APPENDIX I

HARMONIC ANALYSIS

For periodic function of voltage E, we can always express it as the sum of a direct-current component plus a series of alternating components.

$$E = D_o + A_1 \sin wt + A_2 \sin 2wt + A_3 \sin 3wt + \ldots\ldots\ldots$$
$$+ B_1 \cos wt + B_2 \cos 2wt + B_3 \cos 3wt + \ldots\ldots\ldots \quad \ldots(I-1)$$

$$E = D_o + \sqrt{A_1^2 + B_1^2} \left[\frac{A_1}{\sqrt{A_1^2 + B_1^2}} \sin wt + \frac{B_1}{\sqrt{A_1^2 + B_1^2}} \cos wt \right]$$

$$+ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$+ \sqrt{A_n^2 + B_n^2} \left[\frac{A_n}{\sqrt{A_n^2 + B_n^2}} \sin nwt + \frac{B_n}{\sqrt{A_n^2 + B_n^2}} \cos nwt \right]$$

$$+ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \ldots\ldots(I-2)$$

Given $\sqrt{A_n^2 + B_n^2} = C_n$

$$\phi_n = \tan^{-1} \frac{B_n}{A_n}$$

$$E = D_o + C_1 \left[\sin wt \cos\phi_1 + \cos wt \sin\phi_1 \right]$$

$$+ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$+ C_n \left[\sin nwt \cos\phi_n + \cos nwt \sin\phi_n \right]$$

$$+ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \ldots\ldots\ldots(I-3)$$

$$E = D_o + C_1\sin(wt + \phi_1) + \ldots\ldots + C_n\sin(nwt + \phi_n) + \ldots\ldots \ldots(I-4)$$

where D_o= amplitude of direct-current component.

C_1, C_2, etc.= amplitude of corresponding alternating-current components.

ϕ_1,ϕ_2, etc.= phase angle of corresponding alternating-current components.

w = 2π times the fundamental frequency of the wave.

Eq.(I-4) is a periodic electrical waves expressed as the sum of a direct-current component plus a series of alternating components that are all harmonics of the fundamental frequency of the wave.

APPENDIX II

AMPLITUDE MODULATION ANALYSIS

An expression for the instantaneous voltage of the modulated wave may be derived from the following considerations. For the unmodulated carrier, the instantaneous voltage e is

$$e = E_c \sin 2\pi f_c t \qquad \dots\dots\dots\dots\dots\dots\dots(II\text{-}1)$$

$$= E_c \sin w_c t \qquad \dots\dots\dots\dots\dots\dots\dots(II\text{-}2)$$

where $\qquad E_c$ = amplitude of carrier voltage,

$\qquad f_c$ = frequency of carrier wave.

For the modulating wave, the instantaneous voltage e_m is,

$$e_m = E_m \sin 2\pi f_m t \qquad \dots\dots\dots\dots\dots\dots\dots(II\text{-}3)$$

$$= E_m \sin w_m t \qquad \dots\dots\dots\dots\dots\dots\dots(II\text{-}4)$$

where $\qquad E_m$ = amplitude of modulating voltage,

$\qquad f_m$ = frequency of modulating wave.

The effect of the modulation is to modify the amplitude so that it has no longer the constant value E_c but varies with time above and below E_c. In the wave, the amplitude variation about E_c is sinusoidal, so that the amplitude, as a function of time, is given by the expression $(E_c + kE_m \sin w_m t)$, where the value of k depends upon the modulator circuit. It has a maximum value equal to $E_c + kE_m$ and a minimum value equal to $E_c - kE_m$. So from the Eq.(II-2), the instantaneous voltage of the modulated wave is then

$$e = (E_c + kE_m \sin w_m t) \sin w_c t \qquad \ldots\ldots\ldots\ldots (II\text{-}5)$$

$$= E_c \left(1 + \frac{kE_m}{E_c} \sin w_m t \right) \sin w_c t \qquad \ldots\ldots\ldots\ldots (II\text{-}6)$$

The ratio kE_m/E_c is known as the modulation factor and is designated by the symbol m.

$$m = k\frac{E_m}{E_c} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (II\text{-}7)$$

So $\qquad\qquad e = E_c (1 + m \sin w_m t) \sin w_c t \qquad \ldots\ldots\ldots\ldots\ldots (II\text{-}8)$

The factor m normally ranges in value from zero to one, when m = 0, there is no amplitude modulation present. When m = 1, the percentage modulation is 100%. If the modulating voltage is made greater than that for which m = 1, a condition described as over-modulation exists.

