A POLLING SYSTEM FOR DATA ACQUISITION USING A SINGLE HF/SSB VOICE CHANNEL

C. W. W. Palihawadana
S. Sridharan
P. Sivaprakasapillai

Abstract

A digital system has been developed which enables a central monitoring station to poll a number of unmanned outstations and acquire telemetry or other data from them. The system has the advantage that a single HF/SSB voice channel could be used for polling all the outstations as well as for the return transmission of data from them to the central monitoring station. It has been ensured that random noise and/or voice communication present shall not accidentally activate the responding system of any of the outstations. The precaution against any interference from voice makes it possible for a potential user of this data acquisition system to use it on an HF/SSB channel employed by him and perhaps other users, for voice communication as well. Due to the difficulty of obtaining frequency allocations in the HF band there has been for some time now a need for a data acquisition system of this type. It is felt that the system developed is a good example of what could be done in this country to meet our own specific requirements.

1. Introduction

Very often need arises in public utility organisations and elsewhere, for a central monitoring station to acquire data from a number of substations or outstations. For example, an electricity distribution authority may want the electrical parameters at different points in its distribution network continuously monitored at a central control station. Or a flood protection agency may require the water levels at different points on a system of rivers conveyed to a single monitoring point.

The location of the stations would very often determine whether a radio or line communication network is to be used and in the case of a radio communication network, the most suitable frequency band as well. A very large volume of data would require a separate communication channel linking each outstation to the Central Monitoring Station. As the number of outstations increases the total bandwidth required will increase correspondingly in the case of a radio communication system using separate channels. However, if the volume of data to be transmitted from each outstation is sufficiently low it is possible to use a single communication channel to obtain the required data in turn from all the outstations. Such a single channel data acquisition system becomes particularly useful when there is a large number of outstations and when the radio frequency that has to be used is in a very crowded band such as the H.F. band where large bandwidth is impossible to obtain.

The system that has been developed uses a single voice communication channel in the H.F. band. The Central Monitoring Station and the outstations are each fitted with a transmitter-receiver tuned to the channel frequency. In addition to a transmitter-receiver each outstation is provided with a responding system which may be activated by a command signal from the central station. Every outstation has its own command signal.

