A RX CANCELLATION LOOP CONFIGURATION FOR POWER AMPLIFIER MODULE

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ABSTRACT

The cancellation loop configuration for power amplifier module is proposed to reject the RX signals using feed-forward technique. In this paper, we implement the 1W-ampilfier module to show validity of the proposed cancellation loop. The power amplifier module with the proposed cancellation loop can provide low TX insertion path loss due to duplexer and choice of loose RX attenuation characteristic for various wireless communication systems. It shows at least 90 % improved RX rejection characteristic compared to power amplifier module without RX band cancellation loop.

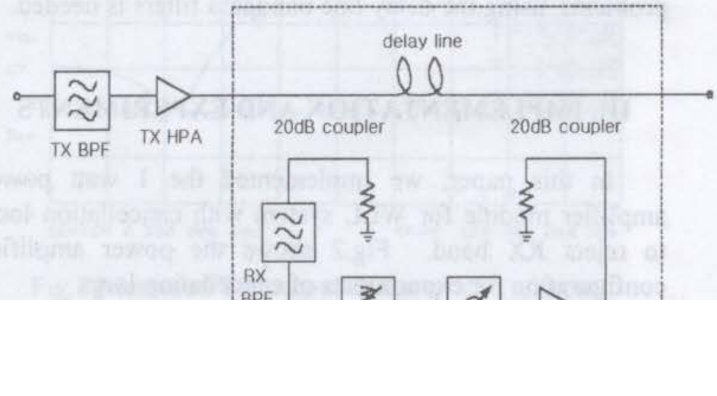
I. INTRODUCTION

A significant increasing in system performance requirements makes a growing cost of components and sub-systems for wireless communication service applications. The isolation plays a main role in various RF systems. The isolation characteristic between RX and TX path mainly augments the price of RF front-end section. In order to improve the isolation characteristic to RX path, the attenuation of TX bandpass filter should be increased. However, it always gives rise to increasing the TX path loss. Thus, in order to compensate the increased path loss, increasing output power of a power amplifier module is needed. As the output power increases, the cost for implementing the power amplifier module is also increased with the same rate. Considerations for improvement of the isolation characteristic should follow the significant increasing of the system prices.

In this paper, we propose the novel power amplifier module with cancellation loop to improve the RX rejection characteristic. The proposed cancellation loop, which has for implementation of RX cancellation amplifier module is approximately 1watt. Proposed cancellation loop technique for TX amplifier module can largely eliminate RX signals in TX output.

II. CONFIGURATION OF CANCELLATION LOOP

The proposed cancellation loop is based on the second loop of conventional feed-forward linearizer, which isolate the distortion of the power amplifier and re-inject it 180 degree out of phase to cancel the distortion at the output. A TX power amplifier module with the proposed cancellation loop is shown in the block diagram of Fig.1. Difference between cancellation loop and second loop in feed-forward is only that the low power RX bandpass filter is used to reject a relative TX band. The amplifier module encompasses a loop, which is intended to provide a sample of the RX signals to the error amplifier, as indicated Fig.1. At output section of power amplifier a sample of the output signals is injected into RX bandpass filter in cancellation loop. The amplitude of the sampled output signals is filtered such that only the RX signals can go through a line. This replica of RX signal is amplified and into the output line with equal amplitude but opposite phase so as to cancel the RX signals and noise.



characteristic. The proposed cancellation loop, which has RX bandpass filter to reject the TX signals, is very similar to second loop configuration of feed-forward technique [1], [2], [3], [4], [5]. To show the validity of the proposed cancellation loop, a power amplifier is implemented with hybrid type. The output capability of the hybrid amplifier

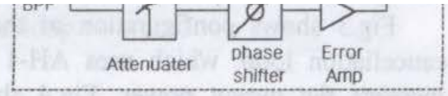


Fig.1 Proposed cancellation loop configuration.

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It is important that RX signal level in the output of power amplifier be low enough such that the filtered RX signal does not overload the error amplifier in cancellation loop. In practical CDMA frequency spectrum, it is much weaker than TX signal such that it appears as noise level. However, experiment for the proposed cancellation loop is carried out with vector network analyzer. Thus, the TX bandpass filter is needed to reject the RX band as seen in Fig.1.

