Booster | Canceller | Economizing Cost Efficient

Technology Reports

Outdoor Booster for 800 MHz FOMA

To economically improve areas where the downlink signal is received at low power, we have developed an outdoor booster (repeater) for 800 MHz FOMA. This booster is effective in FOMA Plus Areas where the downlink signal is received at low power and traffic is low, such as in mountains.

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1. Introduction

We are trying to economically improve the FOMA coverage areas in mountains, where the traffic is low and the downlink signal from base station is received at a low power level. While Optical Feeder Transmitter and Receiver (OF-TRX) type base stations[*1], boosters and other equipment have been applied, we had previously developed an outdoor booster for 2 GHz band FOMA [1]. The outdoor booster is inexpensive and can expand the service area in low-traffic regions economically without a transmission line.

For FOMA Plus Areas[*2], only 800 MHz band base stations are used in areas of relatively low traffic, and outdoor boosters must be developed to expand 800 MHz band service areas (as was done for the 2 GHz band).

Outdoor boosters suffer from the issue of feedback signal, which is the radio signal retransmitted from the antenna directed at the mobile station and received again by the antenna directed at the base station. In the 2 GHz band, this phenomenon is decreased by adjusting antenna direction and separating the two antennas by a sufficient distance [1].

In the 800 MHz band, however, the wavelength is longer than in the 2 GHz band, so the required antenna distance is longer and it is difficult to operate the booster while suppressing the effects of the feedback signal with the two antennas installed on the same utility pole. In addition, coupling loss[*3] degradation due to reflections makes it more difficult to operate with high gain compared to the 2 GHz band [2]. A canceller is applied to allow the booster to operate at high gain by suppressing the feedback signal.

2. Device Design

2.1 FOMA Outdoor Booster and its Application Area

The application area of the radio network equipment for constructing an 800 MHz band outdoor FOMA service area is the same as is described for 2 GHz band FOMA [1]. Applications for small villages and roads include one-carrier and one-sector Base Transceiver Stations (BTS), one-carrier OF-TRX type base station, and outdoor boosters. The outdoor booster is particularly suitable for economically expanding service areas where traffic is low.

2.2 Booster Configuration and Canceller

The booster configuration is shown in **Figure 1** and an actual installation is shown in **Figure 2**. Two antennas are connected to the main unit of the boost-

*1 **OF-TRX type base station**: Equipment connected to base station Modulation and Demodulation Equipment (MDE) by optical fiber. Extension of up to about 20 km from the MDE is possible.

*2 **FOMA Plus Area**: An area serviced only by 800 MHz band FOMA base stations. Compatible devices include the FOMA 90X series after the FOMA 901iS (except FOMA 901iTV) and the FOMA 70X series after the FOMA 701iS.

*3 **Coupling loss**: Power loss between two antennas, which consists of free space loss and each antenna gain. Larger coupling loss is preferred to prevent oscillation when using a booster.

er, one for the base station and one for the mobile station. The booster main unit consists of the cancellers, duplexers, Low Noise Amplifiers (LNA) and High Power Amplifiers (HPA). As shown in Fig. 2, the booster and the two antennas are installed on a single utility pole.

The booster amplifies the base station radio signal that is received by the antenna directed at the base station and retransmits it from the antenna directed at the mobile station. The antenna directed at the base station receives both the radio signal that arrives directly from the base station (main signal) and the feedback signal that is transmitted from the antenna directed at the mobile station (Fig. 1). The feedback signal includes a direct signal that arrives from the antenna directed at the mobile station directly and reflected signals from buildings and other structures. The feedback signal is amplified by the booster and received again by the antenna directed at the base station, so the received level of the feedback signal rises and oscillation occurs, making it difficult for the booster to continue operation.

Our booster is equipped with a canceller that suppresses the effects of the feedback signal. The canceller generates a canceling signal whose phase is the opposite of the feedback signal from the radio signal and adds that signal to the original radio signal to cancel the feedback signal. The canceller can reduce the required antenna coupling loss L_C, so high-gain operation of the booster is possible and the required distance between the antenna and reflective object can be reduced.