Eq.(II-8) can be rewritten in the form

$$e = E_c \sin w_c t + mE_c \sin w_c t \sin w_m t \qquad \ldots\ldots\ldots\ldots (II\text{-}9)$$

$$= E_c \sin w_c t + \frac{mE_c}{2} \cos(w_c - w_m)t - \frac{mE_c}{2}\cos(w_c + w_m)t$$
$$\ldots\ldots\ldots\ldots (II\text{-}10)$$

It is seen from Eq.(II-10) that the modulated wave is the sum of three sinusoidal components. These include a carrier component having the same frequency and amplitude as the unmodulated RF wave and two side-frequency components, one at a frequency equal to the carrier frequency plus the modulating signal frequency, called upper sideband, the other at a frequency equal to the carrier frequency minus the modulating signal frequency, called lower sideband. The relative amplitude of the side-band

components depends upon the m, modulation factor, being equal to half the amplitude of the carrier when m = 1. $\lfloor$ Eq.(II-10).$\rfloor$

APPENDIX III

RADIO BROADCASTING STATIONS IN BANGKOK

FREQUENCY (KC)	POWER (KW)	NAME	TIME
540	1	Thai Airforce (Tung Mahamek)	Repeater
555	1	Thai Army (Armored) Music	---
570	1	Thai Army (Signal Dept.)	0600 - 1300
580	1	Thai Navy (STR. Special)	0600 - 1300
590	10	Thai Army (Provost Marshal Dept.)	-
600	1	Thai Army (Antiaircraft Artillery Division).	0600 - 0900 1100 - 1400 1800 - 2400
610	1	Border Patrol Police	-
630	1	Thai Army (Signal Dept.)	Repeater
650	1	Thai Army (Signal Dept.)	0600 - 1300 1630 - 2300
662	1	Agricultural University	0600 - 2300
674.15	2.5	Public Relations Dept. 8 (Agricultural)	1130 - 1400 1600 - 2200
695	10	Thai Navy (STR.)	0530 - 1000
705	0.25	Thai Army (Energy Dept.)	1100 - 1300
738	1	Thai Army (Dept. of Territorial Defense)	0700 - 2230
750	0.5	Post & Telegraph Dept.	2015 - 2300

760	1	Police Dept. (Sieng Varajak)	0600 - 2300
785	10	Thai Army (Armored)	0600 - 2400
800	5	Thai Airforce (01 Donmuang)	1700 - 2300
830	10	Public Relations Dept.	0600 - 1140
			1230 - 1730
			1800 - 2245
856.6	10	Public Relations Dept.	0600 - 1430
		(PRD. 1, 2, 3, 4)	1500 - 2230
890	1	Thai Army (Armored)	0600 - 2200
900	1	Police Dept.	0525 - 1300
			1425 - 2345
910	1	Public Relations Dept.	0600 - 0915
		(PRD. 7)	1045 - 1400
			1600 - 2415
927	10	Public Relations Dept.	0600 - 0830
			1730 - 2230
940	1	Thai Airforce (01 Special)	0600 - 2300
980	1	Public Relations Dept.	1200 - 1300
		(PRD. 10) Thammasart Univ.	1700 - 2100
990	0.5	Post & Telegraph Dept. (1 PT)	0900 - 1430
1010	1	Post & Telegraph Dept.	-
1020	1	Post & Telegraph Dept.	1200 - 1630
1030	1	Post & Telegraph Dept.	-
1043	20	Thai Army (Experimental	0530 - 0830
		Military Intelligence 1)	1000 - 1500
1060	1	Post & Telegraph Dept.	1200 - 1600