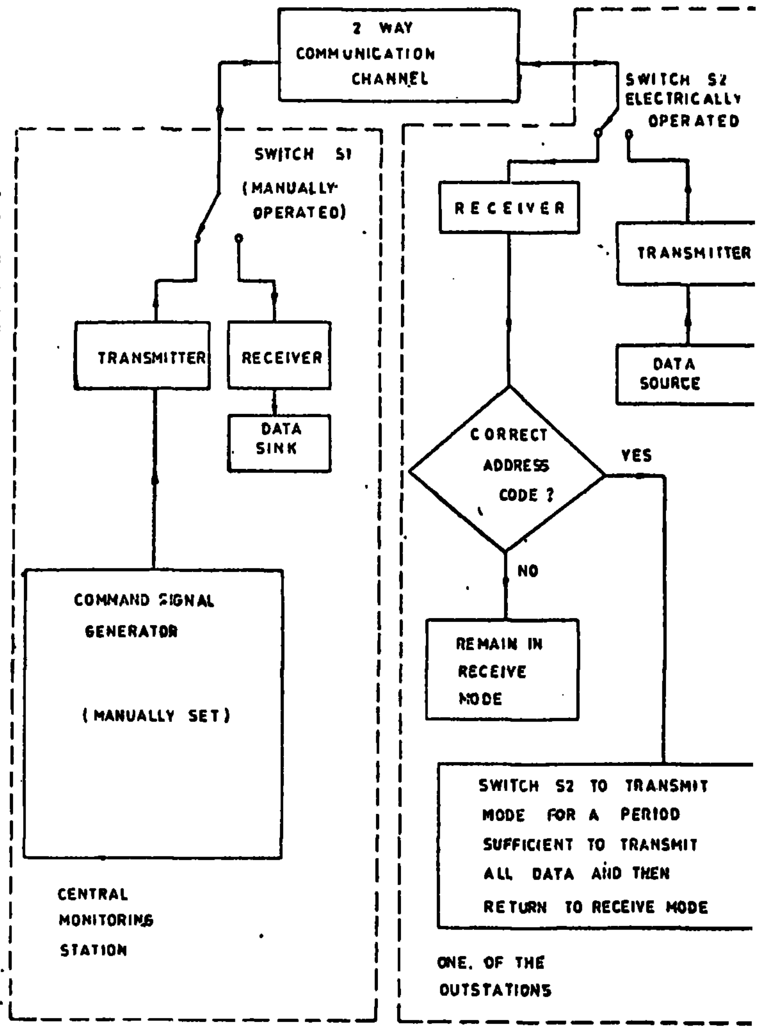

FIG. 1 SIMPLIFIED SCHEMATIC DIAGRAM SHOWING SYSTEM LOGIC

On receipt of the appropriate command signal the responding system at a particular outstation will switch the transmitter-receiver from the receive mode to the transmit mode and feed the required data into the trans-

C. W. W. Palihawadana, B.Sc.Eng. (Sri Lanka). is an Electronic Engineer in the National Engineering Research and Development Centre of Sri Lanka.

S. Sridharan, B.Sc.Eng.(Ceylon), M. Sc.(Manchester), M.I.E. (Sri Lanka), C.Eng. is a lecturer in the Department of Electronic and Telecommunication Engineering, University of Sri Lanka, Katubedda Campus.

Pratab Sivaprakasapillai, B.Sc.Eng.(Ceylon), Ph.D.(London), C.Eng., M.I.E.E., M.I.E.(Sri Lanka). is a Senior Lecturer in the Department of Electronics and Telecommunication Engineering, University of Sri Lanka, Katubedda Campus.

mitter. At the end of data transmission the transmitter-receiver will automatically revert to the receive mode. A certain amount of additional flexibility has been built into the system by ensuring that any voice communication present in the channel does not accidentally activate any of the responding systems at the outstations. Thus a channel normally used for voice communication may also be used for automatic data acquisition.

The system designed is of fairly general application. It has however been developed by the NERD Centre and the Katubedda Campus of the University of Sri Lanka to meet the need of the Department of Irrigation for monitoring river levels at different parts of the country from its Head Office at Jawatte. A method of converting the water level to electrical signals suitable for transmission on this communication channel had already been developed by Mr. A. Makalanda of the Irrigation Department.[1] The communication channel used for data acquisition is the HF/SSB voice channel that has been assigned to the Irrigation Department and another user.

The Principle of Operation of the system is given in the next section and Section 3 is a detailed description of the system. In Section 4 the salient features of the design of hardware are mentioned and reference for a complete description is given. The final dicussion and conclusions are in Section 5.

2. Principle of Operation

The polling system developed is basically a digital signalling arrangement. Each outstation is assigned a unique address code. When data from a particular outstation is required, the appropriate command signal incorporating the address code of the outstation is transmitted from the Central Monitoring Station. The principle of operation is indicated in Fig. 1 which is a simplified schematic diagram showing the system logic.

The address code of each outstation is a 5-bit sequence so that a maximum of [2 exp(5)] or 32 outstations can be given unique addresses. More than 32 outstations may of course be catered for by increasing the number of bits of the address code. Signalling via the communication channel is effected by the on-off modulation of a 1.5 KHz tone, at a rate of 50 bits per sec. It was empirically found that if the address code was repeated eight times in the command signal and if the responding system at the outstation was set to activate the transmitter only if the address code was received correctly all eight times, then any voice communication or noise present in the channel did not accidentally activate the responding system at the outstation. When the number of repetitions required of the 5-bit address code was made less than eight it was found that voice communication present in the channel did occasionally activate the responding system at the outstation. The system thus makes use of the well-known principle that in a signalling system of this type, increasing the effective code length i.e. incorporating redundancy in the system, reduces the probability of error due to spurious signals in the channel.

