Appendix A

Specifications

Input frequency	54 through 860 MHz (excluding data carrier frequency)
HRC/IRC frequency assignments	Downloadable
Number of channels:	136 carriers per cable, 1 or 2 cables
Analog	1 channel per carrier
Digital	More than 1 channel per carrier, content dependent
Dual A/B cable switching	Optional A/B (field upgradeable)
Input analog video level	0 dBmV through +15 dBmV
Input analog sound level	–17 dBmV through +2 dBmV
Average digital input level	–10 dBmV through +5 dBmV
Data carrier:	QPSK-modulated carrier
Frequency	75.250 MHz or 72.75 MHz or 104.2 MHz
Bandwidth	1.5 MHz
Level	–10 dBmV through +5 dBmV
Video s/n	49 dB @ 0 dBmV input level
Output frequency accuracy	±150 kHz
Return loss:	
Input	6 dB minimum
Output	8 dB minimum
Spurious output	–57 dBc maximum, in band
Cross-modulation distortion	–56 dB (136 channels, each @ +15 dBmV)
Composite second order distortion	–57 dB (136 channels, each @ +15 dBmV)
Second order distortion	–60 dB (136 channels, each @ +15 dBmV)
Composite triple beat distortion	–57 dB (136 channels, each @ +15 dBmV)
Set-top input beats (with all input signals)	–25 dB (136 channels, each @ +15 dBmV)
Hum modulation distortion	3 IRE
Output level	10 through 15 dBmV
Isolation (input/output)	70 dB minimum
Differential phase	10 degrees (maximum)
Analog descrambling method (optional)	Gated sync suppression or dynamic gated sync suppression, video inversion, audio privacy, and Hamlin compatibility
On-screen display (OSD):	
Screen size	352 x 480 pixels (configuration dependent)
Message/barker capacity	Up to 40 pages (configuration dependent)
Mechanical security	Standard: security screws, unichassis construction

Specifications and Features

Specifications

Input frequency	
Video	54 MHz through 860 MHz
DOCSIS	Up to 860 MHz
HRC/IRC frequency assignments	Downloadable
Number of channels	136 carriers per cable, 1 or 2 cables
Analog	1 channel per carrier
Digital	More than 1 channel per carrier, content dependent
Input analog video level	0 dBmV through +15 dBmV
Input digital average level	64 QAM: –18 dBmV through +5 dBmV
	256 QAM: –12 dBmV through +5 dBmV
Data carrier	QPSK-modulated carrier
Frequency	Agile Receiver 70 – 130 MHz
Bandwidth	1.5 MHz
Level	–15 dBmV through +5 dBmV
Mechanical security	Standard: security screws, unichassis construction
Operating environment range	
Temperature	15° through 40°C (32° through 104°F)
Humidity	5% through 95% (noncondensing)
ac voltage	105 through 125, 60 Hz
Power dissipation	30 W nominal at 115 Vac; 38 W (DCT6208)
Size	17.13 in. × 12.75 in. × 2.75 in.
Weight	9.5 pounds (DCT6200)
	11.5 pounds (DCT6208)
Hard Disk (DCT6208 only)	80 GB capacity

Chapter 17 Tutorials

17.1 Carrier-to-Noise Measurement Through a Set-Top Converter

This tutorial is intended for those undertaking to determine the carrier-to-noise ratio delivered to subscribers through a set-top converter, based on computation of the carrier-to-noise ratio at the input to the converter, and the noise figure of the converter, as determined from the manufacturer or other source of authority. It is intended to be used with Section 3.3: "Measuring Noise of Systems using Converters" on page 52.

The carrier-to-noise ratio (C/N) measured at the output of a set-top converter (or any other device for that matter) is a complex function of the incoming carrier-to-noise ratio and the noise figure of the device. Noise figure is a quantity which tells us how much noise is added over and above the thermal noise. Thermal noise is the theoretical minimum noise always present in any real system, regardless of how good we make it. The lower the noise figure, the less the carrier-to-noise ratio will be affected as the signal passes through the device.

