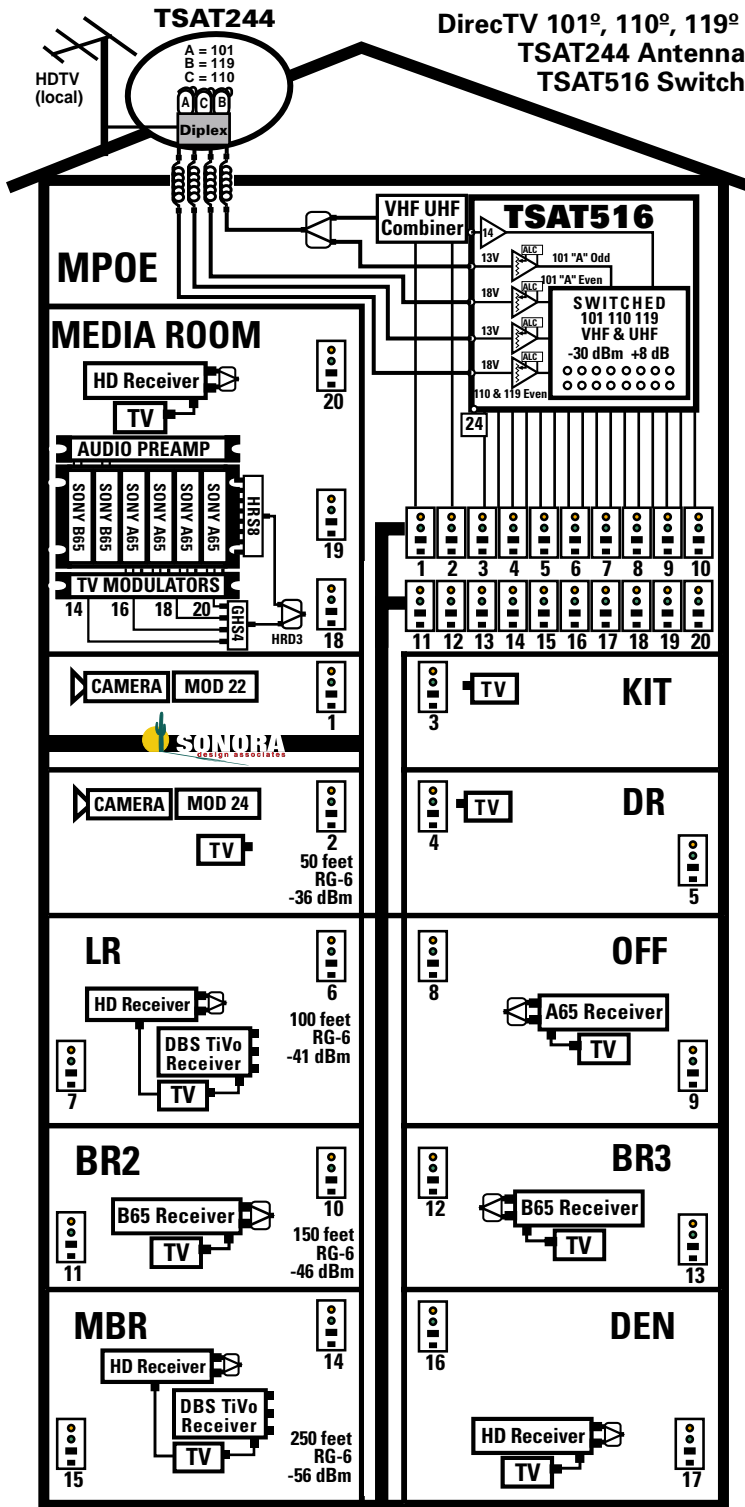
App_40d_TSAT242_126AL.eps



App_40d_TSAT242_166AL.eps

Custom Home Installations

DirectTV

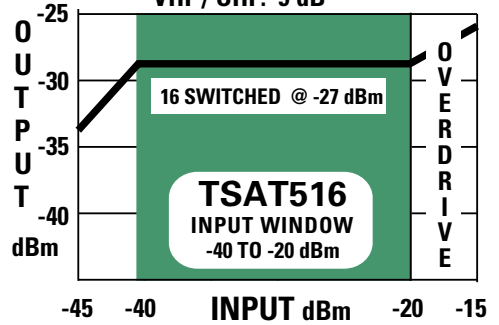


App_40d_TSAT242_126AL.eps



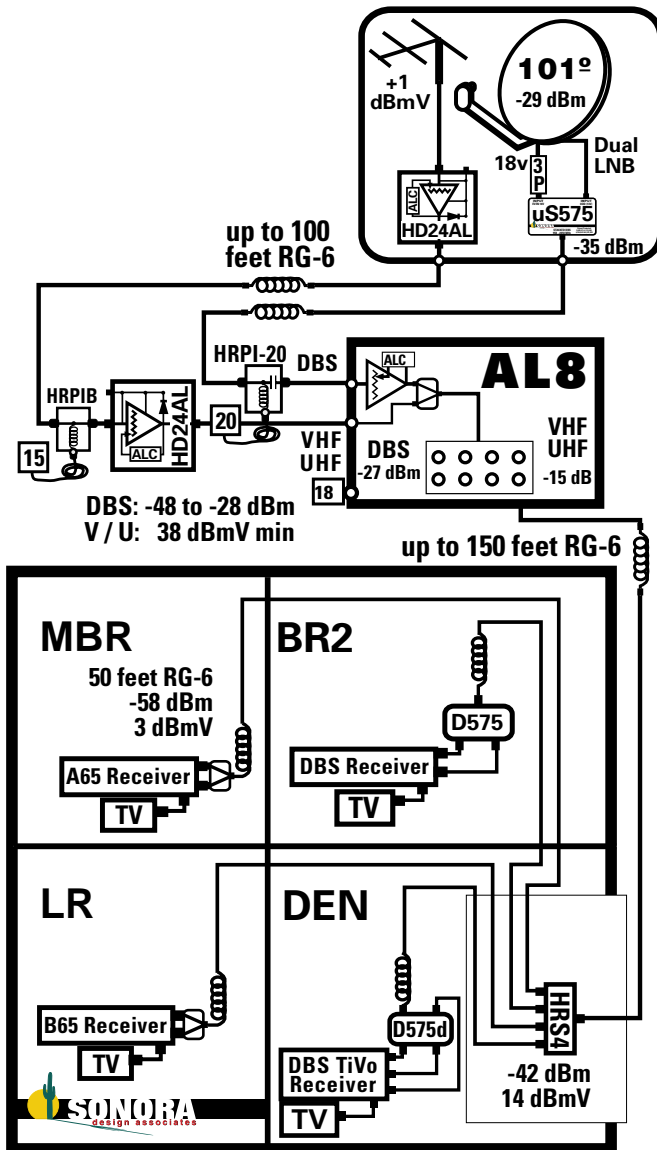
Financial limits sometimes push installers to on-site creations of amplifiers, jumpers and switches. Model TSAT516 is a basic amplified switch box that can provide up to 16 receivers with multiple-satellite DBS signals. The trade-off compared to a TSAT166AL router is the requirement of (4) properly identified coax cables from the dish versus (2).