1075	1	Thai Army (Signal Dept.)	0600 - 2300
1100	10	Thai Army (Dept. of Territorial Defense)	0700 - 2230
1110	10	Thai Army (Provost Marshal Dept.)	0530 - 0900
			1100 - 1400
			1600 - 2200
1120	10	Thai Navy (STR.2)	0530 - 1400
1150	10	TTV Music	1700 - 2300
1160	5	Police Dept.(Sieng Samyod)	0600 - 1000
			1100 - 1400
			1645 - 2400
1180	2	Ministry of Education	0830 - 1400
1200	10	Thai Airforce (01 Donmuang)	0600 - 1400
			1630 - 2300
1256	1	Public Relations Dept. (PRD. 7)	-
1268	1	Thai Airforce (Tung Mahamek)	0530 - 0900
			1100 - 1345
			1630 - 2300
1280	10	Thai Army (Transportation Div.)	0630 - 0915
			1100 - 1330
			1700 - 2200
1300	1	Thai Army (Armored)Special	0600 - 0800
1310	10	Agricultural University	0600 - 2300
1320	1	Thai Airforce (Tung Mahamek)	1100 - 1345
			1630 - 2300

1333.33	1	Office of the Royal Household	1600 – 1800
1355	10	Thai Army (First Infantry Div.)	1700 – 2400
1360	1	Thai Army	0600 – 1700
1400	1	Thai Army (Experimental Military Intelligence 4)	1000 – 2100
1420	1	Thai Navy (STR.)	0600 – 1400
		STR. Music	1500 – 2200
1430	1	Police Dept.	0525 – 1300
			1425 – 2345
1446	0.5	Thai Army (Experimental Military Intelligence)	–
1470	10	Thai Army (Dept. of Territorial Defense)	0700 – 2230
1500	10	TTV	0600 – 2300
1520	10	Station 20	0600 – 0800
			1200 – 1300
			1800 – 2000
1530	0.5	Thai Army (Experimental Military Intelligence)	–
1550	0.25	Thai Army (Armored)	Repeater
1560	1	Post & Telegraph Dept. (P.T. 5)	0900 – 1400
			1525 – 2155
1570	1	Thai Army (First Infantry Div.)	0600 – 2300
1580	1	Marine Police Div.	–

FCC RULES AND REGULATIONS FOR STANDARD BROADCAST STATIONS

§ 3.1 <u>Standard broadcast station</u>. The term "Standard broadcast station" means a broadcasting station licensed for the transmission of radiotelephone emissions primarily intended to be received by the general public and operated on a channel in the band 535-1605 kilocycles.

§ 3.3 <u>Standard broadcast channel</u>. The term "Standard broadcast channel" means the band of frequencies occupied by the carrier and two side bands of a broadcast signal with the carrier frequency at the center. Channels shall be designated by their assigned carrier frequencies. Carrier frequencies assigned to standard broadcast stations shall begin at 540 kilocycles and be in successive steps of 10 kilocycles.

§ 3.11 <u>Service areas</u>.

(a) The term "primary service area" of a broadcast station means the area in which the ground wave is not subject to objectionable interference or objectionable fading.

(b) The term "secondary service area" of a broadcast station means the area served by the sky wave and not subject to objectionable interference. The signal subject to intermittent variations in intensity.

(c) The term "intermittent service area" of a broadcast station means the area receiving service from the ground wave but beyond the primary service area and subject to some interference and fading.

§ 3.40 Transmitter; design, construction, and safety of life requirements.

(a) Design. The general design of standard broadcast transmitting equipment [main studio microphone (including telephone lines, if used, as to performance only) to antenna output] shall be inaccordance with the following specifications. ----------- The equipment shall be so designed that:

(1) -----------

(2) The equipment is capable of satisfactory operation at the authorized operating power or the proposed operating power with modulation of at least 85 or 95 per cent with no more distortion than given in (3) below.

(3) The total audio frequency distortion from microphone terminals, including microphone amplifier, to antenna output does not exceed 5 per cent harmonics (voltage measurements of arithmetical sum or r.s.s.) when modulated from 0 to 84 per cent and not over 7.5 per cent harmonics (voltage measurements of arithmetical sum or r.s.s.) when modulating 85 per cent to 95 per cent.