The noise figure may be measured using rather specialized equipment and techniques not normally available in a cable system. It is possible to measure noise figure using a very clean signal source which has no noise over and above thermal noise, and measuring the carrier-to-noise out of the converter. Because the carrier-to-noise ratio will be so high, it will be especially difficult to measure accurately, so we don't normally recommend trying this with field equipment. Rather, it is better to rely on the manufacturer to characterize the converters for you.

We deal with at least two different converter configurations in the field, generally pre- and post-FCC Part 15. This goes back to a case before the Commission in the late 80s, which resulted in set-top converters being classified as Part 15 devices by the FCC. Part 15 of the rules applies to most types of equipment used in both commercial and residential environments. Part 15 is to the manufacturer like Part 76 is to the operator: a series of requirements which must be met before equipment can be legally sold in the United States.

When the new rules were adopted for converters, one of the requirements was to limit the output level from converters to a maximum of +15.56 dBmV for any input level up to +25 dBmV. This forced manufacturers to put delayed AGC circuits in the front end of RF set-top converters. At the same time, it was becoming the expectation in the industry that the converters should contribute less noise, so pre-amplifiers were added to reduce noise figure. The same architecture was used for baseband as well as RF converters (and was in some baseband units before the new rules went into effect).[1]

All of this complicates the way we would add noise generated in a set-top converter to the incoming noise. Let's consider first the simpler case, that of conventional (pre Part 15)

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[1] For a discussion of the architecture of old and new converters, see Farmer, J.O. and Cook, A.M., "The New Part 15 Set-top Requirements," CED Magazine, June 1990. This article is reprinted beginning on page 349 of the first printing of the SCTE BCTE, Reference Bibliography Reprint Manual. This may be purchased from the SCTE at (610)-363-6888 or at www.scte.org.

converters without preamplifiers or AGC. Noise generated in a converter adds in a rather complex way to the noise coming in. We are interested only in the ratio of signal-to-noise, not in the absolute noise level. Figure 17-1 plots some examples of the way in which the noise adds. Along the X axis is plotted the signal level into the converter, and along the Y axis is plotted the carrier-to-noise ratio out of the converter. The three curves apply to carrier-to-noise ratios of 43, 45 and 47 dB on the cable, just before the converter. We have assumed that the converter has a noise figure of 13 dB.

A common mistake is to assume that this means the output carrier-to-noise ratio is 13 dB higher than the input carrier-to-noise ratio. This is only true if the sole noise content in the input signal is thermal noise, and such is not the case by the time the signal gets to the home.