Gain @ inputs below ALC threshold
DBS: 11 dB
VHF / UHF: 9 dB

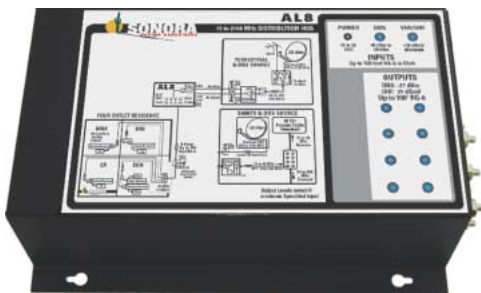


Apartment Installations

DirectTV



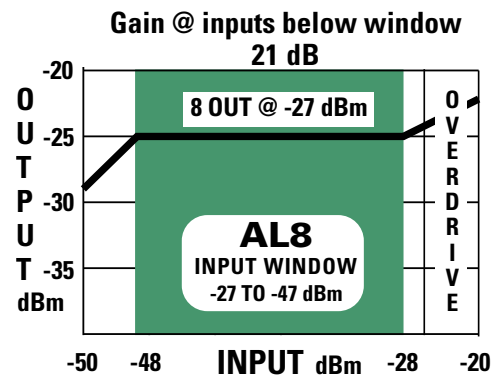
App_71d_AL8 Garden.EPS



Apartment buildings and condominiums provide opportunities for custom installation services. While some balconies face south, most residents have no access to DirecTV signals. The core programming for DirecTV resides on the 101° w satellite. In most cases delivery of the main satellite is sufficient, especially when no access was available before.