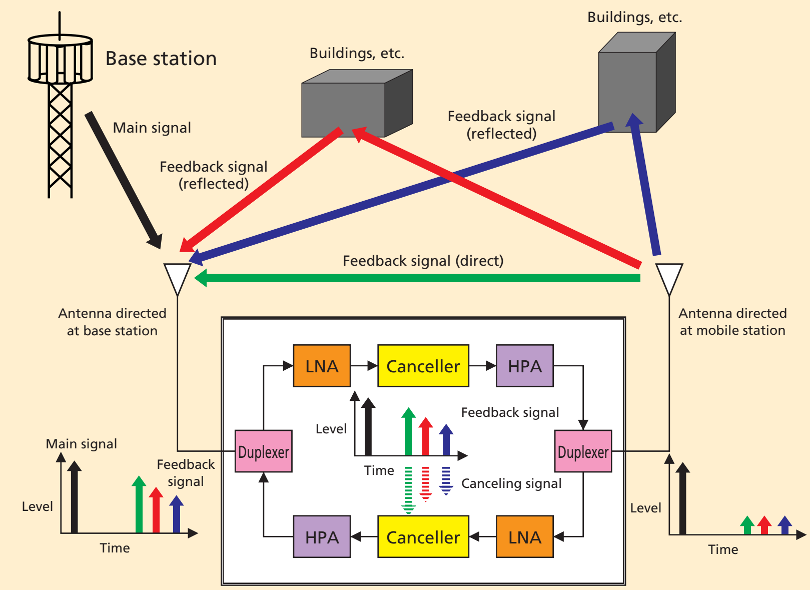


Figure 1 Configuration of the 800 MHz booster

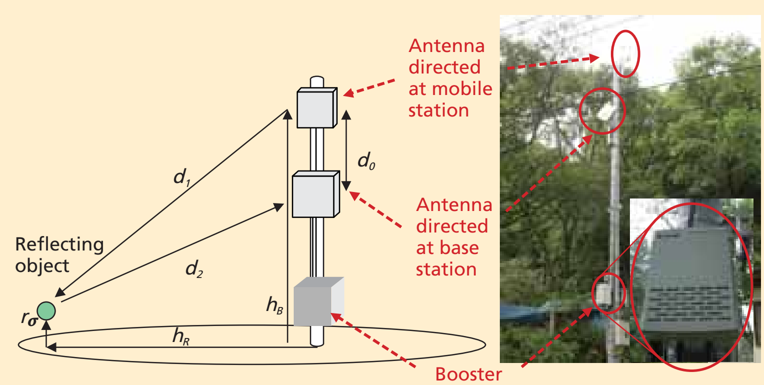


Figure 2 Booster installation

2.3 Antenna Coupling Loss

In investigating the amount of antenna coupling loss in the outdoor booster, we assumed that the two antennas are placed on the same utility pole a few meters apart (Fig 2). The amount of coupling loss between the antennas, L_C, is the sum of the coupling loss due to the antenna pattern, L_{C0}, which represents attenuation of the direct feedback signal, and the coupling loss L_R, which represents the attenuation of the reflected component of the feedback signal (equation (1)). Denoting the gain of the antenna directed at the base station as G_{BS} (θ, ϕ), the gain of the antenna directed at the mobile station as G_{MS} (θ, ϕ), the cross-sectional radius of reflecting object as γ_σ, and the distances from the two antennas to the reflecting object as d_1 and d_2, L_R is expressed by equation (2) [2]. Here, the reflectivity of the object is taken to be the worst case of 1, which means total reflection.

$$L_C = L_{C0} + L_R \quad (1)$$

$$L_R = -10\log\left(\frac{G_{BS}(\theta, \phi)\cdot G_{MS}(\theta, \phi)\cdot (r_\sigma/\lambda)^2}{64\pi^2\cdot (d_1/\lambda)^2\cdot (d_2/\lambda)^2}\right) \quad (2)$$

On the other hand, even for large amounts of coupling loss due to the antenna pattern, L_{C0}, the reflecting object must be distant from the antenna to maintain the required amount of antenna coupling loss L_C.

Stable operation of the outdoor booster requires satisfaction of the conditions of equation (3), where G_B is the booster gain, C is the effect of the canceller, and M is the margin for no oscillation.

$$L_C > G_B + M - C \quad (3)$$

The coupling loss calculated on the basis of equation (1) and (2) for the computation conditions given in **Table 1** are shown in **Figure 3**. The booster gain is 80 dB when the beam directions of the two antennas are the same (worst case). In that case, the required distance between the antenna and the reflecting object is about 30 m for the 800 MHz band and about 15 m for the 2 GHz band, even considering a margin M of 5 dB. If the effect of the canceller is 10 dB, stable operation is possible even for a required coupling loss of 70 dB, so it is possible to have a distance to the reflecting object of 10 m for the 800 MHz band and a few meters for the 2 GHz band. When the antenna beam directions are different, the amount of coupling loss decreases because the antenna gain in the direction of the reflected signals is lower.

3. Device Overview

3.1 Characteristics of Equipment

The basic specifications of the 800 MHz band FOMA outdoor booster are shown in **Table 2**. There are two types.