The probability of accidental activation of the responding system by random noise is also reduced by increasing the effective code length. Possibility of interference from voice communication or random noise in the channel is further reduced by using a limiter and a narrow-band filter in the receiving system at each outstation. Also, a relatively low signalling rate of 50 bits/sec for the command signal is deliberately chosen in order to ensure easy detection and to prevent any impulsive noise present in the system from producing bit errors.

3. Description of System

3.1 Command Signal Generator

The general format of the command signal for any outstation is shown in Fig. 2.

0	1	X	X	X	X	X	1

5-bit address code.

(a) Segment A of Command Signal (8 bits).

0	0	0	0	0	0	0	0

(b) Segment B of Command Signal (8 bits).

A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B

(c) Complete Command Signal (128 bits).

Fig. (2) — Command Signal Format

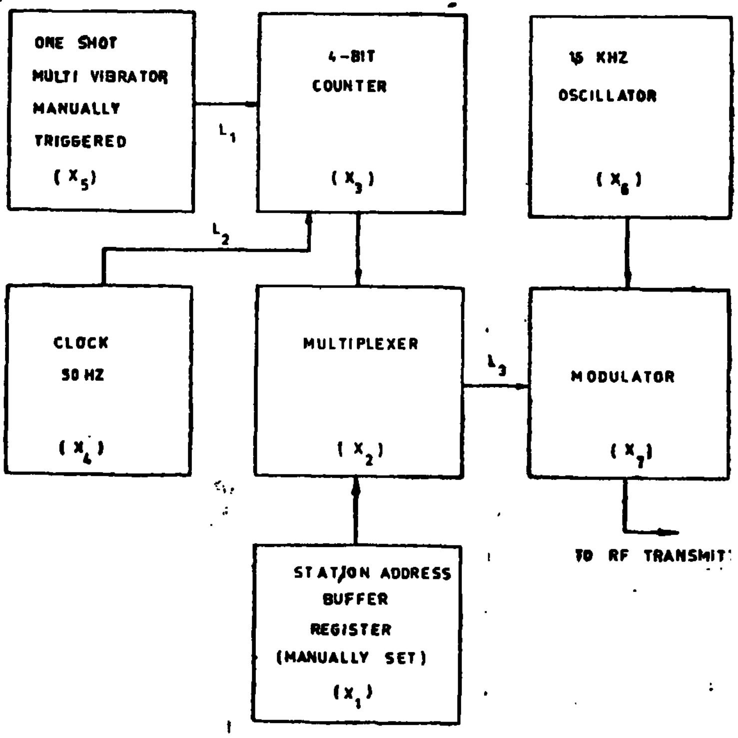

FIG. 3 COMMAND SIGNAL GENERATOR

The block diagram of the command signal generator at the Central Monitoring Station is shown in Fig. 3. The 8-bit segment A of the command signal consists of the 5-bit address code for the outstation and 3 extra bits as shown, which are used for synchronization purposes at the outstation receiver.

The segment A of the command signal is manually set on the buffer register (X1) from where it is fed to the 8 inputs of a multiplexer (X2). On pressing a push-button which triggers the one-shot multivibrator (X5), the following events occur :

(i) The one-shot multivibrator (X5) gives an output pulse (L1) of duration equal to that of the complete command signal which consists of 128 bits as shown in Fig. 2(c).

(ii) The pulse (L1) switches on the 4-bit counter (X3) which remains on for the duration of the pulse (L1).

(iii) The counter (X3) which is initially reset counts the pulses (L2) from the 50 Hz clock (X4). The MSB of the counter is used to strobe the multiplexer and maintain its output at 0 while the other 3-bits drive the multiplexer. The first 3-bits thus select the 8-multiplexer inputs in turn, thereby generating the 8-bit segment A of the command signal. When the MSB of the counter becomes 1, this bit keeps the output of the multiplexer at 0 for the next 8 clock pulses, thereby generating segment B of the command signal. The counter automatically resets after 16 clock pulses and the process is repeated until the complete 128-bit command signal is generated.