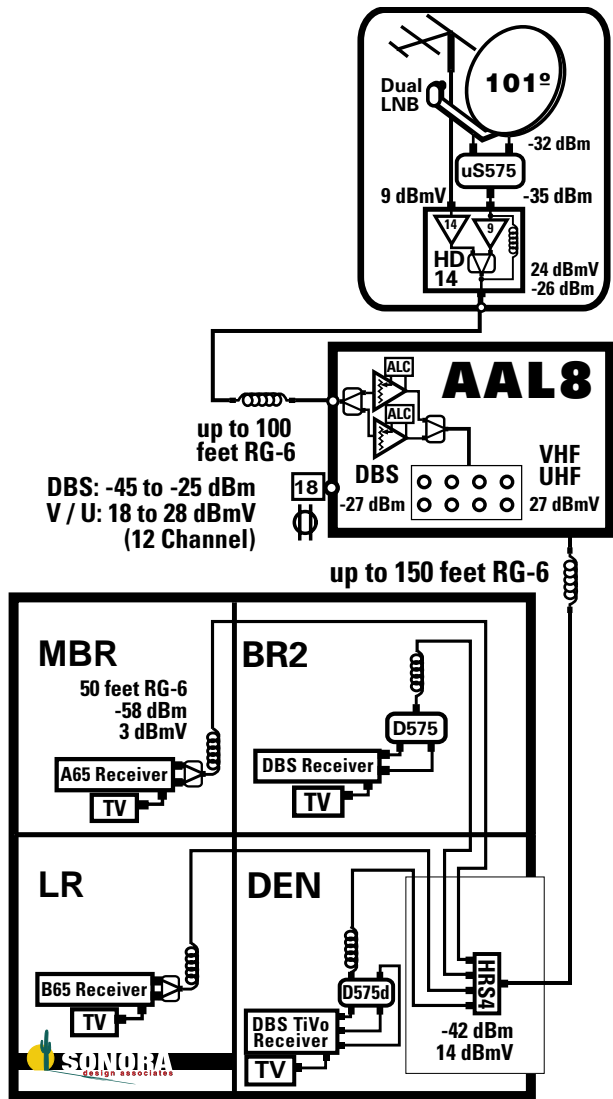
Stacked distribution allows both polarities of the 101° w satellite and the local terrestrial signals to share a single drop cable to each apartment. Within each apartment, the signal is split to serve up to (4) outlets. Sony wideband receivers can receive the stacked signal without the use of mode D575 destackers. Dual tuner TiVo recorders require a D575D destacker to allow independent channel selection from both tuners.

A model AL8 distribution Hub amplifies the DBS and duplexes the terrestrial signal for (8) apartments. Automatic gain eliminates adjustments so the dish-to-Hub distance can be up to 100 feet RG-6 and the Hub-to-apartment distance can be up to 150 feet of RG-6.



Apartment Installations

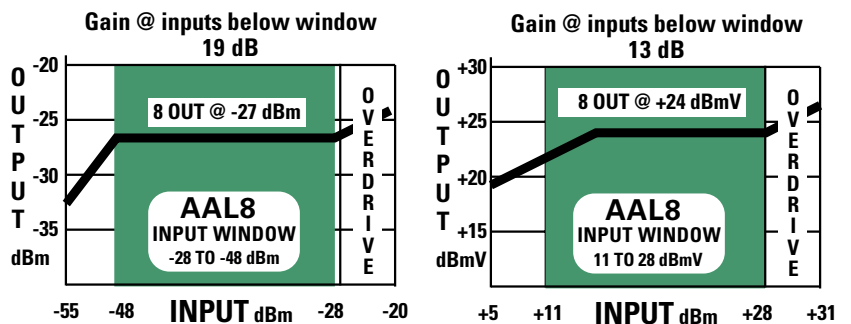
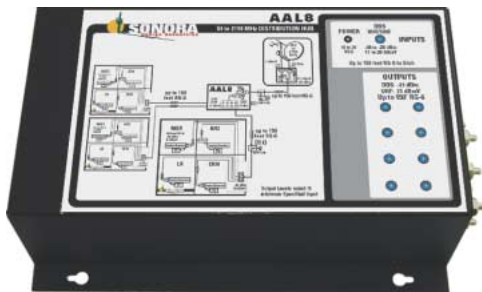
DirectTV



Further integration of distribution electronics is provided in model AAL8 distribution Hubs. The figure illustrates the use of model HD14 as an active diplexer of the DBS 101° signal and the terrestrial broadcast signal on a single coax from the dish to the distribution Hub. Signal levels are noted at each phase of the signal distribution. The minimum levels required to serve four outlets in each apartment is used as the starting point.