(4) The audio frequency transmitting characteristics of the equipment for the microphone terminals (including microphone amplifier unless microphone frequency correction is included in which event proper allowance shall be made accordingly) to the antenna output does not depart more than 2 db from that at 1,000 cycles between 100 and 5,000 cycles.

(5) The carrier shift (current) at any percentage of modulation does not exceed 5 per cent.

(6) The carrier hum and extraneous noise (exclusive of micro-
phone and studio noises) level is at least 50 db below
100 per cent modulation for the frequency band of 150 to
5,000 cycles and at least 40 db down outside this range.

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(9) The transmitter is equipped with automatic frequency con-
trol equipment capable of maintaining the operating fre-
quency within the limit specified by $\S$ 3.59.

    (iii) It is preferable that the tank circuit of the
oscillator tube be installed in the temperature
controlled chamber.

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(11) Adequate margin is provided in all component parts to
avoid over heating at the maximum rated power output.

(12) Any emission appearing on a frequency removed from the
carrier by between 15 KC and 30 KC, inclusive, shall be
attenuated at least 25 db below the level of the unmod-
ulated carrier. Compliance with the specification will be
deemed to show the occupied bandwidth to be 30 KC or less.

(13) Any emission appearing on a frequency removed from the
carrier by more than 30 KC and up to and including 75 KC,
inclusive, shall be attenuated at least 35 db below the
level of the unmodulated carrier.

(14) Any emission appearing on a frequency removed from the
carrier by more than 75 KC shall be attenuated at least

$43 + 10\log10$(power in watts) db below the level of the unmodulated carrier, or 80 db, whichever is the lesser attenuation.

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§ 3.55 Modulation.

(a) A licensee of a broadcast station will not be authorized to operate a transmitter unless it is capable of delivering satisfactorily the authorized power with a modulation of at least 85 per cent. When the transmitter is operated with 85 per cent modulation, not over 10 per cent combined audio frequency harmonics shall be generated by the transmitter.

(b) All broadcast stations shall have in operation a modulation monitor approved by the commission.

(c) The operating percentage of modulation of all stations shall be maintained as high as possible consistent with good quality of transmission and good broadcast practice and in no case less than 85 per cent on peaks of frequent recurrence during any selection which normally is transmitted at the highest level of the program under consideration.

§ 3.57 Operating power; maintenance of.

The licensee of a broadcast station shall maintain the operating power of the station within the prescribed limits of the licensed power at all times except that in an emergency when, due to causes beyond the control of the licensee, it becomes impossible to operate with the full licensed power, the stations may be operated at reduced power for a period of not to exceed 10 days, provided that the Commission and the Engineer in Charge shall be notified in writing immediately after the emergency develops.

§ 3.58 Indicating instruments.

Each broadcast station shall be equipped with suitable indicating instruments of accepted accuracy to measure the antenna current, direct plate circuit voltage, and the direct plate circuit current of the last radio stage. These indicating instruments shall not be changed or replaced, without authority of the Commission, except by instruments of the same type, maximum scale reading, and accuracy.

§ 3.59 Frequency tolerance.

The operating frequency of each broadcast station shall be maintained within 50 cycles of the assigned frequency until January 1, 1940, and thereafter the frequency of each new station or each station where a new transmitter is installed shall be maintained within 20 cycles of the assigned frequency, and after January 1, 1942, the frequency of all stations shall be maintained within 20 cycles of the assigned frequency.

§ 3.60 Frequency monitor.

The licensee of each standard broadcast station shall have in operation at the transmitter a frequency monitor independent of the frequency control of the transmitter. The frequency monitor shall be approved by the Commission. It shall have a stability and accuracy of at least 5 parts per million.

§ 3.97 Station inspection.

The licensee of any radio station shall make the station available for inspection by representatives of the Commission at any reasonable hour.

§ 3.111 Logs.

The licensee of each standard broadcast station shall maintain program and operating logs and shall require entries to be made as follows:

(b) In the operating log:

(1) An entry of the time the station begins to supply **power to the antenna, and the time it stops.**

(2) An entry of the time the program begins and ends.

(3) An entry of each interruption to the carrier wave, its cause, and duration.

(4) An entry of the following each 30 minutes.

(i) Operating constants of last radio stage.(total plate current and plate voltage).