(iv) The command signal bits (L3) coming out of the multiplexer are used to modulate a 1.5 KHz sub-carrier which is generated by a Wien bridge oscillator (X6).

(v) The output of the modulator (X7) is used to modulate the H.F. carrier of the transmitter.

3.2 Response Activator

The main function of the response activator at each outstation is the realization of the system logic shown for the outstation in Fig. 1. The block diagram of the Response Activator is shown in Fig. 4. The R.F. receiver output is limited in amplitude by a limiter (Y1). It is also limited in bandwidth to 300 Hz about the centre tone frequency at 1.5 KHz by active filter (Y2). The band chosen eliminates noise to a great extent and is sufficient to preserve bit pulse shape. A diode detector (Y3) demodulates the filter output to obtain the command signal bits (M1). Bit pulse shape is next restored by means of a comparator (Y4), the threshold of which is set at a level equal to half the height of the bit.

To decode the address code in the command signal, the bits must be re-timed and the address codeword must be synchronized using the 3 sync bits in the segment A of the command signal. In order to achieve bit synchronization there is a local clock (Y8) running at 800 Hz, which is 16 times faster than the local clock (X4) in the Command Signal Generator at the Central Monitoring Station.

The output (M2) of the comparator (Y4) is re-timed using a re-timing flip flop (Y5) and the 800 Hz clock (Y8). It is then shifted into an 8-bit shift register (Y7) using bit synchronizing pulses (M7) which are derived at a bit rate of 50 per second. From the timing diagram Fig. 5 of the pulse trains (M1), (M2), (M3), (M4), (M5) and (M7) it is seen that bit synchronizing pulses (M7) shift the command signal pulses (M4) into the 8-bit shift register (Y7) at instants of time corresponding to the nominal middle of each command signal pulse. The instant corresponding to the nominal middle of each command signal pulse has been deliberately chosen as it is at this instant that the pulse is most likely to be at its full amplitude.

The parallel outputs of the shift register (Y7) are wired to the station address decoder (Y11) in such a way that (Y11) gives out a decode pulse (M9), every time the segment A of the command signal is correctly