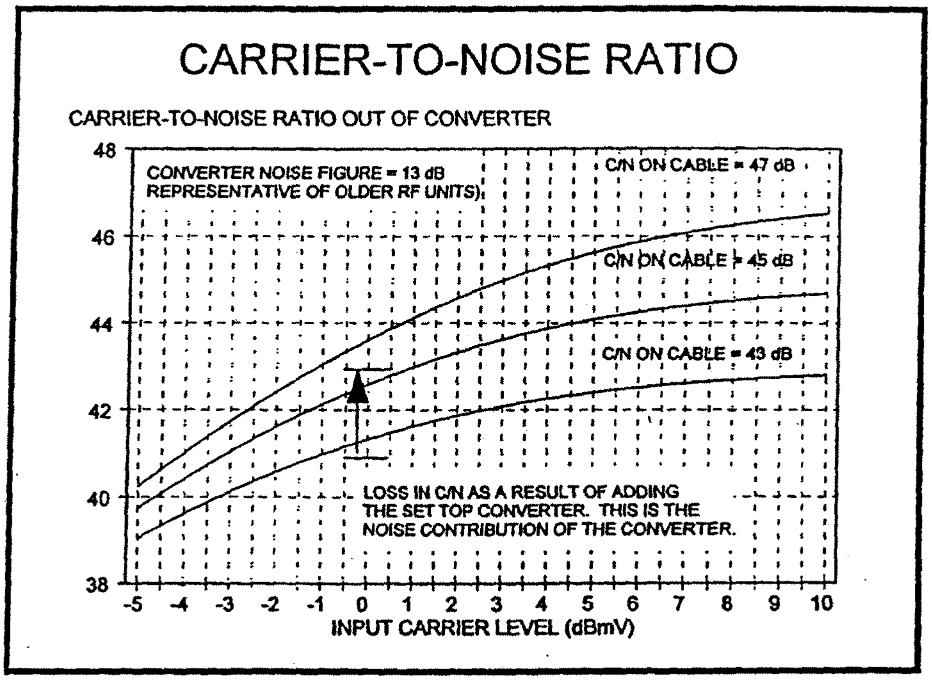

Figure 17-1: Set-Top C/N as a Function of Signal Level and Cable C/N, No Delayed AGC

Figure 17-1 shows the real situation in the example case. If we start with a carrier-to-noise ratio (C/N) coming in, of 43 dB (lowest curve), the ultimate (for now) FCC requirement, and have an input level of 0 dBmV, we see that the signal-to-noise ratio out of the converter has been degraded to about 41.3 dB. If we increase the carrier level into the box, the C/N asymptotically approaches the incoming 43 dB, but never quite gets there.

Note also that the C/N is degraded more if the C/N coming in is higher. This is because the noise contributed by the converter makes more of a difference if there is less noise coming in. For an input of 0 dBmV and a carrier-to-noise ratio of 47 dB, the degradation is from 47 dB to about 43.6 dB, a loss of 3.4 dB. On the other hand, if the cable C/N is only 43 dB, the loss is from 43 to 41.3 dB, a loss of only 1.7 dB.

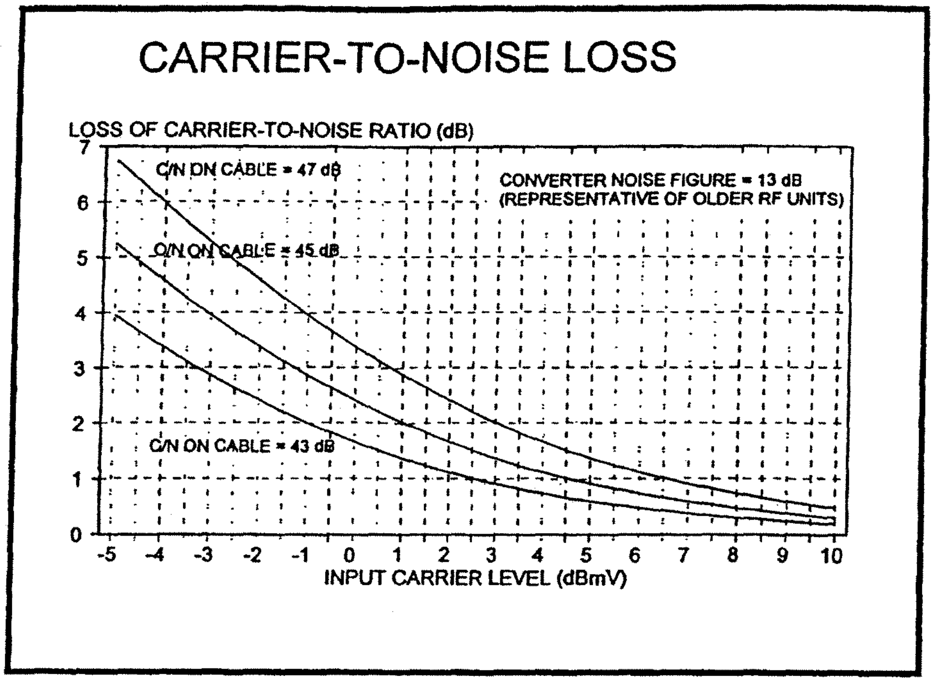

Figure 17-2: Loss of C/N Computed in Figure 17-1

We can plot this loss in C/N just as we plotted the C/N itself. Figure 17-2 is a plot for the same cases as we studied in Figure 17-1. Here we can see more easily that if the incoming C/N is 47 dB and the signal level is 0 dBmV, then the loss is 3.4 dB. If the incoming C/N is 43 dB at the same signal level, the loss is only 1.7 dB. From this chart you see that the reduction of C/N is a function of both the incoming signal level and the incoming C/N.