(ii) Antenna current.

(iii) Frequency monitor reading.

(iv) Temperature of crystal control chamber if thermometer is used.

(5) Log of experimental operation during experimental period. (If regular operation is maintained during this period, the above logs shall be kept.)

(i) A log must be kept of all operation during the experimental period. If the entries required above are not applicable there to, then the entries shall be made so as to fully describe the operation.

APPENDIX V

ITU RADIO REGULATIONS

Broadcasting Service. A radio communication service in which the transmissions are intended for **direct** reception by the general **public.** This service may include sound transmissions, television transmissions another types of transmissions.

Occupied Bandwidth. The frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5% of the total mean power radiated by a given emission. In some cases, for example multi-channel frequency-division systems, the percentage of 0.5% may lead to certain difficulties in the practical application of the definitions of **o**ccupied and necessary bandwidth; in such cases a different percentage may prove useful.

Necessary Bandwidth. For a given class of emission, the minimum value of the occupied bandwidth sufficient to ensure the transmission of information at the rate and with the quality required for the system employed, under specified conditions. Emissions useful for the good functioning of the receiving equipment as, for example, the emission corresponding to the carrier of reduced carrier systems, shall be included in the necessary bandwidth.

Spurious Emission. Emission on a frequency or frequencies which are outside the necessary band, and the level of which may be reduced without affecting

the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions and intermodulation products, but exclude emissions in the immediate vicinity of the necessary band, which are a result of the modulation process for the transmission of information.

Harmful Interference. Any emission, radiation or induction which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radiocommunication service operating in accordance with these Regulations.

APPENDIX VI

PRINCIPLES IN REQUESTING FOR RADIO & TELEVISION
BROADCAST STATION INSTALLATION

Request for Registering Radio Frequency

The use of radio frequency in various services is under the control
of an organization called the ITU (International Telecommunication Union)
whose headquarter situates at Geneva, Switzerland. Various countries of the
world are members of this Organization, including Thailand.

The ITU had assigned one of the offices in the membered country to
control, communicate, and to take the responsibility in using the frequen-
cy in its own country under the IFRB's control and suggestion. This IFRB
(International Frequency Registration Board) is an office or a branch re-
garding the frequency business of the ITU.

In Thailand, the Post and Telegraph Department is the representative
for the ITU to control and take the responsibility concerning various radio
frequencies in the country accurately and orderly. Therefore, a person who
wishes to install any kind of radio stations including radio and/or television
broadcast station has to request for the permission in using the radio fre-
quency according to each radio station service, and submit the request for
registering that radio frequency in his own patent to the Post and Tele-
graph Department. Then, the Post and Telegraph Department, after an ex-
haustive consideration on that request covering its function and details

of that transmitter, will proceed the request to the ITU. The confirmed letter from ITU through the Post and Telegraph Department to the requested person will render him to get the rightful patent.

This radio frequencies are divided into 3 regions, that is region 1, region 2, and region 3. Each region geographically regulates the situation of a countries. Thailand situates in the region 3. Therefore, in requesting to use the radio frequency, the requested person has to examine the radio frequency according to the nature of its duty; on the other hand, according to the service which the ITU has already regulated in the "Table of Frequency Allocations" in the latest issue of the Radio Regulations.

Either the "Table of Frequency Allocation" or the other documents the ITU had regulated and set up meetings can be obtained from the office in the afore-mentioned district.

Request for Radio and Television Broadcast Service

Whereas the Public Relations Department was assigned to control the radio and television broadcast service for publicity according to the Radio Broadcast & Television Act B.E. 2498 (A.D. 1955). Therefore, the person with this purpose has to submit his request to the officer who issues the license at the Radio Engineering and License Division or to the registrar at the Radio Registration and Statistics Division, Public Relations Region Office or at the Post and Telegraph Department where the Post Officer is assigned as registrar before installing a station. That is, to get the permission from the officers who issue license before proceeding the business.

Besides, the requested person has to pay for the license fee according to the price rate mentioned in the Act of which a more detailed information can be found in the Radio Broadcast & Television Act.

[Translated from "The Radio Broadcast & Television Act" B.E. 2498 (A.D. 1955).]

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