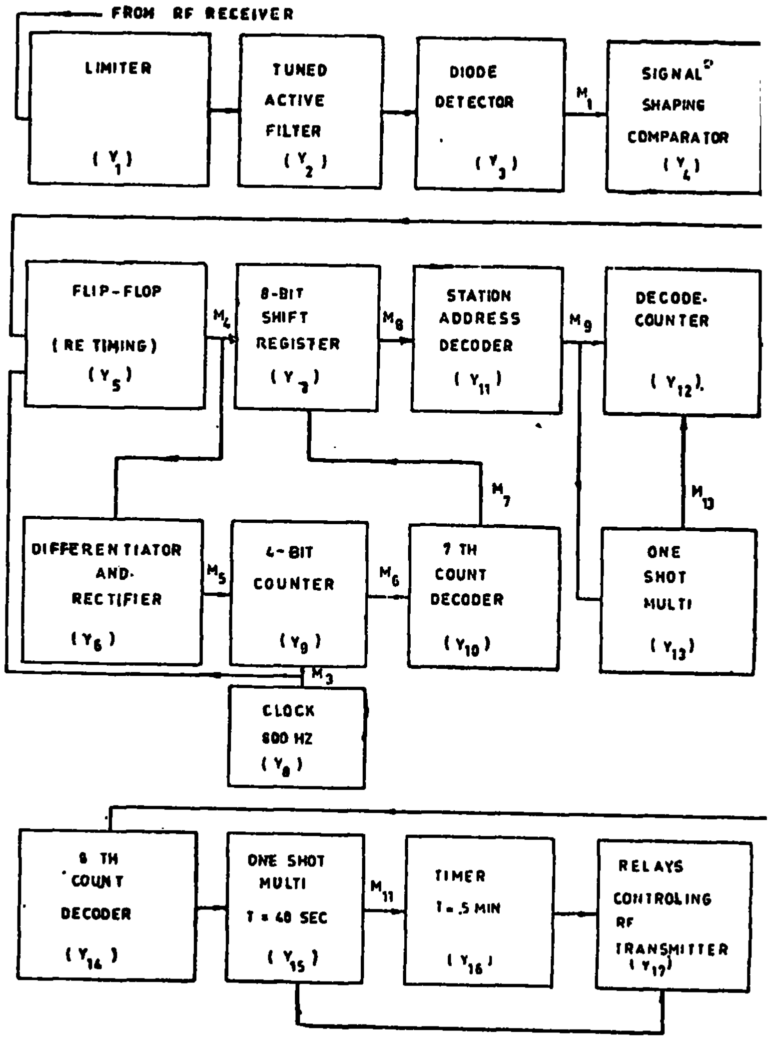

FIG. 4 RESPONSE ACTIVATOR

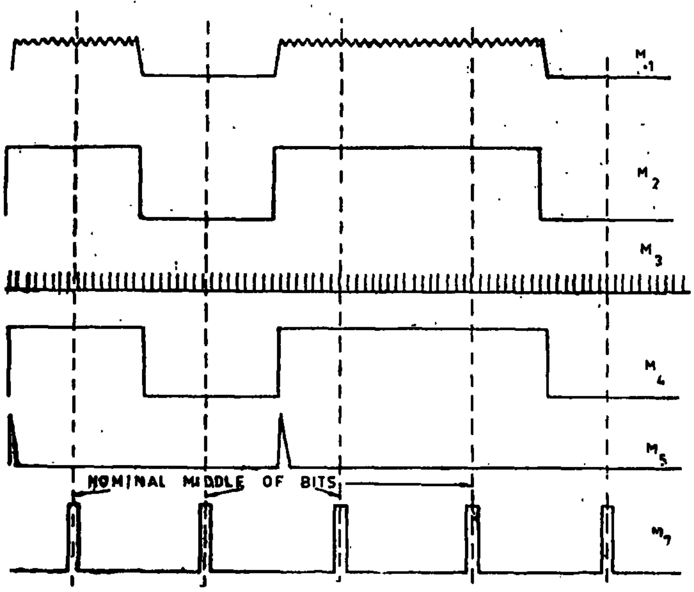

FIG. 5 TIMING DIAGRAM

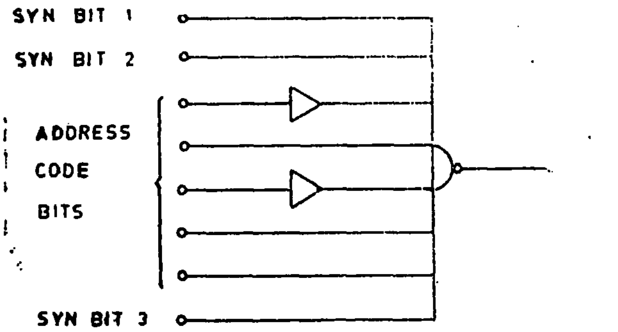

FIG. 6 STATION ADDRESS DECODER

assembled in (Y7). The station address decoder (Y11) consists of an 8-input NAND gate and inverters. Fig. 6 shows the actual wiring of the decoder for address code 01011. The 3-sync bits ensure that the decoder gives an output only when the complete address is assembled. The counter (Y12) counts the decode pulses (M9) for a time-interval equal to the command signal duration, beginning from the first pulse of (M9). This time-interval is controlled by the one shot multivibrator (Y13) which is triggered by the first pulse of (M9), and gives an output (M13). (M13) enables the counter (Y12) for the duration equal to the command signal.

The 8th count decoder (Y14) gives an output [0] if the segment A of the command signal has been received correctly 8 times. This decode is then used to trigger the circuits providing the inputs to the relays controlling the R.F. transmitter. The one-shot multivibrator (Y15) provides a 40 sec time-interval between the switching on of the heater circuits and the switching on of the H.T. supply of the R.F. transmitter. The timer (Y16) switches the transmitter off after 5 minutes. The time of transmission controlled by the timer (Y16) should in general be chosen so that it is adequate to transmit all the data required from the outstation.