One could use Figure 17-2 with conventional set-top converters to compute the effect on C/N of adding the converter. However, it would be somewhat difficult to publish a set of curves for every case of noise figure, input level and C/N. In order to make the curves somewhat easier to use, the curve of Figure 3-4 is used. It is more versatile than is the Figure 17-2 of this part, because its X axis combines two things into one. In using Figure 3-4 for set-top converters, start with the measured input signal level and subtract the C/N measured on the cable. This is the number on the X axis. Go up from this to the curve corresponding to the noise figure of the converter, and go across to the Y axis, which is the same as the Y axis of Figure 17-2, the loss in C/N as a result of adding the converter.

The same procedure may be used for modern converters having delayed AGC, except that one must be aware of the possibility that the input signal level is above the delayed AGC threshold. In this case, the effective noise figure of the converter will be higher than assumed, resulting in poorer C/N out than would be expected.

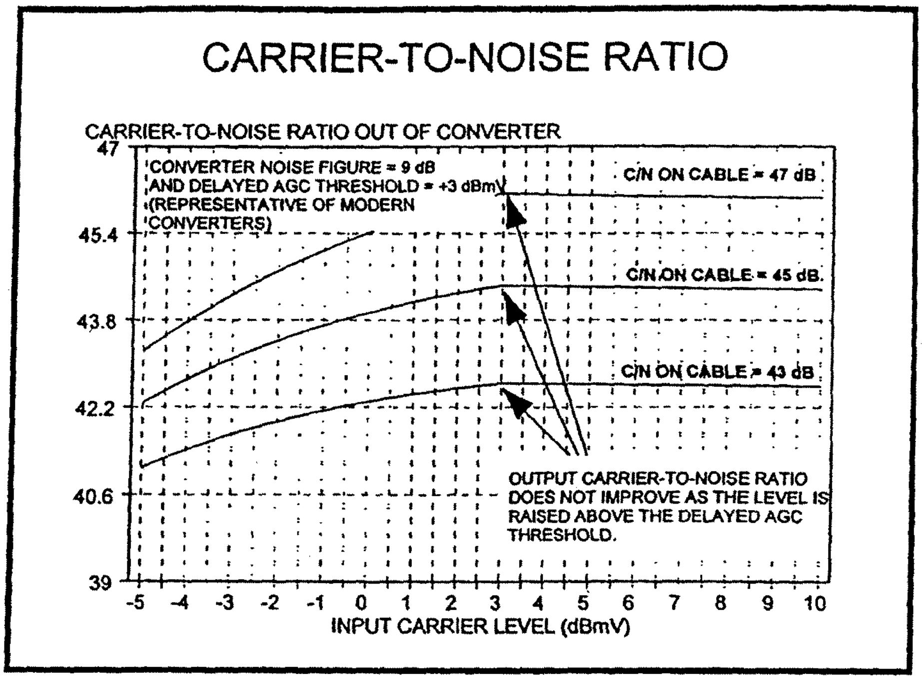

Figure 17-3: Set-Top C/N as a Function of Signal Level and Cable C/N, Delayed AGC Threshold +3 dBmV (Compare to Figure 17-1).

Figure 17-3 is the same as Figure 17-1 except that we have assumed typical characteristics for modern converters. We have assumed a 9 dB noise figure and a delayed AGC threshold of +3 dBmV. Though these are typical values, you should not use them in calculation: the only proper way to know the characteristics of the converters you are using, is to either measure with equipment not normally available in the field, or to talk to the manufacturer. Note that above the AGC threshold, there is no increase in C/N as the signal level is increased.

Figure 17-4 is the same as Figure 17-2 except for the assumption of a modern converter. Figure 3-4 may be used in this case, but the noise figure used must be the noise figure of the device below threshold, minus the number of dB by which the input signal level exceeds the threshold.

and is also capable of rejecting some noise. The FFE cancels pre-echoes. However, the FFE cannot take advantage of the noise rejection properties of the decision circuitry. The FFE introduces gain at frequencies where the channel has loss and, as a result, adds noise at those frequencies.