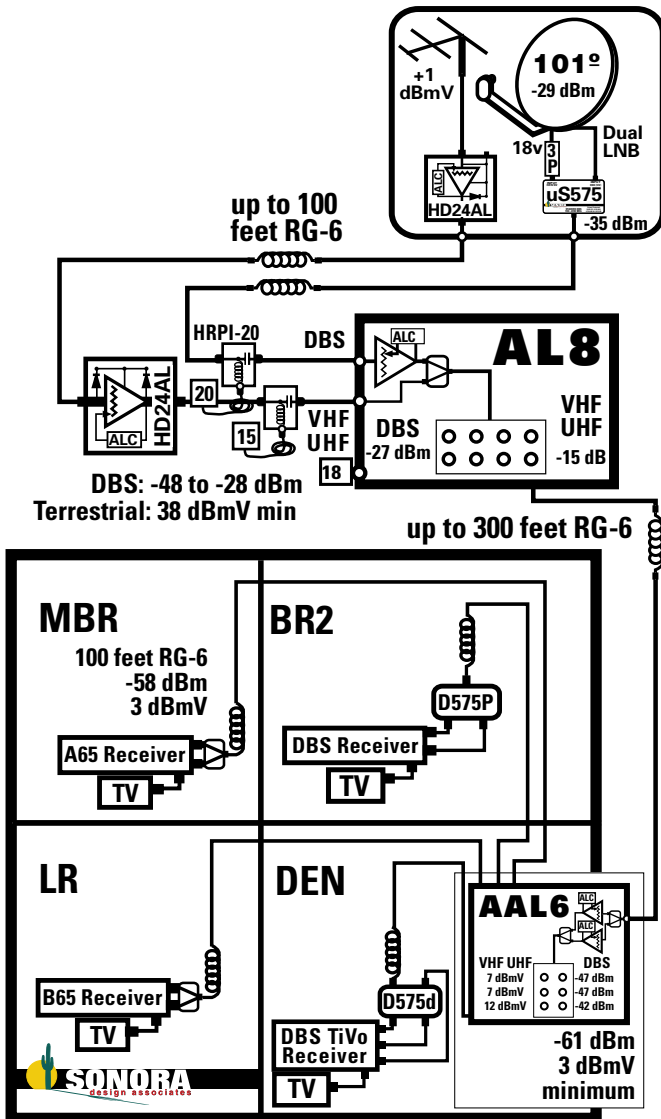
The HRS4 splitter needs a DBS level of -42 dBm and a minimum terrestrial input of 14 dBmV. The AAL8 Hub needs a minimum of -45 dBm of DBS signal and a minimum of 18 dBmV of terrestrial signal. Working our way to the dish, the minimum input to the HD14 is -35 dBm of DBS (typical of 24-inch dishes) and 9 dBmV of terrestrial.

Model AAL8 distribution hub amplifies the DBS, amplifies the terrestrial signal and dplexes the terrestrial signal for (8) apartments. Automatic gain eliminates adjustments so the dish-to-Hub distance can be up to 100 feet RG-6 and the Hub-to-apartment distance can be up to 150 feet of RG-6.



Apartment Installations

DirectTV

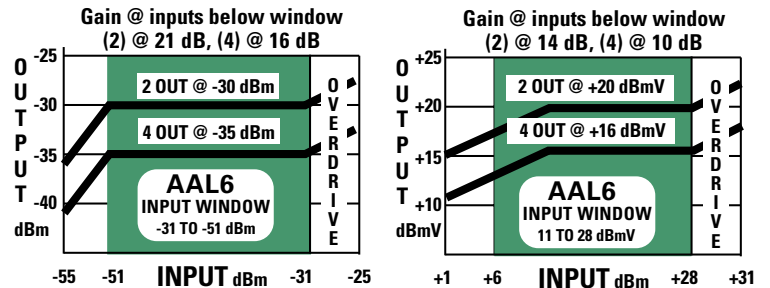


App_72d_AL8 Garden_AAL6.EPS



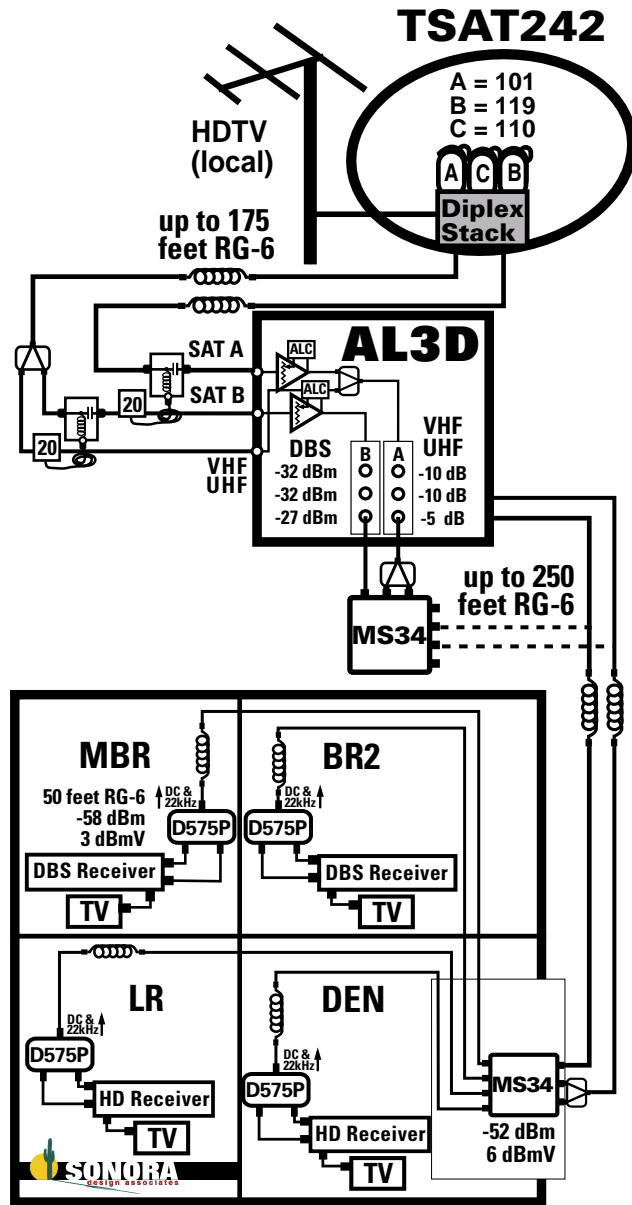
Amplification may be required for apartments either having a large number of outlets or having a location farther than 150 feet from the distribution Hub. Model AAL6 is a (6) output distribution Hub containing both DBS and terrestrial amplification. The signal may drop to -61 dBm for DBS and 3 dBmV for the terrestrial and the Hub can provide outputs to drive (6) receivers up to 100 feet from the Hub.