4. Hardware Design

The circuitry for this system was built using hardware elements that were readily available from the stocks at Katubedda Campus. TTL logic elements have been used throughout to realize system logic. Considerable attention has been paid to make the circuitry used in the response activator simple and reliable as these have to be installed at the outstation and left unmanned. Details of circuitry used are described elsewhere.[9]

Table 1 gives the list of integrated circuits and the corresponding function in the block diagram of the system in which they have been used.

TABLE 1.

Integrated Circuit (Signctics)	Function
8 input multiplexer N74151	X2
4 bit counter N7493	X3, Y12, Y9
Timer 555	X4, Y8, Y16
Monostable multivibrator N74121	X5, Y13, Y15
D type flip flop N7474	Y5
Dual J-K flip flop N7473	Y7
8 input NAND N 7430	Y11
Operational amplifier MC 1741	Y4, Y2
Dual 4 input NAND N7420	Y10, X4
Hex inverter N 7404	Y8, Y10, Y11
Quad 2 input NAND N7400	Y17
Quad operational amplifier MC 3403	X6

5. Discussion and Conclusions

The polling system described is for the use of the Department of Irrigation for acquiring at a central station, the telemetry data from a number of outstations located at different points in the island. The system is of course of general application and has been specially designed so that a single communication channel may be used for polling and acquiring data from all outstations. The communication channel used for data acquisition may be used without interference for voice communication as well, a particularly useful feature when the radio frequency band used for communication is a crowded one, such as the H.F. band.

The system has been successfully tested on the H.F./SSB voice channel assigned to the Department of Irrigation. The following modifications may easily be made if necessary to achieve more stringent operating requirements.

(a) A frequency of 1.5 KHz has been chosen for the sub-carrier so that HF/SSB transmitter-receivers designed primarily for voice communication may be used for this telemetry application as well. Such transmitter-receivers have the best output and maximum modulation index at about 1.5 KHz. However, as the normal voice frequency spectrum has a maximum amplitude around this frequency, the probability of interference from voice is also greatest at this frequency. Hence if it is desired to reduce further the possibility of interference from voice, a sub-carrier frequency may be chosen which lies on a less pronounced part of the normal voice frequency spectrum but is still within the specified bandwidth for the channel.

(b) Another modification that could be made if it is necessary to reduce even further the possibility of interference from voice and also noise is to use a signalling rate that is lower than the 50 bits/sec. used in this system. The bandwidth of the filter (Y2) in the Response Activator could then be reduced effectively reducing the voice power likely to cause interference. There is, however, a limit to this process as the filter bandwidth should be sufficient to allow for any drift in the receiver local oscillator frequency. Such a drift could result in the sub-carrier shifting to a frequency outside the filter bandwidth if the latter is made too narrow.

(c) The system has been designed using TTL logic elements. CMOS logic elements may be used instead with all its attendant advantages such as greater immunity to noise, less power consumption and greater tolerance to variation in the power supply voltage.

References

1. Irrigation Department (Hydrology Division): '*Report on an Automatic Water Level Transmitter*', *Feb.* 1974.

2. Palihawadana, C. W. W., Sridharan, S., Sivaprakasapillai, P., '*A Polling System for Data Acquisition Using a Single HF/SSB Voice Channel*', Joint Technical Report of the National Engineering Research and Development Centre, Colombo and University of Sri Lanka, Katubedda Campus, Moratuwa, Feb. 1978.

Acknowledgements

The authors wish to thank the Chairman and the General Manager, NERD Centre, the President, Katubedda Campus, the Director of Irrigation and their staff, for facilities provided and for assistance in designing and testing this system. Particular mention is made of Mr. A. Makalanda of the Irrigation Department and Mr. D. Taldena of the NERD Centre for their constant help and encouragement.

The authors also wish to thank Mr. Y. A. B. D. Wickramasinghe, Electronic Engineer, Katubedda Campus, for his valuable help.