In both sections, the tap values are adaptively adjusted based on results of the constellation decisions. Most equalizers used in digital TV adjust the tap values using the normal data input. This is known as blind equalization. The equalization process starts by setting all tap coefficients equal to zero with the exception of one tap (known as the reference tap) whose coefficient is set equal to one. As successive data symbols are input to the equalizer, the tap values are updated based on results of the constellation decisions. When the equalizer reaches convergence, the tap values can be used to characterize the echoes on the system (See Section 9.2: "Digital Adaptive Equalizer Impulse Response" on page 145.

Adaptive equalizers are either T (i.e. – symbol period) spaced (also called synchronous designs) or T/2 spaced (also called fractionally spaced equalizers). Although, the fractionally spaced equalizer offers reduced sensitivity to sampling phase errors, it has a longer convergence time, is subject to coefficient drift and has higher complexity and cost.

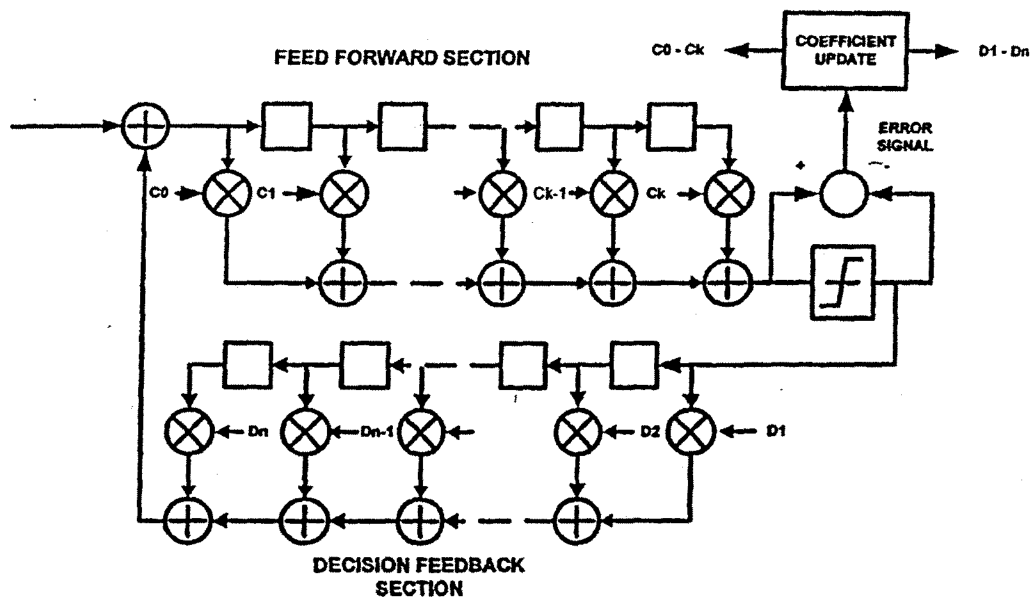

Figure 17-5: Adaptive Equalizer Block Diagram

17.3 Peak Voltage Addition

When multiple signals are combined in a single system the peak voltage of the combination is not simply the addition of the peaks of the separate signals. Furthermore the total average power obtained by adding the separate average powers is not an indicator of the composite peak.

A sinusoid (CW signal) has a well-known peak-to-rms ratio of $20 * \log(\sqrt{2}) = 3$ dB. A composite signal made up of *n* carriers of equal level and randomly phased, has a total