Power for the AAL6 hub is obtained from the DBS receivers. Model D575P destackers are suggested so all receivers have the potential of powering the Hub.

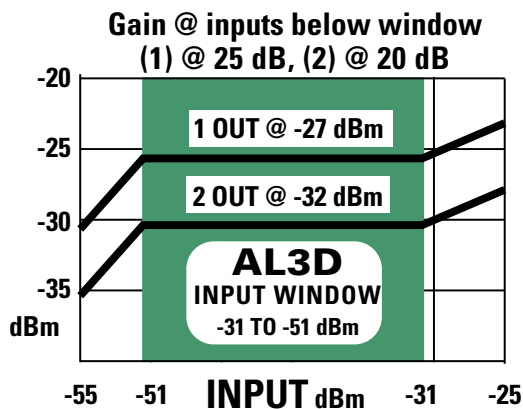


Apartment Installations

DirectTV



App_75d_AL3D Garden.EPS



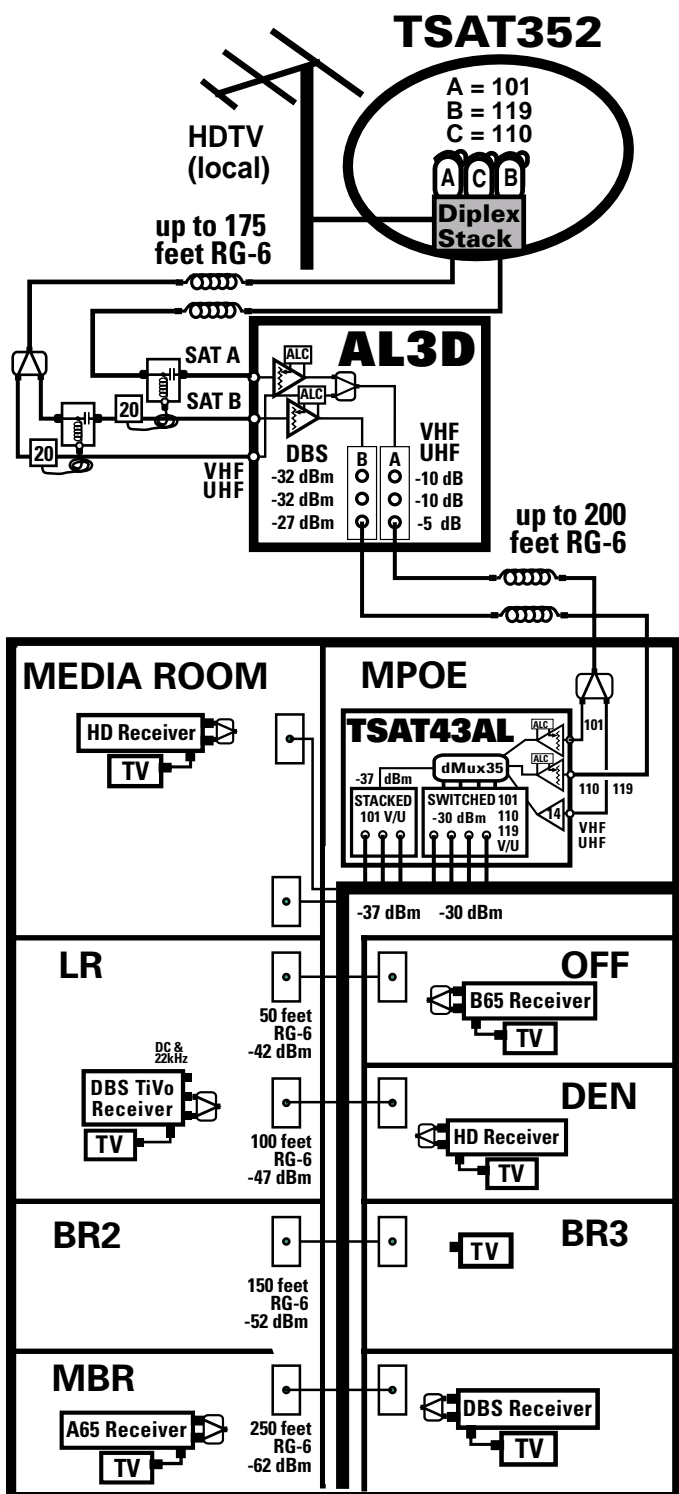
Multiple satellite signals may be delivered to multiple receivers in apartments and condominiums provided (2) drop cables are run to each apartment or condo. Sonora designs Multiple Dwelling Unit (MDU) systems to have scalable costs dependent on the level of subscribers. Backbone electronics are installed to cover the minimum level of subscribers. In this example the backbone electronics consist of a TSAT242 dish and an AL3D dual satellite distribution hub. The hub can drive (3) pairs of outputs.