සංක්ෂිප්තය

මන්තුකිරීමේ මධ්‍යස්ථානයක සිට බාහිර ස්ථාන කිහිපයක් දුරමානනය කිරීම හා ඒවායින් තොරතුරු ලබා ගැනීමේ සංඛ්‍යාත පද්ධතියක් දියුණු කර ඇත. එකම අධිසංඛ්‍යාත/තනි පැති කලාප ශබ්ද නාලියක් අනුසාරයෙන් බාහිර ස්ථාන ඇමතීම හා ඒවායින් තොරතුරු ආපසු ලබා ගැනීමට හැකිවීම මෙම ක්‍රමයේ ඇති වාසියකි. ශබ්ද නාලියෙහි ඇති පනිවිඩ සහ/හෝ එහි නිරතුරුවම ඇති සසම්භාවී ඝෝෂාවන්ගෙන් හදිසියේ බාහිර ස්ථාන පනගැන්වීම වැලැක්වීමට විශේෂ විධිවිධාන යොදා ඇත. මෙම ක්‍රියාමාර්ග යටතේ අධිසංඛ්‍යාත/තනි පැති කලාප නාලියේ කථා පනිවුඩ හුවමාරු කර ගැනීමටද එක විටම කල හැක. අධි සංඛ්‍යාත කලාපයේ සංඛ්‍යාතයක් ලබා ගැනීමට ඇති අපහසු බව නිසා මෙවැනි දත්ත රැස්කිරීමේ පද්ධතියක අවශ්‍යතාවය දැන් ඉස්මතුවී ඇත. අපේ අවශ්‍යතාවයන් සඳහා මේ රටේ කල හැකි දේ ගැන මෙම පද්ධතිය හොඳ උදාහරණයකි.

சுருக்கம்

மனிதனால் இயக்கப்படாத வெளி நிலையங்களை தன்னகத்தே கொண்டு தொலைமானமிடல் அல்லது அதையொத்த தகவல்களை அவற்றிடம் இருந்து பெறும் மத்திய தெரிதல் நிலையம் ஒன்றைத் தர வல்ல இலக்கத் தொகுதி ஒன்று உருவாக்கப்பட்டுள்ளது. எல்லா வெளி நிலையங்களையும் தன்னகத்தே சேர்ப்பதற்கும், அவற்றில் இருந்து பெறப்பட்ட தகவல்களை மீண்டும் மத்திய தெரிதல் நிலையத்திற்கு அனுப்புவதற்கும் ஒரு தனி உயர் அதிர் லெண்/தனிப் பக்கப் பட்டை குரல் கால்வாய் பயன்படுத்தப்படும். சிறப்பை இத் தொகுதி கொண்டுள்ளது. எந்த ஒரு வெளி நிலையத்திலும் உள்ள உணர்த்தும் தொகுதியை யதேச்சையான சத்தமோ அல்லது குரலோ தற்செயலாகவேனும் பாதிக்காத வண்ணம் இது உறுதிப்படுத்தப்பட்டுள்ளது. குரலினால் ஏற்படும் தலையீட்டைத் தவிர்ப்பதற்கு எடுக்கப்படும் பாதுகாப்பினால், இந்த தகவல்களை எடுக்கும் தொகுதியைப் பாவிக்கும் ஒருவர் அதை தனது உயர் அதிர் லெண்/தனிப்பக்கப் பட்டை (HF/SSB) கால்வாயாகவும், அதே நேரத்தில் மற்றும் சிலருக்கு குரல் தொடர்பு பாதையாகவும் பாவிக்கக் கூடியதாக உள்ளது. உயர் அதிர் லெண் பட்டையில் எல்லா அதிர் லெண்களுக்கும் இடமளிக்க முடியாததால், இப்படியான தகவல்களை எடுக்கும் தொகுதி சில காலத்திற்கு தேவையாக உள்ளது. இந்த நாட்டின் தனித்துவமான தேவைகளைத் திருப்திப்படுத்துவதற்கு இங்கு சொல்லப்பட்ட தொகுதி ஒரு சிறந்த உதாரணமாகக் கருதப்படுகிறது.