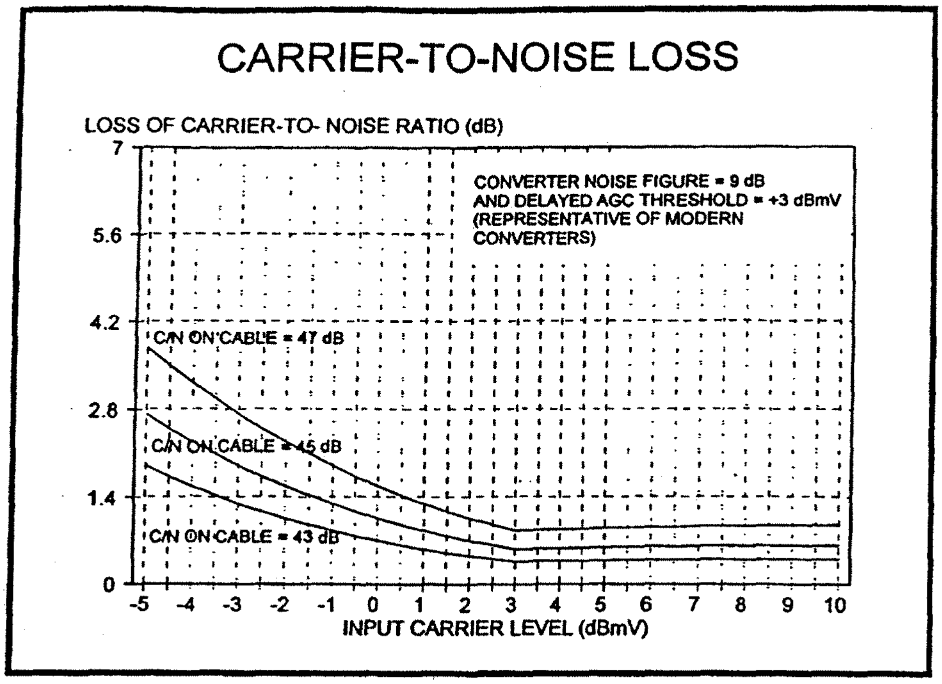

Figure 17-4: Loss of C/N Computed in Figure 17-3 (Compare to Figure 17-2)

17.2 Adaptive Equalization

Practical QAM demodulators must contain an adaptive equalizer to reduce the effects of intersymbol interference (ISI) caused by reflections. A block diagram of a typical adaptive equalizer is shown in Figure 17-5. The equalizer is a tapped delay line that creates delayed versions of the main signal. The tap outputs are multiplied by coefficients whose values are adaptively adjusted to maximize the MER. When a digital signal is transmitted over a cable channel, its frequency response can be distorted by microreflections, resulting in a received signal spectrum which is different from the desired spectrum. The equalizer's function is to restore the desired spectrum by generating a frequency response that is the inverse of the channel response. This may be expressed mathematically as follows: The frequency response, $H_R(f)$, of the received signal is:

$$H_R(f) = H(f) * H_C(f) \qquad (9)$$

where

$H(f)$ = desired response

$H_C(f)$ = channel response

In order to get back to the desired response, the equalizer response, $H_E(f)$ must be equal to the inverse of the channel response. That is

$$H_E(f) = H(f) / H_R(f) = 1 / H_C(f) \qquad (10)$$

The block diagram of Figure 17-5 shows an equalizer that is a combination of a feed forward equalizer (FFE) and a decision feedback equalizer (DFE). The DFE cancels post echoes

Installation Manual

DCT5100
Digital Consumer Terminal

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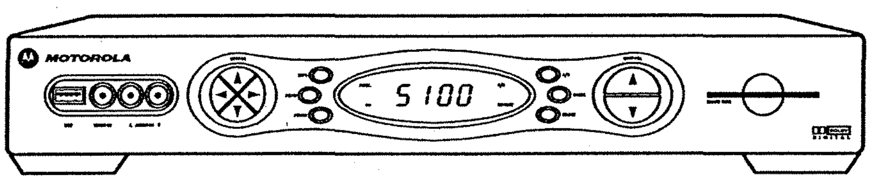