Scalable electronics include the MS34 stacked switches. The MS34 switches may be located near the hub or they may be located within the apartment or condo. The location is dependent on the number of receivers required by each condo. When only (2) receivers are required, the switch is placed at the hub. Two of the (4) MS34 outputs are connected to condo #1 and (2) remain available for another condo. When more than (2) receivers are required at a condo, the switch is placed at the MPOE of the condo. TSAT routers are used in place of MS34 switches for large condominiums with long runs and many receivers

Model AL3D distribution Hubs incorporate PAL20 amplifiers, high frequency splitters and coax jumpers to make on-site installation in condominiums less labor intensive. Pre-assembly and test of the AL3D also makes the installation more reliable. Installers need to know how to point a dish, install connectors and estimate drop lengths. The PAL20 amplifiers give them an operating window to allow for unforeseen variations. The PAL20 amplifiers also prevent overload of the MS34 switches. Hitting the switches at their near maximum provides the maximum possible drop distance. Automatic gain also assists with rain fade issues.

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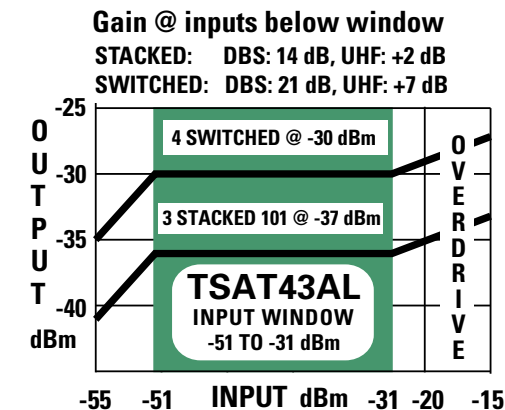
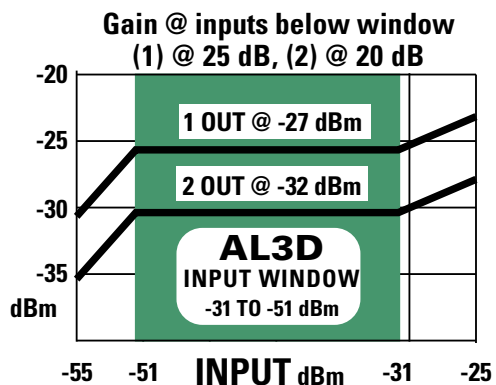


App_76d_TSAT352_AL3D_43AL.EPS

Multiple satellite signals may be delivered to multiple receivers in upscale condominiums provided (2) drop cables are run to each condominium. Sonora designs Multiple Dwelling Unit (MDU) systems to have scalable costs dependent on the level of subscribers. Backbone electronics are installed to cover the minimum level of subscribers. In this example the backbone electronics consist of a TSAT352 dish and an AL3D dual satellite distribution hub. The hub can drive (3) pairs of outputs.