Another important thing is the depth of cancellation in output line of power amplifier module. For enough cancellation depth, the well-matched amplitude and phase between the two paths in output coupler are required across the RX frequency band. Cancellation limitations are given by function of phase error and amplitude error as follows, respectively [1]

$$Cancellation(dB) = 10\log\left[\sin^2\phi_e + (1-\cos\phi_e)^2\right] \quad (1)$$

$$Cancellation(dB) = 20\log\left|10^{E/20} - 1\right| \quad (2)$$

In above equation, ϕ_e and E mean the phase error and the amplitude error in dB between the two paths in output coupler, respectively. The cancellation limitations show some constraints placed on the components in the cancellation loop. The amplitude error does not make serious limitation because that controlling the attenuation level or error amplifier gain can compensate the amplitude error enough. However, the significant constraint can be occurred on RX bandpass filter in cancellation loop. The group delay time of bandpass filter is quite long. In order to match the phase, the quite long delay line is needed at main path seen in Fig.1. In general, delay performances have been provided through a predetermined length of coaxial cable in both the high and low power applications. But, there are several limitations to using coaxial type delay line, including large occupied volume, high insertion loss and grounding difficulties. In order to resolve these problems, using the delay line bandpass filters is needed.

III. IMPLEMENTATION AND EXPERIMENTS

In this paper, we implemented the 1 watt power amplifier module for WLL system with cancellation loop to reject RX band. Fig.2 shows the power amplifier configuration for experiments of cancellation loop.

Fig.3 shows configuration of the error amplifier in cancellation loop, which uses AH-1 as a final stage to increase the output power. Fig.4 shows measured gain characteristics of HPA, which has 30dB gain in TX band

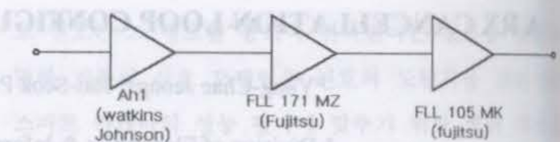

Fig.2 Configuration of TX power amplifier.

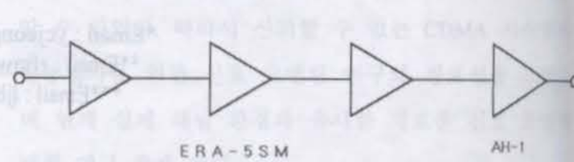

Fig.3 Configuration of error amplifier in cancellation loop.

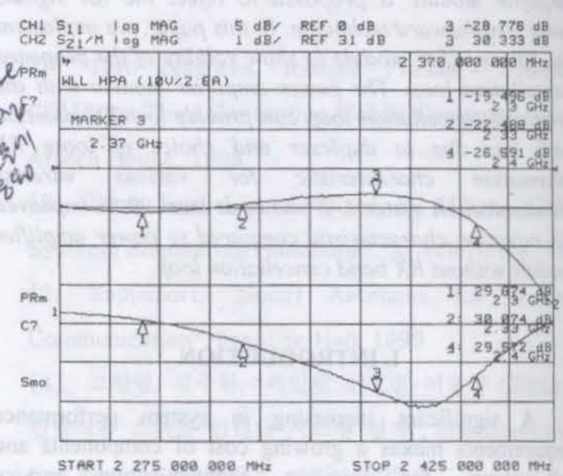

Fig.4 Measured gain characteristic of HPA seen in Fig.2.

To show the rejection of RX signal effectively, we use HP-8753D vector network analyzer for measurements. Thus, by using the TX bandpass filter RX signals should be eliminated to prevent saturation of error amplifier. Fig.5 shows the measured characteristic of ceramic TX bandpass filter, which is DFM4R2385CCA, SEMCO Co.

Fig.6 shows the measured characteristic of ceramic RX bandpass filter, which is DFM4R2315CCA, SEMCO Co.

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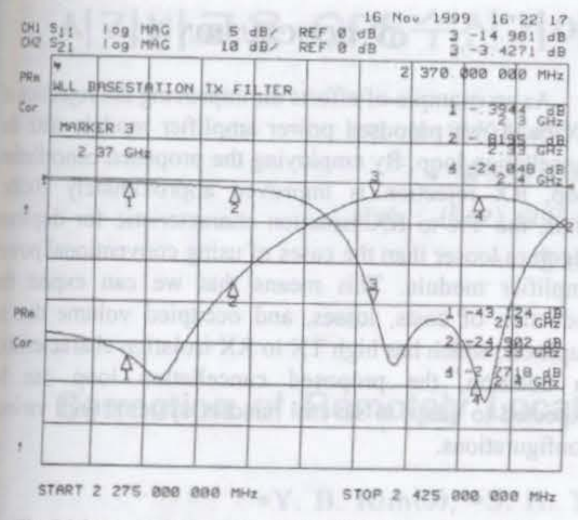

Fig.5 Measured characteristic of TX bandpass filter.