Specifications and Features

Specifications

Input frequency	
Video	54 MHz through 860 MHz
DOCSIS	Up to 860 MHz
HRC/IRC frequency assignments	Downloadable
Number of channels	136 carriers per cable, 1 or 2 cables
Analog	1 channel per carrier
Digital	More than 1 channel per carrier, content dependent
Input analog video level	0 dBmV through +15 dBmV
Input digital average level	64 QAM: –18 dBmV through +5 dBmV
	256 QAM: –12 dBmV through +5 dBmV
Data carrier	QPSK-modulated carrier
Frequency	Agile Receiver 70 – 130 MHz
Bandwidth	1.5 MHz
Level	–15 dBmV through +5 dBmV
Mechanical security	Standard: security screws, unichassis construction
Operating environment range	
Temperature	15° through 40°C (32° through 104°F)
Humidity	5% through 95% (noncondensing)
ac voltage	105 through 125, 60 Hz
Power dissipation	30 W nominal at 115 Vac
Size	17.13 in. × 12.75 in. × 2.75 in.
Weight	9.5 pounds

Installation Manual

DCT1800
Digital ConsumerTerminal

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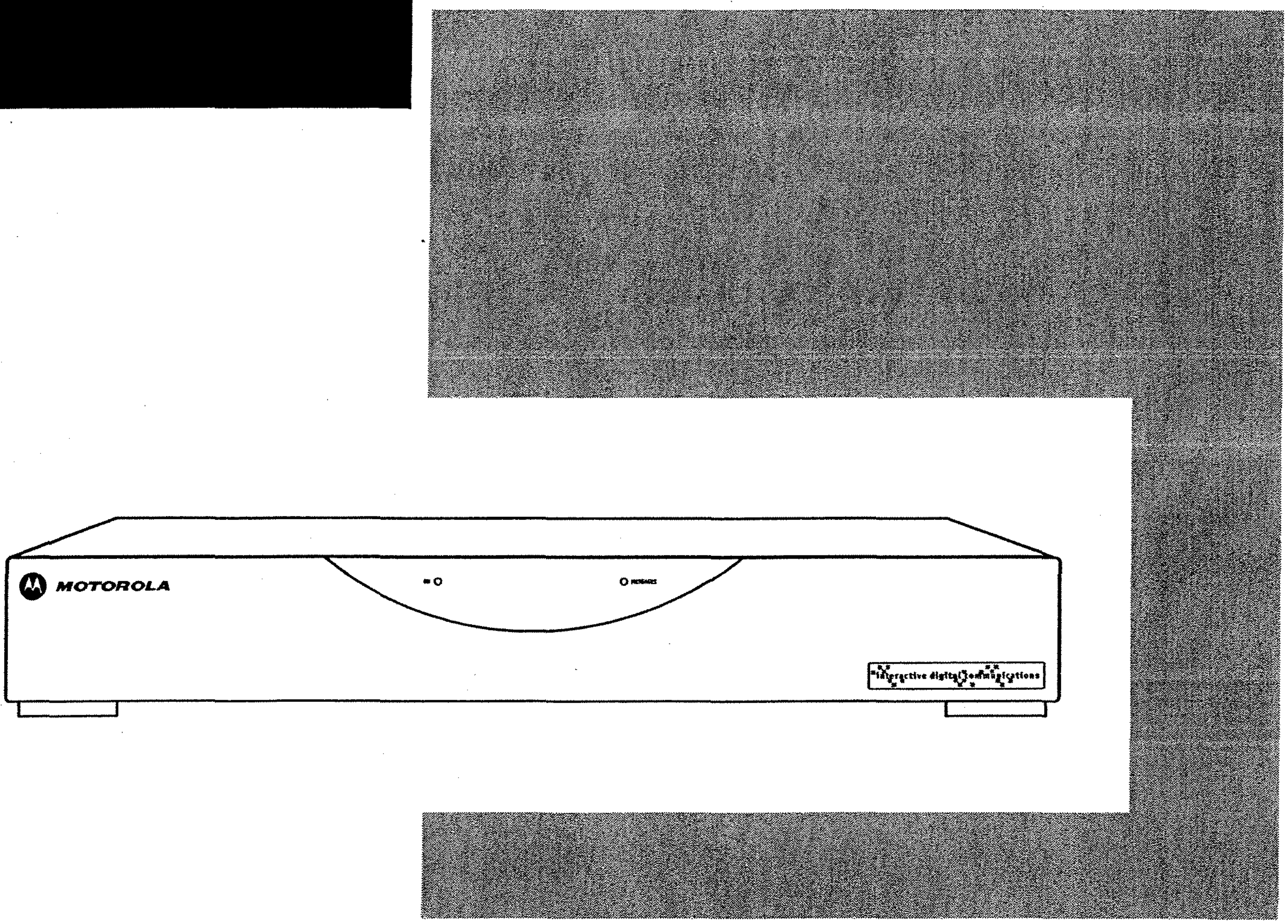