Table 1 Coupling loss computation conditions

Item	Value
Frequency f	830 MHz, 2,000 MHz
Cross-sectional radius of reflecting object, r_σ	0.5 m
Height of the reflecting object, h_R	1.5 m
Antenna gain	Antenna gain G_{BS} directed at base station: 10 dBi Antenna gain G_{MS} directed at mobile station: 10 dBi
Antenna height	Antenna height h_B-d_o directed at base station: 11 m Antenna height h_B directed at mobile station: 15 m
Coupling loss caused by antenna pattern, L_{co}	88 dB

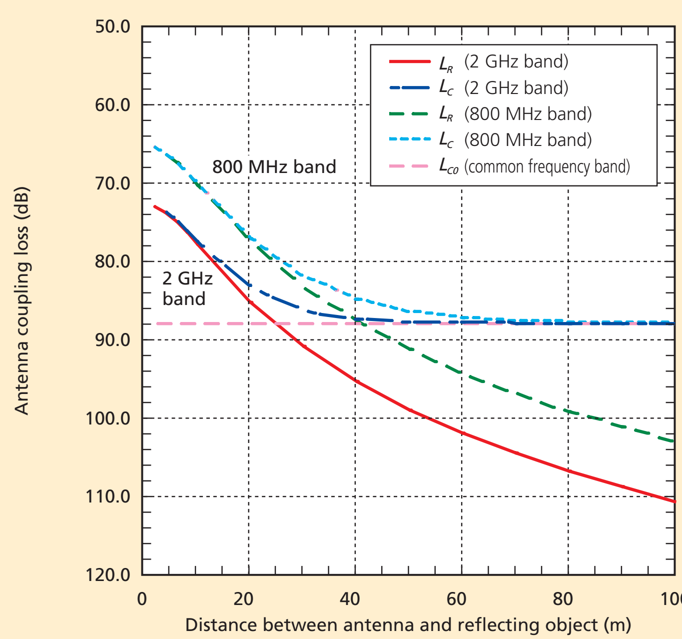
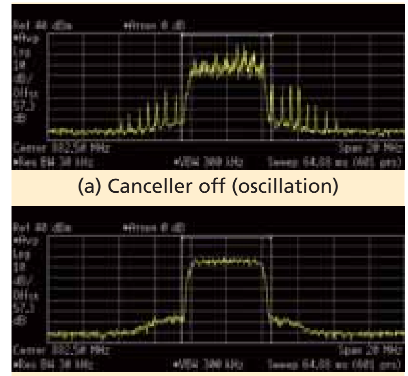


Figure 3 Calculated coupling loss

Table 2 Basic specifications of the booster

Item	Downlink	Uplink	Notes
Transmitted band	875-880 MHz	830-835 MHz	A type
	880-885 MHz	835-840 MHz	B type
Number of carriers	1 carrier		
Gain	57-87 dB		
Maximum output power	37 dBm	20 dBm	
ACLR	-45 dBc or less	-33 dBc or less	5 MHz spacing
	-50 dBc or less	-43 dBc or less	10 MHz spacing
Input D/U ratio	-10 dB or more		
Dimensions	W360 × D220 × H520 mm or less		
Weight	35 kg or less		



(a) Canceller off (oscillation)

(b) Canceller on

Vertical axis: 10 dB/div
Horizontal axis: 2 MHz/div

Figure 4 Booster spectrum (downlink)

Type A has a pass band of 875 - 880 MHz for the downlink and 830 - 835 MHz for the uplink; type B has a pass band of 880 - 885 MHz for the downlink and 835 - 840 MHz for the uplink. The maximum downlink output power is 37 dBm and the maximum gain is 87 dB.

This booster, like the 2 GHz band booster, has the same radio characteristics as the base station in the downlink [3] and the same radio characteristics as the mobile station in the uplink[4] with respect to Adjacent Channel Leakage power Ratio (ACLR)[*4] and spurious emission[*5]. The canceller booster can operate stably even with a desired to undesired (feedback) input signal ratio (D/U) of -10 dB (**Figure 4**).

4. Conclusion

We described an outdoor booster for 800 MHz band FOMA. We explained the effects of the feedback signal, which is a particular issue when the booster is applied in the 800 MHz band. We also described a canceling function that suppresses those effects to achieve stable operation. In future work, we will expand the application area of the booster by improving the canceller performance and continue to investigate economical means of dealing with service areas where the downlink signal is received at a low level.

REFERENCES

[1] Ito, et. al: "Outdoor Booster Equipment for 2 GHz FOMA," NTT DoCoMo Technical Journal, Vol. 9, No. 1, pp. 32-36, Jun. 2007.

[2] Y.Ito, H.Arai and M.Kijima: "Study of Antenna Coupling Loss Adopting Repeater Equipment for Open Area," IEICE, B-5-196, 2007.

[3] 3GPP TS25.104: "BS Radio transmission and Reception (FDD)"

[4] 3GPP TS25.101: "UE Radio transmission and Reception (FDD)"

*4 **ACLR**: The power ratio of desired signal to undesired signal from an adjacent channel when a modulated signal is transmitted. In FOMA (W-CDMA), the power of the desired modulated signal is measured in a 3.84 MHz band around the center frequency; the undesired signal power is measured in a 3.84 MHz band whose center is 5 MHz away from the center frequency of the desired signal.

*5 **Spurious emission**: An undesired signal that appears out of band when a signal is transmitted.