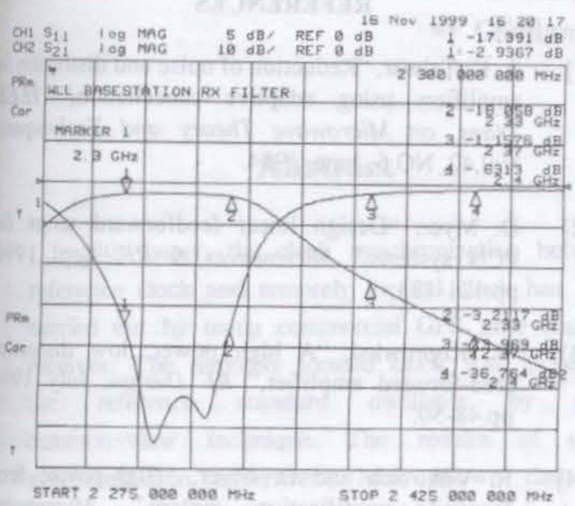

Fig.6 Measured characteristic of RX bandpass filter.

Cancellation loop seen Fig.1 has 25ns group delay. In order to achieve 25ns delay characteristic, approximately 5 meters long (5ns/meter) of semirigid coaxial cable was needed [6]. Thus, insertion loss to main path due to the delay line was approximately 1.75dB (0.35dB/meter for 0.141" diameter semirigid coaxial cable). Fig.7 shows the cancellation loop transfer characteristic for swept full band signals. For RX band 20dB rejection could be achieved as seen in Fig.7.

Fig.8 shows the measured TX output characteristic without cancellation loop. The swept spectrum shape of TX output depends on the TX bandpass filter characteristic as seen in Fig.8. Measured RX rejection, which depends on TX bandpass filter seen in Fig.1 shows about 25dBc. For mobile communication base-station system, at least 120dB

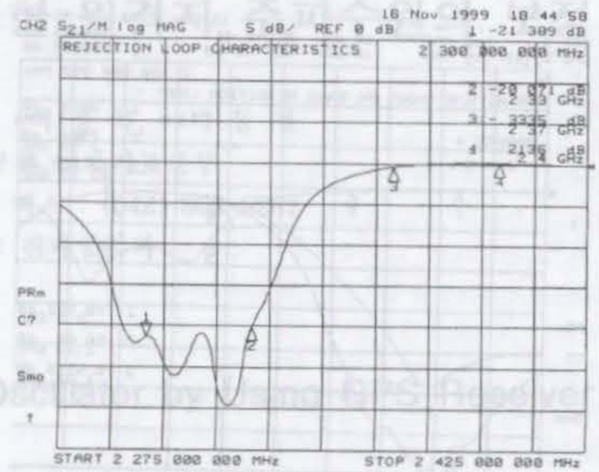

Fig.7 Measured cancellation loop characteristic.

c of TX to RX isolation characteristic is required. Thus, TX to RX isolation of duplexer with this power amplifier should be at least 95dBc. There are several limitations to achieve this relatively high isolation characteristic with duplexer, including large occupied volume, high insertion loss and costs. In order to resolve these problems, TX output spectrum with more rejection of RX band is required. Fig.9 shows output spectrum of TX amplifier module with the improved rejection characteristic of RX band. By employing the cancellation loop, RX rejection is improved approximately 20dBc as shown in Fig.9.

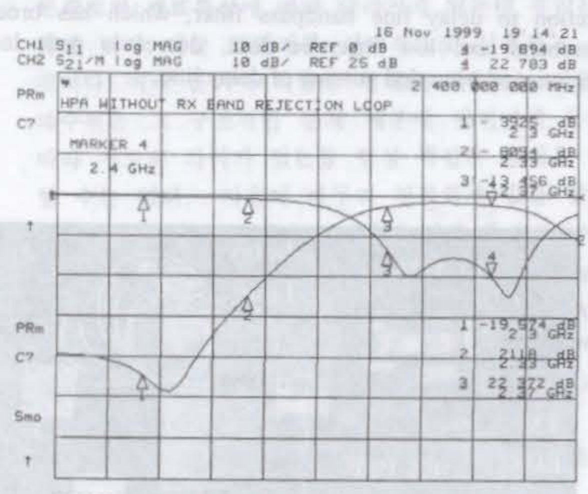

Fig.8 Measured TX output characteristic without cancellation loop.