Specifications

Input frequency	54 - 860 MHz (excluding data carrier frequency)
HRC/IRC frequency assignments	Downloadable
Number of channels:	136 carriers per cable
Analog	1 channel per carrier
Digital	More than 1 channel per carrier, content dependent
Input analog video level	0 dBmV – +15 dBmV
Input analog sound level	–17 dBmV – +2 dBmV
Average digital input level	–10 dBmV – +5 dBmV
Data carrier:	QPSK-modulated carrier
Frequency	Agile
Bandwidth	1.5 MHz
Level	–10 dBmV – +5 dBmV
Video s/n	49 dB @ 0 dBmV input level
Output frequency accuracy	±150 kHz
Return loss:	
Input	6 dB minimum
Output	8 dB minimum
Spurious output	–57 dBc maximum, in band
Cross-modulation distortion	–56 dB (136 channels, each @ +15 dBmV)
Composite second order distortion	–57 dB (136 channels, each @ +15 dBmV)
Second order distortion	–60 dB (136 channels, each @ +15 dBmV)
Composite triple beat distortion	–57 dB (136 channels, each @ +15 dBmV)
Set-top input beats (with all input signals)	–25 dB (136 channels, each @ +15 dBmV)
Hum modulation distortion	3 IRE
Output level	10 - 15 dBmV
Isolation (input/output)	70 dB minimum
Differential phase	10 degrees (maximum)
On-screen display (OSD):	
Screen size	352 x 480 pixels (configuration dependent)
Message/barker capacity	Up to 40 pages (configuration dependent)
Mechanical security	Standard: security screws, unichassis construction
Operating environment range:	
Temperature	0° - 40°C (32° through 104°F)
Humidity	5 - 95% (noncondensing)

Model 8610 Addressable Home Terminal with On-Screen Display

Scientific Atlanta

SPECIFICATIONS

Environmental

Temperature
- 0°C to 45°C

Relative humidity
- 5% to 95%

Electrical

Input bandwidth
- 54 MHz to 750 MHz

Number of channels
- 116 channels (single cable)
- 255 channels (dual cable)

Output channel downloadable
- 3 or 4

Output level
- 9.0 dBmV, typical

Noise figure
- 8.7 dB (including baseband circuitry)

Return loss
- Input
  - 8 dB
- Output
  - 12 dB

Spurious response
- Output
  - -60 dBc in channel

Frequency accuracy
- ±100 kHz max

Frequency stability
- ±100 kHz max

AC input
- 105 V to 125 V

Power consumption
- 12 W max

Surge protection
- AC
  - Spark gaps and transformer isolation
- RF
  - Inductor shunt to ground

Distortion at +15 dBmV, 78 channel load/116 channel load (750 MHz)
- Flat input, second order
  - -60 dB
- Cross modulation
  - -60 dB
- Composite triple beat
  - -63 dB max

Input level
- -7 dBmV to +20 dBmV

Audio distortion
- THD 1%

Audio signal-to-noise
- 50 dB min

Mechanical

Dimensions
- 9.2 in. L x 7.0 in. W x 2.4 in. H

Weight
- 3.6 lbs

Keyboard type
- 11 keys (front access)

Display type
- LED, 4-digit
- On-screen 10-line by 24-column character display

IPPV MODULE SPECIFICATIONS

RF Return (Optional)

Frequency range
- 15.45 MHz to 17.75 MHz

Modulation rate
- 20 kbps

Modulation technique
- BPSK

Maximum output power
- +60 dBmV

Unless otherwise noted, specifications are typical.

Specifications and product availability are subject to change without notice.