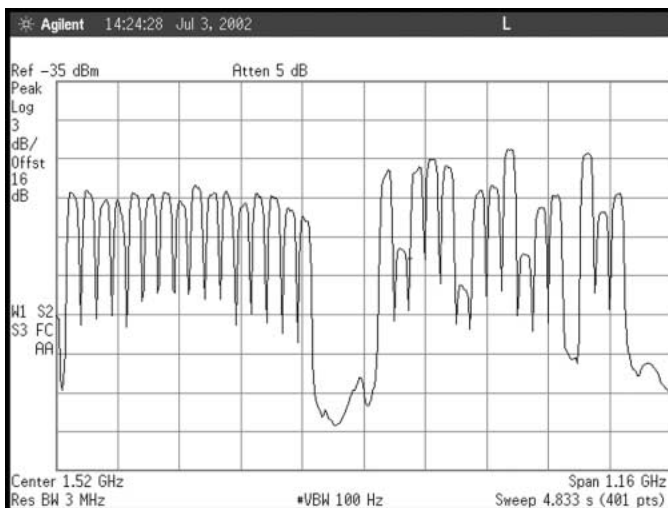
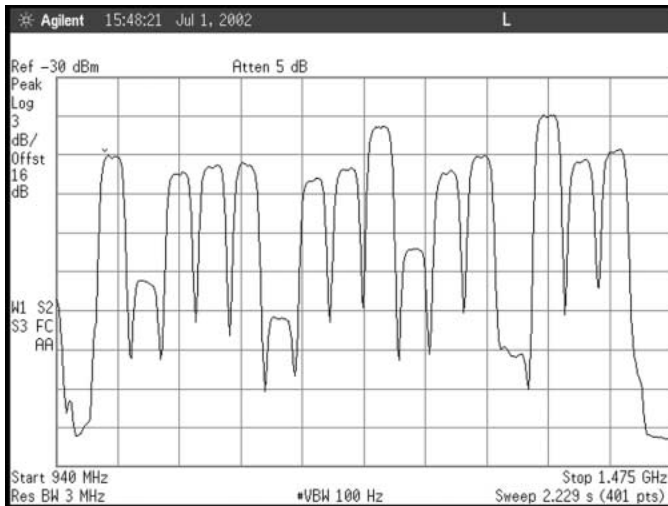
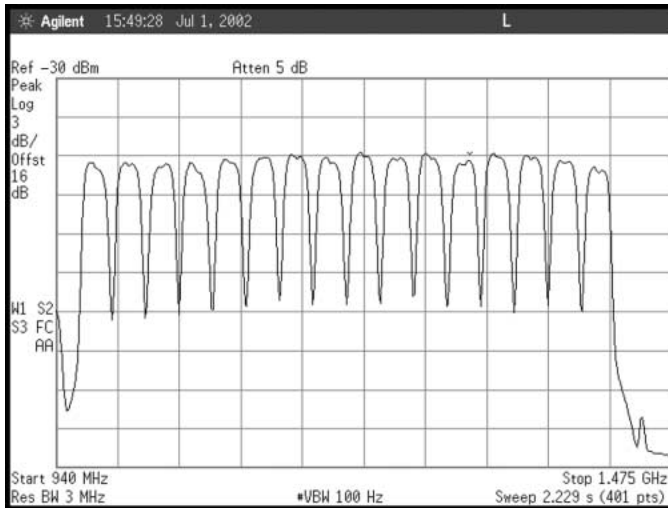
Scalable electronics may include MS34 switches as used in the previous example or TSAT43AL, TSAT86AL, TSAT126AL or TSAT166AL routers. From a business standpoint, the cost of the backbone is a shared expense for the building while the cost of the in-condominium electronics is a direct expense of the condominium resident. A TSAT router provides more flexibility than a MS34 or MS38 switch. With a router, the need for D575P destackers is eliminated.

Backbone electronics can be expanded to provide AL3D hubs on each floor of a high rise building. ALD hubs include models AL3D, AL6D, AL8D and AL12D. They provide 3, 6, 8 & 12 pairs of outputs respectively.



Custom Home Installations

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Spectrum analyzer plots of the odd and even transponders are displayed in the first (2) illustrations. The plots were taken in Los Angeles, CA on July 2002 from a 1-meter dish after 100 feet of RG-6 cable. The top illustration of the odd transponders on the 101° indicate all (16) transponders are active and nearly the same height and shape.

The second illustration of the even transponders of 101° indicates some holes in the spectrum. The holes are spot beams pointed at a US location other than Los Angeles. Note the two higher level transponders. These are transponders that carry the local broadcast channels for the Los Angeles market

The bottom illustration is plots of the 101°w satellite from a 24-inch dish using a Sonora model uS575 stacker and a DirecTV approved dual LNB. The even polarity is "stacked" above the odd polarity.

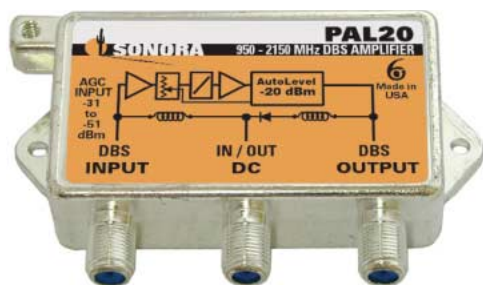
Spectrum analyzers display frequency of the measured signal along the horizontal axis and amplitude of the signal along the vertical axis. Start and stop frequencies are noted at the bottom of the display. Amplitude information is indicated at the left of the display.

Note the "Ref Peak" is -30 dBm. This indicates the top of the display is at -30 dBm. Also note the value of one "square" of amplitude is "3dB/". This means each vertical division from the top is 3 dB less than the previous division. There are 10 vertical divisions, therefore the total view is from -30 dBm to -60 dBm.

