A RX CANCELLATION LOOP CONFIGURATION FOR POWER AMPLIFIER MODULE

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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.

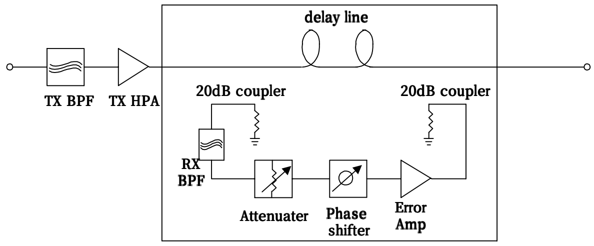
1 Introduction

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 band pass 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 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 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.

2 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 band pass 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 band pass filter in cancellation loop. The amplitude of the sampled output signals is filtered such that only the RX signals can go through a line. These replica of RX signal are amplified and into the output line with equal amplitude but opposite phase so as to cancel the RX signals and noise.



Cancellation loop configuration

Fig.1 Proposed cancellation loop configuration

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. So cancellation loop can be realized with small signal amplifiers. However, experiment for the proposed cancellation loop is carried out with vector network analyzer. Thus, the TX band pass 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].

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

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

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 band pass filter in cancellation loop. The group delay time of band pass 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, the delay line band pass filters that insertion loss is fairly low than conventional coaxial delay line are needed.

3 Implementation and experiment

In this paper, we implemented the 1 watt power amplifier module for WLL system with cancellation loop to reject RX band. The implemented high power amplifier consists of a AH-1 manufactured by Watkin-Johnson and FLL171ME and FLL105MK of Fujitsu Co., it has 29.95dB gain and ±0.38dB flatness over WLL TX band. And an implemented error amplifier consists of three ERA-5SM of Mini-Circuit and an AH-1 manufactured by Watkin-Johnson. Fig. 2 shows measured gain characteristics of HPA.

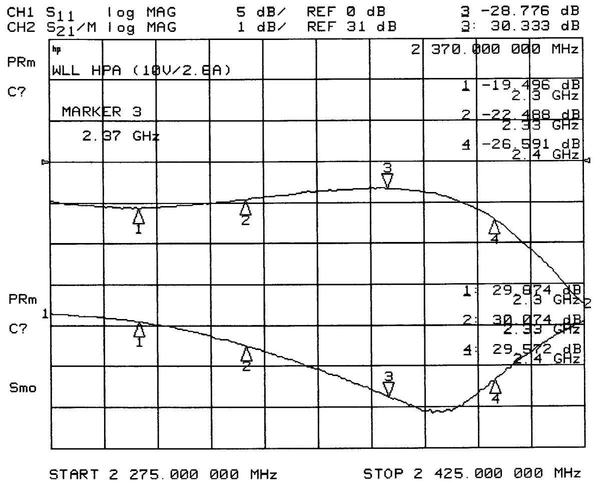


Fig. 2 Measured gain characteristic of HPA

To show the rejection of RX signal effectively, we use HP-8753D vector network analyser for measurements. Thus, by using the TX band pass filter RX signals should be eliminated to prevent saturation of error amplifier. Fig.3 shows the measured characteristic of ceramic TX band pass filter, which is DFM4R2385CCA, SEMCO Co. TX band pass filter is attached to VNA and then connected to the proposed high power amplifier, which input signals characteristic is shown in Fig. 3. Fig.4 shows the measured characteristic of ceramic RX band pass filter, which is DFM4R2315CCA, SEMCO Co. 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. 5 shows characteristic of only cancellation loop for swept full band signals. For RX band 20dB rejection could be achieved as seen in Fig.5. Fig.6 shows the measured TX output characteristic with and without cancellation loop. By employing the cancellation loop, RX rejection is improved approximately 20dBc.