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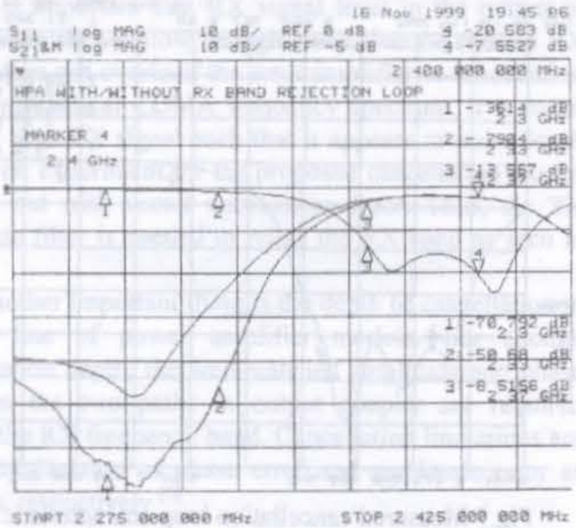
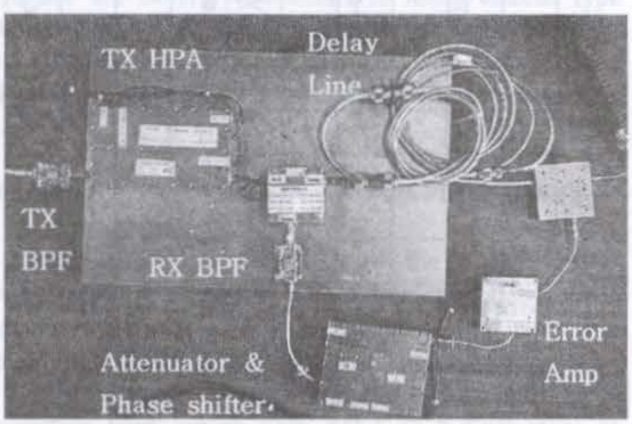


Fig.9 Comparison of measured TX output with cancellation loop vs. measured TX output without cancellation loop.

Theoretically, we can expect more rejection of RX band with ideal phase balance. But there is a group delay deviation of 3ns in cancellation loop due to RX bandpass filter. This delay deviation gives rise to serious limitation of cancellation from Eq.(1). Thus, more excellent rejection for RX band can be expected by decreasing the delay deviation characteristic of RX bandpass filter, which means improvement of phase balance between main path and cancellation paths. Also, a replacement of delay line section to delay line bandpass filter, which has broad passband and low insertion loss, decreases path loss section and occupied volume of delay line.



IV. CONCLUSION

As an example of efforts on improving the rejection of RX band, we proposed power amplifier module with the cancellation loop. By employing the proposed cancellation loop, RX rejection is improved approximately 20dBc. Thus, the TX to RX isolation characteristic for duplexer becomes looser than the cases of using conventional power amplifier module. This means that we can expect the reduction of costs, losses, and occupied volume due to duplexer, which has high TX to RX isolation characteristic. In addition, the proposed cancellation loop can be expected to adapt to several handset systems with various configurations.

REFERENCES

[1] A .K. Talwar, "Reduction of noise and distortion in amplifiers using adaptive cancellation," *IEEE Trans. on Microwave Theory and Techniques*, Vol.42, NO.6, June. 1994.

[2] D. Myer, "Design linear feedforward amps for PCN systems," *Microwaves & RF*, Sep. 1994, pp.121-133.

[3] W. Koprowksi, "A high power, low distortion feed-forward amplifier," *RF Design*, July 1994, pp.48-50.

[4] R. Vitkovich and D. Myer, "High-power feed-forward amplification system," *Microwaves Journal*, Vol.37, No.2, Feb. 1994.

[5] J. Yamas, "An HF dynamic range amplifier using feedforward techniques," *RF Design*, July 1994, pp.50-59.

[6] K&L Microwave INC., "Cavity and surface-mount delay line filters for feedforward power amplifiers," *Microwaves Journal*, Vol.42, No.9, Sep. 1999, pp.212-220.

Fig.10 Photograph of implemented power amplifier module with the proposed cancellation loop

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