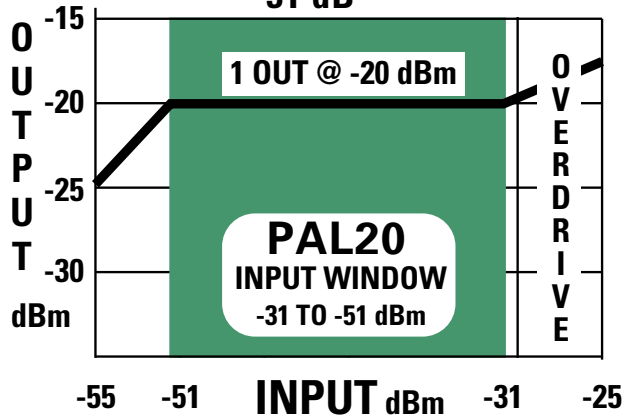
Other critical set-up information is noted. The Res BW is 3MHz, the VBW is 100 Hz and the offset is 16 dB. These factors relate to bandwidth correction to assure the trace is displayed at true power level. (More information on spectrum analyzers can be found on the sonora web site "Tutorial" at www.sonoradesign.com.)

Apartment Installations

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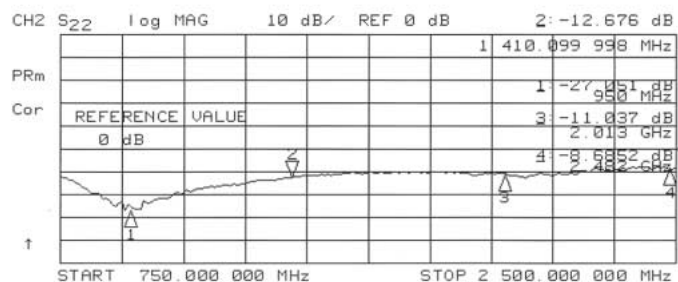
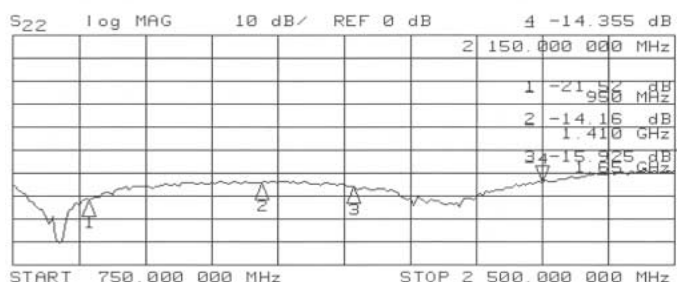
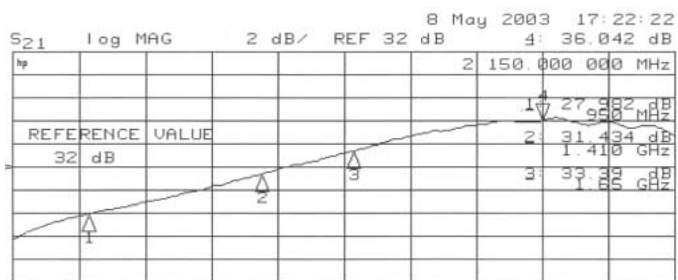


**Gain @ inputs below window
31 dB**



Let's leave the applications briefly to look at L-band amplifier requirements. Critical requirements are frequency (950 to 2150 MHz), gain measured in dB, output power (measured in dBm) and return loss (measured in dB). We want uniform amplification across the entire DBS band, high gain, high output power and high return loss. The most common problem created by amplifiers is distortion of the signal due to overloading. Signal goes in, gets amplified, and is pushed past the limit of the maximum output power. Sonora specializes in DBS amplifiers with automatic gain control. Our automatic gain amplifiers protect themselves from distortion by measuring the output power and adjusting an internal attenuator.

The figure to the left illustrates the "operating window" for Model PAL20 amplifiers. Across the bottom of the graph is the input level. Vertically, the output level is plotted. Within the green input of -51 to -31 dBm, the amplifier produces an output of -20 dBm. This is the window. Let's say one hits the amplifier with an input below the window, say -55 dBm; the resulting output is the input level plus the fixed gain (31 dB) of the amplifier... $-55 + 31 = -24$ dBm. If the input exceeds -31 dBm (-30 dBm is more signal than -31 dBm), distortion occurs even though the signal is amplified.



The network analyzer plot to the left is of interest to engineers. Briefly, the (3) traces indicate the gain of the amplifier, the input return loss and the output return loss (how closely it matches 75 ohms). Those who want further explanation on reading spectrum and network analyzer plots can visit our web site and view the "Tutorial" on DBS distribution. For the rest of us, gain is the top trace and should be going uphill starting at 950 and going all the way 2150 MHz. In the bottom traces of return loss, we want the trace to be as far below the center "0 dB" line as possible. A value of 15 dB return loss is better than value of 10 dB.

The effects of poor return loss are explained later in the updated application note.