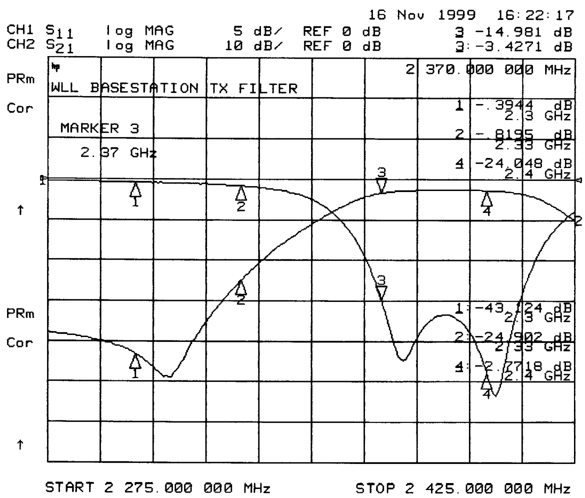


Fig.3 Measured characteristic of TX band pass filter

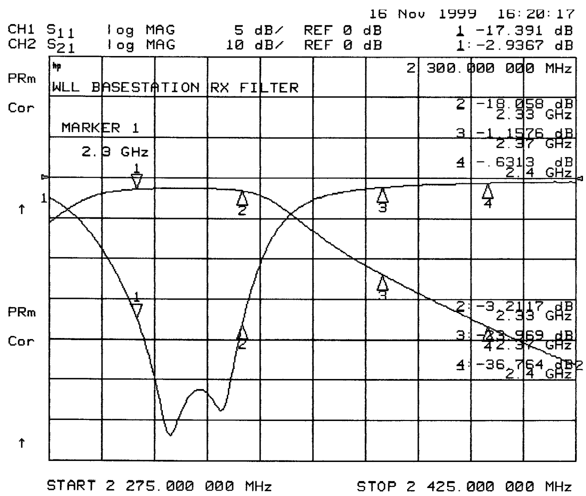


Fig.4 Measured characteristic of RX band pass filter

Theoretically, we can expect more rejection of RX band with ideal phase balance. But there is

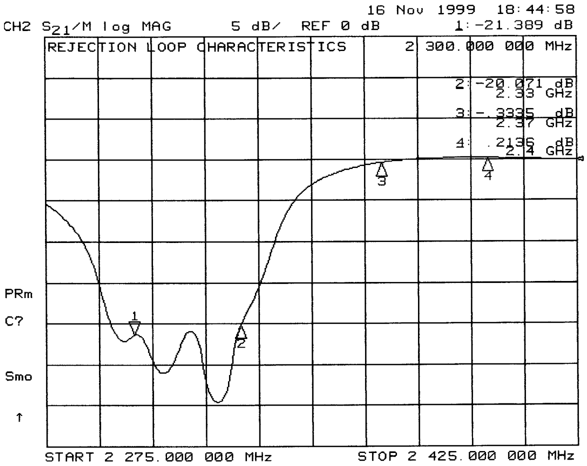


Fig.5 Measured cancellation loop characteristic

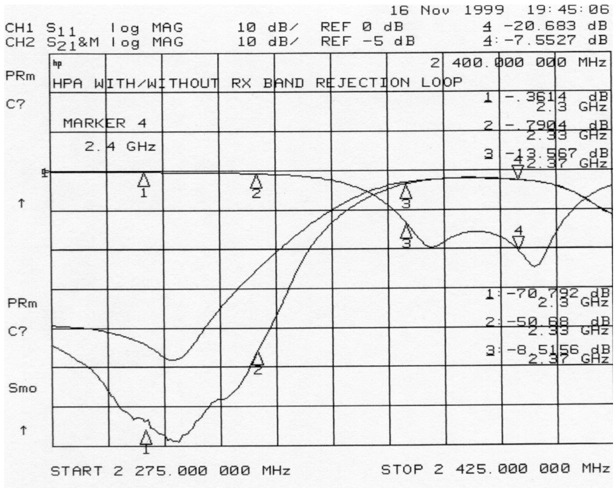


Fig.6 Comparison of measured TX output with/ without RX band cancellation loop

a group delay deviation of 3ns in cancellation loop due to RX band pass 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 band pass filter, which means improvement of phase balance between main path and cancellation paths. If replacement of delay line section to delay line band pass filter, which have low insertion loss and good phase balanced characteristics, more excellent cancellation for RX band can be expected.

4 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.

Acknowledgments

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